

ANNUAL REPORT

2018 to 2019

Center for the Management, Utilization,
& Protection of Water Resources



CENTER FOR THE MANAGEMENT,
UTILIZATION & PROTECTION
OF WATER RESOURCES

JUSTIN MURDOCK,
INTERIM DIRECTOR

Annual Report for Fiscal Year
July 1, 2018, through June 30, 2019

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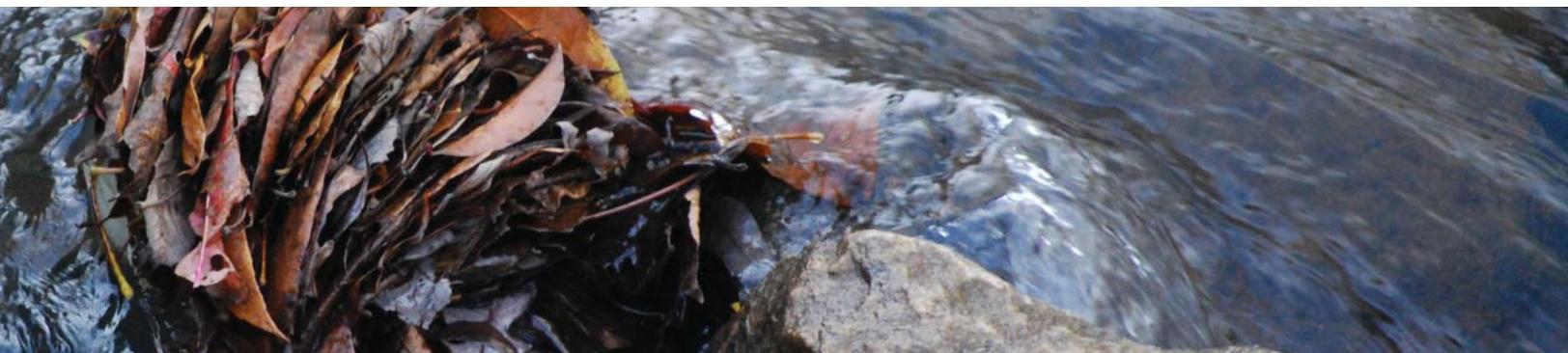


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PROGRAMMATIC REPORT



MESSAGE FROM THE INTERIM DIRECTOR

Dear Stakeholders,

This past year, the Center has strived to continue to support the needs of the state through water-related research, the education of future water professionals, and public outreach. We have strived to increase our collaborations with faculty across campus, increased Center support of undergraduate and graduate student research, and made new collaborations with state and federal agencies and public stakeholder groups. We have grown in all of these areas. Additionally, we continue to support the water related needs of the state through a diverse portfolio of research projects with many state and federal agencies. This year's projects include TWRA funded investigations of invasive Asian carp in our rivers, TDOT funded research to understand nutrient runoff in urban areas and roadways, and USDA funded research to assess how wetland restoration in agricultural landscapes can help improve surface water quality in the state. Projects such as these provide a strong base that enables the Center to maintain a leading role in regional and national water resource protection and management.

After a thorough search for a new permanent Center Director, we are excited to welcome Dr. Jeff Schaefer to lead the Center into the future. Jeff comes to Tennessee Tech from his position as the Chief Branch Supervisor of the Coastal Ecosystems Unit at the USGS Water Science Center in Ann Arbor, Michigan. His background in fisheries management, landscape ecology, wetland restoration, and managing large interdisciplinary projects provides a strong

base to move the Center forward. We are enthusiastic about Jeff's vision for the Center and look forward to the great things and new opportunities he will bring to Tennessee Tech.

During the next year, we plan to grow our support of graduate student education through increasing assistantship funding, providing additional space and equipment for studying and performing research, and reaching out to students to make sure they receive needed research related guidance. We will also prioritize establishing new connections with faculty across departments to help initiate multidisciplinary research groups that can provide the background to acquire and perform the ever-complex research needs of the state. Since its inception, the Water Center has maintained strong relationships with many state and federal agencies. We will continue to prioritize these relationships as we strive to position ourselves to address the most pressing issues facing Tennessee and our region.

Thank you for your continued support as we further our mission to improve water resources and better serve the state, national, and global water resource stakeholders.

Sincerely,

A handwritten signature in black ink that reads "Justin N. Murdock". The signature is written in a cursive, slightly slanted style.

Justin Murdock, Center Interim Director

BENEFITS TO THE STATE OF TENNESSEE

The Water Center's work in water and wastewater research, wildlife and fisheries management, hydrological modeling, sensor development, ecosystem services, and many other areas related to water resource protection is becoming more relevant as environmental issues continue to be pushed to the front of our nation's attention. Additionally, as Tennessee's economy becomes more interlinked with natural resources, the Center's role in meeting state water informational needs is expanding. Specifically, the Water Center has benefited Tennessee by drawing in millions of dollars of externally funded research and providing its citizens with the awareness and knowledge needed to effectively manage the state's precious and imperiled water resources.

Water Center researchers work closely with the Tennessee Department of Environment and Conservation (TDEC) and Tennessee Department of Transportation (TDOT) to assess surface water quality issues. For example, civil and environmental engineering associate professors Tania Datta and Alfred Kalyanapu are researching nutrient movement within stormwater, and the potential of vegetation swales to infiltrate stormwater runoff from Tennessee's highways. Center researchers serve as the primary research arm of the Tennessee Wildlife Resources Agency Fisheries Division and the State's greater than \$480 million annual fishing industry and \$21 billion annual outdoor recreation industry, which reaches approximately 900,000 anglers. The work of Mark Rogers and Amanda Rosenberger in the U.S. Geological Survey (USGS) Cooperative Fishery Research Unit at Tennessee Tech, and biology and envi-

ronmental study professors Brad Cook, Hayden Mattingly, Carla Hurt, Kit Wheeler, and Justin Murdock have helped protect endangered and threatened aquatic species in rivers throughout the state, as well as helped better manage fisheries resources from invasive species such as Asian carp and didymo.

This past fiscal year, the Center provided Tennessee Tech with more than \$200,000 in student support. Also this past fiscal year, Water Center faculty and associates made 19 presentations to Tennessee agencies or within the state. (For a complete listing of presentation and publication information, see Page S4.)

The Water Center's faculty and associates realize the importance of sharing their research and expertise with the citizens of Tennessee. One way they do this is by serving on committees or becoming members of State organizations or active boards. As an example, last fiscal year, our faculty and associates took part in the following committees, organizations or events that benefit the state: Tania Datta and Alfred Kalyanapu served on the Technical Work Group for the Tennessee Water Plan. Steven Hayslette served as an Executive Board member (a Southeastern Section Representative) of the Tennessee Chapter of The Wildlife Society. Hayden Mattingly was a federally appointed member of the Bluemask Darter Technical Team of the U.S. Fish and Wildlife Service. Justin Murdock served as a member of the Tennessee harmful algal bloom working group, and Tennessee stream nutrient reduction taskforce.

ACCOMPLISHMENTS AND AWARDS

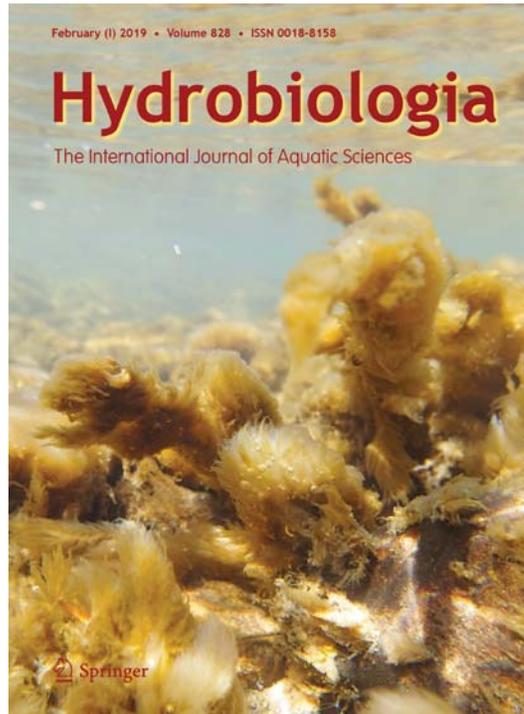
Water Center faculty and associates are recognized nationally for research in aquatic biodiversity, technology development, and water security and sustainability.

Water Center faculty and associate faculty secured more than \$1.9 million (including indirect costs) from local, state and federal agencies to seek solutions to that state's environmental problems. The direct monetary return on the State's investment is \$1.62/ State-allocated dollar. This is a 54% increase from just five years ago. Our current external funding level trend emphasizes the growing research productivity of our faculty. Center external research funding has shown a steady growth during the last five years with a five-year running average of \$1,623,884, and a three-year running average of \$1,841,563.

The Center supported 28 graduate students this year, a 37% increase from the previous year, as well as 85 hourly students, a 5% decrease.

The Water Center researchers produced 11 refereed publications and made 47 presentations this year.

Chemical engineering Assistant Professor Laura Arias Chavez was awarded "Most Outstanding Professor" in the Department of Chemical Engineering in April 2019 by the Student Chapter of the American Institute of Chemical Engineers at Tennessee Tech. Haley White, chemical engineering Ph.D. student advised by Chavez, won the Best Graduate Student Chemical Engineering Poster award at the 2019 Tennessee Tech Research and Creative Inquiry Day for her work titled "Use of Desalination Brine for Low-Energy Concentration of Orange Juice." White



also earned the American Water Works Association's Henry "Bud" Benjes Award of \$5,000 toward her research.

Students of Tania Datta, assistant professor of environmental engineering, won honors this fiscal year. Alisa Danielle Kirkpatrick received the 2018 KY/TN Water Environmental Federation Scholarship; Grace McClellan received the 2018 KY/TN American Water Works Association Scholarship; and Joseph Brockwell received the Civil and Environmental Engineering graduate award for his poster at the 2019 Tennessee Tech Research and Creative Inquiry Day.

Biologist Keith Gibbs advises fisheries student Aiden Blackburn who won the Best Poster Presentation Award at the 2019 Tennessee American Fisheries Society meeting.

Water Center Ph.D. student John Brackins (Civil and Environmental Engineering) was awarded a National Science Foundation Graduate Research Fellowship for his work studying hurricane storm surges.

Amanda Rosenberger, assistant unit leader of the Tennessee Cooperative Fishery Research Unit and associate professor of biology, was awarded certification as a Fisheries Professional by the American Fisheries Society (2018-2023) and won the 2018 Performance Award from the United States Department of the Interior, U.S. Geological Survey.

The research of Lucas Hix (former Water Center graduate student) and Justin Murdock (Interim Director) was highlighted on the cover of the journal *Hydrobiologia*. Their work investigated the conditions supporting the spread and growth of the invasive algae, *Didymo*.

FACULTY AND EXPERTISE

Faculty and Associates in *Biodiversity*

Brian Carver
(Biology)

Dan Combs
(Biology)

Brad Cook
(Biology)

Keith Gibbs
(Biology)

Steve Hayslette
(Biology)

Carla Hurt
(Biology)

Robert Kissell
(Biology)

Hayden Mattingly
(Environmental Studies)

Justin Murdock
(Biology)

Chris Murray
(Biology)

Mark Rogers
(Biology and USGS Cooperative
Fishery Research Unit)

**Amanda
Rosenberger**
(Biology and USGS Cooperative
Fishery Research Unit)

Faculty and Associates in *Enabling Technologies and Tools*

Jeff Boles
(Chemistry)

Tania Datta
(Civil and Environmental
Engineering)

Alfred Kalyanapu
(Civil and Environmental
Engineering)

Chris Murray
(Biology)

Sheikh Ghafoor
(Computer Science)

Justin Murdock
(Biology)

Faculty Associates and Associates in *Water-Energy-Food Nexus*

Laura Arias Chavez
(Chemical Engineering)

Michael Best
(Agriculture)

Brian Leckie
(Agriculture)

Holly Stretz
(Chemical Engineering)

Tania Datta
(Civil and Environmental
Engineering)

Satish Mahajan
(Center for Energy
Systems Research)

Faculty and Associates in *Water Security and Sustainability*

Laura Arias Chavez
(Chemical Engineering)

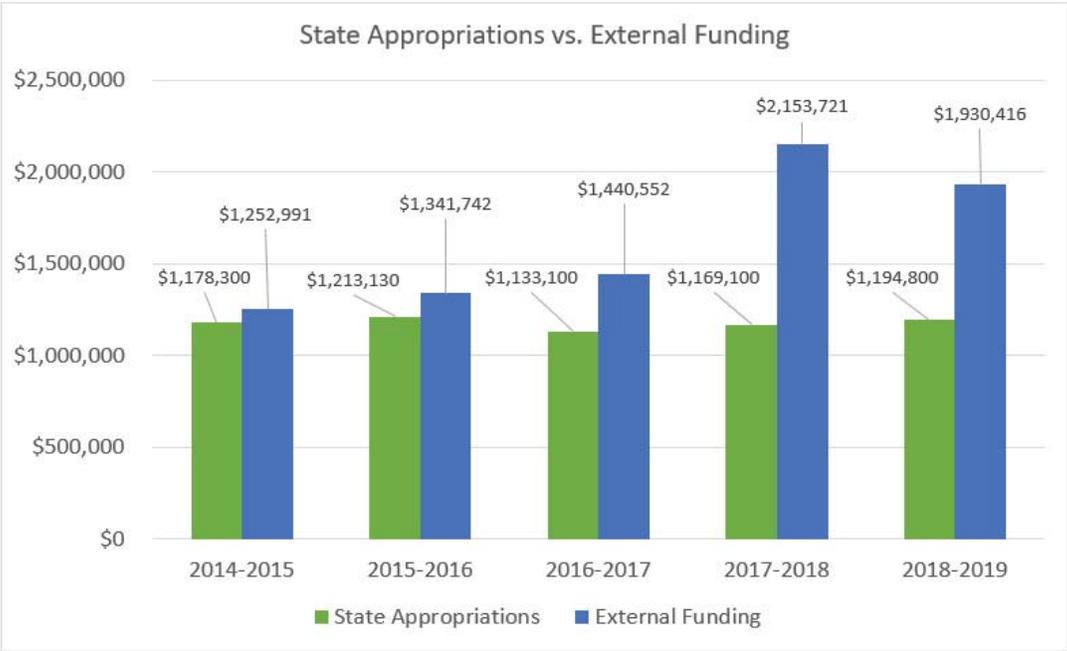
Joseph Asante
(Earth Sciences)

Alfred Kalyanapu
(Civil and Environmental
Engineering)

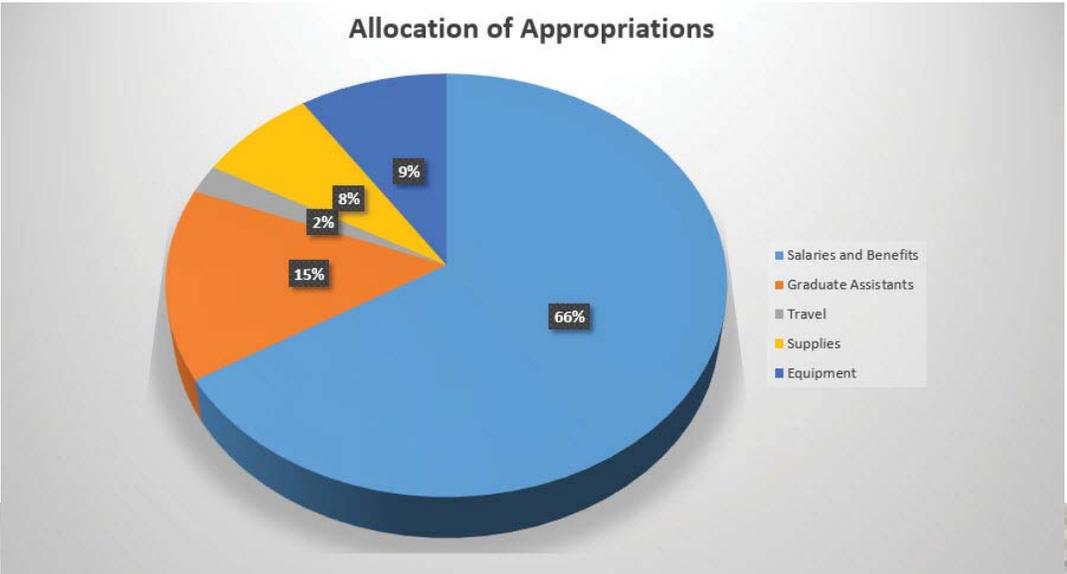
Justin Murdock
(Biology)

Tania Datta
(Civil and Environmental
Engineering)

RETURN ON THE STATE'S INVESTMENT IN THE CENTER



Note: External funding amount includes indirect costs.



CENTER PROJECT HIGHLIGHTS

NUTRIENT REMOVAL IN AGRICULTURAL WETLANDS



Drs. Justin Murdock (Biology) and Alfred Kalyanapu (Civil and Environmental Engineering) received a \$1.96 million grant to assess nutrient removal abilities of restored agricultural wetlands in Tennessee and Kentucky. The grant is funded through the United States Department of Agriculture's Natural Resources Conservation Service (USDA NRCS) and The Nature Conservancy.

Nutrient runoff into streams from agricultural fields is a major issue in agricultural ecosystems and areas downstream receiving this water. Excess nitrogen and phosphorus can lead to harmful algal blooms, low oxygen availability, fish kills, and lower overall aquatic habitat quality. This research will quantify the nutrient removal ability of restored agricultural wetlands in the USDA Wetlands Reserve Program (WRP), with an aim at determining how restoration practices within a wetland influences water quality. The WRP is a voluntary conservation program that provides technical and financial assistance to private landowners and Tribes to restore, protect, and enhance wetlands in exchange for retiring agricultural land. This program allows the USDA to carry out high priority wetland protection, restoration and enhancement and to improve wildlife habitat and ecosystem services of wetlands. Easement enrollment is often accompanied by restoration efforts designed to hasten wetland functional recovery. These modifications often include changes to water flow, vegetation planting, or site grading.



This team will assess WRP nutrient retention performance as a function of time as an easement at floodplain restoration sites in Tennessee and Kentucky. Specifically, researchers will assess easements against agriculture sites and minimally disturbed forested wetlands and assess nutrient retention potential relative to time enrolled in the WRP. Easements are river floodplain wetlands located along the major rivers in Tennessee and Kentucky that flow directly into the Mississippi River. These wetlands often

receive river water during high river flows and filter the water as it moves across the watershed. This project is also focusing on how different characteristics of the wetland influence nutrient retention, including soil structure, microbial community composition, vegetation, and water residence time to help managers better rehabilitate current and future wetland easements. A total of 40 sites across western Tennessee and Kentucky will be assessed.

The grant supports four PhD students and two masters students and will last four years. This project is part of a larger effort that creates a partnership among Tennessee Tech, USDA NRCS, The Nature Conservancy, Murray State University, and the University of Missouri. In addition to water quality and nutrient retention benefits of the WRP, this larger project will investigate improvements in vegetation, waterfowl use, aquatic habitat, and biodiversity.

NEW FACULTY HIGHLIGHT: ASST. PROFESSOR KIT WHEELER EXAMINES FISH POPULATIONS IN FRESHWATER ENVIRONMENTS



Kit Wheeler started as an assistant professor in the biology department in August 2018. Kit completed his Ph.D. in ecology at Utah State University in 2014 before getting positions as a visiting assistant professor at Georgia Southern University and a postdoctoral research associate at the University of Georgia River Basin Center. His general research interests include examining the functional role of organisms in freshwater environments, modeling stream fish population and community responses to environmental change, and conservation of threatened stream fishes. Since arriving at Tennessee Tech, Kit has been involved in the initiation of several research projects that fall within the scope of the Water Center. He is working

with TTU's Hayden Mattingly and Justin Murdock at Arnold Air Force Base to understand how environmental conditions are affecting freshwater resources. As part of this project, Kit and his graduate student are examining temporal changes in fish assemblages and putting them in the context of management and conservation decisions that will be made by air force base personnel. Another project is focused on the conservation and ecology of the striated darter, a threatened endemic fish restricted to a small portion of the Duck River watershed in middle Tennessee. Kit and collaborators from TTU are working to update the understanding of the distribution and abundance of the striated darter, and to examine the potential that individuals use distinct habitats in different portions of their life cycle, thereby influencing the extent and nature of habitat types that need to be preserved to ensure species persistence. Finally, Kit and his lab are studying the migration of spawning suckers in Citico Creek, a small, nutrient-poor stream in East Tennessee that receives runs of tens of thousands of individual suckers every spring. They are quantifying nutrients transported by the migrating fishes from an adjacent reservoir to the creek to get a sense of how nutrient dynamics in Citico Creek are affected by the annual sucker migration. Additionally, they are examining how ecosystem-level properties like stream metabolism and decomposition respond to the sucker migration, which could ultimately influence the movement of energy and nutrients farther downstream.

STAFF HIGHLIGHT: SANDY DODSON RETURNS TO THE CENTER



As the Water Center's external funding and resulting number of research projects grow, Center administrators realized that the existing staff load was not enough to cover the demands. An Administrative Associate 3 position was created to meet that need, and the Center was happy that Sandy Dodson, who had worked with us several years ago, applied and got the job. Sandy files travel claims, purchases supplies, reconciles pro-card statements, manages the motor pool and performs many other tasks of the office. The Center is excited to have her rejoin the team.

STUDENT HIGHLIGHT: ENVIRONMENTAL SCIENCE PH.D. STUDENT ROBERT PAINE USES MOLECULAR TOOLS TO DETECT RARE FRESHWATER FISHES

Robert Paine is a Ph.D. student in Environmental Sciences advised by Dr. Carla Hurt. Robert's research focuses on the use of molecular tools for the detection of rare and cryptic freshwater fishes in Tennessee rivers. Environmental DNA (eDNA) is DNA that is shed into the environment and can be collected and extracted from environmental samples. In the case of fishes, eDNA is readily extracted from samples of river water; purified DNA can then be collected and analyzed using species-specific amplification techniques or using high-throughput DNA sequencing methods. Robert has used eDNA detection to study the distribution of both endangered fish, such as the pygmy madtom, and invasive fish, like the silver carp. Environmental DNA surveillance can also be used to characterize entire fish communities. Robert has used next generation sequencing of eDNA samples to understand factors that influence the composition of fish communities in the Duck and Clinch rivers, which are both considered freshwater fish biodiversity hotspots in temperate North America. Robert will graduate in August, 2019 and has accepted a post-doctoral position under Dr. Mark Rogers (U.S.G.S. – TN Tech Cooperative Fisheries Research Unit) where he will continue to use eDNA surveillance to investigate the ecology of invasive species, like silver carp in Tennessee and African walking catfish in Puerto Rico.

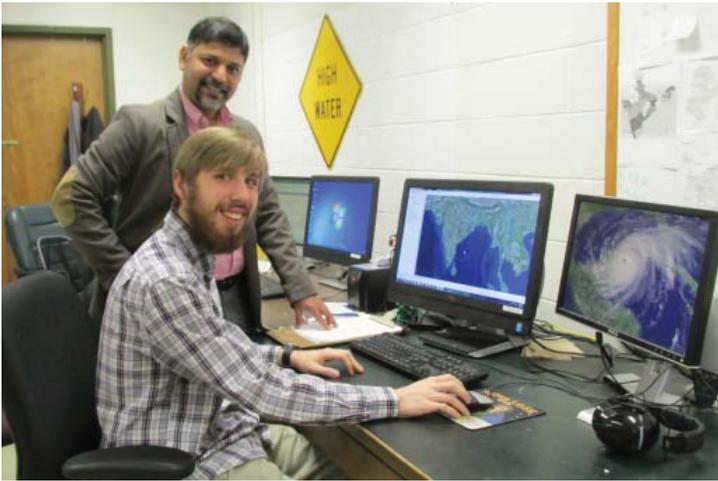


STUDENT HIGHLIGHT: CIVIL AND ENVIRONMENTAL ENGINEERING PH.D. STUDENT JOHN BRACKINS EARNS PRESTIGIOUS NSF GRADUATE RESEARCH FELLOWSHIP

John Brackins, a doctoral student under Dr. Alfred Kalyanapu in Civil and Environmental Engineering, was recently selected as a recipient of the prestigious National Science Foundation's Graduate Research Fellowship Program (NSF-GRFP). Brackins earned his Bachelors of Science in Civil and Environmental Engineering from Tennessee Tech University in 2017, and he went on to earn his Masters of Science in Engineering there in 2018. His research work began early in his undergraduate career with his interests in hurricane storm surge and how civil engineering could play a key role in mitigating flood risks. Since then, Brackins' work has branched into the fields of hydrology and hydrodynamics as applied to civil engineering problems, from as local as the corner of Jackson Street and Willow Avenue in Cookeville to as remote as the coastlines of India and Bangladesh. He was recently invited to participate in the National Water Center Innovators Program Summer Institute at the U.S. National Oceanic and Atmospheric Administration's National Water Center at the University of Alabama in Tuscaloosa. While at the Summer Institute, he, along with several other competitively-selected graduate students and faculty, pursued research on potential improvements to the National Water Model, which provides river forecasts for the entire conterminous United States.

Brackins' research also encompasses potential engineering solutions to coastal flooding. While US coastal counties account for 10% of the land area, they are home to 39% of the US population. Tropical cyclones (TCs) have threatened to flood these communities, locally producing up to 40% of annual rainfall and up to 27.8 feet in storm surge within the last 20 years alone. To defend these communities from flooding and offer recovery resources as part of the National Flood Insurance Program (NFIP), the Federal Emergency Management Agency (FEMA) maps flood elevations for both riverine

STUDENT HIGHLIGHTS (CONT.): BRACKINS



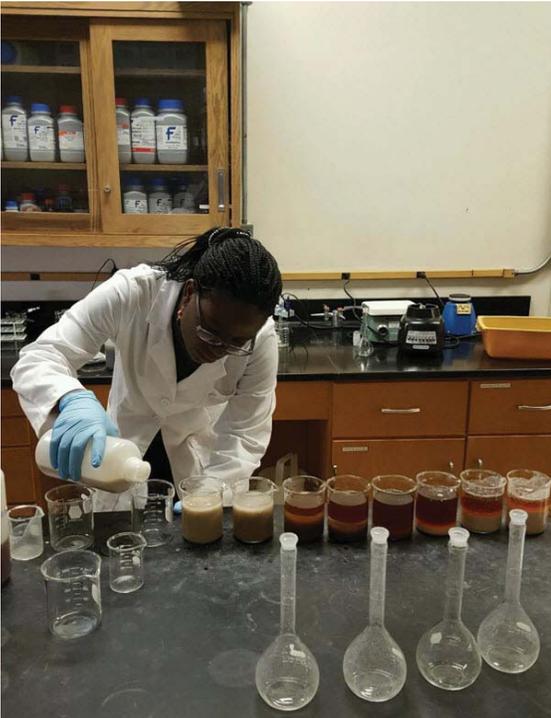
and coastal communities. Floods in coastal communities can occur from either rainfall-runoff flooding, coastal flooding (including storm surge, wave setup, breaking waves, and tides), or interactions between the two phenomena. Interactions between storm surge and the rainfall-runoff flood wave have been noted in scientific literature. A recent example is Hurricane Irma's 2017 urban flooding in Miami due to a combination of heavy rainfall (up to 12 inches in 48 hours) and urban runoff failing to drain into the bay due to storm surge-elevated water levels 4 to 6 feet above normal. Although these interactions can result in larger flooding depths and extents, resulting in greater risk to coastal residents, storm surge and rainfall-runoff flooding are currently modeled as separate phenomena for FEMA flood insurance studies (FIS), potentially failing to adequately

capture the expected risk. Brackins' NSF-GRFP research will develop a methodology accounting for the nonlinear interactions between storm surge and TC rainfall-runoff flooding, exposing currently hidden flood risks and allowing communities to better mitigate these "new" risks. In order to accomplish this, Brackins plans to adapt an existing coastal FIS storm surge model to accept the floodwaters produced by rainfall-runoff for a suite of hypothetical hurricanes, allowing a more complete picture of flood risk near the coast. While some of the scientific literature has performed case studies on interactions during individual storms, he plans to consider the impacts these interactions have on the overall flood risk statistics, as well as whether flood zone boundaries need to be adjusted accordingly. This research has the potential to allow both coastal and upriver communities to better understand and mitigate their flood risk.

STUDENT HIGHLIGHTS: PH.D. ENVIRONMENTAL ENGINEERING STUDENT JULIET OHEMENG-NTIAMOAH USES ENGINEERING DESIGN PRINCIPLES TO OPTIMIZE RENEWABLE ENERGY RECOVERY

Juliet Ohemeng-Ntiamoah is currently in the final year of study for PhD in Civil & Environmental Engineering at Tennessee Tech University where she is advised and mentored by Dr. Tania Datta. Her doctoral research focuses on employing engineering design principles and microbiological tools for optimizing renewable energy recovery from organic waste via a bio-engineered process known as anaerobic co-digestion. More specifically, a part of her research investigates the co-digestibility of waste activated sludge (WAS) with various proportions of food waste and fats, oils and grease (FOG) towards enhanced biogas production using bench scale anaerobic bioreactors operated at mesophilic conditions. Her work further expands the understanding of the co-digestion process by examining the microbial community structure and activity (based on DNA and RNA methods) underlying stable and unstable conditions during co-digestion. Juliet

STUDENT HIGHLIGHTS (CONT.): OHEMENG-NTIAMOAH



will be graduating in December 2019 and has accepted a position as Water/Wastewater Engineer at Jacobs Engineering Group where she hopes to translate the knowledge gained from bench-scale anaerobic co-digestion study into full-scale design and operations.



INVESTMENTS FOR THE FUTURE

- Addressing the effects of climate changes on endangered species and water availability.
- Expanding research on the causes and consequences of harmful algal blooms.
- Developing methods for using environmental DNA to detect and enumerate endangered and invasive species in Tennessee waterways.
- Advancing work in remote sensing of aquatic ecosystems using site-based and aerial imaging.
- Furthering outreach through local water resource protection and management projects and student activities like Engineering a Future and the Creative Inquiry and Research Day.

Mission Statement

The mission of the Water Center is to support state and federal agencies, communities, and industry in solving water quality, biodiversity, and water security problems and advancing scientific understanding of all aspects of water science and engineering through basic and applied research. Center researchers study aquatic biodiversity and ecology from genes to ecosystems; address water quality challenges and develop better treatment technologies; and

implement state-of-the-art technologies and tools for watershed sciences, modeling and simulation, data acquisition and geospatial analysis. The Center provides a strong water resources research infrastructure at Tennessee Tech by supporting faculty research, training and mentoring of future water professionals, and serving the citizens of the state of Tennessee.

R E S E A R C H

THE CENTER'S STRATEGIC GOALS

- **Increase recognition of the Center and its faculty through invited presentations, refereed publications, and other promotion initiatives. Produce a minimum of eight refereed publications per year and present at a minimum of 10 professional, regional, national or international meetings per year.**

Related University Strategic Focus Area:

Create Distinctive Programs and Invigorate Faculty

Action Plan:

The Center plans to meet this goal through encouraging refereed publications, continued external funding, focused research, and participation in professional organizations, faculty obtain state, regional and national recognition.

Assessment:

Annual faculty achievement reports contain information on scholarly works.

- **Increase externally funded research, which addresses the diverse water-related problems in Tennessee, the nation and the world. Toward this goal, the Water Center strives to maintain a minimum external funding of 100% of state appropriations.**

Related University Strategic Focus Area:

Create Distinctive Programs and Invigorate Faculty

Action Plan:

Strategic focus areas have been established by Center faculty and faculty associates. A portion of Water Center funds is being invested in selected high-return, research focus areas. Priority for the remaining research funds will be given to projects with potential to secure additional related external funds. The Center annually supports faculty who seek external research funds by: reviewing proposals prior to their being sent off campus; providing travel funds to support PIs in meeting with agency program directors to discuss research opportunities; keeping faculty informed about research opportunities; bringing faculty together to develop interdisciplinary research proposals; and providing essential matching funds and student research support. The Center is working with the university administration to keep Tennessee's Congressional delegation informed about

research findings and new emerging areas of research.

Assessment:

The Water Center will assess its goal of increasing external funding through the expansion of external collaborations. These collaborations will extend into all aspects of improving water quality including expanding initiatives in water-energy-food-nexus projects and sensors and other information technology tools to help society and the community. Collaborative relationships and intellectual capital will also be developed to support the Tennessee Department of Environment and Conservation and the Tennessee Department of Transportation in their environmental efforts throughout the state.

The Water Center annually assesses the external funds received during the State's fiscal year. The Center conducts trend analyses to determine progress toward achieving goals and asserts corrective action when needed.

- **Increase the number and quality of graduate students supported.**

Related University Strategic Focus Area:

Create Distinctive Programs and Invigorate Faculty

Action Plan:

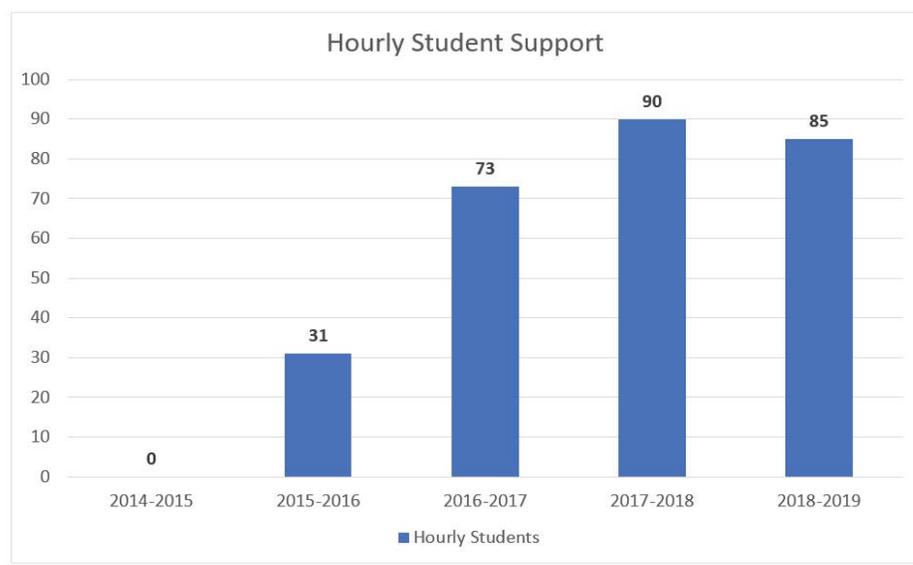
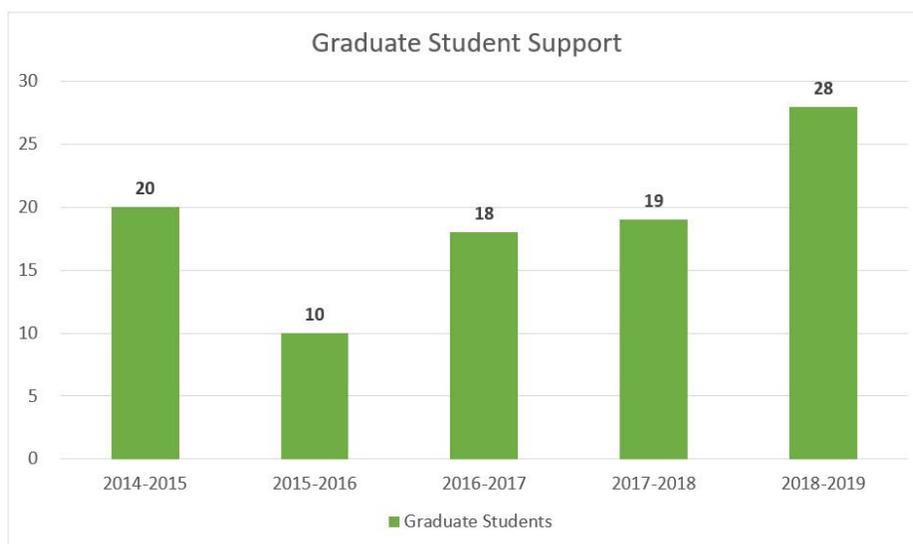
The Water Center has recently raised graduate student stipends from \$1,200 to \$1,400 per month for master's students, and from \$1,500 to \$1,750 per month for Doctoral students. The Center is also pursuing pathways to provide graduate students with support for health insurance. The Center will continue to work with academic units and faculty to provide full support for up to 12 graduate students annually. Toward improving graduate student enrollment, the Water Center will also focus on sustaining undergraduate student research through offering research opportunities with the Center faculty.

Assessment:

The Center will continue to increase its initiative to support graduate students in their environmental science-/engineering-related research. Annually, the Center will assess how many students have been supported.

ENHANCING EDUCATION AND RESEARCH

Without students, the Water Center could not continue to engage in its research initiatives. Therefore, the Center strives to ensure that its students are offered the most cutting-edge opportunities in environmental research. This fiscal year, the Center supported 28 graduate research assistants. The Center also supported 85 students on an hourly basis to work on research and service projects in the field, in laboratories and in the office.



PROFESSIONAL SERVICE

Laura Arias Chavez, assistant professor in Chemical Engineering, and her doctoral student Haley White developed and implemented a three-day activity for Engineering a Future Summer Camp (July 2018) for middle school girls. The activities focused on membrane technologies and how they could be implemented to reclaim wastewater resources. They also developed a one-day activity for the Engineering a Future Day Camp (February 2019) that allowed middle school girls to use scanning electron microscopy to image samples of leaves, insects, flowers, and membranes for water separation. This exposed them to another method of science and engineering problem solving. Arias Chavez and White also created a one-day activity for the Explorations in Engineering and Computing Camp, which focused on various small-scale water treatment devices for treating or reclaiming water (July 2018).

Tania Datta, associate professor in environmental engineering, hosted two visiting students from Chiba University, Japan, over the fall semester as part of a research collaboration. Datta also served as Task Force Chair for WEF Water Reuse Task Force, for the Municipal Water Resource Recovery Design Committee. She also served on the Technical Work Group for the Tennessee State Water Plan that was initiated under the leadership of Gov. Haslam. Datta also reviewed papers for the *Science of the Total Environment* and *Water Science and Technology*. She led an activity for the 2019 Engineering a Future event, served as a judge for the 2019 Tennessee Tech Research and Creative Inquiry Day, and also volunteered with the 2019 Merit Badge University. Extending her services to the community further, Datta organized and led the Ensor Sink cleanup with Engineers Without Borders, helped organize and host the First Water Professionals Student Conference at Tennessee Tech, and volunteered as a judge at the 64th Annual Cumberland Plateau Regional Science and Engineering Fair.

Alfred Kalyanapu, associate professor in environmental engineering, is the past-president of the Tennessee Section of the American Water Resources Association (AWRA); president-elect of the Computational Hydraulics Committee of the American Society for Civil Engineers (ASCE); committee member of the Tennessee Infrastructure Report Card Committee of the ASCE, and member of the Tennessee H2O Surface Water Subcommittee. Kalyanapu also is a reviewer for the American Geophysical Union Student Travel Award and is a member of the Civil and Environmental Engineering Renaissance Spectrum Awards Committee. He has reviewed articles for Computers and Geosciences and for the Tennessee AWRA conference.

Hayden Mattingly, director of the School of Environmental Studies, is an editorial board member and manuscript editor for *Southeastern Naturalist*. He is also a federally appointed member of the Bluemask Darter Technical Team of the U.S. Fish and Wildlife Service and a member of the American Fisheries Society and Southeastern Fishes Council.

Justin Murdock, associate professor in biology and interim Water Center director, is a member of the state harmful algal bloom working group, which is designing a coordinate approach to monitor and address toxic algal blooms in the state. He is also a on the state's stream nutrient reduction task-force, a multi-stakeholder group to address nutrient pollution in state surface waters.

Amanda Rosenberger, assistant unit leader of the Tennessee Cooperative Fishery Research Unit, is a member of the Freshwater Mussel Conservation Society, the American Fisheries Society, and the Sigma Xi Scientific Research Society. She is also an associate editor for the *Transactions of the American Fisheries Society*.

ANALYTICAL CAPABILITIES

The Water Center offers unique analytical capabilities through its state-certified consulting lab including the following services:

- Industrial wastewater treatment process analysis design
- Drinking water and wastewater treatability studies
- Wastewater characterization studies
- Wastewater treatment unit process evaluation using nonstandard analytical techniques including particle size distribution analysis, solids oxygen demand determination, and long-term biochemical oxygen demand
- Aerobic and anaerobic biological wastewater treatment process pilot studies
- Coagulation process optimization using zeta potential measurements
- Activated carbon absorption studies
- Robotic reservoir/stream water quality analysis
- GIS capabilities for field study design

The environmental quality lab continues to support faculty and student research, as well as the surround-

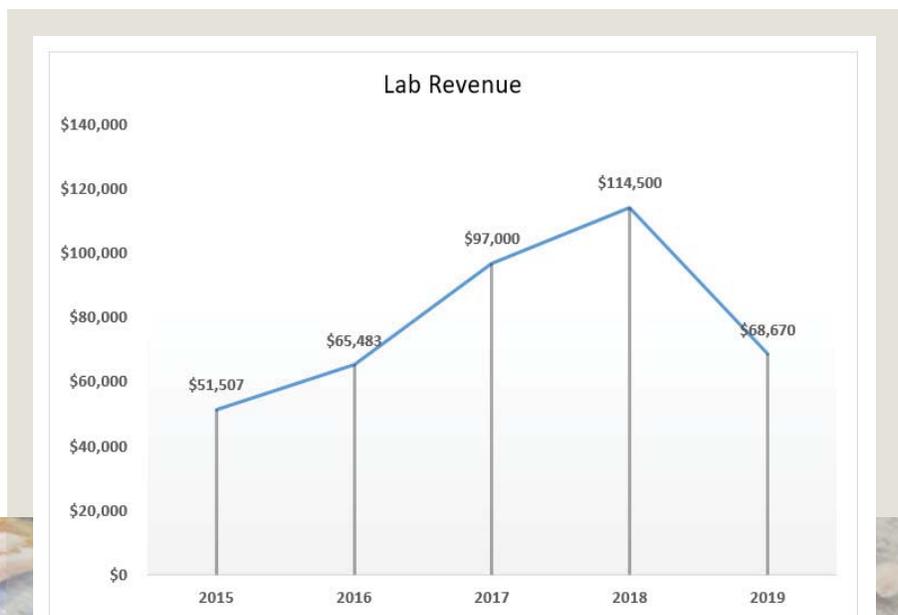
ing community by offering stand-alone analytical services at a reasonable cost. These include:

- Drinking water regulatory parameters
- Conventional wastewater pollutants
- Metals
- Bacteriological analyses
- Organic analysis, GC and GCMS capabilities to analyze for THMs, HAAs, and semi-volatiles

The Water Center Laboratory also offers field sampling and monitoring capabilities including:

- Composite field sampling for local businesses
- Stream velocity measurements
- Field-dissolved oxygen, pH, temperature, conductivity, and ORP measurements
- GPS position logs of all sampling sites

The lab is managed by Dan Dodson, and is staffed by analysts Phillip Burr and David Hobbs.



SUPPORT STAFF



*Sandy Garrison,
Office Manager*



*Karen Warren,
Financial Associate*



*Sandy Dodson,
Administrative Associate 3*



*Amy Hill,
Editor*



*Dan Dodson,
Lab Manager*



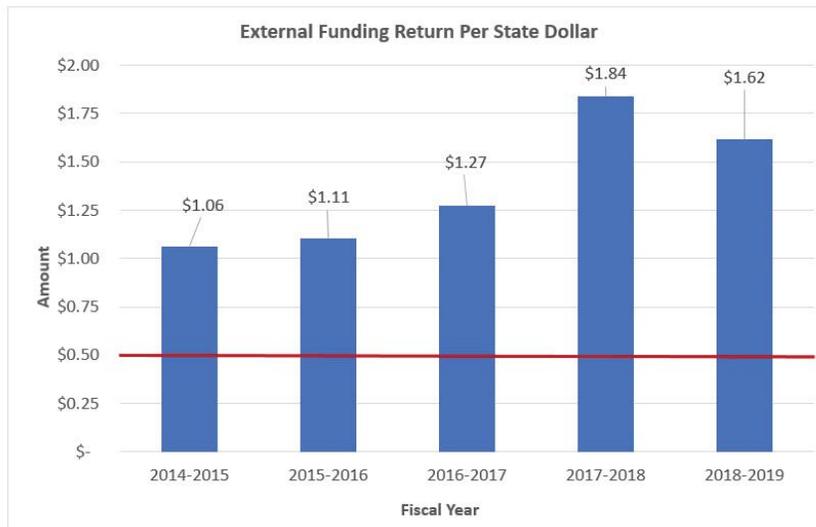
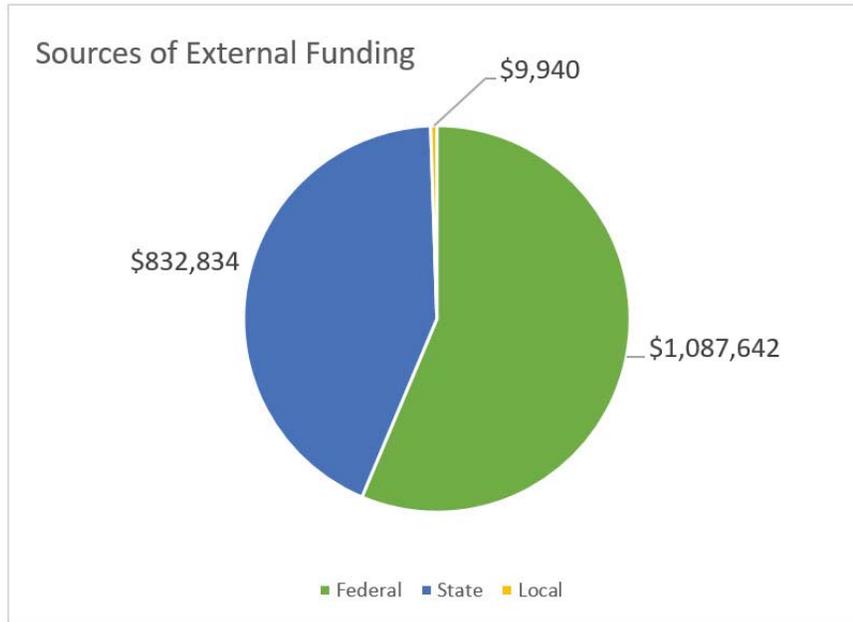
*Phillip Burr,
Academic Support
Associate 8
(lab technician)*



*David Hobbs,
Lab Support*

Our staff brings years of expertise in their respective areas of work, and they include Sandy Garrison, office manager, and Karen Warren, financial associate, who work with faculty to prepare budgets for grants and are also integral in administering the financial reporting and details required once a grant is earned. Sandy Dodson, administrative associate 3, provides support in preparing travel claims, administering the Motor Pool, and purchasing supplies. Amy Hill, editor, provides editorial, graphic design and poster-printing assistance to faculty and students and also prepares the Center's annual report and updates the website. The Water Center Analytical Laboratory is managed by Dan Dodson, who oversees all of the lab's functions and has also been a principal investigator on funded research. Phillip Burr is an academic support associate, and David Hobbs provides additional lab support. Center staff are recognized across campus for excellence in their respective duties.

CURRENT FISCAL YEAR



This year, Center researchers partnered with state and federal governmental agencies and private entities to secure in excess of \$1.9 million through externally funded projects. Of this, funding from states' governmental agencies accounted for \$832,834; federal agencies \$1,087,642; and local entities \$9,940. These amounts reflect a \$1.62 return per dollar of State appropriation.

SUPPORTING MATERIALS

Externally Funded Projects (Projects Activated in Fiscal Year 2018-2019)

AEDC Bat Aquatic Study

Hayden Mattingly/U.S. Fish and Wildlife

Activation This Year: \$63,881

Project Period: 7/1/2018-12/31/2020

Aquatic Agroecosystems

Justin Murdock/U.S. Department of Agriculture

Activation This Year: \$10,000

Project Period: 9/1/2017-8/31/2022

Brawley's Fork Crayfish

Hayden Mattingly/Tennessee Wildlife Resources Agency

Activation This Year: \$15,000

Project Period: 10/1/2018-6/30/2021

Collection of Biological Data

Steve Hayslette/Tennessee Wildlife Resources Agency

Activation This Year: \$2,000

Project Period: 7/1/2016-6/30/2021

Cookeville Wastewater Plant

Tania Datta/City of Cookeville

Activation This Year: \$9,940

Project Period: 6/20/2019-3/30/2020

Development and Improvement of High-Resolution
Flood2D-GPU Modeling for Titan HPC Environment

Alfred Kalyanapu/UT-Oak Ridge

Activation This Year: \$148,096

Project Period: 8/16/2018-8/15/2019

Efficient Water Resource Use

Alfred Kalyanapu/UT-U.S. Department of Agriculture

Activation This Year: \$128,439

Project Period: 4/1/2015-1/31/2020

Evaluating Sport Fisheries

Mark Rogers/Tennessee Wildlife Resources Agency

Activation This Year: \$38,996

Project Period: 7/1/2017-6/30/2022

Evaluating Stocked Fisheries

Mark Rogers/Tennessee Wildlife Resources Agency

Activation This Year: \$65,519

Project Period: 7/1/2017-6/30/2022

Evaluation Asian Carp TN and Cumberland River

Mark Rogers/Tennessee Wildlife Resources Agency

Activation This Year: \$197,000 | \$134,066

Project Period: 7/1/2018-6/30/2021

GOAL: Reclaim Res Wastewater

Laura Chavez/National Science Foundation

Activation This Year: \$98,642

Project Period: 8/15/2016-7/31/2020

Missouri Conservation Longnose Darter

*Amanda Rosenberger/Missouri Department
of Conservation*

Activation This Year: \$52,800

Project Period: 7/1/2018-6/30/2021

Missouri Conservation Meramec Drainage

*Amanda Rosenberger/Missouri Department
of Conservation*

Activation This Year: \$16,500 | \$30,742

Project Period: 7/1/2017-6/30/2019

Missouri Conservation Ozark River Mussel

*Amanda Rosenberger/Missouri Department
of Conservation*

Activation This Year: \$47,300

Project Period: 7/1/2018-6/30/2021

**Externally Funded Projects (cont.)
(Projects Activated in Fiscal Year 2018-2019)**

Streamflow Network for Falling Water
Alfred Kalyanapu/UT-U.S. Geological Survey
Activation This Year: \$16,459
Project Period: 6/18/2018-6/17/2019

Streamside Salamander
Carla Hurt/Tennessee Wildlife Resources Agency
Activation This Year: \$13,834
Project Period: 1/1/2018-6/30/2019

Stream Survey Lick Creek
Tania Datta/Water Authority of Dickson County
Activation This Year: \$70,981
Project Period: 7/20/2018-8/31/2019

Tennessee Heelsplitter Habitat
Amanda Rosenberger/U.S. Geological Survey
Activation This Year: \$62,000
Project Period: 12/21/2018-5/31/2021

Water Quality Tennessee and Kentucky
*Justin Murdock/The Nature Conservancy-U.S.
Department of Agriculture*
Activation This Year: \$660,736
Project Period: 10/19/2018-7/31/2022

Wastewater Reclaim GRFP (Haley White)
Alice Camuti/National Science Foundation
Activation This Year: \$46,000
Project Period: 7/19/2018-7/31/2021

Refereed Publications and Reports

Ahmadisharaf, E.A., A.J. Kalyanapu, and P.D. Bates. 2018. "A Probabilistic Framework for Floodplain Mapping Using Hydrological Modeling and Unsteady Hydraulic Modeling," *Hydrological Sciences Journal*, doi:10.1080/02626667.2018.1525615.

Ahmadisharaf, E.A., A.J. Kalyanapu, J.R. Lillywhite, and G. Tonn. 2018. "A Probabilistic Framework to Evaluate the Uncertainty of Design Hydrograph: Case Study of Swannanoa River Watershed," *Hydrological Sciences Journal*, 63(12), 1176-1790.

Bouska, K., A.E. Rosenberger, S.E. McMurray, G. Lindner, and K. Key. 2018. "State-Level Freshwater Mussel Programs: Current Status and a Research Framework to Aid in Mussel Management and Conservation," *Fisheries*, doi:10.1002/fsh.10106 (TPI-076251).

Esfahani, R.A., and T. Datta. 2018. "Nitrate Removal from Water Using Zero Valent Aluminum," *Water and Environment Journal*, accessed online at onlinelibrary.wiley.com/doi/abs/10.1111/wej.12438.

Gibbs, W.K., J.N. Murdock, and M.A. Kulp. 2019. "Interim Report -- Assessment of Benthic Macroinvertebrate Response to Antimycin During Brook Trout Restoration in Little Cataloochee Creek, Great Smoky Mountains National Park" - Study #: GRMS-02362, Permit #: GRSM-2015-SCI-2362.

Hix, L.A., and J.N. Murdock. 2019. "*Didymosphenia geminata* Establishment and Mat Accumulation Require Distinct Water Quality Conditions in the Upper Tennessee River Basin," *Hydrobiologia*, 828(1), 147-164.

Hurt, C., N. Ellis, A. Harman, and C. Savage. 2019. "Genetic Structure at the Major Histocompatibility Complex in the Endangered Barrens Topminnow (*Fundulus julisia*)," *Southeastern Naturalist*, 18, 29-36.

Kunza, L.A., C.A. Gillis, J.Z. Haueter, J.N. Murdock, J.M. O'Brien. 2018. "Oligotrophication as a Potential Driver for the Emergence of *Didymosphenia geminata* in North American Rivers," *River Research and Applications*, 34(8), 1105-1110.

Ohemeng-Ntiamoah, J., and T. Datta. 2019. "Perspectives on Variabilities in Biomethane Potential Test Parameters and Outcomes: A Review of Studies Published Between 2007 and 2018," *Science of the Total Environment*, accessed online at www.sciencedirect.com/science/article/pii/S0048969719305698.

Omori, K., T. Datta, Y. Amano, and M. Machida. 2019. "Effects of Different Types of Extracellular Polysaccharides Isolated from Cyanobacterial Blooms on the Colony Formation of Unicellular *Microcystis aeruginosa*." *Environmental Science and Pollution Research*, 26(4), 3741-3750.

Rogers, M.W., and J.N. Murdock. 2018. "Final Report Cooperative Agreement Award No. F16AC01049: Effects of Asian Carp Invasion on the Food Web of a Mussel Biodiversity Hotspot in Tennessee," A Final Report to the U.S. Fish and Wildlife Service, Atlanta, Georgia.

Publications in Press

DiStefano, R.J., J.T. Westhoff, C.J. Rice, and A.E. Rosenberger. "Life History of the Endemic Crayfish *Faxonius* (*Procericambarus*) *medius* (Decapoda: Cambridae) (Faxon 1884) in Missouri, USA," *Freshwater Crayfish*.

Grisnik, M., R.J. Hanscom, and O. Bowers. 2019. "*Desmognathus Conanti* (spotted dusky salamander). Parental Care." *Herpetological Review*.

Hargrove, J.S., M.W. Rogers, P.T. Kacmar, and P. Black. "A Statewide Evaluation of Florida Bass Genetic Admixture Across a Gradient of Stocking Rates and Reservoirs in Tennessee," *North American Journal of Fisheries Management*, <https://doi.org/10.1002/nafm.10295>.

Hargrove, J.S., M.W. Rogers, and P.T. Kacmar. 2019. "Quantifying Contributions to Tournament Catches Among Resident, Stocked, and Hybrid Black Basses (*Micropterus* spp.)," *Fisheries Management and Ecology*, Accepted for publication.

Hurt, C.R., R.F. Thoma, D.I. Withers, C.E. Williams, and R.T.R. Paine. "Extensive Regional Endemism and Cryptic Diversity in the Tennessee and Kentucky, USA Populations of the Burrowing Crayfish *Cambarus deweesae* (Bouchard & Etnier, 1979) (*Decapoda: Astacidea: Cambaridae*) as Revealed by Molecular Genetics," *Journal of Crustacean Biology* (2019) 1-10. Accepted April 1, 2019.

Zuber, B.C., and H.T. Mattingly. "*Etheostoma forbesi*, Barrens Darter," in George, A.L. (ed.). Conservation Plans for Imperiled Fishes of the Mobile, Tennessee, and Cumberland Rivers. Tennessee Aquarium Institute, Chattanooga, TN.

Presentations

Adjovu, G.E., R., Gamble, and A.J. Kalyanapu. "Development of HEC-HMS Model for the Cane Creek Watershed," presented at the 28th Tennessee Water Resources Symposium, Montgomery Bell State Park, Tennessee, April 2019.

Arias Chavez, L.H. "Cultivating Student Engagement, Ethics, and Environmental Awareness in a Large, Introductory Chemical Engineering Course," presented at the Association of Environmental Engineering and Science Professors Research and Education Conference, Tempe, Arizona, May 2019.

Bhuyian, M.N., A.J. Kalyanapu, T. Papanicolaou, S.M. Ghaneizad, B. Abban, and C.G. Wilson. "Predicting Future Flood Risk in an Agrarian Watershed in Northwest Tennessee," presented at the 2018 American Geophysical Union Fall Meeting, Washington DC, December 2018.

Bhuyian, M.N., T.T. Dullo, A.J. Kalyanapu, S. Gangrade, and S.-C., Kao. "Application of Geomorphic Correlations for River Bathymetry Correction in Two-Dimensional Hydrodynamic Modeling for Long-Term Flood Risk Evaluation," presented at the 2019 World Environmental and Water Resources Congress, Pittsburgh, Pennsylvania, 2019.

Bhuyian, M.N., and A.J. Kalyanapu. "Assessing DEM Error in Major River Basins of the World," presented at the 28th Tennessee Water Resources Symposium, Montgomery Bell State Park, Tennessee, April 2019.

Blackburn, A. "Benthic Macroinvertebrate and Periphyton Response to Antimycin During Brook Trout Restoration in a Small Headwater Stream," presented at the Tennessee Tech Research and Creative Inquiry Day, Cookeville, Tennessee, April 9-10, 2019.

Blackburn, A., W.K. Gibbs, and J. Murdock. "Benthic Macroinvertebrate and Periphyton Response to Antimycin During Brook Trout Restoration in a Small Headwater Stream," presented at the Tennessee American Fisheries Society Chapter Meeting, Chattanooga, Tennessee, April 2019.

Presentations (cont.)

Blackburn, A. "Benthic Macroinvertebrate and Periphyton Response to Antimycin During Brook Trout Restoration in a Small Headwater Stream" presented at the 2019 Tennessee American Fisheries Society Meeting, Chattanooga, February 2019.

Brackins, J.T., and A.J. Kalyanapu. "Comparison of Parametric Rainfall Models of Tropical Cyclone Rainfall for Flood Risk Studies," presented at the 28th Tennessee Water Resources Symposium, Montgomery Bell State Park, Tennessee, April 2019.

Brown, R., J. Murdock, and J. Evans. "Developing Standard Collection Procedures for Intact Sediment Cores Used in Continuous Flow Experiments," presented at the Society for Freshwater Science Annual Conference, Salt Lake City, Utah, May 2019.

Blum, P., M. Green, S. Tuberty, and J. Murdock. "Effects of *Didymosphenia* on Larval Chironomid Diversity and Feeding Structures," presented at the Society for Freshwater Science Annual Conference, Salt Lake City, Utah, May 2019.

Chilton, J., A. Rosenberger, and R. DiStefano. "Habitat Associations and Distributions of Endemic Crayfishes in the Meramec River Drainage," presented at the Missouri Natural Resources Conference, Osage Beach, Missouri, February 2019.

Datta, T., and G. McClellan. "A Look into the Microbial Community of a Wastewater Treatment Facility Undergoing Optimization for Nutrient Removal," presented at the 2018 KY/TN Water Professionals Conference, Nashville, Tennessee, July 2018.

Davis, A.J., and A.J. Kalyanapu. "Developing an Early Warning System for Floods for Window Cliffs State Natural Area, Putnam County, Tennessee," presented at the 28th Tennessee Water Resources Symposium, Montgomery Bell State Park, April 2019.

Day, S., and J. Murdock. "Establishing *Didymosphenia geminata* Cellular Response Thresholds to Water Quality Changes Using Fourier-Transform Infrared (FTIR) Microspectroscopy," presented at the Tennessee American Fisheries Society Chapter Meeting, Chattanooga, TN, April 2019.

Day, S., and J. Murdock. "Establishing *Didymosphenia geminata* Cellular Response Thresholds to Water Quality Changes Using Fourier-Transform Infrared (FTIR) Microspectroscopy," presented at the Society for Freshwater Science Annual Conference, Salt Lake City, Utah, May 2019.

Dullo, T., S. Gangrade, A.J. Kalyanapu, S.-C. Kao, S.K. Ghafoor, and K. Evans. "Reconstruction of Hurricane Harvey Riverine Flooding for Harris County, TX, Using a GPU-Accelerated 2D Flood Model," presented at the 2018 American Geophysical Union Fall Meeting, Washington DC, December 2018.

Fernholz, S.R., and M.W. Rogers. "Relative Densities and Population Characteristics of Bighead and Silver Carp in Reservoirs of the Tennessee and Cumberland Rivers," presented at the American Fisheries Society Annual Meeting, Atlantic City, New Jersey, 2018.

Flanagan, T., and M.W. Rogers. "Evaluating Asian Carp Movement in the Tennessee River with a Focus on Prohibiting Lock and Dam Passage," presented during the 2019 Southern Division of the American Fisheries Society Meeting, Galveston, Texas.

Hargrove, J.S., and M.W. Rogers. "Rethinking Florida Bass Stocking as a Fishery Management Tool," presented at the Southeastern Association of Fish and Wildlife Agencies Meeting, Mobile, Alabama, 2018.

Hargrove, J.S., M.W. Rogers, P.T. Kacmar, and P. Black. "A Statewide Evaluation of Florida Bass Introgression Across a

Presentations (cont.)

Gradient of Stocking Rates and Reservoirs in Tennessee,” presented at the American Fisheries Society Annual Meeting, Atlantic City, New Jersey, 2018.

Hurt, C. “Molecular Tools in Aquatic Conservation Genetics,” presented during a departmental seminar at Belmont University, Nashville, Tennessee, 2018.

Hurt, C. “Environmental DNA (eDNA) Tracking of Invasive Silver Carp (*Hypophthalmichthys molitrix*) in the Duck River, Tennessee,” presented at the Southeastern Fishes Council 2018, Hickory Knob State Park, McCormick, South Carolina, November 2018.

Hurt, C. “Environmental DNA and Rare Fishes in Tennessee,” presented at the Rare Fishes Meeting 2019, University of Tennessee-Knoxville, Tennessee, March 2019.

Islam, M., T. Cunningham, N.J. Snigdha, and A.J. Kalyanapu. “Reservoir Routing Model for Cane Creek Lake, Cookeville, Tennessee,” presented at the 28th Tennessee Water Resources Symposium, Montgomery Bell State Park, Tennessee, April 2019.

Jackson, C., A.J. Kalyanapu, and C. Cervone. “Use of Unmanned Aerial Systems (UAS) for Velocimetry Estimation,” presented at the 2018 American Geophysical Union Fall Meeting, Washington D.C., December 2018.

Johansen, J.W., H.T. Mattingly, C.A. Taylor, and G.A. Shuster. “Assessing Rarity Patterns in Crayfish at Multiple Spatial Scales Using Scale-Area Curves,” presented at the International Association of Astacology 22nd International Symposium on Freshwater Crayfish, Pittsburg, Pennsylvania, July 2018.

Jones, V.J., H.T. Mattingly, S.A. Allen, and J.W. Simmons. “Distribution and Abundance of the Bluemask Darter *Etheostoma akatulo* in the Collins River during Summer 2018,” presented at the Southeastern Fishes Council Annual Meeting, Hickory Knob State Park, McCormick, South Carolina, November 2018.

Kacmar, P., M.W. Rogers, and T. Flanagan. “Influences of Sampling Method and Season on Florida Largemouth Bass Genetic Introgression at Chickamauga Reservoir, Tennessee,” presented at the 2019 Southern Division of the American Fisheries Society, Galveston, Texas.

Kacmar, P., and M.W. Rogers. “Influences of Sampling Method and Season on Assessments of Florida Largemouth Bass (*Micropterus floridanus*) Genetic Introgression at Chickamauga Reservoir, Tennessee,” presented at the American Fisheries Society Annual Meeting, Atlantic City, New Jersey, 2018.

Leckie, B., E. Kohler, B. Castleberry, and G. Delay. “Genomics Enabled Sustainable Agriculture,” presented at the Life Science Tennessee’s Annual Conference, Nashville, Tennessee, 2018.

McClellan, G., and T. Datta. 2019. “Microbial Community Structure and Stability During Optimization of a Full-Scale Biological Nutrient Removal Process,” presented at the 28th Tennessee Water Resources Symposium, Montgomery Bell State Park, Tennessee, April 2019.

Murdock, J., A. Kalyanapu, L. Webb, et al. “Assessing the Restoration Success of the Wetlands Reserve Program in Western Kentucky and Tennessee,” presented at the West Tennessee Water Resources Symposium, Jackson, Tennessee, March 2019.

Murdock, J., and S. Day. “Detecting Water Quality Thresholds for Algal Blooms Using a Short-Term, Multi-Species Assay,” presented at the Society for Freshwater Science Annual Conference, Salt Lake City, Utah, May 2019.

Ohemeng-Ntiamoah, J., and T. Datta. “Optimizing Renewable Energy Recovery from Organic Waste Substrate Using Anaerobic Co-Digestion,” presented at the AEESP Conference, Arizona State University, Phoenix, May 2019.

Presentations (cont.)

Ohemeng-Ntiamoah, J., and T. Datta. "Exploring Renewable Energy Recovery for Sustainable Wastewater Management," presented at the 28th Tennessee Water Resources Symposium, Montgomery Bell State Park, April 2019.

Paine, R.T.R., M.W. Rogers, and C. Hurt. "Environmental DNA (eDNA) Tracking of the Invasive Silver Carp (*Hypophthalmichthys molitrix*) in the Duck River, Tennessee," presented at the Southeastern Fishes Council Annual Meeting, South Carolina, 2018.

Rogers, M.W., J. Murdock, and D. Hubbs. "Implications of Silver Carp Invasion on the Food Web of a Freshwater Mussel Biodiversity Hotspot," presented at the Southeastern Association of Fish and Wildlife Agencies Meeting, Mobile, Alabama, 2018.

Rosenberger, A. "Fire and Ice: Landscape Ecology of Life on the Edge," Seminar for the Department of Wildlife, Fisheries, and Aquaculture presented at Mississippi State University, March 2019.

Rosenberger, A., S. McMurray, K. Bouska, G. Lindner, K. Key, M. Schrum, and L. Lueckenhoff. "Towards a Statewide, Strategic, and Spatially-Explicit Mussel Conservation Assessment and Monitoring Program--Our Vision," presented at the Tennessee Chapter of the American Fisheries Society Annual Meeting, Knoxville, Tennessee.

White, H.D., L.M. Templeton, S.L. Jones, and L.H. Arias Chavez. "Use of Desalination Brine for Low-Energy Concentrations of Orange Juice," presented during the Gordon Research Seminar and Gordon Research Conference on Membranes: Materials and Processes, New London, New Hampshire, August 2018 (Dr. Arias Chavez served as a Discussion Leader at this conference.)

White, H.D., L.M. Templeton, S.L. Jones, and L.H. Arias Chavez. "Use of Desalination Brine for Low-Energy Concentration of Orange Juice," presented at the Tennessee Tech Research and Creative Inquiry Day, Cookeville, Tennessee, April 2019 (won Best Chemical Engineering Graduate Student Poster Award).

White, H.D., L.M. Templeton, S.L. Jones, and L.H. Arias Chavez. "Use of Desalination Brine for Low-Energy Concentration of Organic Juice," presented at the Annual Meeting of the North American Membrane Society, Pittsburgh, PA, May 2019.

White, H.D., L.M. Templeton, S.L. Jones, and L.H. Arias Chavez. "Use of Desalination Brine for Low-Energy Concentration of Orange Juice," presented at the Association of Environmental Engineering and Science Professors Research and Education Conference, Tempe, Arizona, May 2019.

Wigner, R., D. Kirkpatrick, T. Wright, and T. Datta. 2019. "Potential Contributions of Atmospheric Deposition to Nitrates and Ammonia in Tennessee's Highway Stormwater Runoff," presented at the AEESP Conference, Arizona State University, Phoenix, May 2019.

Womble, S., and J. Murdock. "Distribution of *Didymosphenia geminata* in Southern Appalachian Watersheds," presented at the Tennessee American Fisheries Society Chapter Meeting, Chattanooga, Tennessee, April 2019.

Womble, S., and J. Murdock. "Distribution of *Didymosphenia geminata* in Southern Appalachian Watersheds," presented at the Society for Freshwater Science Annual Conference, Salt Lake City, Utah, May 2019.



Personnel

Administration and Faculty

Dr. Justin Murdock
Dr. Tania Datta
Dr. Alfred Kalyanapu
Dr. G. Kim Stearman

Interim Center Director, Associate Professor of Biology
Assistant Professor of Civil and Environmental Engineering
Associate Professor of Civil and Environmental Engineering
Professor of Agriculture

Support Staff

Phillip C. Burr
Daniel P. Dodson
Sandy Dodson
Sandy Garrison
Amy K. Hill
David Hobbs
Karen Warren

Laboratory Technician
Technical Laboratory Manager
Administrative Associate 3
Office Manager
Editor
Laboratory Support
Financial Associate



Graduate Student Support

Name

Master's Students

Godson Adjovu
Joseph Brockwell
Jennifer Caudle
Aaron Coons
Alexander Davis
Samuel Day
Savannah Fernholz
Wesley Giddens
Jordan Holtswarth
Minhazul Islam
Phillip Kacmar
Danielle Kirkpatrick
Xi Zhe Ong
Zishan Onik
Ryan Wigner
William T. Wood
Tyler Wright

Ph.D. Students

Nowfel Bhuyian
John Brackins
Robert Brown
Tigstu Dullo
Kayla Key
Eric Koehler
Grace McClellan (NSF Fellowship)
Juliet Ohemeng-Ntiamoah (Diversity Assistantship)
Robert Paine
Md Bulbul Sharif
Haley White (NSF Fellowship)

Major

Civil and Environmental Engineering
Civil and Environmental Engineering
Biology
Biology
Civil and Environmental Engineering
Biology
Biology
Biology
Biology
Civil and Environmental Engineering
Biology
Civil and Environmental Engineering
Chemical Engineering
Computer Science
Civil and Environmental Engineering
Biology
Civil and Environmental Engineering

Engineering
Engineering
Environmental Science
Engineering
Environmental Science
Environmental Science
Engineering
Engineering
Environmental Science
Engineering
Engineering

Hourly Student Support

Name	Major
Dakota Aaron	Electrical and Computer Engineering
Godson Ebenezer Adjovu	Civil and Environmental Engineering
Samantha Allen	Environmental Informatics
Dipayan Banik	Computer Science
Jacob Barber	Civil and Environmental Engineering
Ryan Bauer	Wildlife and Fisheries Science
Nd Nowfel M. Bhuyian	Civil and Environmental Engineering
Aden Blackburn	Wildlife and Fisheries Science
Jacob Blocker	Civil and Environmental Engineering
Mike Bolan	Environmental Science
Olivia Bowers	Pre-Med Technology
Grayson Bridges	Computer Science
Joseph Brockwell	Civil and Environmental Engineering
Robert Brown	Environmental Science/Biology
Sarah Brown	Wildlife and Fisheries Science
Brittany Burke	PSM-Environmental Informatics
Brianah Castleberry	Agriculture
Jennifer Caudle	Wildlife and Fisheries Science
Rebekah Champion	Wildlife and Fisheries Science
Czarinna Clay	Environmental Informatics
Rachel Conradi	Biology
Aaron Coons	Wildlife and Fisheries Science
Trevor Crawford	Wildlife and Fisheries Science
Melody Culver	Environmental Studies
Bruce Cunningham	Civil and Environmental Engineering
Tyler Darroch	Civil and Environmental Engineering
Alexander Davis	Civil and Environmental Engineering
Samuel J. Day	Biology
Grayson Delay	Agriculture
Tigstu Dullo	Civil and Environmental Engineering
Caleb Earhart	Wildlife and Fisheries Science
Fantasia Erdman	Microbiology
Jordan Evans	Biology
Savannah Fernholz	Biology
Rex S. Gamble	Civil and Environmental Engineering
Savannah Gambrell	Biology
Brooks Goans	Chemical Engineering
Ryan Hanscom	Biology
Max Henderson	Biology
Jordan Holtswarth	Biology
Nathaniel Wade Hubbs	Biology
Douglas Huttes	Chemical Engineering
Minhazul Islam	Civil and Environmental Engineering
John Johansen	Environmental Science--Biology
Valerie Jones	Biology
Phillip Kacmar	Biology

Hourly Student Support

Name	Major
Chris Kaczmarek	Civil and Environmental Engineering
Lauren Kelley	Biology
Kayla Key	Environmental Sciences
Danielle Kirkpatrick	Environmental Engineering
Moriah Kitts	Biology
Erik Koehler	Agriculture
Rosilynn Laycock	Environmental Biology
Allison Litmer	Biology
Rajesh Manicavasagam	Computer Science
Mackenzie Martin	Civil and Environmental Engineering
Grace McClellan	Civil and Environmental Engineering
M. Rayhan Ahmed Mithu	Computer Science
Mahdi Mohammadizadeh	Computer Engineering
Stefan Nelson	Biology
Ashlee Nichols	Biology
Juliet Ohemeng-Ntiamoah	Civil and Environmental Engineering
Zishan Onik	Computer Science
Robert Paine	Biology
Isabel R. Papraniku	Environmental Science
Kyle Pattison	Civil and Environmental Engineering
Christopher Rector	Accounting
Sarah Rhoton	Civil and Environmental Engineering
William Schibig	Wildlife and Fisheries Science
Mary Scott	Biology
Reginald Seay	Electrical Engineering
Savannah Shanklin	Biology
Houston Shearin	Computer Science
Clayton B. Smullen	Wildlife and Fisheries Science
Leif Templeton	Chemical Engineering
Prince Turkson	Civil and Environmental Engineering
Macie Waldroup	Civil and Environmental Engineering
David White	Agriculture-Horticulture
Haley White	Chemical Engineering
MacKenzie White	Biology
Ryan Wigner	Civil and Environmental Engineering
Jason Wogsland	Biology
Spencer Womble	Biology
William Wood	Biology
Tyler Wright	Civil and Environmental Engineering



Budget Note: The Center for the Management, Utilization and Protection of Water Resources requests a five percent budget increase for the 2019-2020 fiscal year to accommodate potential increases in salaries and other supplies and equipment expenses.

Interim Center Director and Writer: Justin Murdock
Editor, Designer and Writer: Amy Hill

Center for the Management, Utilization and Protection of Water Resources

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We express our appreciation to Sandy Garrison, Alfred Kalyanapu, Tania Datta, and our other faculty associates for their assistance in the production of this report.

August 2019

Tennessee Tech is committed to maintaining an inclusive community that recognizes and values the inherent worth of every person; fosters tolerance, sensitivity, understanding, and mutual respect; and encourages each individual to strive to reach his/her own potential. Tennessee Tech believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. As such, Tennessee Tech seeks to develop and foster diversity.

Tennessee Tech is committed to ensuring that all individuals have equal access to its employment opportunities, educational programs, services, and activities. Tennessee Tech views, evaluates, and treats all students, employees and applicants on the basis of their own personal abilities, qualifications, and other relevant characteristics.

Tennessee Tech does not condone and will not tolerate discrimination against any individual on the basis of race, religion, color, creed, sex, age, national origin, genetic information, disability, veteran status, and any other bases protected by federal and state civil rights law.

Tennessee Tech does not condone and will not tolerate retaliation against individuals who oppose illegal discrimination or participate in investigations of illegal discrimination pursuant to Tennessee Tech policies.

The following person has been designated to handle inquiries regarding non-discrimination and affirmative action at Tennessee Tech: Libby Gays, Director of Affirmative Action, Derryberry Hall Room 156, Box 5132, Cookeville, TN 38505-001, 931-372-3039, equity@tntech.edu The TTU policy on nondiscrimination can be found at www.tntech.edu/ideaa.

