APPENDIX D

SAES-422

Format for Multistate Research Activity
Accomplishments Report

Note: *This report is submitted each year of an activity's duration and is due 60 calendar days following the annual meeting. The SAES-422 is submitted electronically by AAs into NIMSS. Annual Reports for MRF projects are available to NIFA through NIMSS.*

Project/Activity Number:	**S1089**
Project/Activity Title:	**Quantification of best management practice effectiveness for water quality protection at the watershed scale**
Period Covered:	**2021-2022**
Date of This Report:	**10/26/2022**
Annual Meeting Date(s):	**07/17/2022**

Participants:

In person attendees (7):

- Fouad Jaber - Texas A&M
- Adel Shirmohammadi - University of Maryland
- Rafael Muñoz-Carpena - University of Florida
- Jasmeet Lamba - Auburn University
- Bill Ford - University of Kentucky
- Arun Bawa - Texas A&M
- Soni Pradhanang - University of Rhode Island

Virtual Attendees (4):

- Aleksey Sheshukov - Kansas State University
- David Sample - Virginia Tech
- Latif Kalin - Auburn University
- Elizabeth Boyer - Penn State University

Brief summary of minutes of annual meeting:

The annual meeting was held in Marriott Marquis Hotel in Houston, TX on July 17, 2022, a day prior to the start of the ASABE Annual International Meeting. Discussion topics of the meeting focused on addressing S1089 objectives, presenting accomplishments, and identifying potential tasks and/or research products delivered by the members of the Multistate Exchange Group. Meeting participants submitted state reports, highlighted accomplishments in 2021-2022 year, and posed future goals. All presentations were carried out either in-person or via Zoom.

Committee chair, Dr. Rafael Muñoz-Carpena, overviewed the previous project on TMDL and expressed that the project was successful and focused on process level models and problem centric solutions and recommendations. He concluded that coherence and success of journal collection can be important for multistate activities. Dr. Soni M Pradhanang presented an overview and history of the S1089 project, reporting requirements, and results of last year's meeting.

Project members, in-person and virtual, had extensive discussions on the special collection introduced during 2021 meeting. All participants participated in selection of overarching topic, research subtopics, potential journals, and individual papers. Dr. Adel Shirmohammadi overviewed the efforts of previous multistate projects that resulted in special collections. Journal of Environmental Management was selected as a top priority journal for this collection. Proposals for the special collection will need to be completed and submitted to the journal for consideration in 2022. Below is a tentative list of proposed papers, responsible authors, and brief overviews.

1. Cover (synthesis) paper: Advances and gaps in BMPs (agricultural, urban, forestry, etc.) across critical landscapes and scales (collection editor(s))
2. Using integrative metrics and data sources to characterize additive ecosystem services provided by urban stormwater management (McMillan, Jaber, Birgand, Saurav)
    a. This is a framework paper with the first part describing the key paradigms, barriers, opportunities (where are they placed, how are they designed, what is the goal, maintenance, etc.). Case study examples that integrate at least two dimensions (social, economic, biophysical) across scales from neighborhood or watershed.
3. Advances and gaps in the Monitoring of BMPs: a critical review of methods to enhance BMP understanding, effectiveness, modeling and design (François Birgand, Bryan Maxwell, Randall Entheridge, Tiffany Messer, Jaber, Sheshukov, McMillan, Young, Hunt, Burchell, Pradhanang, Saurav)
4. Progress Toward Achieving Nutrient and Sediment Reduction Goals Through Watershed Management: A regional review (Beth Boyer, Soni Pradhanang, Sanjiv Kumar, Zach Easton, Kevin Wagner, Shreeram Inamdar, Aleksey Sheshukov, Philippe Vidon, Bill Ford, Jasmeet Lamba)
5. Limitations and uncertainties in predicting mitigation of runoff contaminants with vegetation buffers at the field and watershed scale (Soni Pradhanang, Rafa Muñoz-Carpena, Marzia Tamanna, Arthur Gold, Philippe Vidon, Shreeram Inamdar, Kelly

Addy)

6. Critical Spatio-Temporall Scales for BMP design: Systems thinking applied to BMP development and management (Rafa Muñoz-Carpena, Adel Shirmohammadi, Jasmeet Lamba, Saurav, Bill Ford, Aleksey Sheshukov)
    a. Critical BMP physical process scales and human scales; Critical BMP human scales: Data, Management Action, Lifecycle and Maintenance, Societal Benefit; Lag time in BMP response and policy implication; Gaps between scales
7. Alternative water resources in the context of climate change (Adel Shirmohammadi, Fuad Jaber, Masoud Negahban-Azar, Hubert Montas)
    a. Stress on Water Resources under Climate and Future Climate Scenarios; Rain water harvesting; Reusable water (e.g., WTP discharge, Food processing units, desalination, etc); Economic, Social, and policy (e.g., FSMA -Food Safety Modernization Act); Feasibility of Alternative Water Resources.
8. Legacy nutrients and sediments impacting the efficiency of BMP performance: Model assessment and improvement needs (Jasmeet Lamba)
9. A spatial framework for detecting water quality and targeting BMPs in agricultural watersheds (Kevin Wagner)
10. Role of AI/Machine Learning in identifying hotspots and allocation of BMPs (Saurav Kumar)

Time and location of the next annual meeting was discussed and several options are presented below. The leadership group will meet during the year and decide on the potential location of next year's annual meeting:

1. UNL at Lincoln, NE to tag along with next year's ASABE conference
2. Iowa State University at Ames, IA as it is close to next year's ASABE conference
3. University of Puerto Rico - Fouad and Soni will inquire about adding participants from there
4. Auburn University at Auburn, AL
5. Kansas State University at Manhattan, KS to tag along with next year's ASABE conference

Elected officers (2022-2023):

- Secretary: Latif Kalin (Auburn U)
- Vice Chair: Aleksey Sheshukov (KSU)
- Chair: Fouad Jaber (Texas A&M)

Past Chairs:

- Rafa Munoz-Carpena (2020-2022)
- Soni Pradhanang (2020-2021)

Accomplishments:

The main focus of this project is to improve the abilities to better understand and predict pollutants and evaluate the effectiveness of best management practices (BMPs) on critical landscapes at the watershed scale. This includes hillslope soil health, water quality of streams and waterbodies, environmental benefits of mitigation practices and cost effectiveness of BMPs. The objectives will be met through the following activities: monitoring at sub-watershed scales, modeling at larger spatial scales, and analyzing uncertainty in both monitoring and modeling efforts.

Short-term Outcomes: Project activities from October 2021 to September 2022 are summarized in the following state reports:

Texas A&M (F. Jaber)

Texas A&M developed TMDL Report Selection Tool (http://Occviz.com/tmdl), a tool that uses natural language processing to understand linkages between modeling tools and impairments. In addition, we developed BMP-Net a deep neural network based on PlanetScope data to identify vegetative and structural BMPs. We worked with USEPA to develop national scale water quality models at HUC8, 10, 12, and 14 digits for the entire U.S and a GIS Tool for determining flood prone areas in Denton county. In collaboration with Nature Conservancy we developed Green stormwater infrastructure prioritization maps for Dallas flooding, a watershed protection plan for Rowlett Creek, Plano, TX, estimated impact of riparian cover on critical shear stress, and developed and implemented HAWQS.

Auburn University (J. Lamba, L. Kalin, S. Kumar)

A hybrid biophysical-Artificial Intelligence (Physics-AI) model is developed from the first principle to estimate streamflow forecast errors at ungauged locations, improving the forecast's reliability. The first principle refers to identifying the need for the hybrid Physics-AI model, determining physically interpretable and machine identifiable model inputs, followed by the Deep Learning (DL) model development and its evaluations, and finally, a biophysical interpretation of the hybrid model. A very high-resolution National Water Model (NWM) forecast, developed by the National Oceanic and Atmospheric Administration, serves as the biophysical component of the hybrid model. Out of 2.7 million daily forecasts, less than 1% of the forecasts can be verified using the traditional hydrological method of comparing the forecast with the observations, motivating the need for the AI technique to improve forecast reliability at millions of ungauged locations. An exploratory analysis followed by the Classification and Regression Tree analysis successfully determines the dependency of the forecast errors on the biophysical attributes, which along with the NWM forecast, are used for the DL model development. The hybrid model is evaluated in a sub-tropical humid climate of Alabama, and Georgia states in the United States. Long-term streamflow forecasts from zero-day lead to 30-day lead forecasts are archived and analyzed for 979 days (Dec. 2018 to Aug. 2021) and 389 USGS gauging stations. The forecast reliability is assessed as the probability of capturing the observations in its ensemble range. As a result, the forecast reliability increased from 21(±1) % in the NWM only forecasts to 82(±3) % in the hybrid Physics-AI model.

University of Kentucky (B. Ford)

Research at the University of Kentucky has focused on source, fate and transport of contaminants in karst and tile-drained landscapes, as well as river-tributary confluences. Seven graduate students have worked on the project (5 contributing during the 21-22 reporting period). Research in tile drained landscapes has focused on monitoring and modeling of sediment transport in subsurface drainage including ongoing collaborations with the USDA-ARS SDRU in Ohio and USDA-ARS NSERL in Indiana. Deliverables include a peer-reviewed manuscript (Nazari et al., 2022) and a new proposal funded by H2Ohio (ODA) in collaboration with the USDA-ARS SDRU. Research in karst watersheds of central KY has focused on impacts of karst hydrologic and biogeochemical processes on nitrate and dissolved reactive P loadings at the watershed-scale. During the reporting period, two students have worked on this topic, with one (McGill) receiving his MS degree. An NSF BPE proposal was funded, and an NSF EPSCOR proposal was submitted to support students, monitoring and modeling initiatives related to this topic. Two papers (Radcliff et al., 2021 and Husic et al., 2022) were published on this topic. Research on fate and transport of contaminants in streams has focused on aquatic vegetation characterization using UAVs, impacts of stream restoration on hydrology and water quality in karst landscapes, accumulation of PFAS in benthic sediments, and fate and transport of sediments and nutrients in river-tributary confluences. During the reporting period, three students have been supported on this topic (with one graduate), and one peer-reviewed paper published (Riddle et al., 2022).

University of Rhode Island (S. Pradhanang)

Water use and withdrawal research focused on developing private water suppliers' water use database and web interface for the State of. Rhode Island. The research is a part of USGS's water use database research program. In collaboration with the EPA and RI Water Resources Board, agricultural water uses, and allocation optimization model is being developed for southern RI. The Electrical Resistivity survey done in combination with other geophysical methods are used to study saltwater intrusion. The NASA EPSCoR funded grant to study methane and greenhouse gasses in marshes and groundwater aims at understanding whether deep groundwater functions as storage or sink of potent greenhouse gasses. Various stormwater basins within RI Roger Williams Park are monitored to study various pollutants including algae in water. The USGS supported State map project focuses on mapping the surface geology statewide and focuses on specific areas at a smaller scale for mapping additional layers. RIGS, with partners in the state, plans to develop a hydrogeologic model at the watershed scale to inform statewide planning for water resources, flood preparation and response, and drought monitoring.

Kansas State University (A. Sheshukov)

The activities were centered over development of w/q models at the watershed, hillslope, and reservoir scales. We developed and calibrated a SWAT model for the Prairie Band Potawatomi Nation tribal area within the Soldier Creek watershed north of Topeka, KS. The model accounts for specific ag cropland and rangeland practices utilized within the tribal land that were obtained with close partnership with KDHE, tribal community, and local residents. Based on the results we developed a plan of BMP implementation for water-quality improvement. We installed a multi sensor stationary buoy in Marion Reservoir in Kansas for detecting valuable blue-green algae

characteristics instrumented with in-situ sensors for near continuous measurements of water temperature, specific conductance, dissolved oxygen, pH, dissolved organic matter, turbidity, light penetration and chlorophyll and phycocyanin fluorescence. We studied the benefits (production and environmental) of cotton production in western Kansas by collecting and analyzing data on three cotton fields. The updated crop coefficient function was developed to better reflect thermo-limited conditions of southern Kansas. We analyzed crop field susceptibility to ephemeral gully erosion by collecting data from various sources (LiDAR, historic imagery, drones, etc.) and using geospatial and machine learning approaches. Novel approaches to detection of gully formations from aerial images were developed and applied in a HUC-12 area.

University of Maryland (A. Shirmohammadi)
Work was focused on post model outcome development; interfacing SWAT model with agent-based model; identifying hotspots using genetic algorithms; social acceptability and cost effectiveness of modeling results on NPS pollution hotspots. We looked at the importance of picking BMPs based on hotspot identification rather than random allocation. The studies at Warner Creek Watershed in the Monocracy River Basin and Choptank River Watershed in the Coastal Plain of Maryland were on modeling based on available long-term monitoring data, while multicriteria decision analysis framework was developed for water reuse and irrigation economics in agriculture.

University of Florida (R. Muñoz-Carpena, Y. Her)
The accomplishments from the Florida team are about BMP adoption in Florida (Dr. Young Gu Her) and analysis of the effectiveness and long-term effects of a commonly adopted BMP (vegetative filter strips) form surface runoff pollution control, including the regulatory implications (Dr. Muñoz-Carpena). We also study large-scale hydrological, water quality and ecological impacts of agricultural development of smallholders in Africa (Laikipia, Kenya) and adoption of BMP (reduced tillage, soil management) to assess the distant ecological degradation of the dry African savanna introduced by these developments (Dr. Muñoz-Carpena).
Dr. Muñoz-Carpena serves as Chair of this Hatch Project for this year and will coordinate the reporting and efforts. Under the organization of this group, we will submit and develop a special journal collection on the topic of "Advances and gaps in agricultural and urban BMPs across critical scales" that will be submitted to a top-tier journal in the specialty.

Virginia Tech (D. Sample)
Watershed research at Virginia Tech is focused upon stormwater management, watershed modeling, and well water quality. Stormwater research at Virginia Tech is currently focused on 1) monitoring runoff from urban catchments with homogenous land use, and using these data for calibration of hydrologic/water quality models; 2) developing integrated urban hydrologic/sediment transport models of urbanized catchments using SWMM and HEC-RAS with and without best management practices (BMPs) to assess which projects and criteria enhance stream stability. Watershed modeling and management is currently focused on 1) quantifying nitrogen removal rates from spring bioreactors treating legacy nitrogen in groundwater, specifically the effect of nitrogen loading and flow permanence and variability on removal rates. This includes working with partners at Virginia Dept of Environmental Quality (DEQ) to develop a $1 million pilot program using bioreactors to treat legacy nitrogen; 2) integrating real-time

animal/environmental sensing using IoT sensors and modeling with autonomous robotics to manage pasture-based manure nutrients; 3) developing integrated agroecosystem models to evaluate the impacts of climate change, best management practices, uncertainty, and management actions on natural resources and farm viability. Twelve journal articles (10 published and 2 in press), 1 dissertation, and 6 proposals were produced and/or awarded, and 6 presentations were made during 2021-22. Ten students were mentored during this period.

University of Georgia (G. Vellidis)

Research at the University of Georgia focused on developing and evaluating BMPs for the traditional cotton-peanut-corn crop rotation used in the agricultural areas of the state. All crops were planted into a rye cover crop using strip tillage following burndown with glyphosate. Three irrigation × three fertilization treatments were evaluated in the corn and cotton plots. These consisted of two irrigation and two fertilization BMPs compared to standard practice. Fertilization BMPs that were evaluated include using fertigation to apply side-dress N on corn and cotton and using UAV-derived NDVI to apply side-dress N on cotton. Irrigation scheduling BMPs include using soil moisture sensors and ET-based scheduling tools. Since N fertilizer is not applied to peanut during the growing season, nine irrigation treatments were evaluated in peanut. These included seven irrigation scheduling BMPs compared to a rainfed treatment and a farmer-standard irrigation scheduling practice. Data collected include continuous soil moisture measured with matric potential type soil moisture sensors and soil nitrogen and crop biomass measured at regular intervals for the corn and cotton crops. Biomass included dry weight of separate plant tissues as well as Total Kjeldahl Nitrogen (TKN) and yield. Soil samples were analyzed for Nitrate, Ammonium, and TKN.

Purdue University (S. McMillan)

Our project goals are to better understand the mechanisms for effective agricultural conservation practices at the site and watershed scales. This work focuses on identifying environmental controls using experiments and monitoring data to incorporate knowledge in management and restoration strategies. We have multiple projects to address this in wetlands, floodplains, and infield practices on working farms. Our work in wetlands (USDA NIFA) and floodplains (NSF) focuses on maximizing nutrient retention while mitigating the deleterious climate effects of CH_4 and N_2O release. In paired watershed studies (EPA), we are working at the HUC-12 scale to link changes in stream chemistry and nutrient loading to land use practices. Together this work will help generate models that are informed by ecosystem processes as we design restoration practices from site to watershed scales that are optimized to improve water quality through nutrient retention, minimize climate impact by reducing GHG emissions, and maximize agricultural productivity.

University of Delaware (S. Inamdar)

Our overall goal is to better understand the concentrations, forms, and fluxes of nitrogen (N) in watersheds and how land use activities and BMPs affect this pollutant. Currently we have three emphasis areas where we are studying the fate and transport of N. These three focus areas are: (1) the effect of milldams and similar barriers on the concentrations, forms, fate and transport of N in stream and riparian zones; (2) the concentrations, fate and transport of N associated with suspended legacy sediment transport in watersheds; and (3) the concentrations and fate of N in restored stream floodplains. We have multiple NSF and USDA AFRI projects addressing these

areas of research.

Oklahoma State University (K. Wagner)
Watershed research at the Oklahoma Water Resources Center focuses on evaluating implementation of novel regenerative agricultural BMPs and virtual fencing. Through small watershed scale monitoring of water quality and quantity, we are working to inform watershed scale modeling and provide insights into processes that determine pollutant fate and transport and the role these novel BMPs play in pollutant reduction. With funding from USDA-NIFA, 12 small watershed sites were installed this year in Altus, Oklahoma to evaluate the benefits of regenerative agriculture practices in cotton production systems. Samples were collected from 8 runoff events this project period. With funding from OSU's Thomas E. Berry Professorship, monitoring of runoff from 10 small watersheds at the Cross Timbers Experimental Range continued, helping improve understanding of how natural sources and conventional grazing practices impact grazing land water quality. 104 samples were collected over 17 events this project period. Finally, with funding from EPA, 2 paired watersheds were installed this year to evaluate the water resource benefits of using virtual fencing to improve grazing management. 33 samples were collected over 13 runoff events this project period. This first year, continuous grazing is being implemented at all sites to serve as a baseline for evaluation. In year 2, virtual fencing will be used to implement rotational grazing and riparian protection.

Outputs:

Publications, conferences, reports and thesis:
Journals: 75; Thesis/Dissertations: 8; Proposals: 27

Impacts:

Activities: The technical committee and the officers met virtually every other month to discuss project objectives and plans for the annual meeting.

Publications:

1. Nazari, S., Ford, W.I., King, K. 2022. Impact of flow pathway and source water connectivity on subsurface sediment and particulate phosphorus dynamics in tile-drained agroecosystems. *Agricultural Water Management.* 269: 107641. https://doi.org/10.1016/j.agwat.2022.107641.
2. Riddle, B., Fox, J., Mahoney, D. T., Ford, W., Wang, Y., Pollock, E., Backus, J. 2022. Investigation of carbon and nitrogen stable isotope tracers (non)conservativeness for sediment fingerprinting. *Science of the Total Environment*. 817: 152640. https://doi.org/10.1016/j.scitotenv.2021.152640.
3. Radcliff, C., Ford, W.I., Nazari, S. Sheppard, C. 2021. Impact of water source dynamics on dissolved reactive phosphorus loadings in heterogeneous karst agroecosystems with phosphatic limestones. *Hydrological Processes*. 35(11): e14422. 36Thttps://doi.org/10.1002/hyp.1442236T.
4. Husic, A., Fox, J., Al Aamery, N., Ford, W., Pollock, E., Backus, J. 2021. Seasonality of recharge drives spatial and temporal nitrate removal in a karst conduit as evidenced by

nitrogen isotope modeling. *JGR Biogeosciences.* e2021JG006454. https://doi.org/10.1029/2021JG006454.
5. Shahed Behrouz, M.S., Yazdi, M.N., Sample, D.J., 2022. Using Random Forest, a machine learning approach to predict nitrogen, phosphorus, and sediment event mean concentrations in urban runoff. J. Environ. Manage. 317, 115412. https://doi.org/10.1016/j.jenvman.2022.115412
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8. Sangster, S., Gruver, M., Lacerda, L., Perry, C., Washington, B., Vellidis, G. 2021. Evaluation of irrigation and fertilization strategies to improve irrigation and nitrogen water use efficiencies in cotton. 2021 ASA, CSSA, SSSA International Annual Meeting, 08 November 2021, Salt Lake City, UT, USA, https://scisoc.confex.com/scisoc/2021am/prelim.cgi/Paper/136430
9. Vellidis, G., Butts, C., Gallios, I., Ortiz, B. 2021. CropFIT - an integrated SmartIrrigation mobile app for corn, cotton, peanut, and soybean. 2021 ASA, CSSA, SSSA International Annual Meeting, 08 November 2021, Salt Lake City, UT, USA, https://scisoc.confex.com/scisoc/2021am/prelim.cgi/Paper/135167
10. Gallios, I., Butts, C., Perry, C., Vellidis, G. 2021. Making Irrigator Pro and easier to use irrigation scheduling tool. 2021 ASA, CSSA, SSSA International Annual Meeting, 08 November 2021, Salt Lake City, UT, USA, https://scisoc.confex.com/scisoc/2021am/prelim.cgi/Paper/135255
11. Shrestha, S.G. and Pradhanang, S.M., 2022. Optimal selection of representative climate models and statistical downscaling for climate change impact studies: a case study of Rhode Island, USA. *Theoretical and Applied Climatology*.
12. Sharma, S., Talchabhadel, R., Nepal, S., Ghimire, G., Rakhal, B., Panthi, J., Adhikari, B., Pradhanang, S. M., Maskey, S., and Kumar, S., 2022. Increasing risk of cascading hazards in the central Himalayas. *Nat Hazards*. https://doi.org/10.1007/s11069-022-05462-0
13. Panthi, J., Pradhanang, S.M., Nolte, A. and Boving, T.B., 2022. Saltwater intrusion into coastal aquifers in the contiguous United States—A systematic review of investigation approaches and monitoring networks. *Science of The Total Environment*, p.155641.
14. Pengfei Liu, Yu Wang, Wei Zhang, "The Influence of the Environmental Quality Incentives Program on Local Water Quality", *American Journal of Agricultural Economics. 2022.* https://doi.org/10.1111/ajae.12316
15. Odeh, T., Mohammad, A.H., Pradhanang, S.M., Ismail, M. and Rödiger, T., 2021. GIS-based Analytical Modeling on Evaluating Impacts of Urbanization in Amman Water Resources, Jordan.
16. Panthi, J., Talchabhadel, R., Ghimire, G.R., Sharma, S., Dahal, P., Baniya, R., Boving, T., Pradhanang, S.M. and Parajuli, B., 2021. Hydrologic Regionalization under Data Scarcity: Implications for Streamflow Prediction. *Journal of Hydrologic Engineering*, *26*(9), p.05021022.
17. Inamdar, S., Peipoch, M., Gold, A.J., Lewis, E., Hripto, J., Sherman, M., Addy, K.,

Merritts, D., Kan, J., Groffman, P.M. and Walter, R., 2021. Ghosts of landuse past: legacy effects of milldams for riparian nitrogen (N) processing and water quality functions. Environmental Research Letters, 16(3), p.035016.
18. Hollister, J.W., Kellogg, D.Q., Lei-Parent, Q., Wilson, E., Chadwick, C., Dickson, D., Gold, A. and Arnold, C., 2022. nsink: An R package for flow path nitrogen removal estimation. *Journal of Open Source Software*, *7*(71), p.4039.
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22. Muñoz-Carpena, R., Z. Yu, A. Carmona-Cabrero, G. Fox, O. Batelaan, A. Bardossy. 2022. Convergence of mechanistic modeling and artificial intelligence (AI) in hydrologic science and engineering. (under review, *J. Hydrology*).
23. Muñoz-Carpena, R., Reichenberger S., Sittig S., Sur R. (2022). Complex effects of leaching, sedimentation, sorption and degradation on runoff remobilization of pesticide residues in vegetative filter strips (under review, *ACS Environmental AU*).
24. Reichenberger, R., R. Sur, S. Sittig, S. Multsch, Á. Carmona-Cabrero, J.J. López and R Muñoz-Carpena. 2022. Dynamic prediction of effective runoff sediment particle size for improved assessment of pesticide mitigation efficiency with vegetative filter strips (under review, *Sci. Total Env.*)
25. Muñoz-Carpena, R., A. Ritter, R. Sur, S. Reichenberger. 2022. Effect of hydrograph type on the calculation of pesticide mitigation efficiencies of vegetative filter strips with VFSMOD in the regulatory context. (Under review, *Integr. Environ. Assess. Manag.*).
26. Zhang, Y., R. Bhattarai and R. Muñoz-Carpena. 2022. Effectiveness of vegetative filter strips for sediment control from steep construction areas. (Under review, *Catena*)
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of subsurface preferential flow experimental observations in a riparian buffer. *Trans. ASABE* 64(5). doi:10.13031/trans.14559.
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36. Song, J.H., Her, Y. and Guo, T., 2022. Quantifying the contribution of direct runoff and baseflow to nitrogen loading in the Western Lake Erie Basins. Scientific Reports, 12(1), pp.1-13.
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2) Thesis/Dissertation:

1. Timothy McGill. Assessing machine learning utility in predicting hydrologic and nitrate dynamics in karst agroecosystems, MS Student (Primary Advisor, Fall 2019-May 2022).
2. Rosalia Agioutanti. Classifying and mapping aquatic vegetation in heterogenous stream ecosystems using visible and multispectral uav imagery, MS Student (Primary Advisor, Fall 2019-May 2022).
3. Gina DeGraves. Sediment nitrogen dynamics in backwater wetland confluences of a regulated river, MS Student (Primary Advisor, Summer 2019-Fall 2021).
4. Lorena Lacerda. 2021. Using remote sensing to develop irrigation scheduling tools for variable rate irrigation, Ph.D. Dissertation, University of Georgia, pp 183.
5. Shahed Behrouz, M., 2022. Improving Predictions of Stormwater Quantity and Quality through the Application of Modeling and Data Analysis Techniques from National to Catchment Scales, Ph.D. Dissertation, Virginia Tech, pp 203.
6. Umme Fatema Piu. 2022. Evaluating evapotranspiration rates for corn and cotton in thermo-limited climate of southwest Kansas. MS, Kansas State University.
7. Dey, S., 2021. Enabling large-scale hydrologic and hydraulic modeling through improved topographic representation. PhD dissertation, Purdue University.
8. Phillippe, A.J. 2022. Determining bacterial and nutrient concentrations and loadings of surface runoff from differing grazer access and vegetative cover in Northcentral Oklahoma. MS Thesis, Oklahoma State University.

3) Proposals Awarded/Submitted:

1. Fox, J., Ford, W., Mahoney, D., Armstead, M., Dadi, G. BPE-Track 3: Inclusive Mentoring Hub for Enabling Pathways from Inner-City and Rural Appalachian Households to Engineering in Kentucky and West Virginia. NSF-BPE. $799,445. Role Co-Investigator. July 2022-July 2027
2. Ford, W. Using edge-of-field data and modeling to inform H2Ohio. Ohio department of

agriculture $150,000 (as sub-award from USDA-ARS). Role: Principal Investigator.

3. Fox, J., Mahoney, D., Ford, W., Armstead, M. RII-BEC: Undergraduate research as a model of excellence to broaden STEM participation in EPSCoR jurisdictions: What are the mentoring costs? NSF RII-BEC. $1,000,000. Role Co-Investigator.
4. Improving the Sustainability of Georgia Cotton by Increasing Nitrogen and Water Use Efficiencies, Georgia Cotton Commission, 2021-2022, $58,000, Vellidis PI
5. Expansion of an Irrigation Scheduling Application to the U.S, Cotton Incorporated, 2021-2022, $50,000, Vellidis PI
6. Incorporating Volumetric Water Content (Capacitance) Sensors into the Irrigator Pro-Based Irrigation Scheduling Tool, 2021-2022, $18,000, Vellidis PI
7. Making Irrigator Pro an Easier-to-Use Irrigation Scheduling Tool, 2021-2022, Southern Peanut Research Initiative, $25,000, Vellidis PI.
8. Sample, D.J. and Scott, D., Vibrant Virginia-Improving the Resilience of Stormwater Treatment in Fredericksburg: Amount: $60,000. Sponsor: VT Center for Economic and Community Engagement, 1/01/2021 - 06/30/2022.
9. Shahed Behrouz, M., 2021. New Conceptualizations of Catchment-Scale Stormwater Pollution Generation Processes, Virginia Water Resources Research Center Competitive Grant, $7,000, 10/1/21-8/31/22.
10. Cardace, D., Pradhanang, S. M., and Moseman-Valtiera, S., Planetary Methane in Ultramafic Contexts: Searching for Cyclicity in Methane Emissions at a Planetary Analog Site in Northern California, NASA-EPSCoR $735,000 (6/2022-6/2025)
11. Savage, B., Pradhanang, S. M., Boving, T. Mapping Bedrock and Saltwater Intrusion in Rhode Island, USGS $90,000 (09/2021-08/2022)
12. Savage, B., Pradhanang, S. M., Boving, T., Mapping Bedrock and Saltwater Intrusion in Rhode Island USGS $117,337 (09/2022-08/2023)
13. Pradhanang, S., Kumar, R, and Rashid T, Floating Treatment Wetland System (FTWS) - Sustainable green technology to remediate polluted surface water bodies in the COVID 19-era , Asia- Pacific Network $78,000 (09/2021-08/2023)
14. Pradhanang, S. M., Boving, T., and Savage, B. The Rhode Island Water Resources Board (RIWRB) and University of Rhode Island (URI) Statewide Water Withdrawal Data Enhancement and Database Development Project. RIWRB-USGS $197,488 (10/20-09/22)
15. T Franti, A. Sheshukov, J. Lory, R. Cruse. Developing and assessing innovative ephemeral gully erosion control practices. (2021-2023). USDA $344,538
16. R.L. North, A. Ohler, L. McCann, T. Moore, A. Sheshukov. Valuing Water Quality Improvements in Heartland Reservoirs. (2022-2025) EPA $741,285
17. Pradhanang, S.M., Liu, P. Water Availability through the Integration of Hydrologic Model and Water Management Optimization Tool for Chipuxet River Watershed, Rhode Island. RIWRC-USGS. (2022-2023) USGS $50,000
18. USDA-Cooperative Agreement. Fuka, D.R., Z.M. Easton, R.R. White. Developing and evaluating rapidly deployable inexpensive weather, soil moisture, shock, and streamflow sensors to aid the monitoring, inspection, and rehabilitation of aging dams. $225,000. Dec 2021-Nov 2022.
19. USDA-Cooperative Agreement. Easton, Z.M. Modeling the Lake Champlain Basin CEAP watersheds to understand and predict conservation effects on legacy phosphorus. $134,223. Oct 2021-Sept 2023.
20. Virginia Tech CALS Strategic Plan Advancement. Easton, Z.M., R.R. White, K. Hamed,

D.R. Fuka, M. Eick. Eyes in the Sky and Boots on the Ground: Collaborative Technologies for Monitoring and Managing Livestock Pastures. $60,000. Oct 2021-May 2023.

21. NSF CPS (Cyber-Physical Systems). White, R.R., E. Feuerbacher, Z.M. Easton. Collaborative Research: CPS: Medium: Greener Pastures: A pasture sanitation cyber physical system for environmental enhancement and animal monitoring. $998,232. Jan 2022-Dec 2024.
22. Lewis, K., K. Wagner, A. Berthold, P. DeLaune, J. Bell, D. Miller Sustainable. Agricultural Intensification and Enhancement through the Utilization of Regenerative Agricultural Management Practices. Amount: $583,438 (Total Award: $10,000,000). Sponsor: USDA-NIFA Sustainable Ag Systems Program, 9/1/2021-8/31/2026.
23. Wagner, K. Dam Analysis Modernization of Tools, Applications, Guidance, and Standardization (DAM-TAGS) Project – Year 1. Amount: $478,238. Sponsor: USDA-ARS Cooperative Agreement, 6/10/2021-6/9/2022.
24. Wagner, K., R. Bonett, A. Sewell, J. Gonzalez Estrella, S. Kim, A. Dzialowski. Oklahoma Water Resources Research Institute Program (USGS Base Funds FY21). Amount: $125,000. Sponsor: USGS, 9/1/2021-8/31/2022.
25. Mirchi, A, K. Wagner, S. Taghvaeian, Sarah Alian, R. Bailey. Conjunctive Freshwater-Saltwater Management for Climate-Resilient Agroecosystems. Amount: $181,568 (Total Award: $749,786). Sponsor: USDA-NIFA Foundational Program, 12/31/2021-12/12/2025.
26. Wagner, K., S. Sharma, S. Taghvaeian, S. Frazier, J. Warren, A. Mirchi. Oklahoma Master Irrigator Program and Ogallala Aquifer Study. Amount: $150,000. Sponsor: Oklahoma Conservation Commission, 7/1/2021-6/30/2022.
27. Reuter, R., K. Wagner, L. Goodman, C. Duchardt, B. Murray. Increasing the pace & scale of adoption of prescribed grazing through virtual fence technology. Amount: $93,188 (Total Award: $1,365,774). Sponsor: USDA-NRCS Conservation Innovation Grant, 7/1/2022-6/30/2025.