

# 2025 Kentucky Water Resources Annual Symposium



September 12, 2025

Central Bank Center – Lexington, KY

 Kentucky Water  
Research Institute

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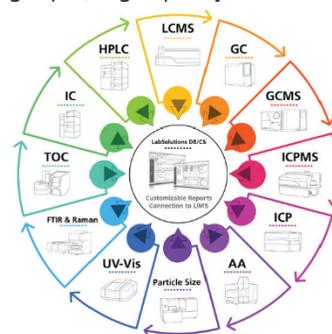
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Associate Professor | Writing, Rhetoric, & Digital Studies  
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## **Plenary Session**

### ***USGS Flood Monitoring, Tools, and Partnerships***

**Peter J. Cinotto, Acting Director, United States Geological Survey (USGS)  
Ohio-Kentucky-Indiana Water Science Center**



Pete is the Acting Director of the US Geological Survey's Ohio-Kentucky-Indiana Water Science Center (OKI WSC) and, in this role, he oversees all OKI WSC operations across the three-state region; he also, typically, has numerous ancillary duties that include serving on various scientific committees and(or) as a project chief for local- and National-scale projects. Pete has a diverse background in earth sciences spanning over 30 years and, prior to relocating to Kentucky in 2007, he worked in the private sector (oilfield services), USGS National Water Quality Laboratory, USGS Georgia WSC, and USGS Pennsylvania WSC. Pete has also served as Acting Director for the Dakota WSC (North and South Dakota) and the New Mexico WSC.

## Agenda

# 2025 Kentucky Water Resources Annual Symposium

September 12, 2025

Central Bank Center, Lexington, Kentucky

**Registration (Coffee Break) (8:00 a.m. - 8:30 a.m.)**

**PLENARY SESSION (8:30 a.m. - 09:20 a.m.)**

**Location: Meeting Rooms 10 & 11**

- 8:30 *Welcome, Introductions, and KWRI Updates*, Jason Unrine, Director, KWRI.
- 8:40 *USGS Flood Monitoring, Tools, and Partnerships*, Peter J. Cinotto, Acting Director, USGS Ohio-Kentucky-Indiana Water Science Center.
- 9:10 Q & A.

**SESSION 1 (9:20 a.m. - 10:40 a.m.)**

**Location: Meeting Rooms 12, 13, & 14**

### **Track 1A - Room 12— Flooding**

Moderator: Donna McNeil

### **Track 1B - Room 13— PFAS- Occurrence, Toxicity and Treatment**

Moderator: Emily Byers

### **Track 1C - Room 14— Nutrients and Watershed Management I**

Moderator: Andrea Drayer

- |  |   |  |
|--|---|--|
| <p>9:20 <i>Overview of the Historic February &amp; April 2025 Floods including Usage of the New NWS Flood Inundation Mapping in Kentucky</i>, Andrea Schoettmer, NOAA/NWS.</p> | <p><i>Deep Eutectic Solvents as an Eco-friendly Alternatives in the Fabrication of Polymeric Membranes for Water Treatment Applications</i>, Odianosen Ewah, Chemical and Materials Engineering, UK. +</p>    | <p><i>Six Year Record of Nitrate Isotopic Ratios Suggest Soil Nitrogen and Denitrification Control Seasonality: Evidence From a Karst Aquifer and Meta-Analysis for Tracer-Aided Numerical Modelling</i>, Brenden Riddle, Civil Engineering, UK. +</p> |
| <p>9:40 <i>Don't Change the Channel: Untangling Drivers of Appalachian Flooding</i>, Meredith Swallow &amp; Jason Dortch, KGS, UK.</p>   | <p><i>Membrane-supported Catalytic Strategies for PFAS Detoxification</i>, Subrajit Bosu, Chemical and Materials Engineering, UK. +</p>   | <p><i>Development of a Concept Model of the Causes of Cyanobacterial Algal Blooms on the Ohio River</i>, Jordan Spears, Civil Engineering, UK. +</p>   |
| <p>10:00</p>   | <p><i>Toxicity Assessment of Hexagonal-Boron Nitride and PFAS Through Behavioral and Lipid Accumulation Assays Towards Caenorhabditis Elegans</i>, Lucca Madeo Cortarelli, Plant and Soil Sciences, UK. +</p> | <p><i>Water Quality Monitoring at McConnell Springs, Lexington, KY (2010-2025)</i>, David Price, Division of Water Quality, LFUCG.</p>   |
| <p>10:20 <i>Spatiotemporal Shifts in Extreme Streamflow Events Across the Kentucky River Watershed, C.</i> Andrew Day, Geographic and Environmental Sciences, UL.*</p>         |   | <p><i>Reimagining Watershed Planning: An Interactive Approach for the Glenss Creek Watershed</i>, Adam Shelley, Kentucky Water Research Institute, UK.</p>   |

\* Denotes project supported by USGS 104b grant funds.

+ Denotes a student project.

**BREAK (10:40 p.m. - 11:00 a.m.)**

**SESSION 2 (11:00 a.m. - 12:00 p.m.)**

**Location: Meeting Rooms 12, 13, & 14**

**Track 2A - Room 12—  
Flooding**

Moderator: Emily Byers

**Track 2B - Room 13—  
Utility Planning**

Moderator: Donna McNeil

**Track 2C - Room 14—  
Restoration**

Moderator: Andrea Drayer

11:00 *Stormwater Management Using an Integrated Flood Modeling Approach for FEMA Floodplain Mapping in Urban Karst Watersheds*, Jason Polk, Center for Human GeoEnvironmental Studies, WKU. \*

*Drinking Water Shutoffs in Kentucky*, Rebecca Shelton, Appalachian Citizens' Law Center.

*Evaluating Urban Stream Restoration Success: Assessing the Impact of Urban Reforestation Efforts on Water Quality and Aquatic Systems in the Inner Bluegrass*, Ben Brammell, Science and Health, Asbury, Kenton Sena, Lewis Honors College, UK. \*

11:20 *Karst Groundwater Flow Profile for Jennings Creek, Kentucky for Flood Management*, Noah Jennings & Logan Sileo, Center for Human GeoEnvironmental Studies, WKU. \*\*

*Doing Community-Engaged, Collaborative, Action-Oriented Research on Small Rural Water Systems in Central Appalachia: LiKEN's Approach, Values and Methodological Framework*, Deborah Thompson & Madison Mooney, LiKEN.

*Incorporation of a Kentucky Trade Association for Ecological Restoration*, Chuck Davis, Beaver Creek Hydrology, Kentucky Ecological Restoration Association.

11:40 *Urban Karst Flood Hazard Mitigation at Fairview Plaza, Bowling Green, Kentucky, USA*, Quade Miles, Center for Human GeoEnvironmental Studies, WKU. \*\*

*WaterWorks: A Serious Gaming Platform for Effective Water Distribution System Training*, Brent Vizanko, Civil Engineering, UK.

*Insights from Kentucky Stream Restoration Professional Interviews*, Noah Lane, Biosystems and Agricultural Engineering, UK. +

**AWARDS LUNCHEON (12:00 p.m. - 1:00 p.m.)**

**Location: Meeting Rooms 10 & 11**

**SESSION 3 (1:00 p.m. - 2:20 p.m.)**

**Location: Meeting Rooms 12, 13, & 14**

**Track 3A - Room 12—  
Climate**

Moderator: Steve Evans

**Track 3B - Room 13—  
Water Quality**

Moderator: Brent Vizanko

**Track 3C - Room 14—  
Remote Sensing/Drones**

Moderator: Chuck Davis

1:00 *Measuring Extreme Weather and its Effects on Agricultural Productivity in the United States*, Steven Buck, Agricultural Economics, UK.

*Tiny Troubles in Karst: Landuse and Transport of Microplastics in South-Central Kentucky*, Katie Norman, Earth, Environmental, and Atmospheric Sciences, WKU. +

*Semiautomated Approach for Mapping Complex Sinkholes in the Pennyroyal Karst Plain Using Lidar and Machine Learning*, Desiree Cunningham, Kentucky Geological Survey, UK.

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**SESSION 3 (1:00 p.m. - 2:20 p.m.)****Location: Meeting Rooms 12, 13, & 14****Track 3A - Room 12—  
Climate**

Moderator: Steve Evans

**Track 3B - Room 13—  
Water Quality**

Moderator: Brent Vizanko

**Track 3C - Room 14—  
Remote Sensing/Drones**

Moderator: Chuck Davis

1:20 *Mapping the Landscape: A National Inventory of University-Based Climate Entities*, Myranda Hentges, Biosystems and Agricultural Engineering, UK. +

*Community-Engaged Research Approach for Disinfection By-Product (DBP) Risk Mitigation in Rural Appalachian Kentucky Households*, Abelline Fionah, Civil Engineering, UK.

*Analysis of Soil Loss in Western Kentucky Agricultural Watersheds using sUAV-Based LiDAR and Multispectral Imaging*, Leighia Eggett, Plant and Soil Sciences, UK.

1:40 *Emergent Vegetation (Typha spp.) Synergistically Enhances Methane Emissions in Small, Peri-Urban Wetlands Dominated by Floating Vegetation (Lemna, Wolffia spp.)*, Nathan Earl, Biology, UL. \*\*

*The Impact of Extreme Weather Events on Drinking Water Quality in Kentucky*, Munib Inam, Agricultural Economics, UK. +

*The Greatest Threat(s) to Prairie Pothole Wetlands*, Brett Werner, Centre College.

2:00 *Effects of Duckweed (Lemna and Wolffia spp.) on Decomposition Rates in Small, Peri-Urban Wetlands*, McKenzie Goodwyn, Biology, UL. \*\*

*Disinfection Byproduct Concentrations at Point of use in Rural Drinking Water Systems Impacted by Elevated Bromide Concentrations*, Emily Byers, Kentucky Water Research Institute, UK.

*Division of Water Drone Program- Collecting Data Via Unmanned Vehicles*, Wesley Turner, Watershed Management, KDOW.

**POSTER SESSION (2:20 p.m. - 3:30 p.m.)****Location: Meeting Room 9****SESSION 4 (3:30 p.m. - 4:40 p.m.)****Location: Meeting Rooms 12, 13, & 14****Track 4A - Room 12—  
Groundwater**

Moderator: Steve Evans

**Track 4B - Room 13—  
Sediment**

Moderator: Brent Vizanko

**Track 4C - Room 14—  
Nutrients and Watershed  
Management II**

Moderator: Chuck Davis

3:30 *Investigating Groundwater Dynamics in Barbados using Forensic Hydrology and Dye Tracing Techniques*, Autumn Singer, Crawford Hydrology Laboratory, WKU.

*A New Model for the Characterization of Concentration-Discharge Hysteresis loops Based on Self-Organizing Maps*, Arlex Marin-Ramirez, Civil and Environmental Engineering, UL. +

*Development of the Kentucky Watershed Watch Data Portal*, Doug Curl, Kentucky Geological Survey, UK.

3:50 *Application of Stable Isotopes to Estimate Ohio River Infiltration and Groundwater Contributions to Radial Collector Wells in the Alluvial Aquifer, Louisville, Kentucky, 2019–20*, Surya Freeman, OH-KY-IN WSC, USGS.

*Sediment Transport Dynamics in a Complex Fluviokarst System, South-Central Kentucky*, Sarah Arpin, Kentucky Geological Survey, UK. +

*Partnering Up for Planning*, Haileigh Arnold, Watershed Management Branch, KDOW.

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**SESSION 4 (3:30 p.m. - 4:40 p.m.)**  
**Location: Meeting Rooms 12, 13, & 14**

	<b>Track 4A - Room 12— Groundwater</b>	<b>Track 4B - Room 13— Sediment</b>	<b>Track 4C - Room 14— Nutrients and Watershed Management II</b>
	Moderator: Steve Evans	Moderator: Brent Vizanko	Moderator: Chuck Davis
4:10		<i>Seasonal Variation of the Stream's Sediment Transport Regime Using Sensor Networks in the South Elkhorn Watershed</i> , Melissa Beckman, Civil Engineering, UK. +	<i>Clearing the Way: A Framework for Supporting Local Efforts in Aquatic Trash Removal</i> , Nathan Alexander, Nonpoint Source Section, KDOW.
4:30	<i>A Half-Century Ahead of Its Time: R.B. Anderson's Remarkable 1925 Hydrogeologic Analysis of the Mammoth Cave System for the Louisville Gas and Electric Company</i> , Chris Groves, Department of Earth, Environmental, and Atmospheric Sciences, WKU.	<i>Predicting Sediment Transport by Coupling Sediment Connectivity with the Unit Sediment Graph: Method Develop and Watershed-Scale Application</i> , Nabil Al Aamery, Civil Engineering, UK.	<i>Kentucky Waterways Alliance Green River Tire and Access Identification</i> , Elijah Miller, Kentucky Waterways Alliance.

**Student Awards (4:50 p.m. - 5:00 p.m.)**  
**Location: Meeting Room 9**

**Adjourn (5:00 p.m.)**

**Poster Session (2:20 p.m. - 3:30 p.m.)**

1. *Critical Mineral Recovery from E-Wastes Using Nanocomposite Membranes*, Tridwip Sen, Chemical and Materials Engineering, UK. +
2. *Exploring the Effect of Single-Layer and Polydopamine-bonded Bilayer PVDF-HFP and Polysulfone Membrane via Green Solvents for Wastewater Treatment*, Eesh Kulshrestha, Chemical Engineering, UK. +
3. *Water Workforce Training Center*, Sahar Alameh, College of Education, UK.
4. *Investigating Headwater Contributions to Downstream Discharge: Insights From a Process-based Hydrologic Model*, Ridwan Mohammed Nur, Civil and Environmental Engineering, UL. +
5. *Unraveling the Role of Model Structure to Simulate Streamflow in Appalachian Headwaters using the MARRMoT Framework*, Franklin Kondum, Civil and Environmental Engineering, UL. +
6. *Comparative Evaluation of Satellite and Field-Based Soil Moisture in Eastern Kentucky's Appalachian Headwater System*, Anju Thapa, Civil and Environmental Engineering, UL. +
7. *Investigation of Rainfall-Induced Slope Failure Using Physical Models*, Mir Ali Hosseini, Civil and Environmental Engineering, UL.+
8. *Evaluating the Effects of Ecological Restoration on Amphibian Communities in Lotic Systems in the Inner Bluegrass Region of Kentucky*, Ethan Hoogerheide, Biological Sciences, ECU. \*+
9. *Reconstructing Hydrography in Eastern Kentucky Mine Lands*, Demetrio Zourarakis, College of Agriculture, UK.
10. *Predictive Modeling of Total Trihalomethanes in the Martin County Water System: A Comparison of Linear and Machine Learning Approaches*, George Fordjour, Civil Engineering, UK. +
11. *Life Cycle Assessment (LCA) of Green Infrastructure: Urban Tree Soil Cells*, Kimia Khanlari, Civil Engineering, UK. +
12. *Integrated Research and Education to Assess Sustainability of a Mobile Water Treatment System for Emergency Response in Kentucky*, Isaac Oluk, Civil Engineering, UK. \*+
13. *Quantifying Soil Moisture Impacts on Sediment Transport and Hysteresis in Karst: A Dual-Sensor-Based Modeling Study with Mentored Undergraduate Research Support*, Leonie Bettel, Civil Engineering, UK. +
14. *Carbon Isotopic Ratios of Benthic Algae Show Impacts to Fluvial Sediment Carbon Seasonality in South Elkhorn Creek, Lexington, Kentucky*, Joseph Ammons, Civil Engineering, UK. +
15. *Hydrologic Modeling to Predict Flash Flood Events and Uncertainty in the Appalachian Region in Future Decades*, Sarah Holt, Civil Engineering, UK. +
16. *Investigation of Turbulence Parameters in a Karst Cave System in the Inner Bluegrass Region, Kentucky, USA*, Matthew Lynch, Civil Engineering, UK. +
17. *What's in the Air and Water? Understanding Per- and Polyfluoroalkyl Substances (PFAS) and Potential Vapor Intrusion Risks in Kentucky*, Ariel Robinson, Civil Engineering, UK. +
18. *Filtering the Future: Evaluating Constructed Wetlands in Rural Water Treatment*, JuLeah Edie, Biosystems and Agricultural Engineering REU, UK. +
19. *Water Quality Modeling and Variability Among Nested Watersheds in Eastern Kentucky Data Deserts*, Amanda Beall, Biosystems and Agricultural Engineering REU, UK. +
20. *Analyzing Factors of Harmful Algal Blooms in Old Lake: A Geospatial Study with Implications for Distilleries*, Avery Krahwinkel, Biosystems and Agricultural Engineering REU, ECU. +
21. *Restoration Without Reconstruction: Hydraulic Function in Urban Riparian Areas*, Abigail Davidson, Biosystems and Agricultural Engineering, UK. +
22. *Modeling Subsurface Sediment Transport Through Macropores in Heterogenous Fine-textured Soils: Importance of Preferential Flow Dynamics and Macropore Connectivity*, Ayesha Sadia, Biosystems and Agricultural Engineering, UK. +
23. *Reforested Stormwater Basins: A help or a hindrance to stormwater management in Lexington, KY?*, Noah Howie & Jacob Crabtree, Biosystems and Agricultural Engineering, UK. \*+
24. *Storm Event Nitrate Source Tracking Using  $\delta^{15}N$  and  $\delta^{18}O$  at Edge-of-Field Water Quality Monitoring Stations in Western Kentucky*, Scott Furlong, Earth and Environmental Sciences, UK. \*+
25. *The Role Soil Spatial Complexity and Resource Patterning Play in Greenhouse Gas Emissions From Mineral Soil Wetlands*, Delaney McCoy, Biological Sciences, MSU, & Nadia Castillo, Earth and Environmental Sciences, MSU. \*+
26. *Analysis of Soil Quality Dynamics under No-Till and Conventional Tillage Practices*, Durga Bastola, MSU. +
27. *Examining Long Term Trends of Precipitation-Based Climate Indices for Kentucky River Basin*, Jasmin Saric, Mechanical and Civil Engineering, PUNW. +
28. *Preliminary Investigation on Stream Flow Variations in the Black Canyon Complex, Roppel Section of the Mammoth Cave System*, Ljubomir Veljan Risteski, Earth, Environmental, and Atmospheric Sciences, WKU. +
29. *Effects of Organic and Inorganic Fertilizers on Soil Properties and Tomato Yield*, Navdeep Singh, WKU.
30. *Rapid and Field-ready System for Fecal Matter Contamination Detection in Water Resources*, Soroosh Torabi, Mechanical and Aerospace Engineering, UK.

\* Denotes project supported by USGS 104b grant funds.

+ Denotes a student project.

**Past Recipients of Institute Awards**

**William Barfield Award for Outstanding Contributions in Water Resources Research**

Jason Polk (2024)	James C. Currens (2014)
Christopher D. Barton (2023)	Art Parola (2013)
Lindell Ormsbee (2022)	Andrew Ernest (2012)
Carmen Agouridis (2021)	James Dinger (2011)
Chris Groves (2020)	Alice Jones (2010)
Jimmy Fox (2019)	Sylvia Daunert (2009)
Susan Hendricks (2018)	Gail Brion (2008)
Jim Kipp (2017)	David White (2007)
Stephen F. Higgins (2016)	Wes Birge (2006)
Dibakar Bhattacharyya (2015)	Don Wood (2005)

**Lyle Sendlein Award for Outstanding Contributions in Water Resources Practice**

David Hamilton (2024)	Derek R. Guthrie (2014)
Roger Recktenwald (2023)	Sandra Gruzesky (2013)
Peter Goodmann (2022)	Michael Griffin (2012)
Kurt Mason (2021)	Linda Bridwell (2011)
Richard Walker (2020)	Greg Heitzman (2010)
Jack Stickney (2019)	Susan Bush (2009)
Barry Tanning (2018)	Steve Reeder (2008)
Lynn Jarrett (2017)	Bill Grier (2007)
Steven K. Hampson (2016)	Jack Wilson (2005)
Richard Warner (2015)	

PAST RECIPIENTS

**Robert A. Lauderdale Award for Outstanding Contributions in Water Quality**

Tom “Fitz” FitzGerald (2024)	Brian C. Reeder (2014)
Tom Biebighauser (2023)	H. David Gabbard (2013)
Christopher Lorentz (2022)	Henry Francis (2012)
Russ Turpin (2021)	Amanda Gumbert (2011)
John Webb (2020)	Malissa McAlister (2010)
Maggie Morgan (2019)	Bruce Scott (2009)
Charles Martin (2018)	Ken Cooke (2008)
Amy Sohner (2017)	Judith Petersen (2007)
Paulette Akers (2016)	Eddie Foree (2006)
Dale Reynolds (2015)	

**Session 1A: Flooding**

## **Overview of the Historic February & April 2025 Floods including Usage of the New NWS Flood Inundation Mapping in Kentucky**

Andrea Schoettmer<sup>1</sup>

<sup>1</sup>NOAA/NWS Louisville, KY

<sup>1</sup>[andrea.schoettmer@noaa.gov](mailto:andrea.schoettmer@noaa.gov)

Back to back historic floods impacted the lower Ohio Valley including Kentucky in early 2025. Widespread moderate to major river flooding as well as several instances of flash flooding occurred during both mid February and early April with some rivers reaching their top 5 all time crests. A combined total of 17 flood fatalities were confirmed from both of these events in Kentucky. This presentation will provide an overview of the floods and their impacts as well as the precipitation forecasts and other significant weather hazards surrounding each. NWS offices across Kentucky were able to utilize the new NWS Flood Inundation Mapping (FIM) services to aid in flood response and decision making for the first time. Largely FIM proved to be a very valuable flood tool at the county and state emergency management (EM) levels and received many outstanding compliments from Kentucky EM Director Gibson as well as Governor Breshear. This presentation will detail some of the FIM success stories in flood response and recovery for the historic February and April 2025 floods.

## **Don't Change the Channel: Untangling Drivers of Appalachian Flooding**

Meredith Swallom<sup>1</sup>, Jason Dortch<sup>1</sup>

<sup>1</sup> Kentucky Geological Survey

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Precipitation patterns are determined by interactions between atmospheric moisture and topography; thus steep Appalachian terrain is susceptible to flooding under extreme storm scenarios. Watersheds are heavily influenced by human activities, including mountaintop removal mining, reengineering of river channels, and construction of roads, buildings, and bridges. Though these modifications may lead to worsened flooding compared to a natural landscape, their relative contributions remain equivocal. A July 2022 flood in eastern Kentucky provided the opportunity to calibrate a flood model incorporating major alterations to the landscape, then to iteratively test to determine which, if any, exacerbated flooding. While bridges, roads, and buildings had insignificant effects on modeled discharge and flooding despite their proximity to main channels and floodplains, results were sensitive to channel narrowing and increased surface runoff facilitated by mountaintop removal sites. Narrowed channels decreased capacity, slowed discharge, and notably increased flood heights. Mountaintop removal sites increased total discharge and flood volumes in some but not all portions of the watershed. These nuances are attributable to spatial variations in land use across the watershed. By identifying the human-controlled factors most likely to contribute to future flooding, mitigation efforts in Appalachian catchments may be more informed.

## Spatiotemporal Shifts in Extreme Streamflow Events Across the Kentucky River Watershed\*

C. Andrew Day<sup>1</sup>, Marlea Ferber<sup>1</sup>, Cameron Tinnell<sup>1</sup>

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Climate variability and change can disrupt hydrological cycles at a variety of spatial scales, including the timing and magnitude of extreme high and low streamflow events. Increases in the intensity and frequency of extreme precipitation events may result in rapid increases in streamflow and flooding. Droughts can also be exacerbated by prolonged periods of reduced rainfall and extended low flow periods. Existing research has generated conflicting outcomes as to the impacts on specific surface flow responses, resulting in both increased high and low flow events depending on the season. Our research quantified the scale and effect of these potential changes on historical extreme streamflow responses for eight basins within the Kentucky River watershed using a baseline period of 1982-2022. Defining extreme streamflow events as the daily upper and lower ten-percentile discharges, we extracted a range of hydrological measures from USGS gages including: total number of extreme flow events by season, timing of first and last extreme flow events, maximum consecutive extreme flow events and their timing. We also obtained the corresponding basin seasonal precipitation and air temperature measures using 4km gridded datasets from the PRISM Group. Trends in the annual, five- and ten-year rolling means of each flow and climate measure were analyzed using Mann-Kendall/Sen's Slope tests with potential underlying cycles explored using an autocorrelation function (ACF) following trend removal.

Our preliminary findings uncovered commonalities and spatially varied outcomes across the extreme flow and climate measures. Regarding flow measures, many significant trends in the five- and ten-year rolling means occurred, suggesting higher frequency inter-annual variability masking longer term trends. The maximum consecutive days of extreme high flow events increased for several basins, with the timing of these events shifting earlier in the year towards spring and summer. The number of extreme high flow events also increased for many basins across spring and summer, while summer low flow extremes decreased. After detrending, widespread examples of negative five- and ten-year lags became apparent indicating the presence of multiple underlying cycles at those lags. Climate trends and ACF outputs were more consistent across the basins, with marked increasing trends in precipitation and minimum air temperatures across all seasons, particularly spring and summer again. Significant negative five- and ten-year lags further indicate the presence of both short- and long-term underlying cycles in these measures. Additionally, spatial variation in individual basin characteristics may play a further role in their specific extreme flow response, including geology, topography, basin area/shape and landcover. The presence of underlying cycles at various phases in both flow and climate measures also intimates at possible influencing regional climate indices that warrant further investigation.

*\*This presentation is based upon work supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G21AP10631-03, WRRRA 104B Annual Grant Program*

**Session 1B: PFAS- Occurrence, Toxicity, and Treatment**

## **Deep Eutectic Solvents as an Eco-Friendly Alternatives in the Fabrication of Polymeric Membranes for Water Treatment Applications**

**Odianoson Ewah<sup>1</sup>, Jake Childress<sup>1</sup>, Isabel Escobar<sup>1</sup>**

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Membrane technology plays a crucial role in water treatment applications, offering versatile solutions for water purification and separation processes. However, traditional membrane fabrication methods rely heavily on petroleum-derived solvents that pose significant environmental and health concerns. This research investigates the development of sustainable alternatives by exploring deep eutectic solvents (DES) as green solvents for membrane fabrication. Deep eutectic solvents are formed by combining hydrogen bond donors and acceptors, creating biodegradable and low-toxicity alternatives to conventional organic solvents. DES are considered eco-friendly due to their renewable feedstock origins, reduced environmental persistence, and minimal health hazards compared to traditional petroleum-based solvents. This study evaluates a lignin-derived DES composed of thymol and 2,6-dimethoxyphenol for non-solvent induced phase separation (NIPS) fabrication of cellulose acetate and polysulfone membranes. The NIPS technique involves casting polymer solutions and immersing them in non-solvent baths to induce phase separation and membrane formation. Performance of membranes fabricated with DES was compared against those made with traditional solvents. Comprehensive characterization was conducted using scanning electron microscopy for morphological analysis, Fourier Transform Infrared spectroscopy for chemical composition, contact angle measurements for hydrophobicity assessment, mechanical testing for durability evaluation, and filtration performance analysis using a 100ppm aqueous bovine serum albumin (BSA) solution. This research addresses the need for environmentally friendly membrane fabrication processes. The use of renewable lignin-derived solvents aims to reduce negative environmental impacts associated with traditional solvents while maintaining membrane performance for water purification applications.

## Membrane-Supported Catalytic Strategies for PFAS Detoxification

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The persistent accumulation of perfluorinated alkyl substances (PFAS) in the food web, coupled with their exceptional chemical stability, has positioned them as contaminants of global concern. PFAS are widely found in products such as coated paper, textiles, synthetic resins, paints, and firefighting foams. Among them, perfluorooctanoic acid (PFOA) is the most prevalent, contaminating groundwater across the globe and contributing to kidney, liver, and neurological disorders in both humans and animals. The carbon–fluorine bonds in PFAS, with a high bond dissociation energy of 440.99 kJ/mol, make them highly resistant to chemical, thermal, and biological breakdown. Destructive treatment methods like sonochemistry and thermal degradation require significant energy input, whereas non-destructive approaches consume less energy but often leave residual contaminants, necessitating further cleanup using techniques like adsorption, ion exchange, or nanofiltration. Transition metals such as palladium (Pd), ruthenium (Ru), rhodium (Rh), and platinum (Pt) have shown promise as dehalogenation catalysts due to their high reactivity and resistance to oxidation. Commercial microfiltration and ultrafiltration membranes have been adapted for the removal and degradation of priority pollutants by incorporating pH- and temperature-responsive polymers embedded with catalytic bimetallic nanoparticles. These functionalized membranes, when supplied with hydrogen as an electron donor, facilitate the hydrogenation of PFOA in aqueous systems. Batch experiments were carried out using PFOA in the presence of commercial Pd supported on alumina, in-situ synthesized Fe/Pd nanoparticles on membrane matrices, and lab-prepared Fe/Pd nanoparticles, with hydrogen supplied during the process. Model compounds were also included for comparative analysis. Liquid chromatography–tandem mass spectrometry (LC-MS/MS) was used to quantify PFOA before and after treatment and to detect any hydrogenated byproducts. Scanning electron microscopy (SEM) confirmed the successful surface modification of the membranes, while transmission electron microscopy (TEM) revealed the deposition of palladium on zero-valent iron nanoparticles. This project is supported by NIH funding through NIEHS sponsored UKSRC under award number P42ES00730 and Southern company.

## **Toxicity Assessment of Hexagonal-Boron Nitride and PFAS Through Behavioral and Lipid Accumulation Assays Towards *Caenorhabditis Elegans***

Lucca Madeo Cortarelli<sup>1</sup>, Anika Azme<sup>2</sup>, Jerilynn Hutton<sup>1</sup>, Jason Unrine<sup>1,3</sup>, Nirupam Aich<sup>2</sup>, Isabel C. Escobar<sup>4</sup>,  
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<sup>1</sup>Department of Plant and Soil Sciences, University of Kentucky

<sup>2</sup>Department of Civil and Environmental Engineering, University of Nebraska-Lincoln

<sup>3</sup>Kentucky Water Research Institute, University of Kentucky

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Hexagonal-boron Nitride (h-BN) is a 2D nanomaterial (NM) that has unique physical and chemical properties with potential for usage in the degradation of per- and polyfluoroalkyl substances (PFAS). PFAS are contaminants of emerging concern due to their widespread presence and persistence in soil and water and their environmental and human health toxicity. A Safe(r) and Sustainable by Design (SSbD) approach remains essential in assessing h-BN for PFAS degradation in order to ensure minimal environmental impact. *Caenorhabditis elegans*, a model organism, was utilized to screen for toxicity of PFOA across growth, behavioral, lipid accumulation and Reactive Oxygen Species (ROS) endpoints. Assessment of lipid accumulation in *C. elegans* following PFOA exposures was essential in order to understand and discern PFAS effects separate from h-BN. Lipid disruption was observed starting at 0.15 mg/L PFOA and changes in growth and locomotion occurred at 0.8mg/L. The impact of bulk and exfoliated h-BN on *C. elegans* was assessed on nematode's mortality, reproduction, growth, and behavior.

Mortality data suggest that the exfoliated form is more toxic than bulk. Reproductive toxicity testing indicates that exfoliated h-BN causes effects between 1 and 4 mg/L. Meanwhile, it affects growth at concentrations greater than 10 mg/L and behavioral effects at 2 mg/L up to 4 mg/L.

These findings help SbD development of nanotechnology applications such as h-BN utilization at safe concentrations for environmental remediation with PFAS degradation into the compounds with lower toxicity.

**Session 1C: Nutrients and Watershed Management I**

## **Six Year Record of Nitrate Isotopic Ratios Suggest Soil Nitrogen and Denitrification Control Seasonality: Evidence from a Karst Aquifer and Meta-Analysis for Tracer-Aided Numerical Modelling**

**Brenden Riddle<sup>1</sup>**, Jimmy Fox<sup>1</sup>, William Ford III<sup>2</sup>, Minjae Kim<sup>1</sup>, Admin Husic<sup>3</sup>, Jason Backus<sup>4</sup>, Erik Pollock<sup>5</sup>

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The isotopic ratios of nitrate ( $\delta^{15}\text{N NO}_3$  and  $\delta^{18}\text{O NO}_3$ ) present significant potential for tracer-aided numerical modeling of nitrate pollution; however, their investigation is limited in karst groundwater systems and knowledge of their applicability to numerical modelling structures is lacking. This study utilizes a comprehensive six-year dataset from the inner Bluegrass Region of central Kentucky to analyze seasonal patterns of nitrate isotopic ratios and their correlation with hydrological and biogeochemical factors. We observe distinct isotopic measurements during wetter winter-spring (January-March) and drier summer-fall (August-October) periods, with  $\delta^{15}\text{N NO}_3$  averaging  $+6.0 \pm 1.6\text{‰}$  and  $\delta^{18}\text{O NO}_3$  averaging  $+1.6 \pm 2.3\text{‰}$  in winter-spring, and  $\delta^{15}\text{N NO}_3$  averaging  $+9.0 \pm 1.1\text{‰}$  and  $\delta^{18}\text{O NO}_3$  averaging  $+3.4 \pm 1.7\text{‰}$  in summer-fall.

Our findings indicate that seasonal trends are influenced by intra-annual variability in soil nitrogen, with elevated nitrate concentrations in winter-spring attributed to increased leaching and reduced biological activity, while denitrification processes significantly lower nitrate levels and enrich isotopic ratios during drier summer-fall periods. Utility of an isotope bi-plot and Rayleigh diagram provide framework for identifying denitrification processes in this system. The isotopic signatures reflect a seasonal distribution between nitrogen source mixing and transformation processes, emphasizing the necessity for long-term data collection to enhance our understanding of nitrate dynamics in agricultural karst systems.

Additionally, a meta-analysis of existing studies reveals that nitrate isotopic ratios in surface and groundwater exhibit distinct positively correlated trends between  $\delta^{15}\text{N}$  and  $\delta^{18}\text{O}$  in denitrification-dominated systems, while source mixing scenarios display more scattered relationships. This research contributes to the calibration of numerical models aimed at improving groundwater management and safeguarding drinking water quality, emphasizing the critical need for further studies on nitrate seasonality and denitrification in karst environments.

Ultimately, our results suggest that stable isotopic ratios of nitrate are underutilized in constraining nitrogen pollution modeling, likely due to the dual impacts of denitrification and end-member mixing. By contextualizing these findings within the frameworks of denitrification (DEN) and end-member mixing analysis (EMMA), we highlight the broader utility of isotopic ratios in understanding nitrate dynamics.

## **Development of a Concept Model of the Causes of Cyanobacterial Algal Blooms on the Ohio River**

**Jordan Spears**<sup>1</sup>, Nabil Al-Aamery<sup>2</sup>, Jimmy Fox<sup>1</sup>, Mindy Yeager-Armstead<sup>3</sup>, Bill Ford<sup>2</sup>, Minjae Kim<sup>2</sup>

<sup>1</sup>Department of Civil Engineering, University of Kentucky

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Large cyanobacterial algal blooms in riverine systems are becoming more frequent, causing detrimental environmental and economic harm. In 2015, one of such blooms occurred on the Ohio River, costing many river-side towns their water supply, cancelling recreational activities, causing humans and pets to become ill, and killing massive amounts of aquatic life. Human exposure to toxic algae can be harmful even through skin contact or eating contaminated seafood, and physical symptoms range from mild skin irritation or stomach symptoms to neurological symptoms and even liver damage. In addition to posing a risk to humans, livestock or pets can be at even higher risk for exposure to the cyanobacteria, and due to the small size of many mammals, can even cause death. These HABs also deplete dissolved oxygen in waterways and can cause hypoxic zones downstream, killing massive amounts of fish and, by extension, negatively impacting economies that depend on fish for survival. The long-term risks to human and animal health and welfare are not well documented, but long-term water treatment difficulties have been reported. Ohio River WTPs have spent millions of dollars since the algal bloom in 2015 to remedy this issue. Prior to the 2015 algal bloom, the largest on record lasted 10 days in 2008 and spanned just 30 miles. Since the 2015 algal bloom, one large bloom has been reported by the media: a bloom that lasted 2 months in the summer of 2019.

Far more research currently exists on the detrimental effects of HABs than on the causes. Of the sparse research available on the causes of HABs, much of the work focuses on lakes, estuaries, and marine waters, rather than riverine HABs. However, the studies on the effects of HABs in riverine ecosystems implore researchers to study the root cause. Discovering the cause can inform policy making and guide organizations in effective mitigation and prevention strategies.

Available volumetric flowrate data (USGS) was used to examine the consensus among scientists that low discharge leads to algal blooms. Upon visual examination of discharge trends, in the years with HAB formation, a peak flow event was seen immediately followed by incredibly low flow. This observation led to an updated hypothesis that these peak discharge events in the early summer months wash in sediment, nutrients, and even possibly algae. When these episodic events are followed by low flow, residence time within the pools is increased, sediment can settle, and light attenuation increases, leading to a “perfect storm” that allow algal bloom proliferation.

The visualized trends in the sensor discharge data were used to create a HAB prediction model with threshold cutoffs for a high flow event of at least 7500 cubic meters per second in the early summer and the extended low flow event in the late summer where flow does not exceed a discharge cutoff of 1500 cubic meters per second for more than 20 days in two months. This HAB prediction model was taken a step further to see how HABs might change in the future

## SESSION 1C: Nutrients and Watershed Management I

using 15 Global Climate Models (GCMs) from Versions 3 and 5 of the Coupled Model Intercomparison Projects (CMIP3 and CMIP5). Discharge was modeled for Markland using observed climate data to ensure the discharge models performance in the HAB prediction model, and then outputs from the GCM climate data were used to model discharge at Markland for hindcast and forecast scenarios. The modeled discharge for the hindcast and forecast scenarios were then ran through the HAB prediction model to output the number of HABs for each GCM hindcast and forecast scenario.

A HAB prediction model for the Ohio River will allow future scientists to build upon this study. HAB prediction in one riverine system can open the possibility of predicting HABs in riverine systems worldwide. With an ability to predict algal blooms before they occur based on data that is already being collected and analyzed, this quantitative model can be used by appropriate agencies to mitigate risk within the Ohio River and implement preventative measures.

## Water Quality Monitoring at McConnell Springs, Lexington, Kentucky (2010-2025)

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McConnell Springs is a historically significant site where in 1775 the city of Lexington was named and first settled in 1779 by William McConnell. Located near downtown Lexington, Kentucky, the property was used by various industries over the past two centuries but now it is a natural area park maintained by the Lexington-Fayette Urban County Government (LFUCG) Division of Parks and Recreation. McConnell Springs Nature Park, a 26-acre urban forest with nearly two miles of trails, was opened to the public in 1994. The artesian spring system at the park consists of the Blue Hole, where water emerges from an underground channel and flows for approximately 38 m (125 ft.) then disappears underground; the “Cave”, an open fracture that receives and retains surface runoff; the Boils, where water emerges again as an artesian spring and flows for approximately 152 m (500 ft.); and the Final Sink, the point where water once more disappears underground. The water resurfaces at Preston's Cave and flows into Wolf Run Creek, which empties into the Town Branch of Elkhorn Creek. Since 2010, both McConnell Springs and the Stormwater Quality Wetland Pond system have been monitored by the LFUCG Division of Water Quality to determine the effectiveness of pollutant reduction.

During the period of 2010 through 2025, a total of 88 sampling events were conducted at McConnell Springs by the LFUCG Division of Water Quality. The four sites monitored included the Blue Hole, Cave, Boils, and Final Sink. On-site measurements included: temperature, pH, ORP, dissolved oxygen (DO), conductivity, and total dissolved solids (TDS). Laboratory analysis included: alkalinity, hardness, carbonaceous biological oxygen demand (CBOD<sub>5</sub>), total suspended solids (TSS), total ammonia, nitrate, nitrite, total phosphorus, orthophosphates, and bacterial enumeration (fecal coliforms, *E. coli*, and total coliforms). Metals in water samples were analyzed in 2013, 2014, 2017, and 2021. Metal analyses included: Ag, Al, As, Cd, Cr, Cu, Fe, Pb, Mg, Mn, Ni, P, K, S, and Zn.

Overall pH values at all sites in McConnell Springs were consistent from 2011 to 2025. DO concentrations remained low, with the highest oxygen levels observed in the winter and the lowest during summer. DO increased from the Blue Hole to the Final Sink. Average DO concentrations were 3.4, 3.5, 4.3, and 5.7 mg/L for Blue Hole, Cave, Boils, and Sink, respectively. Conductivity slightly decreased with time, although occasional spikes were observed. TDS and total alkalinity remained constant during the monitoring period. Total hardness was initially elevated but became steady after 2016. As expected, TSS levels were lowest in the Blue Hole and highest in the Cave and Final Sink. Overall ammonia levels were low in 2011-2021, but a spike was observed in the February 2022 collection. Ammonia levels decreased from the Blue Hole to the Final Sink. Average nitrate concentrations were highest in 2011 (6.45 mg/L), although still elevated, nitrate levels decreased in 2012-2025. Average nitrite concentrations were consistent in 2011 through 2018, however, in 2019 and 2022 nitrite levels spiked followed by a return to decreased levels. Both total phosphorous and orthophosphate concentrations showed slight decreases over time, but levels were similar at the four sampling locations. Of the 15 metals tested, Silver and Cadmium were not detected at any of the sites. In

## SESSION 1C: Nutrients and Watershed Management I

2017, low levels of Cr, Cu, and Pb were detected. Nickel was detected in 2013 and 2014 with concentrations ranging from 2.0-3.0 µg/L. Zinc was detected in 2021, with the Cave having the highest concentration (30 µg/L). Fecal coliforms and *E. coli* were detected in McConnell Springs during the monitoring period. Fecal coliform geometric means generally decreased over time. *E. coli* geometric means decreased over time, except at the Cave which spiked in 2024. Bacterial enumerations tended to be elevated in June through November.

Most of the water quality results observed were consistent with levels found in artesian springs. After more than a decade of water quality monitoring, an established baseline for McConnell Springs has been attained and significant deviations can be quickly recognized. Although fecal contamination has been a historic problem at McConnell Springs, it is encouraging to observe decreases in fecal coliforms and *E. coli* counts over time. Results by LFUCG Division of Water Quality have shown that the addition of the Stormwater Quality Wetland Pond system has reduced non-point source pollution that entered McConnell Springs Park. This abatement also lessens the detrimental impacts to McConnell Springs and the receiving waters of Wolf Run Creek and Elkhorn Creek. LFUCG will continue to monitor water quality regularly. With special attention to ammonia, nitrates, nitrites, and bacterial counts.

## **Reimagining Watershed Planning: An Interactive Approach for the Glens Creek Watershed**

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Traditional EPA 319 watershed plans often remain static, technical, and inaccessible to broader audiences. To address this limitation, the Kentucky Water Research Institute pioneered a novel digital framework that transforms static documents into interactive and engaging components. KWRI was awarded an EPA 319 watershed planning grant for the Glens Creek Watershed in Woodford and Franklin Counties, Kentucky to capitalize on ongoing monitoring efforts over two decades and strong community interest from stakeholders including community volunteers, bourbon distilleries, City of Versailles, Woodford County, and agricultural partners.

In this presentation, we will outline some new strategies, methods, challenges, and successes encountered in developing the watershed plan and its interactive framework. This includes interactive GIS watershed characterization, use of stakeholder interviews and surveys, new pollution grading schemes to communicate science data, and a Kentucky triple-bottom line conservation practice evaluation tool. These tools should assist future planning projects for watershed managers and coordinators in urban and rural settings.

We will then showcase "StreamWalk," one of the plan's components. StreamWalk utilizes the ArcGIS JavaScript SDK and 360° imagery to enable users to explore an immersive virtual version of the Glens Creek Watershed. Through synchronized maps, panoramic views, and interactive pop-ups, users can investigate water quality data, observe erosion sites, and learn about watershed science. By making watershed science more accessible and engaging, this approach aims to foster greater awareness, encourage proactive stewardship, and inspire continued community participation in watershed conservation.

**Session 2A: Flooding**

## **Stormwater Management Using an Integrated Flood Modeling Approach for FEMA Floodplain Mapping in Urban Karst Wetlands\***

**Jason Polk<sup>1</sup>**, Nick Lawhon<sup>2</sup>, Adam Desloge<sup>1</sup>

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Threats from stormwater flooding in Kentucky are ongoing and, in the past five years alone, billions of dollars of damage, along with dozens of lives, have been lost due to unpredictable and poorly mapped floodplains and a lack of flood extent and monitoring data. These hazards are exacerbated in karst regions, where landforms like caves, sinkholes, and underground rivers serve as threat multipliers for hazardous environmental conditions, which are then compounded by continued population growth and development in urban areas. In Kentucky, nearly 50% of the state is karst and relies upon, and is impacted by, groundwater resources. Recent flooding across the state in 2021, 2022, and again in 2025 caused headlines due to the repeated, widespread, and intensive occurrence of these flood events in the state. Recent studies suggest more than 50% of infrastructure is not protected in karst areas based on FEMA 100-year floodplain maps.

Stormwater infrastructure in karst areas is often integrated with the groundwater system, such as in Bowling Green, KY, through the use of sinkholes and injection wells, which can exacerbate flooding and complicate modeling efforts. This study builds upon a successful pilot study to develop a predictive flood mapping and modeling method using ArcGIS GeoAI toolbox for urban karst groundwater systems using a high-resolution precipitation and water level data monitoring network, while integrating that model and the requisite parameters with FEMA-approved modeling software. The outcomes of this work allow for better understanding and predictability of the karst hydrologic response to a 100-year flood events, and those of varying, smaller magnitudes, while serving as an integrated framework for future modeling and community partnerships to address these floodplain mapping and stormwater management issues in other karst areas.

*\*This presentation is based upon work supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G21AP10631-03, WRRR 104B Annual Grant Program*

## **Karst Groundwater Flow Profile for Jennings Creek, Kentucky for Flood Management\***

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Jennings Creek is located in Bowling Green, Kentucky and is a spring-fed tributary to the Barren River. Flooding along Jennings Creek is a concern in part due to development and urbanization throughout the city, as well as the various groundwater inputs that can activate during large storm events. The karst landscape underlying the city contributes flow through groundwater and springs to the Creek, which can enhance flooding. The creation of a gaining stream discharge profile using the U.S. Geological Survey standard methods allows for the identification and quantification of the many surface and subterranean tributaries of Jennings Creek. A Global Flowprobe and Sontek Acoustic Doppler Current Profiler (ADCP) were used in conjunction with Onset water level loggers to measure discharge and water level, respectively, at multiple sites along the main reach of Jennings Creek and its tributaries and spring inputs. Data collected represent recharge inputs via the contribution of major springs that could influence flooding and water quality and the prediction of flood occurrences and magnitudes. Results indicate complex flowpaths under varying hydrologic conditions within the groundwater-surface water system, wherein groundwater contributions may influence flood magnitude and attenuation. Additionally, this research will inform the EPA 319 Watershed Plan being developed for the Jennings Creek watershed.

*\*This presentation is based upon work supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G21AP10631-03, WRRR 104B Annual Grant Program*

## **Urban Karst Flood Hazard Mitigation at Fairview Plaza, Bowling Green, Kentucky, USA\***

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The City of Bowling Green, KY is established on karst topography, a landscape notable for caves and sinkholes providing direct drainage into underground aquifers. Fairview Plaza, a highly urbanized area, is prone to flooding because stormwater is directed from the surrounding commercial and area into a drainage complex of injection wells and sinkholes. The purpose of this study is to model flooding in Fairview Plaza using water level and rainfall data. Data were collected at a one-minute resolution before and during the February-April 2025 floods to establish a flooding threshold for prediction of future flooding during storms to help prevent damage and risk to people. Results of this study provide a better understanding of urban karst flood dynamics, which can be utilized for future stormwater management practices and to implement real-time monitoring for improved safety measures using triggered warning lights and signage during storm events, along with public data display and alerts. The methods used may improve safety and prevent damage to other similar locations in urbanized karst areas using technology combined with hydrologic modeling to mitigate future hazards and promote awareness.

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**Session 2B: Utility Planning**

## **Drinking Water Shutoffs in Kentucky**

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Drinking water affordability is a problem for low-income families across Kentucky. Unaffordable water rates result in water insecurity, with many families regularly struggling to pay their bills and avoid disconnection from service. Maintaining access to water is critical from a human rights perspective as well as a public health perspective. During the COVID-19 pandemic, the Governor of Kentucky as well as other governors across the country placed moratoriums on water disconnections to help address this public health emergency. Congress, for the first time in history, created a customer assistance program to help households pay water bills and prevent service disconnections. However, with the end of the pandemic, these protections evaporated while water bills continued to increase. Using reports on disconnection and arrearages that water systems submit to the Kentucky Public Service Commission (PSC), we analyze disconnection rates across water utilities between 2018 and 2024, pre and post pandemic. We examine disconnection trends across and within water systems. These insights help illuminate 1) water systems where drinking water affordability is an issue 2) changes in disconnection rates over time and 3) policy recommendations related to disconnection protections and customer assistance programs.

## **Doing Community-Engaged, Collaborative, Action-Oriented Research on Small Rural Water Systems in Central Appalachia: LiKEN's Approach, Values and Methodological Framework**

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This paper delves into the methodologies and methods of a community-based and action-oriented research project – the Water Climate Equity project (WCE), an ongoing collaboration between Livelihoods Knowledge Exchange Network (LiKEN), Pacific Institute (PI) and Rural Community Assistance Partnership (RCAP). This project aims to create a shared framework for better understanding the complexities of how extreme weather events further exacerbate already existing water inequalities, and how these inequalities hinder or even make impossible, resilience-building efforts and disaster preparedness plans. In particular, it aims to highlight potential leverage points that can disrupt synergies among causal factors and vicious cycles, which lock small water systems into distinctive configurations in the flow of resources and power, and set up trajectories in the development of built water and wastewater infrastructure that often have considerable inertia and might require structural change to reorient toward resilience. At the same time, this project is seeking to identify leverage points that can ignite virtuous cycles that nurture community capacity to take collective and equitable action.

In the context of the WCE project, LiKEN has focused on the small rural water and wastewater systems in two counties of Eastern Kentucky, in Appalachian communities, which are facing problems of too much or too little water, have long legacies of resource-extraction and, in the long-term, have faced social and environmental injustices. This paper sheds light on the reasons why LiKEN is choosing to talk about ‘deep listening’ instead of ‘interviews’, our focus on place-based knowledges, and on our collaborative approach to knowledge production. It also highlights the values that we share with community and project partners, and which underpin all LiKEN’s projects and programs. Furthermore, this paper discusses LiKEN’s processes of nurturing *brave spaces* of *mutual learning* and *collaborative action* among the communities we work with and the cross-sectoral forums of knowledge exchange we participate in. In doing so, it points to the necessary skills for participating in such spaces; the skills of *trust-building*, *critical inquiry* and *democratic deliberation*. By drawing examples from knowledge-products, or toolkits we have co-created in the context of the WCE project – two Water Resilience Toolkits for Harlan and Martin Counties, and the Community Engagement Guide– this paper highlights how LiKEN is building bridges of knowledge exchange across diverse sectors and knowledge systems to co-create accessible toolkits for sharing with community partners as well as with partners across the civic, governmental, and expert sectors. In delving into our processes for knowledge exchange across sectors, this paper also demonstrates the participant action research (PAR) methods that LiKEN has devised for creating these knowledge products, thus shedding light on the processes through which LiKEN is planting the seeds for *evidence-based praxis* -a type of action that incorporates reflection into action and can propel meaningful change towards more resilient and just futures.

## **WaterWorks: A Serious Gaming Platform for Effective Water Distribution System Training**

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Water distribution system (WDS) analysis has made significant progress in the past several decades, with the development of sophisticated computer programs that contain an abundance of features to aid in simulation. The myriad features, including basic functionality such as running hydraulic and water quality simulations, are still only accessible to technical experts, and have not been translated to a format that can be easily digested by system operators, community stakeholders, or water consumers. System operators and water consumers are the true recipients of policy changes often motivated by the expert analysis frequently done without their engagement. Tools that engage system operators and water consumers are needed to implement more informed WDS operational policies. This research develops WaterWorks, a serious gaming environment for training and educating system operators and water consumers. WaterWorks embeds a fully functional, skeletonized water distribution model with hydraulic and water quality simulation computed client-side. The interface includes an interactive 3D map of the system, node information, and player hints to ensure broad accessibility. Players progress through increasingly complex levels, in which they are given one or two system operational parameters to change including chlorine dosing, tank levels, operator pay, water rates, and water loss. Players see trade-offs first hand, making connections between operational parameters and output pressure, flows, and water quality. For example, increasing the chlorine dosing rate will decrease the likelihood of a chlorine residual violation but will increase the likelihood of a disinfection by-product violation and increase operational costs. WaterWorks removes the barrier of setting up the simulation environment and presents the physical trade-offs clearly with calculated revenue and cost values and nodal graphs that indicate violation thresholds. To encourage innovation, players are placed on an anonymous leaderboard that tracks achievements in comparison to others playing WaterWorks. Players have access to the leaderboard, which incentivizes operational improvements. Beta testing of WaterWorks shows engagement with the platform and will continue to guide development. WaterWorks is an important step in consumer and water operator education that will foster better community-based policy decision-making.

**Session 2C: Restoration**

## **Evaluating Urban Stream Restoration Success: Assessing the Impact of Urban Reforestation Efforts on Water Quality and Aquatic Systems in the Inner Bluegrass\***

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Urban development reduces stream health both by altering fundamental watershed hydrological processes and by impairing stream-water quality. Streams draining urbanized watersheds tend to experience flashy hydrology caused by impervious surfaces that rapidly shed surface runoff during storm events. Furthermore, stream-water quality in urban areas is frequently impaired by contaminants including fertilizers, pesticides, and industrial effluents, as well as fecal material from human and pet waste. In agricultural watersheds, riparian buffers have demonstrated significant capacity for improving water quality; however, the potential for riparian buffers in urban watersheds to similarly improve water quality is not well understood. The Lexington-Fayette Urban County Government (LFUCG) has planted over 20 forest patches across the city since 1999, prioritizing riparian and floodplain sites with the goal of improving stormwater quality. Additionally, stream channel restoration has been completed on a subset of these sites. This project was initiated to evaluate whether riparian reforestation and stream reconstruction efforts in seven urban streams in Lexington, KY have influenced stream health. Our study assessed water quality using a standard chemical analyte panel, traditional surveys of aquatic invertebrates and amphibians, and environmental DNA (eDNA) metabarcoding surveys of aquatic invertebrates and vertebrates. Samples were taken in paired upstream non-restored and downstream restored sites, as well as in both relatively undisturbed and heavily degraded reference sites. Chemical water testing indicates that stream restoration efforts have significantly improved water quality in several study streams, yet have had no effect in others. Conventional surveys of macroinvertebrate community composition showed no significant difference between restored and unrestored sites. Invertebrate eDNA metabarcoding detected five insect orders and at least nine families, of which Chironomidae comprised the majority of reads. Vertebrate eDNA metabarcoding detected a total of 71 species: 34 fish, 7 amphibian, 10 mammal, 17 bird, and 3 reptile species. Amphibian eDNA was greater at undisturbed reference sites relative to both restored and unrestored stream sections. Analyses comparing vertebrate and invertebrate eDNA community assessments from restored and unrestored sites are currently underway. These data should provide valuable insight into the effectiveness of restoration projects, as well as guidance for future restoration efforts.

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## Incorporation of a Kentucky Trade Association for Ecological Restoration

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The Kentucky Ecological Restoration Association (KERA) is a trade association comprised of contractors, engineers, surveyors, environmental consultants, mitigation bankers, and financial professionals involved with the ecological restoration and compensatory mitigation industry. Our members, and supporting companies, contribute to the commonwealth's economic growth and help facilitate critical infrastructure projects. With significant, repeated flooding events throughout the state recently (including across large portions of eastern Kentucky in July 2022), there has been an increased interest in Nature-based Solutions (NbS) to address flooding impacts through ecological restoration. KERA represents a majority of the professional consulting firms in the state with expertise to bring these NbS solutions to bear for Kentucky communities. The focus of this presentation is to introduce KERA to the broad community of Kentucky water stakeholders, to present typical mechanisms by which private companies engage in restoration projects in the commonwealth, and to encourage collaboration across the academic, non-profit, public agency, and private sector stakeholders.

KERA was formed around four primary goals:

- (1) Educate the public about the outstanding ecological restoration work being accomplished by third-party mitigation providers in Kentucky;
- (2) Promote, develop, and improve restoration science and best practices to accomplish ecological restoration in Kentucky;
- (3) Improve coordination and promote collaboration with regulatory agency stakeholders; and
- (4) Encourage expansion and long-term durability of third-party mitigation markets in Kentucky.

KERA holds regular membership meetings to accomplish these goals through innovative initiatives. We have held collaborative meetings recently with our regulatory agency stakeholders, including the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, Kentucky Energy and Environment Cabinet, Kentucky Department of Fish and Wildlife Resources, and others. KERA is excited to build on our individual members' collaborative work with water science professionals, through the Kentucky Water Research Institute (KWRI) and other groups, to achieve net positive outcomes for the commonwealth's water resources and ecological resources, local communities, and the economy. This would focus primarily on promoting, developing, and improving restoration science in Kentucky; at the same time, we want to communicate the good work that already occurs in Kentucky and build on that ongoing success with the academic and research communities through awareness. For example, Figure 1 below shows 157 stream and wetland restoration sites in Kentucky listed in the Corps of Engineers' Regulatory In-lieu Fee and Bank Information Tracking System (RIBITS) database currently in various stages of the permit process. KERA

SESSION 2C: RESTORATION

members have been part of the design, permitting, construction, financing, and/or monitoring for dozens of these sites. Additionally, KERA has a website which provides additional information regarding all of the goals above, <https://www.kyrestoration.org/>.

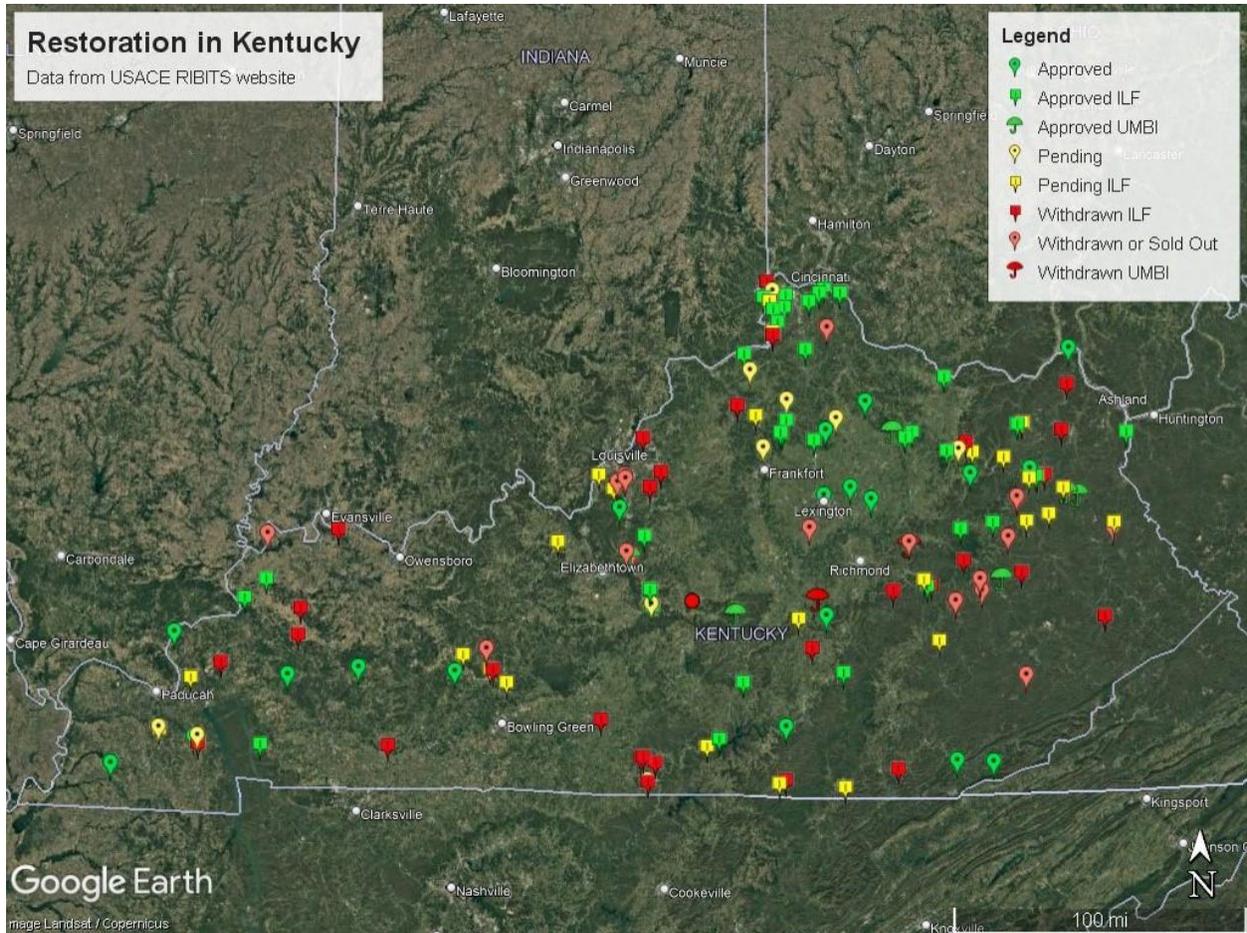


Figure 1. Stream and wetland restoration sites in Kentucky in the U.S. Army Corps of Engineers’ RIBITS database. 157 sites are listed in this database as of June 2025.

## **Insights from Kentucky Stream Restoration Professional Interviews**

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Nature-based solutions (NBS) is an encompassing toolbox that supports multiple ecosystem services across the Mississippi River basin and beyond. Stream restoration is a common practice in this toolbox and is implemented through various regulatory, incentive-based, and voluntary measures. Stream restoration primarily addresses water quality through erosion reduction and improved nutrient cycling; water quantity through increased storage and connection to the flood plain; and species abundance and richness through instream and riparian features that provide habitat, increase dissolved oxygen, and reduced water temperature. Traditional methods of stream restoration focused on channel stabilization and involved the use of rigid, hard-scape methods. But as concern for environmental impacts and water quality have increased, advocacy for the use of NBS in water resources have become more prevalent. This has inspired new methods and practices for water resource management that aim to restore degraded streams and waterways using natural processes that resemble conditions found in areas unimpacted by urban development, commonly referred to as reference reaches. In the state of Kentucky, there are currently no set guidelines for how to perform restorations and published information on state-specific procedures is scarce. To address this, an interview series was conducted with industry professionals from academic, administrative, consulting, and construction positions to assess what restoration procedures are currently being used in Kentucky and to document their personal insights on the state of the industry and increase restoration success rates. This presentation focuses on the quantified results that could be used to develop Kentucky-specific guidance materials by emphasizing commonalities among professionals' methods, identifying flaws in the current industry structure, and what improvements could be made to correct them.

**Session 3A: Climate**

## Measuring Extreme Weather and Its Effects on Agricultural Productivity in the United States

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This paper looks at how measurement errors introduced by spatial interpolation of weather data can bias estimates of extreme weather impacts on agricultural productivity in the United States. Our focus is on extreme weather events, such as heatwaves, frosts, droughts, and heavy precipitation, that can significantly influence crop yields. Although using spatially interpolated weather data is a common practice in applied economics research, less attention has been paid to how the order of operations (interpolating raw data first versus calculating weather metrics first and then interpolating) might systematically affect the magnitude and significance of extreme weather measures when we look at their impact on agricultural productivity.

To investigate this, we use daily weather data from weather stations across the U.S. Corn Belt for the period 1950–2023, and use several non-linear weather measures that are key to crop growth. We then employ two approaches: 1) In the “pre-interpolation” approach, the weather measures are calculated directly at each station prior to any spatial interpolation and only then interpolated to a uniform grid, 2) In the “post-interpolation” approach, we first interpolate the raw weather data and then derive the weather metrics of interest. Next, we link both sets of weather measures to county-level corn yields from USDA-NASS using fixed-effects regression models.

The results suggest that, while pre-interpolated measures yield similar coefficients for GDD and KDD (our measures for beneficial and harmful heat), they produce notably different coefficients extreme wet conditions, suggesting that extreme precipitation may be overlooked by averaging first. We further explore how these differences translate into yield predictions. By holding the regression coefficients constant and switching the weather inputs from pre- to post-interpolated, we look at how yield predictions deviate due to the order of operations in constructing the weather measures, and find a consistent tendency for post-interpolated data to predict higher yields, perhaps due to the fact that it underrepresents extreme heat. A Shapley decomposition of these yield-prediction differences reveals Killing Degree Days as the primary driver, accounting for about 93% of the total average difference in predicted yields.

From a methodological standpoint, our findings caution against relying on post-interpolated weather data. Studies focused on extreme events may misestimate the true impact of extreme weather if those extremes are attenuated in the input data. Moreover, since many agricultural and economic decisions rely on accurate assessments of climatic risk, failing to capture localized extreme weather events can bias results in ways that are relevant for policymakers, insurers, and producers managing climate risk.

This paper offers evidence on how the calculation sequence of non-linear weather transformations interacts with spatial interpolation and yield estimates. The differences are nontrivial: pre-interpolation more accurately captures the tails of the distribution, especially for threshold-based weather measures like KDD, and these differences ultimately affect both regression parameters and predicted yield outcomes. Future research may benefit from exploring

whether advanced interpolation techniques can further mitigate measurement error in weather extremes and improve the precision of agricultural impact analyses.

## Mapping the Landscape: A National Inventory of University-Based Climate Entities

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Resilience, adaptation, and mitigation in the face of climate change are prominent areas of focus for research and action across both public and private sectors. Addressing such a multifaceted challenge involves numerous stakeholders and interconnected components, including government agencies, non-profits, private companies, and academic institutions. Universities, with their established infrastructure, skilled personnel, and commitment to community impact at various levels- local, national, and global – are uniquely positioned to play a leading role in these efforts. Over recent decades, universities have responded to climate-related challenges by creating various types of climate entities: centers, laboratories, consortia, hubs, institutes, networks, and collaborative groups. These entities often work with external agencies to secure funding or foster partnerships that promote awareness and understanding of climate change impacts. However, the complexity of this active and crowded space often leads to lack of awareness or understanding regarding the diverse missions, roles, organizational structures, and connections among these entities. To address this, a comprehensive inventory of university-based climate organizations in the United States is being developed. This resource enables a detailed comparative analysis of their missions, organizational frameworks, and funding approaches. This will enhance public awareness of existing resources and clarify the trajectories of research and implementation efforts. Additionally, this will provide valuable insights for universities looking to establish their own climate-focused entities, offering guidance on efficient start-up strategies, effective collaborations, and sustainable funding mechanisms. Ultimately, this initiative aspires to elevate the impact of research and outreach in climate mitigation and adaptation, fostering a society better equipped to confront the challenges of climate change.

**Emergent Vegetation (*Typha* spp.) Synergistically Enhances Methane Emissions in Small, Peri-Urban Wetlands Dominated by Floating Vegetation (*Lemna*, *Wolffia* spp.)\***

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Wetlands are often important carbon sinks, but methane emissions may offset their potential climate benefits. The climatic role of small peri-urban ponds depends largely on plant community structure: duckweed (*Lemna* and *Wolffia* spp.)-covered ponds have been shown to emit more methane than open water ponds, and emergent vegetation such as cattails (*Typha* spp.) are known to conduct gases through aerenchyma tissue. To assess the capacity of cattails to facilitate methane transport and augment emissions in duckweed-covered ponds, we applied a generalized linear mixed effects modeling approach to flux data collected from ponds representing four plant assemblages: open water, duckweed only, cattail only, and duckweed + cattail. Fluxes were measured under both light and dark conditions to simulate photosynthetic and respiratory periods, allowing for a more comprehensive understanding of how plant assemblage influences greenhouse gas (GHG) emissions, with a focus on CH<sub>4</sub> and CO<sub>2</sub>. Water quality data were collected to identify biogeochemical factors that may predict community assemblage or drive emissions. Preliminary data suggest a trend toward elevated GHG fluxes in duckweed–cattail assemblages compared to duckweed-only ponds or cattail-only ponds. These findings would help characterize how plant community composition and nutrient loading influence GHG emissions and could inform land management strategies that implement nature-based solutions to mitigate climate change.

## Effects of Duckweed (*Lemna* and *Wolffia* spp.) on Decomposition Rates in Small, Peri-Urban Wetlands\*

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Duckweeds (family Lemnoideae) are the smallest and fastest growing vascular plants on Earth. These tiny, free-floating plants can rapidly blanket a body of water and cause hypoxia below the water's surface. Hypoxia is generally believed to slow organic matter breakdown, but, in a preliminary study, we measured significantly faster organic matter decomposition in a hypoxic duckweed-covered pond. To augment our understanding of this phenomenon, we have tested that (1) while bulk organic matter decomposes more rapidly, (2) lignin decomposes more slowly in hypoxic duckweed-covered ponds. Plastic mesh bags filled with wood or leaf litter were submerged in six small ponds (three with duckweed cover) near Louisville, Kentucky. Four bags of wood and two bags of leaf litter (*Acer saccharum*) were periodically removed from each pond over a 5-month incubation period while dissolved oxygen and temperature were monitored in each site. Bulk decomposition rates were measured as the change in percent dry mass remaining over time. Dried litter was analyzed for cellulose, hemicellulose, lignin, and non-fibrous material, and mass loss of all four structural components was compared between pond types. We employed a generalized linear mixed effects modeling approach to identify factors driving enhanced decomposition in duckweed-covered ponds. This study improves our understanding of how duckweed ponds alter decomposition rates and storage of organic matter, and the role of floating wetland plants in altering global carbon cycling.

**Session 3B: Water Quality**

## **Tiny Troubles in Karst: Landuse and Transport of Microplastics in South-Central Kentucky**

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Groundwater in karst areas is susceptible to contamination from various sources of pollution. Microplastics are a relatively new source of pollution entering groundwater. This study examines karst groundwater in three areas of interest. One point of interest is an area that is impacted by urban activities, the Lost River Groundwater Basin, which includes water drainage from the City of Bowling Green, Kentucky. Another point of interest is Great Onyx Spring, which is a part of the Great Onyx Groundwater basin located in Mammoth Cave National Park, Kentucky, relatively unimpacted by urban activities. The third point of interest Biz Falls, located within Great Onyx Cave upstream from the spring, representing a relatively pristine area. This research sought to understand the distribution and characterization of microplastics in karst groundwater. This study utilized water grab sampling to collect two liters from each site each month from September 2023 through February 2024. This study quantified and described microplastic contamination at each site. In total, Lost River Rise had a total of 278 microplastic fragments detected, while GO Spring and Biz Falls had a total of 286 and 260 microplastics, respectively. These results indicate that the sampled karst areas, including within a relatively pristine part of Mammoth Cave National Park, are vulnerable to microplastic pollution. This demonstrates the apparent ease with which microplastics can be transported through the environment.

## **Community-Engaged Research Approach for Disinfection By-Product (DBP) Risk Mitigation in Rural Appalachian Kentucky Households**

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Chlorine-based disinfection is crucial for controlling waterborne diseases and providing safe drinking water. However, its reaction with natural organic matter can create disinfection by-products (DBPs), including trihalomethanes (THMs) and haloacetonitriles (HANs), which have been linked to cancer and other health problems. This study focuses on assessing exposure to THMs and HANs in rural Appalachian communities, where aging water systems and socioeconomic pose unique challenges. The Agency for Toxic Substances and Disease Registry (ATSDR) Shower and Household 5-Compartment Model was used to estimate exposure through ingestion, inhalation, and skin absorption. Important factors like shower duration, bathroom ventilation, and age were considered to account for household variability. Inhalation during showering was identified as a major contributor to overall exposure. This model aims to support future decisions by helping residents understand their personal risks and find practical ways to reduce exposure. Findings will be presented that provide a basis for creating community-led efforts to lower DBP-related health risks while preserving the essential benefits of chlorinated water disinfection.

## **The Impact of Extreme Weather Events on Drinking Water Quality in Kentucky**

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While the specific regional impacts of climate change vary, atmospheric warming and shifts in weather patterns are expected to pose significant challenges for water resources, for example through changing hydrological components and aggravating diffused pollution. Kentucky, with its aging water infrastructure and increasing precipitation extremes, provides an important case study for understanding how extreme weather events impact drinking water quality. Specifically, we examine whether extreme weather increases the probability and frequency of Safe Drinking Water Act (SDWA) violations and analyze the differential effects on contaminant groups including *E. coli*, total trihalomethanes (TTHM), total haloacetic acids (HAA5), and nitrate. Unlike previous studies that relied on coarser temporal resolutions, we exploit sub-daily changes in weather to capture the short, intense rainfall bursts responsible for flash floods and water infrastructure failures to examine how extreme weather affects both acute and chronic drinking water quality violations and key contaminant concentrations in drinking water. Preliminary results show that extreme precipitation significantly increases the risk of Tier 1 violations (e.g., acute water quality violations such as *E. coli* presence), while effects on Tier 2 violations (chronic) are more muted. Nitrate concentration shows a stronger effect with sustained precipitation duration than with isolated downpour events, indicating the effect of cumulative wet conditions in mobilizing nitrogen pollutants. Disinfection byproducts (TTHM and HAA5) also increase following extreme precipitation, with short-term precipitation extremes contributing to measurable increases in their concentrations. The preliminary findings suggest that extreme weather impairs drinking water quality, with these impacts likely magnified in regions with aging water infrastructure and limited resources for system upgrades, particularly in Eastern Kentucky. This highlights the need for a more resilient water infrastructure and adaptive regulatory strategies. The paper also discusses implications for public health protection, infrastructure investment, and the disproportionate risks faced by communities least equipped to handle climate extremes.

## Disinfection Byproduct Concentrations at Point of Use in Rural Drinking Water Systems Impacted by Elevated Bromide Concentrations

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Rural communities are vulnerable to the formation of disinfection byproducts (DBPs) due to degraded infrastructure, financial constraints, and large distribution networks with low demand. Nitrogenous DBPs have raised increasing concern due to their toxicity and tendency to form when source waters have elevated concentrations of nitrogen and bromide. While regulated DBPs such as trihalomethanes (THMs) have been considered as the indicator for the presence of unregulated DBPs, such as haloacetonitriles (HANs), differences in precursors, disinfectants used, and variability within the distribution network can enhance the formation of other types of DBPs, reducing the reliability of THMs as an indicator for toxicity. This study analyzed the spatial-temporal complexity (e.g., seasonality, climate variables, water age, source water quality) characterized by rural Appalachian drinking water distribution networks and its relationship to HAN and THM concentrations. Monthly tap water ( $n_{\text{homes}}=38$ ;  $n_{\text{total samples}}=639$ ) was sampled over three years across two counties for DBPs. Source waters ( $n=2$ ) were analyzed for bi-monthly concentrations of DBP precursors (e.g., organic carbon, nitrate, chloride, bromide). The 3-year average concentration of total THMs was  $0.074 \pm 0.036$  (62% chloroform; 24% bromodichloromethane; 12% dibromochloromethane; 2% bromoform) with 76 exceedances (17 households) of the EPA maximum contaminant level (0.08 mg/L). Total THM varied seasonally, with greater concentrations from July to November, correlating with increased temperature, source water organic carbon, and source water bromide concentrations. The average total HANs concentration was  $0.005 \pm 0.001$  mg/L (25% dibromoacetonitrile; 20% bromochloroacetonitrile; 36% dichloroacetonitrile; 19% trichloroacetonitrile). Total HANs were also correlated to temperature and source water organic carbon, bromide, and total nitrogen concentrations. Furthermore, the results highlighted an increase in DBP precursors in the source water when additional water was pumped into the reservoir to meet the drinking water system's demands. Continued analysis of the spatial-temporal trends in THMs and HANs throughout the distribution networks will further elucidate the complex relationship between tap water DBPs. Findings will support predictive models to help small drinking water utilities reduce their formation.

**Session 3C: Remote Sensing/Drones**

## **Semiautomated Approach for Mapping Complex Sinkholes in the Pennyroyal Karst Plain using Lidar and Machine Learning**

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Sinkholes are abundant in many parts of Kentucky, specifically in the Pennyroyal Karst Plain, which covers more than 50% of the land surface of the Barren River Area Development District (BRADD). This area features numerous gigantic (>100,000 ft<sup>2</sup>) complex sinkholes that are difficult to delineate in high detail with a GIS-based depression extraction and inspection method. In this project, we apply a machine learning sinkhole segmentation model to the gigantic complex sinkholes to parse out individual sinkholes within the larger complex. This new method resulted in a 52% increase in the number of sinkholes identified in the three counties (Barren, Edmonson, and Hart) we have mapped to date. Upon the completion of the new BRADD sinkhole map using this semiautomated lidar-based technique, we expect a considerable increase in the number of mapped sinkholes from an existing sinkhole dataset obtained from lower resolution topographic maps. The newly derived, more accurate sinkhole map will allow us to improve the assessment of infrastructure and population susceptibility to karst in BRADD via the production of karst vulnerability maps. In turn, these maps will inform local development officers, city planners, emergency management, and other hazard mitigation stakeholders as well as assist in updating karst hazard mitigation plans for the BRADD area.

## **Analysis of Soil Loss in Western Kentucky Agricultural Watersheds using sUAV-Based LiDAR and Multispectral Imaging**

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Accelerated soil erosion remains a serious problem around the world. Indiscernible soil losses in row-crop fields can occur after even a small rainstorm. On fields with steeper slopes, soil losses due to erosion will increase. These losses can add up, with time, to tons of soil. One inch of soil loss represents approximately 167 tons of topsoil per acre and can require hundreds of years to replace. In Kentucky, all surface water drains via the Mississippi River to the gulf where the agricultural runoff contributes to hypoxic conditions. In partnership with the UK Martin-Gatton CAFE, Kentucky Geological Survey, and USDA Natural Resources Conservation Service (USDA NRCS), the Kentucky Soybean Board, the Kentucky Agricultural Development Board, and several cooperating Kentucky farms initiated an edge-of-field water quality monitoring project to measure nutrient and sediment loss from active row-crop fields during precipitation-generated runoff events. This is part of a national effort by the USDA NRCS to evaluate the effectiveness of agricultural best management practices (BMP) like reducing tillage, using cover crops, and implementing grassed waterways. Within Kentucky, we have 22 stations distributed throughout western Kentucky known collectively as Blue Water Farms.

Total solids data from these stations indicate that large erosion events are not necessarily associated with large precipitation events. For example, a 7-inch rainfall event on a growing no-till soybean crop caused very little erosion (0.2 tons acre<sup>-1</sup>). However, a winter 2.2-inch rainfall event resulted in 9 tons acre<sup>-1</sup> soil loss despite the presence of a cover crop. In addition to the runoff data, the research team is utilizing sUAV-based light detection and ranging (LiDAR) to document areas of erosion in six watersheds, three with grassed waterways and three without grassed waterways. LiDAR was flown pre-planting and post-harvest to determine erosion amounts within the monitored watersheds during the growing and fallow seasons. LiDAR data was converted to digital elevation models (DEM) for DEM differencing, which was used to calculate erosion within each watershed.

Watersheds without grassed waterways showed signs of gully erosion with upwards of 9.24 inches eroding in the gully during the growing season. Additionally, multispectral data indicated decreased plant health near areas of gully erosion, which may be linked to crop yield decreases. The surface water quality data from the edge-of-field monitoring stations and the supplemental sUAV data will aid in determining the effectiveness of BMPs that reduce soil loss and improve on-farm nutrient retention in western Kentucky. If effective BMPs are successfully implemented on a larger scale, sediment pollution and downstream eutrophication (e.g. algal blooms or hypoxic zones) may be mitigated. This long-term research project is still ongoing with four additional years of water quality data and sUAV data to be collected.

## The Greatest Threat(s) to Prairie Pothole Wetlands

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Inland temperate wetlands of the Prairie Pothole Region of North America stretch from western Minnesota and Iowa through the eastern Dakotas and northern Montana into Western Manitoba, Saskatchewan, and Alberta. These wetland basins were created by the recession of the glaciers, giving them the “pothole” part of their name, while the “prairie” part comes from grassland matrix surrounding the wetlands, primarily derived from the climatic gradients and precipitation to evapotranspiration ratio. These wetlands have been drained for agriculture (Prince, 2008), while the upland areas have been converted from grassland to cropland (Wright & Wimberly, 2013).

In a meeting with research collaborators around 2009-10, I was offering an overview of my research on the impacts of climate change to prairie wetlands (Johnson et al., 2010) shortly after a colleague had described the impacts of land use and land cover change on the grasslands (Voldseth et al., 2009). Another colleague said to me, “What I’d like to know is whether climate change or land use conversion is a bigger threat to these wetlands. If you could figure that out, you could get it published in *Nature* or *Science*.” For a few years, I pondered that question and what a study would look like that tried to statistically analyze the various threats driving loss and degradation of wetlands.

Around the same time, I was asked to adapt WETLANDSCAPE, a wetland system dynamics model, to investigate the impacts of agricultural tile drainage on prairie wetland ecosystems, and seeing the model experiment results quantifying these impacts (Werner et al., 2016). But I was also continuing these conversations with my research collaborators. Even though we could identify a variety of ways to answer this question, every time we discussed the question, we ended up with the same answer, and it’s an answer that applies to other approaches to this kind of work, including the Millennium Ecosystem Assessment (2005) where drivers of biodiversity loss (habitat change, climate change, invasive species, overexploitation, nutrient pollution) are separated and given separate ratings.

What I offer here is a brief review of these threats in space (geospatial) and time (both intra-annual and inter-annual, or historical). First, I summarize the outcomes from remotely sensed changes in land cover and wetland areal extent (Donnelly et al., 2025), along with the climate mechanisms (Werner et al., under review) and drainage (Werner et al., 2016) apparent from my system dynamics modeling work, noting the significant unknown regarding the extent of subsurface drainage and its role in wetland consolidation. Second, I offer two frameworks—a reductionist framework that separates these threats and a holistic framework that integrates these threats—and recommend that publishers like *Nature* and *Science*, along with the groups similar to the Millennium Assessment, encourage the holistic framework whenever possible rather than a flashy framework (the academic equivalent of clickbait). Finally, I put land use and cover change and climate change into conversations with policy and economics to discuss larger threats, arguing for the greatest threat being the combination of threats.

## **Division of Water Drone Program- Collecting Data Via Unmanned Vehicles**

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The Kentucky Division of Water (DOW) Drone Team is powering data-driven decision-making across a wide range of water resource programs in the Commonwealth. The team is transforming how environmental data are collected, analyzed, and applied. A slideshow will accompany this discussion of past, current, and future projects their results and evolution.

**Unmanned Aerial Vehicle (UAV) technologies** have revolutionized environmental monitoring. The DOW Drone Program was established in 2018 to support dam safety assessments and project monitoring. With four UAVs and two certified pilots, the fleet now supports aerial inspections, flood mitigation, thermal leak detection, riparian buffer studies, and various other requests by management. Several sites have been established for regular data collection as part of pilot projects. Thermal imagery has been particularly effective in identifying groundwater springs, soil drought stress, and potential dam failures. Products derived from UAV data, including digital surface models (DSM) and digital terrain models (DTM), are integrated with satellite imagery and ground-based data to create comprehensive environmental datasets.

**Unmanned Surface Vehicle (USV) systems** are utilized to conduct advanced bathymetric surveys using SonTek's Acoustic Doppler M9 unit mounted to the rQPOD platform. The data collected are processed in Xylem's Hypack software to create 3D models of lakebeds and river bottoms as well as water volumes and capacity curves for drinking water systems.

Water quality monitoring has also advanced through the deployment of multi-parameter EXO sondes, capturing critical indicators like pH, conductivity, algae concentration, temperature, dissolved oxygen, and nitrates. The EXO sondes can be mounted to the rQPOD platform or suspended from docks or other boats to collect data in a variety of environments. These measurements enhance ongoing efforts to monitor ecosystem health and inform regulatory and emergency management decisions.

These data have improved estimates of reservoir capacity, supported drought response, and allowed for sedimentation and pollutant tracking in addition to providing key factors in understanding and addressing Harmful Algal Blooms.

**Land-based efforts** rely on centimeter-accurate GNSS data collection systems, which ensure that all spatial data - from drones to bathymetric surveys - are precisely georeferenced.

Through this multifaceted and technologically integrated approach, the DOW Drone Team exemplifies how real-time, high-resolution data and advanced analytics can directly inform and improve water management decisions - benefiting both DOW and the citizens of the Commonwealth.

**Session 4A: Groundwater**

## Investigating Groundwater Dynamics in Barbados using Forensic Hydrology and Dye Tracing Techniques

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The small karst island of Barbados, located in the North Atlantic Ocean bordering the eastern Caribbean Sea, faces water resource management challenges investigated in this study. The island's vulnerability to changing storm patterns and sea level rise is compounded by its reliance on karst aquifers for its freshwater supply, which highlights the urgency for integrated, sustainable water resource management. Through a collaboration with the Barbados Water Authority, this research aimed to provide meaningful datasets for addressing critical questions regarding groundwater-surface water interactions, recharge dynamics, and the influence of human activities on the islands' karst hydrology. In contrast to the telogenetic, low-porosity aquifers in settings like Kentucky, the island of Barbados is comprised of eogenetic karst, with high matrix porosity; yet, it may share similar karst hydrologic characteristics. Using a multifaceted environmental tracer approach, including water level and precipitation data and fluorescent dye tracing, an investigation was undertaken in the Bowmanston's groundwater basin, which is one of the largest on the island and also a primary source of water for its residents.

Six total dye traces were conducted in January and June of 2025 involving a variety of injection features, including monitoring wells and sinkholes, with nine established dye recovery monitoring sites at springs, as well as monitoring and pumping wells throughout the Bowmanston's and adjacent basins, wherein activated charcoal receptors were placed and exchanged every two weeks. Multiple types of injection and monitoring methods were developed to ensure consistent dye injection and receptor recovery at the sites. Water level and geochemical data from select injection and/or monitoring sites were collected hourly for the duration of the study period. Despite extremely dry conditions during the study period, initial results indicate connectivity between theorized basin boundaries, effectively expanding the potential size of the Bowmanston's basin under the hydrologic conditions during the period of study; however, flow contributions are still being investigated to determine the nature of the groundwater flow gradient and boundary interactions. The relationship between conduit and matrix flowpaths suggest complexity in the recharge and transmissivity of the aquifer, with the potential for sedimentation and contaminants to move rapidly under low flow conditions. Additionally, high elevation recharge sites may provide flow contribution to multiple basins, demonstrating the spatial variability of recharge effectiveness during storm events, along with hydraulic gradient attenuation due to aquifer geomorphology, and the need for additional hydrologic monitoring sites and continued dye trace investigations.

## **Application of Stable Isotopes to Estimate Ohio River Infiltration and Groundwater Contributions to Radial Collector Wells in the Alluvial Aquifer, Louisville, Kentucky, 2019–20**

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From 2000–20 the U.S. Geological Survey (USGS) and the Louisville Water Company (LWC) cooperatively investigated physical and hydrologic conditions in the Ohio River alluvial aquifer and adjacent riverbed sediments to understand processes affecting water sources to collector wells during riverbank filtration system (RBF) operation. The LWC's RBF system includes an initial collector well (CW1) and a tunnel and collector well system (TCWS) with four collector wells (CW2–CW5) routing water to a nearby pumping station and a treatment plant. The wells are adjacent to the Ohio River in the northeast part of Louisville, Kentucky and produce a mixture of groundwater from the aquifer and induced surface-water infiltration from beneath the riverbed. The RBF system withdrew water from the aquifer at lower rates during winter-spring months and at higher rates during summer-autumn months. From 2005–20, pumping from CW1 peaked between 10–19 million gallons per day (Mgal/d), and from 2011–20 CW2-CW5 pumping peaked between 30–50 Mgal/d. Groundwater levels in the surrounding area indicated that water from the collector wells was derived from surface-water infiltration affected by pumping in the collector wells and occasional flooding of the Ohio River, plus from groundwater in the alluvial aquifer. Groundwater-level fluctuations in observation wells near the Ohio River were consistent with gradual depletion of groundwater yield during tunnel pumping system operation at river elevations of about 420 ft above the National Geodetic Vertical Datum of 1929 (NGVD29) and enhanced recharge of the aquifer when river elevations were above flood stage of about 430 ft above NGVD29.

Groundwater and Ohio River contributions to water withdrawals from collector wells in 2019–20 were estimated using representative values of deuterium and oxygen-18 isotopic ratios in groundwater samples from a well in the alluvial aquifer upgradient from the RBF and Ohio River samples from a local site downstream from the RBF and from another regional site. Isotopic ratios in the representative Ohio River end member and groundwater end member were input to a simple binary mixing calculation spreadsheet to compute the relative amounts of each end member that when mixed would approximately match the isotopic composition of water in samples from the collector wells. Groundwater samples from observation wells were mostly from infiltration of water affected by precipitation, as indicated by the similarity of isotopic ratios in their samples to rainfall or snowmelt represented as regional meteoric water. Contributions of Ohio River infiltration to collector wells estimated from deuterium and oxygen-18 isotopic ratios in representative Ohio River and groundwater samples were considerably larger in warmer months and relative groundwater contributions increased in cooler autumn months. Isotopic ratios of the Ohio River end member from May 2019 and May 2020 aligned with regional meteoric water. Ohio River end member samples from November 2019 and November 2020 displayed enriched isotopic ratios, indicating they were modified by evaporative isotopic fractionation.

## **A Half-Century Ahead of Its Time: R.B. Anderson’s Remarkable 1925 Hydrogeologic Analysis of the Mammoth Cave System for the Louisville Gas and Electric Company**

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When explorers from the Cave Research Foundation began an effort in the 1960s to integrate the caves beneath Kentucky’s Flint Ridge and Mammoth Cave Ridge into the world’s longest cave, a large valley separated them. They knew, however, that 40 years earlier a dye trace by geologist R.B. Anderson had shown that the caves beneath the ridges were at least linked hydrologically.

In the 1920’s the Louisville Gas and Electric Company had evaluated potential hydroelectric dam sites on the Green River, concluding that the only topographically suitable location identified was just upstream from Mammoth Cave. Concern about a potential “by-pass through some former underground channel” flowing around the dam, however, led Anderson to implement a remarkable hydrogeologic investigation synthesizing analysis of surface topography and the water table, inventory of springs along the Green River, profile surveys of passages in Mammoth, Great Onyx, Colossal, Salts, and Crystal Caves, and groundwater dye traces with surface and cave injections around Flint Ridge.

He modeled his groundwater tracing methods after A.W. Ambrose who had earlier used fluorescein dye and a “fluoroscope” (a thin glass tube coated with white enamel) to track groundwater associated with leaking Oklahoma oil wells. After some early adjustments for dosing, Anderson’s team completed eight traces—seven to Pike Spring and one to Echo River.

The interpretation of these results was phenomenal. The profiles provided the first recognition of the cave systems’ five major levels, and that groundwater divides were decoupled from surface topography. For this reason, Anderson could not eliminate the possibility of a bypass flowing into Pike Spring and out Echo River Spring, with the dam failing and potentially flooding parts of Mammoth Cave, and the project was abandoned. For the time, the masterful creativity, technical innovation and insight into karst hydrogeology resulting from this project cannot be overstated.

**Session 4B: Sediment**

## **A New Model for the Characterization of Concentration-Discharge Hysteresis Loops Based on Self-Organizing Maps**

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Concentration–discharge (C–Q) hysteresis loops are widely used to characterize the export of suspended and dissolved constituents from watersheds, as the shape and rotational direction of these loops provide insights into transport mechanisms and constituent sources. Traditional methods for analyzing hysteresis loops include classification schemes and hysteresis indices, each with distinct strengths and limitations. Classification schemes can capture key loop features—such as rotation direction and overall shape—but are less effective at representing gradual transitions between loop types. Hysteresis indices, in contrast, excel at quantifying such transitions (e.g., from clockwise through linear to counterclockwise), yet lack the capacity to distinguish finer shape characteristics, such as loop concavity.

To address this gap, we propose a novel technique that merges the descriptive flexibility of classification schemes with the continuous nature of hysteresis indices. This technique leverages the Self-Organizing Maps (SOM) algorithm, an unsupervised machine learning method that projects the distribution of loop types across a dataset onto a two-dimensional grid while preserving topological relationships. The resulting map functions as an automatic, semi-continuous classification surface, enabling smooth transitions between loop types and an enhanced representation of shape features—such as concavity and asymmetry—often overlooked by traditional indices. This approach provides a more comprehensive and nuanced characterization of hysteresis behavior.

We demonstrate the capabilities of SOM through a proof-of-concept application to sediment transport hysteresis loops. Using a curated dataset encompassing the primary loop types in sediment transport, we show that SOM effectively captures key features—including amplitude, direction, and concavity—while also describing gradual transitions between loop types. We introduce the General Turbidity–Discharge (T–Q) SOM model to characterize sediment transport hysteresis and demonstrate how it addresses limitations of conventional techniques. Furthermore, we illustrate the model’s utility in describing frequency distributions of loop types and examining their associations with hydrologic variables to improve our understanding of suspended sediment export mechanisms.

This framework offers a highly flexible tool for analyzing hysteresis loops across a wide range of water quality constituents. Its scalability and adaptability make it particularly well-suited for application to large datasets, opening new opportunities for data-driven insights into watershed-scale mobilization and transport processes.

## **Sediment Transport Dynamics in a Complex Fluviokarst System, South-Central Kentucky**

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Sediment, the most common pollutant in rivers and streams, also transports harmful contaminants such as nutrients, pesticides, and pathogens. In fluviokarst systems, where surface water and groundwater are closely linked, understanding how sediment moves is essential for protecting underground aquifers. However, most studies focus only on suspended sediment and use models to estimate transport, leaving gaps in our knowledge of how sediment behaves in these complex environments. This project focuses on Stillhouse Hollow, an isolated fluviokarst system in Mammoth Cave National Park. Here, karst springs form the creek's headwaters and divide into two tributaries. In the eastern tributary, water flows over Big Clifty Sandstone and sinks into the underlying Girkin Limestone, reemerging at a spring just upstream of the tributary confluence. By tracking how sediment moves through the system, we aim to identify the primary factors driving sediment transport.

We established three initial monitoring sites: one at the spring outlet, one upstream in the dry surface channel, and one in the flowing segment over Big Clifty. At each site, we installed an In-Situ Aqua TROLL 600 multiparameter sonde and a seismic impact plate designed and built by Ian Benson. The sondes continuously monitor stage, temperature, conductivity, and turbidity (a proxy for suspended sediment), while the impact plates detect the vibration and record the number of impacts over time as coarse sediments moving across the plate.

Instrumentation was installed in March 2025. During a major flood event in April 2025, 26.1 cm of rain fell in 96.5 hours at the Munfordville Mesonet station (~35 km ENE)—more than twice the monthly average. One sonde and one impact plate were lost, but the remaining instruments captured valuable high-flow data. Preliminary results show distinct site-specific responses and confirm the viability of seismic impact plates under extreme conditions.

With funding from a USGS 104b grant (via KWRI), we are adding two additional monitoring sites to capture sediment dynamics across the full Stillhouse Hollow basin. Ongoing work includes refinement of sensor placement and settings based on early results. Future efforts will focus on long-term data collection, grain size analysis, reach characterization, and statistical modeling of sediment transport processes. Since climate change and changes in land use can greatly increase sediment transport, establishing a baseline of current conditions is critical. This information can help predict and mitigate future threats to water quality, aquatic ecosystems, and flood risks.

## Seasonal Variation of the Stream's Sediment Transport Regime Using Sensor Networks in the South Elkhorn Watershed

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Fluviokarst systems are prevalent in central Kentucky; and various fluviokarst features, sinkholes, and swallets, have an impact on the sediment transport within the system as well as biological controls within the system. To better understand this, we are investigating the seasonal variation of baseflow sediment transport in a fluvial dominated fluviokarst system. We're investigating the processes that have potentially influencing the sediment signal including biological controls from macroinvertebrate activity, microbial mediated controls from organic matter degradation in the riverbed, and seasonal variation of the critical shear stress attributed to microbial controls. By investigating the causes of the diel cycle, we can see what is causing the sediment transport during off peak times (when discharge is low). Our current hypothesis is that crayfish are driving the diel trend since the sediment trend appears to follow the crayfish activity trends. Other things that may also be impacting the sediment diel cycle include aggregates structure, heterotrophy/autotrophy, and TOC concentrations. Through the use of a high-resolution sensor, a YSI EXO 3, we have been able to assess trends in South Elkhorn watershed which have seasonal trends. This study is focusing on the data collected at South Elkhorn Creek at Fort Spring, KY, which is the outlet point for the watershed.

Results for the South Elkhorn Watershed will be presented and discussed, including (i) Quality Assurance Quality Control (QAQC) results through flagging and removing erroneous data, (ii) visualization of baseflow seasonality and sediment transport from 2017-2023, (iii) sediment duration curves based on 15-minute sensor readings and daily averaged results, (iv) shear stress model of the watershed, (v) empirical mode decomposition results and discussion. The QAQC results will show that the data that has been put through the GCE Toolbox and the data was visually analyzed with the flags from the Toolbox. The visualization of the seasonality of baseflow turbidity within the watershed will show that there are periods when there is more sediment being transported during the summer months than the winter months. The sediment duration curves show that the baseflow sediment transport only occurs 25% of the time. The shear stress model shows that crayfish sediment transport is less than fluid sediment transport, but the crayfish are still responsible for a considerable amount of sediment transport during the summer months. The empirical mode decomposition results show the best aggregation of the data and the significant IMFs that show the seasonal trend for the baseflow sediment transport.

## **Predicting Sediment Transport by Coupling Sediment Connectivity with the Unit Sediment Graph: Method Development and Watershed-Scale Application**

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The unit sediment graph method has rarely been used in the literature over the past 50 years, especially when combined with the latest developments in connectivity theory. We hypothesize that spatially explicit sediment connectivity modeling could be integrated with unit sediment graph theory to identify sediment source zones, determine mobilization timing across the watershed, and estimate sediment flux during hydrologic events. Our model employs the probability of sediment connectivity with a log-normal parameterization of a 1-hour unit sediment graph. We then applied this model to the Upper South Elkhorn Watershed in Kentucky, USA, and calibrated it using a two-stage process. In Stage 1, we calibrated the model parameters utilizing an isolated, single-peaked storm, running 10,000 quasi-random Sobol sequence realizations to sample the parameters. In Stage 2, we calibrated and validated the model using two years of collected sediment data. The calibration was performed on the high-performance computing cluster provided by the University of Kentucky Supercomputer Center.

Results demonstrated strong evidence of the model's effectiveness, with Nash-Sutcliffe Efficiency reaching 0.87 and 0.84 during Stages 1 and 2 of calibration, respectively, and 0.88 during validation. The probability of connectivity varied across and within transport events, recording 7.5% connectivity for the high flow isolated event. The log-normal distribution offers a practical method for simulating the rising and falling limbs of sediment graphs. Running the model without accounting for the probability of connectivity produced unsatisfactory results. Additionally, we used a shallow neural network to simulate sediment fluxes, employing two inputs: sediment connectivity and surface runoff depth, and to estimate the weight of each input. Sediment connectivity was assigned a significant weight in the ANN model. This approach proved effective in capturing the onset and peak of sediment connectivity across the ephemeral gully network. This work is in press at *Hydrological Processes* journal.

**Session 4C: Nutrients and Watershed Management II**

## Development of the Kentucky Watershed Watch Data Portal

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Kentucky Watershed Watch is a community participatory science organization with a mission to “support water quality monitoring that informs, connects, and empowers volunteers and their communities for the improvement and protection of Kentucky's water resources.” Formed in 1997, the organization has trained thousands of volunteers throughout the state and over 20,000 samples have been collected and analyzed.

The Kentucky Geological Survey created a database in 2014 to support public accessibility to the data and utilization for education, impairment screening, success monitoring, and prioritization of implementation activities. However in 2023, the design of a new data management system was initiated due to the decommissioning of a related state managed database, a transition from centralized data entry to volunteer-led data entry, and the implementation of a new organizational structure.

This presentation explores the evolution and development of the architecture and programming of this database addressing user registration, user roles, training logs, sampling supply requests, sampling data forms, dashboards, and data visualizations.

## **Partnering Up for Planning**

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Hazard Mitigation Plans (HMP) and Watershed-Based Plans (WBP) are connected by our shared water resources and problems with water quantity and quality, ultimately recommending some of the same solutions. Specifically, both plans tend to include Green Infrastructure because it addresses both flooding and non-point source pollution. These overlaps and how to make use of them have been discussed before, and these discussions revolve around getting watershed planners involved in the process of creating a Hazard Mitigation Plan and using a watershed approach within it. This can result in a HMP that can be referenced and built upon to create a WBP. This is recommended by FEMA and EPA, but how do we accomplish this? Here we will refer to EPA's recently revised "Nonpoint Source Program and Grants Guidelines" to discuss how to turn Hazard Mitigation Plans into Watershed-Based Plans and (most importantly) how to get them approved!

## **Clearing the Way: A Framework for Supporting Local Efforts in Aquatic Trash Removal**

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No one likes to see trash in their local stream. However, “aquatic trash” is piling up across Kentucky’s 90,000+ miles of rivers and streams.

More than an eyesore, aquatic trash can have very real negative impacts. It presents numerous challenges for local governments, including damage to critical infrastructure and costly cleanup efforts. Economically, litter diminishes property values, undermines tourism and recreation, and threatens agricultural productivity. Public health risks arise from disease vectors, bacteria, and microplastics that can accumulate in fish and game consumed by people. And finally, wildlife is similarly harmed, facing hazards such as ingestion, entanglement, habitat destruction, and the spread of invasive species.

Aquatic trash is a statewide issue, but because of its nature, is a community problem. This means any successful effort to address the issue will require inspiring citizens and/or communities to change their behavior. The conventional wisdom within the environmental community suggests that behavioral changes can be brought about through a combination of education and motivation. This has not been the case for aquatic trash in the Commonwealth. Despite awareness of the problem, a long list of motivating factors and the apolitical nature of this problem, we are not seeing a large-scale shift toward cleanup efforts. However, we are seeing some clever and committed communities having success, less through educating and motivating members, and more through effectively circumventing barriers.

Aquatic trash removal is hard. The work is physically demanding, dirty, hot (or cold), time consuming, potentially dangerous and often requires special equipment. to execute it well requires planning, organization, and communication skills. And the costs to transport and dispose of collected trash can be high. These barriers can be enough to stifle even the most motivated community.

This presentation will look at the scope of the aquatic trash, and the barriers faced by communities working to clean up their local waterways. Case studies from around the state will be used to highlight successes and demonstrate how creative problem solving is used to overcome barriers. This is all to propose a framework of addressing the issue that prioritizes the removal of barriers for communities engaged in the work.

## Kentucky Waterways Alliance Green River Tire and Access Identification

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Tires in waterways across Kentucky have become an abundant and dangerous threat to waterway health, community wellbeing, and access to our most scenic environments. Tire removal activities preserve habitat integrity, remove toxic chemical and/or microplastic exposure, reduce impacts to water temperature and oxygen availability, and reduce the risk of aquatic species population decline. Tire removal protects natural migration paths and aids in protecting fish, invertebrates and other aquatic/amphibious animals, ensuring abundant populations of diverse species and habitats. Outdoor industries, such as boating, fishing, and water sports, greatly benefit from safe and accessible waterways. Tire removal and increased recreational access enhances exposure to clean shores, clear water and thriving aquatic ecosystems which support opportunities for tourism and outdoor industry-related businesses. Community participation aids in education, engagement, and ownership of local waterway health. Tire removal not only positively impacts local waterways health, but the safety and wellbeing of those communities positioned within the watersheds and communities downstream of removal sites.

Groups across the state have begun to combat this issue through tire removal programs and events, however, resources to aid these organizations are far and few between. Kentucky Waterways Alliance (KWA) is taking a leadership role against this persistent and toxic form of pollution in our rivers, streams, and lakes by developing new tools for tire removal through the Green River Tire and Access Identification study (GRTAI). This study has two primary components:

1. Document location of waste tires in the Green River for future removal.
  - GRTAI aims to document baseline habitat conditions and number of tires in the Green River, map geolocations of tires via GIS and remote sensing, encourage participatory science through a community tire reporting portal, facilitate the removal of waste tires from the Green River through the creation of replicable workflows that identify tires in waterways through aerial imagery analysis, and develop a prediction model for areas under threat for tire accumulation.
2. Identify all (public) existing, previously unidentified, and potential new access points along the Green River to support increased recreation and facilitate the removal of tires.
  - Identifying unused or underused locations alongside existing public access and/or identify locations most suitable for future access aids efforts surrounding tire removal and provides additional river access and community engagement opportunities. Encouraging participatory science and engagement will further community conservation efforts, increase recreational opportunities, boost tourism, and encourage community-based education on local waterway health. Methods for data collection and analysis include participatory science through KWA's tire reporting survey, aerial image collection via drone flights, and analysis workflow development through a combination of ArcGIS Pro and Remote Sensing software.

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These efforts will culminate in the development of tools, maps, and dashboards positioned to aid in the removal of tires across the state, starting with the Green River. Upon the successful completion of the GRTAI, KWA aims to expand this work across the state, focusing on other major waterways such as the Kentucky River, Tug Fork River, Salt River, Cumberland River, and others.

**Poster Session**

## 1. Critical Mineral Recovery from E-Wastes Using Nanocomposite Membranes

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Creating sustainable and resilient supply chains for critical minerals is crucial to address the growing demand for renewable energy technologies and electronic devices. This project aims to develop innovative solutions by transitioning away from traditional processing technologies with significant carbon footprints toward low-energy, selective separation processes. Specifically, the research focuses on leveraging deep eutectic solvents (DES) and nanocomposite membranes for selective, low-cost, and carbon-negative recovery of critical metals from electronic waste (E-waste). The proposed work is expected to lead to significant innovations and impacts, including a novel carbon-negative critical metal recovery process and insights into the relationship between DES composition and hydrogen bonding properties for enhanced selectivity. The development of nanocomposite membranes will enable efficient separations, contributing to sustainable solutions for critical energy and environmental challenges. Additionally, the project provides valuable training opportunities for underrepresented graduate students, fostering expertise in sustainable solvent design, nanomaterial development, and critical metal recovery technologies.

## 2. Exploring the Effect of Single-Layer Polydopamine-bonded Bilayer PVDF-HFP and Polysulfone Membranes via Green Solvents for Wastewater Treatment

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The sustainable processing of agricultural biomass has become increasingly important in the pursuit of eco-friendly practices within the agricultural sector. Lignin, a complex aromatic polymer found in lignocellulosic biomass, presents a valuable resource when effectively separated from agricultural waste. This study focuses on the development and comparative analysis of deep eutectic solvent (DES)-resistant membranes for efficient lignin recovery, a critical step in sustainable biomass processing with significant implications for soil health and agricultural sustainability.

Our research investigates the performance of membranes fabricated from poly(vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP), and polybenzimidazole (PBI), in recovering lignin from lignin-DES mixtures. These deep eutectic solvents offer advantages such as low toxicity and biodegradability, making them ideal for environmentally conscious agricultural applications. However, their corrosive nature necessitates the development of robust, DES-resistant membranes. This research aims to identify the most promising membrane candidates for efficient lignin recovery in sustainable agricultural biomass processing.

The findings have potential implications for soil amendment practices, as recovered lignin can be used to enhance soil organic matter content, improve soil structure, and promote carbon sequestration in agricultural soils. By advancing membrane technology for lignin recovery, this study contributes to the development of sustainable agricultural practices and the valorization of agricultural waste streams.

### **3. Water Workforce Training Center**

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As the water utility industry workforce continues to age, there is a national concern about the problem of recruiting and retaining workers. UK's Kentucky Water Research Institute conducted a water workforce survey in 2022 of managers and operators in Kentucky. Under the ARISE grant, an online survey of water utility managers in Appalachia Kentucky and West Virginia was deployed in 2025. Additionally, focus group meetings were held providing valuable information. The presentation will discuss the results of the research and the importance of supporting the water workforce and utilities.

#### 4. Investigating Headwater Contributions to Downstream Discharge: Insights from a Process-Based Hydrologic Model

Ridwan Mohammed Nur<sup>1</sup>, Tyler Mahoney<sup>1</sup>, Jay Christensen<sup>2</sup>, Heather Golden<sup>2</sup>, Charles Lane<sup>2</sup>, Grey Evenson<sup>2</sup>, Chris Barton<sup>3</sup>, Kenton Sena<sup>4</sup>, Franklin Kondum<sup>1</sup>, Anju Thapa<sup>1</sup>

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Non-perennial headwater streams play important roles in both watershed hydrology and ecosystem functioning, supporting water quality, habitat connectivity, and flow generation. However, because these streams typically lack continuous surface water connections to downstream rivers, their protection under the Clean Water Act is not guaranteed. Meanwhile, the hydrologic contributions of headwater streams to downstream water bodies remain poorly quantified, creating uncertainty about the role of headwaters in larger-scale catchment functioning and, importantly, downstream implications of regulatory decisions in headwater systems.

Given the paucity of observational data available in many headwater systems, there is a pressing need to develop modeling tools to quantify the contributions of headwaters to downstream discharge. However, doing so is challenging because traditional hydrologic models often ignore flow intermittency. In reality, headwater streams are dynamic – expanding and contracting with changing hydrologic conditions. The objective of this study was to characterize the intermittency of headwater streams and assess their contributions to discharge at the outlet of a larger perennial system using a process-based hydrologic model.

We developed a semi-distributed, process-based model to simulate both streamflow presence/absence and surface discharge across a headwater network. The model simulates hillslope hydrology using dynamic TOPMODEL, routes channel flow using a kinematic wave approach, and solves for streamflow presence/absence at the reach scale. Model calibration was performed using a multi-objective NSGA-II genetic algorithm across more than 4800 realizations by jointly optimizing the KGE and F1-score against observations from three streamflow gauges and twenty reach-scale state loggers (logging stream wet/dry status). The model was applied to the Clemons Fork watershed, located in the University of Kentucky's Robinson Forest environmental monitoring network.

Preliminary results indicate that intermittent and ephemeral headwaters substantially contribute to total watershed discharge. First-order streams alone contribute ~30% of total flow to the outlet of the watershed, and, combined, first- and second-order streams contribute ~50% of flow over the study period. The multi-objective calibration was found to reduce equifinality of the model simulations, highlighting the efficacy of the additional state-loggers for reducing uncertainty. Ongoing work includes quantification of the variability in these contributions across timescales, (e.g., event, monthly, seasonal, etc.), including contributions from streams flowing only a fraction of the year.

This approach shows promise for improving the representation of headwater streams in hydrologic models and supporting watershed management and policy decisions in non-perennial systems across the US.

## 5. Unraveling the Role of Model Structure to Simulate Streamflow in Appalachian Headwaters using the MARRMoT Framework

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Headwater streams are a critical yet vulnerable component of river networks, playing key roles in biodiversity, watershed hydrology, and water quality. Their vulnerability stems in part from limited knowledge of their spatially and temporally dynamic flow regimes, which complicates efforts to define the jurisdiction of the Clean Water Act. It is typical to rely on hydrologic models to characterize headwater streamflow to support regulatory decisions in headwaters where observational data are scarce.

However, choosing the “right” model for a headwater catchment is a daunting task due to the seemingly endless number of model configurations for representing surface and subsurface processes in small catchments – particularly when observational streamflow data are broadly limited. There is a clear need to systematically evaluate diverse model structures to identify which models (if any) yield meaningful improvements in simulations for headwater catchments – and to establish lower benchmarks that define what constitutes an “adequate” model in these settings.

To address this, we applied the Modular Assessment of Rainfall-Runoff Models Toolbox (MARRMoT), evaluating 47 conceptual hydrologic model structures across 37 headwater catchments in research forests throughout Appalachia. Appalachia was initially targeted to develop our workflow due to its high density of headwater streams and the onslaught of floods that have recently impacted the region. Each model was run using 1,000 random parameter sets. We then assessed model performance using traditional evaluation metrics, such as the KGE and NSE, as well as a suite of hydrologic signatures that reflect the frequency, magnitude, timing, duration, and rate of change of flow regimes. Preliminary results indicate that simpler model structures, characterized by fewer storages and parameters, consistently delivered robust and realistic streamflow predictions. These models exhibited lower variability in performance metrics, accurately replicating key hydrological signatures without calibration, thereby minimizing the equifinality common among more complex structures. In contrast, highly parameterized models generally displayed greater performance variability and struggled consistently to reproduce observed hydrologic signatures. Ongoing analyses aim to benchmark model structures suited for simulating headwater streamflows.

By highlighting simpler, yet sufficiently realistic models, this research promotes model parsimony and informs practical model selection guidelines for ungauged and poorly monitored headwater basins. Ultimately, this approach supports improved watershed management, enhanced streamflow prediction, and ecological sustainability in headwater systems.

## 6. Comparative Evaluation of Satellite and Field-Based Soil Moisture in Eastern Kentucky's Appalachian Headwater System

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Understanding soil moisture variability is essential for hydrologic modeling, flood forecasting, and slope stability assessment. In remote headwater systems, including the Appalachian region of Eastern Kentucky, steep topography and heterogeneous soils complicate water movement and retention, and measurement of soil moisture can be arduous. This study aims to evaluate the accuracy and applicability of satellite-based soil moisture data by comparing remotely sensed products with field-measured values across different locations in Eastern Kentucky.

Corresponding satellite estimates were obtained from NASA's SMAP (0-5 cm depth) and GLDAS (10-40 cm depth) datasets using spatially and temporally matched data extracted procedures. Results showed that SMAP moderately overestimated topsoil moisture but remained within acceptable bounds, suggesting utility for regional-scale monitoring. In contrast, GLDAS significantly overpredicted subsoil moisture across all sites, likely due to model-driven assumptions, coarser spatial resolution, and depth mismatch. Another contributing factor, maybe the temporal resolution of the data, GLDAS provides updates on a monthly basis, and data for the exact sampling date were not available at the time of study. As a result, the closest available dataset, approximately one week earlier than the field measurement date, was used for comparison. The study concludes that while SMAP data hold promise for topsoil moisture estimation with appropriate local calibration, GLDAS subsoil outputs may require substantial adjustment before being applied to site-specific analyses.

## 7. Investigation of Rainfall-Induced Slope Failure Using Physical Models

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This study uses a custom-designed transparent soil box to explore the mechanisms of rainfall-induced slope failure through controlled laboratory experiments. The apparatus, a five-sided acrylic box ( $50.17 \times 40.01 \times 120.02$  cm), simulates natural slope conditions using fine sand and is equipped with embedded sensors to monitor porewater pressure, volumetric water content, temperature, and soil displacement. A rain simulator mounted above the box generates consistent rainfall at 75 mm/h, and image analysis tracks surface deformations during infiltration. Two tests were conducted with distinct soil configurations: (1) a mixture of 95% play sand and 5% kaolinite with a dry density of  $1.4 \text{ g/cm}^3$  and (2) pure play sand with a higher dry density of  $1.6 \text{ g/cm}^3$ . Volumetric water content was recorded throughout the slope at multiple depths and locations using calibrated 5TM sensors, while Geokon 4500BX piezometers captured porewater pressure responses. The results reveal critical insights into slope failure dynamics. In both tests, rainfall infiltration rapidly increased volumetric water content, gradually saturating the slope from the surface downward. However, slope failure occurred only in Test 2 (denser, pure sand), approximately 18 to 20 minutes after rainfall initiation. The failure initiated near the upslope, involved shallow depths, and resulted in visible cracking and soil accumulation at the slope toe. In contrast, despite having a steeper slope and longer rainfall duration, the mixed-soil configuration in Test 1 remained stable. This difference highlights the role of dry density and clay content in enhancing slope resilience by influencing matric suction and permeability. Porewater pressure trends supported these findings. In both tests, pressure buildup was recorded earlier downstream due to faster saturation. Maximum porewater pressure in Test 2 was significantly higher than in Test 1, suggesting a greater volume of saturated soil and a larger reduction in effective stress. The high saturation zone led to a loss of shear strength in a broader soil mass in Test 2, triggering failure. Conversely, including kaolinite in Test 1 likely helped retain matric suction and limited the development of positive pore pressure, preserving slope stability. These observations confirm that volumetric water content and porewater pressure are critical indicators of impending slope failure under rainfall. The combination of dense soil with low clay content resulted in more rapid saturation and destabilization, while the presence of fine clay and lower dry density improved slope performance by enhancing moisture retention and reducing pore pressure escalation.

## 8. Evaluating the Effects of Ecological Restoration on Amphibian Communities in Lotic Systems in the Inner Bluegrass Region of Kentucky\*

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Urbanization is a major contributor to declining stream quality, both in the United States and worldwide, with effects including alteration of stream hydrology through erosion, reduction of fully functioning riparian zones, and deterioration of water quality through eutrophication and pollution. As a key driver of urbanization's negative impacts on stream ecosystems, deforestation eliminates, degrades, and/or fragments formerly suitable habitat and reduces stream integrity. Stream remediation efforts to combat the effects of deforestation often involve the addition of riparian vegetation; however, these approaches often occur in conjunction with channel reconfiguration, and addition of in-stream boulders and/or coarse woody debris to slow water flow. These techniques are often implemented simultaneously, preventing the determination of how individual remediation techniques can impact stream ecosystem structure and function. The Reforest the Bluegrass (RTB) program in Lexington, Kentucky has restored more than 200 acres of floodplains with tree planting events over the past 20 years while evaluating strategies to facilitate ecosystem restoration within urban settings. In the absence of other within-stream remediation efforts, RTB efforts provide rare opportunities to examine impacts of a single remediation technique (riparian reforestation) on previously degraded urban streams. Beginning in 2024, we quantified abundance of adult and larval salamanders in upstream and downstream sections of degraded + restored, degraded + unrestored, and relatively unimpacted reference streams within the inner Bluegrass region using systematic time-constrained visual encounter surveys. In 2025, we also began quantifying macroinvertebrate diversity using similar time-constrained captures, as well as rates of leaf litter loss using leaf bags, to examine the potential roles of invertebrate (primarily shredders) abundance and leaf litter processing on salamander abundance and diversity. These efforts will ultimately be paired with monitoring of various water quality parameters and environmental DNA characterizations of amphibian and macroinvertebrate community structure to identify potential drivers of amphibian diversity in urban streams with varied remediation histories. Results to date indicate reference streams are characterized by significantly higher salamander abundances than either unrestored or restored streams, a pattern which was consistent across 2024 - 2025, and no differences in salamander abundance in degraded streams regardless of restoration efforts. Larval and adult salamander communities are dominated by southern two-lined salamanders (*Eurycea cirrigera*), and thus comparisons of diversity are not yet possible. We are currently processing macroinvertebrate and leaf litter sampling and will discuss these data, but results to date suggest riparian reforestation as a standalone stream remediation technique does not result in recolonization of salamander communities previously impacted by urban stream degradation.

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## 9. Reconstructing Hydrography in Eastern Kentucky Mine Lands

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An assessment of the changes in hydrologic and hydraulic properties brought about by mining and reclamation of past mine sites is of interest, particularly against a backdrop of periodically repeating and devastating flash floods in Eastern Kentucky. Historic topographic maps are useful sources of information on the original terrain and geomorphology of now reclaimed mine sites. This paper presents an attempt to reconstruct the 3D hydrology in sub-watersheds of 14-digit hydrologic units in Martin and Pike Counties, KY and compare it with current knowledge based on high resolution digital elevation models (DEM) obtained from lidar surveys of the area. The 1917 Naugatuck and 1918 Williamson topographic maps were used to digitize elevation contour lines, watershed boundaries and streams (USGS, 2025). The current National Hydrography Dataset (USGS, 2025) and the Phase 3 DEM (Kentucky from Above, 2025) are used for comparison and to calculate topographic and cartographic differences. Despite mountain top removal activities, the findings reveal a relative constancy of the 2D watershed boundaries and in many cases of the stream delineations. The elevation changes in watershed boundaries (3D) were also calculated. There were some indications of streams having been obliterated by the mining and reclamation activities that took place, but also of new hydrologic networks being developed. This type of assessment is ongoing given the potential importance and influence of emerging hydrologic and hydraulic properties of reclaimed mine sites in the context flash flood risk.

## 10. Predictive Modeling of Total Trihalomethanes in the Martin County Water System: A Comparison of Linear and Machine Learning Approaches

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Total trihalomethanes (TTHMs), a class of regulated disinfection by-products (DBPs), are formed when chlorine reacts with natural organic matter in drinking water systems. Given the health risks associated with TTHMs and the limited frequency of monitoring in small rural utilities, predictive modeling offers a valuable tool for estimating concentrations across the system. This study investigates the application of multiple linear regression (MLR) and random forest regression (RF) for predicting TTHM levels at both the treatment plant and selected distribution sites in the Martin County, Kentucky water system. Using quarterly data from 2021 to 2023, the models were developed based on operational and water quality variables, including total organic carbon, water temperature, chlorine demand, water age, alkalinity, and residual chlorine. MLR was selected for its simplicity and interpretability, while RF was considered for its ability to model nonlinear relationships. Based on the initial model performance evaluated using the mean absolute error (MAE) and root mean squared error (RMSE), the RF approach demonstrated improved predictive accuracy compared to MLR. This study provides a preliminary framework for using data-driven models to support DBP management in rural water systems with limited monitoring data.

## 11. Life Cycle Assessment (LCA) of Green Infrastructure: Urban Tree Soil Cells

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Urban trees play a crucial role in cities, acting as green infrastructure that provides many environmental benefits, such as improving air quality, local climate, and reducing runoff. However, these trees confront serious threats due to urban growth and climate change. The hard surfaces of cities, such as pavements, often compact the soil, limiting tree growth and their natural ability to manage water. This significantly reduces the lifespan of urban trees. Soil cells are a new green infrastructure solution designed to help address these challenges. These structures are placed around tree roots, taking on weight from pavements. This design helps reduce soil compaction and allows tree roots to grow more freely, improving the trees natural processes, such as managing stormwater and cleaning the air.

Although soil cells have many advantages for trees and stormwater management, the technology is still new, and the potential sustainability impacts of its implementation are still unknown. To this end, the objective of this study is to quantify the global environmental impacts associated with installing soil cells on the University of Kentucky campus. This research uses life cycle assessment (LCA), a tool for quantifying the global environmental effects of a product or infrastructure throughout its entire life, from material extraction to end-of-life. In this study, the LCA assesses the project in five life cycle phases: materials extraction, transportation, construction, operation, and end-of-life, following the detailed guidelines set by ISO 14040/14044 standards. To perform this analysis, the U.S. Environmental Protection Agency's Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI), accessed through SimaPro, was used to obtain unit impacts, which represent quantified global environmental burdens per unit of materials or processes required for the soil cell installation project. Additionally, Python was employed for performing calculations and analyses, including the impact assessment, uncertainty, and sensitivity analyses. The study aims to use LCA as a tool to help decision-makers identify which stages of the soil cell's life cycle might contribute most to environmental impacts and how different design choices affect these impacts. As a result, this analysis can inform design and operation of soil cell systems in a way that is better for the environment, helping to enhance the sustainability of stormwater management projects on campus.

## 12. Integrated Research and Education to Assess Sustainability of a Mobile Water Treatment System for Emergency Response in Kentucky\*

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Central Appalachia, specifically Kentucky, is historically susceptible to extreme natural disasters that can severely disrupt existing water systems and infrastructure. In the aftermath, affected communities often lack reliable access to clean and portable water to sustain their functioning. Although recommendations such as single-use bottled water, boiled water, and household bleached water exist, these solutions are not always pragmatic during disasters and extended recovery scenarios. The Water-On-Wheels (WOW) cart, developed by WaterStep, a Louisville-based non-profit organization, is a portable mobile emergency water treatment system designed to purify contaminated water and supply safe water following a disaster or contamination of public water supplies. Despite its documented success in disaster response, there remains an opportunity to enhance the WOW cart's design, functional performance, and response deployment strategy from a holistic sustainability perspective.

This study advances the sustainability of emergency water supply in Kentucky through an integrated research and education approach. First, we performed a life cycle costing (LCC) analysis to compare the economic sustainability of WaterStep's WOW cart against bottled water under different water demand and transport distance scenarios. Specifically, we evaluated economic impacts for both systems at multiple water-demand levels (up to 15,000 gallons) and transport distances (up to 200 miles). Second, during Fall 2024 and Spring 2025, we integrated hands-on WOW cart demonstrations and dedicated course modules into an undergraduate civil engineering course, CE 218: Sustainable Engineering at the University of Kentucky. A total of 104 students (48 and 56 for Fall and Spring, respectively) received training on water infrastructure for emergency response, and the application of LCC methodology to compare the economic sustainability of a mobile water treatment system versus an alternative of bottled water. Learning outcomes were assessed via homework assignments and reflective quizzes.

Preliminary LCC results indicate that beyond a certain transport distance and water demand threshold, the WOW Cart is more cost-effective than bottled water during an emergency. Moreover, because the WOW cart's per-unit cost remains constant across distances, its relative cost stability surpasses that of bottled water as demand increases. Education feedback revealed high student engagement. The trainees were intrigued by the WOW cart's simplicity and treatment capabilities, thus sparking newfound interest in disaster-response careers, as reported by some trainees. Ongoing work includes refining the LCC with uncertainty and sensitivity analyses, conducting a full life cycle assessment for environmental impacts, and considering spatiality to support holistic decision-making.

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### 13. Quantifying Soil Moisture Impacts on Sediment Transport and Hysteresis in Karst: A Dual-Sensor-Based Modeling Study with Mentored Undergraduate Research Support

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Sediment transport in karst systems remains underexplored, despite the importance of karst aquifers in supplying drinking water to approximately 25% of the global population. The complexity of karst environments - including subsurface flow pathways, variable storage, and limited direct access - poses major challenges for understanding sediment dynamics, especially under changing hydrologic conditions. One critical but understudied factor is the role of antecedent soil moisture in modulating sediment delivery during precipitation events. While antecedent moisture has been recognized as a driver of hydrologic response, its influence on sediment transport timing and magnitude through karst conduits is not well understood.

This study investigates sediment transport dynamics in the Royal Spring Groundwater Basin of Central Kentucky, focusing on the Cane Run watershed and its main resurgence at Royal Spring. We hypothesize that sediment transport is greatest under intermediate soil moisture conditions, when the balance between infiltration and overland flow maximizes sediment mobilization. To test this, a high-resolution dual sensor network was deployed at the cave inlet (Kentucky Horse Park, KYHP) and the spring outlet (Royal Spring, RYSP). Sensors measured turbidity, conductivity, and discharge, and were integrated with precipitation, soil moisture, temperature, and water withdrawal data to capture both event-based and seasonal trends.

To understand the transport and fate of sediment within the cave system, we employ sediment continuity modeling that incorporates processes such as resuspension, deposition, travel time, and dynamic aquifer recharge. These models are supported by observed shifts in hysteresis loop behavior between KYHP and RYSP. Previous studies suggest that averaged hysteresis loops evolve from clockwise or counterclockwise figure-eight patterns within the cave to J-loops at the spring, indicative of complex storage and release mechanisms. Our modeling framework aims to quantify sediment retention, estimate storage durations, and link observed patterns in sensor data to underlying physical processes.

Preliminary findings, supported by mentored undergraduate researchers, reveal clear distinctions in event responses between KYHP and RYSP. Turbidity and conductivity peaks typically appear earlier at KYHP, with lagged or muted responses at RYSP, suggesting attenuation or storage within the conduit. Sediment loads consistently decline downstream, and some events at RYSP show double-peaked turbidity signatures, reflecting both surface inputs and delayed in-cave resuspension. Seasonal trends further show increased sediment transport during wetter periods and reduced activity during droughts, aligning with antecedent soil moisture and aquifer saturation.

These results highlight soil moisture as a key control on sediment delivery in karst systems and

suggest the existence of an optimal moisture range for mobilization. By integrating multi-sensor data with climate and soil metrics, this work advances understanding of karst sediment dynamics and improves forecasting of water quality under variable hydrologic regimes.

In addition to its scientific contributions, this study serves as a platform for undergraduate engagement. Students have contributed to fieldwork, sensor maintenance, QA/QC, and data analysis. Ongoing efforts include developing improved turbidity–TSS curves and advancing sediment load estimation. Mentorship emphasizes weekly meetings, collaborative goal-setting, and shared deliverables, fostering both technical and research skills.

## 14. Carbon Isotopic Ratios of Benthic Algae Show Impacts to Fluvial Sediment Carbon Seasonality in South Elkhorn Creek, Lexington, Kentucky

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Sediment transport is a prominent topic in environmental studies with complexities related to geomorphology and ecology. Stable carbon isotopic ratios ( $\delta^{13}\text{C}$  ‰) have been commonly utilized in tracer studies focused on elucidating sediment source, fate, and transport across many different ecosystems. Watersheds in combined surface-groundwater systems are important to processing and transporting carbon within the global carbon cycle, particularly because of the intersection between terrestrial and aquatic continuum and seasonal environmental conditions influencing organic and inorganic carbon fluxes. However, there is still a notable lack of knowledge regarding the interactions of various carbon pools and the subsequent impact on carbon isotopic ratios.

Formation of organic carbon produced during biogeochemical processes often enriches carbon isotopic ratios. Primary producers, such as benthic algae, show isotopic enrichment variability that is dependent on environmental conditions including temperature, sunlight, flowrate, and nutrient availability. Through algal stabilization, algal material decomposes and assimilates to in-stream sediment deposits. There have been many studies focused on direct causes to variability of  $\delta^{13}\text{C}$  signatures within benthic algae. However, few studies consider the impacts that variations in benthic algae carbon isotopic ratios have on fluvial sediment carbon isotopic ratios.

Biweekly sediment trap samples and source samples (soils, banks, and algae) were collected from the South Elkhorn Creek within Lexington, Kentucky from 2018 to 2020. Samples were split into the three following subsets based on acidification methods: Total Carbon (TC), Organic Carbon (OC), and Recalcitrant Organic Carbon (RC). TC were not acidified, OC were subjected to a 0.5 M HCl acid wash to remove inorganic carbon compounds (carbonate), and RC was heated to 105°C and subjected to a 6 M HCl acid wash to burn off bio-reactive (labile) carbon compounds.

Results indicate differences in sediment TC (%C =  $4.3\% \pm 1.1\%$ ), OC (%C =  $3.7\% \pm 0.7\%$ ), and RC (%C =  $+1.2\% \pm 0.3\%$ ). 87% of the TC remained as OC after .5 M HCl acidification, and 33% of the OC remained as RC after 6 M HCl acidification. Sediment carbon isotopic ratios for TC, OC, and RC averaged  $-25.4\% \pm 1.0\%$ ,  $-27.5\% \pm 0.2\%$ , and  $-27.4\% \pm 0.3\%$ , respectively. Source samples often showed enriched carbon isotopic ratios in OC relative to RC carbon isotopic ratios. Carbon isotopic ratio measurements of benthic algae produced higher-than-expected mean  $\delta^{13}\text{C}$  values ( $-17.4\% \pm 0.8$ ,  $-18.0\% \pm 0.7$ ,  $-24.4\% \pm 1.0$ , respectively).

Future work includes an intense benthic algae sampling scheme, collecting samples monthly across five sampling sites in South Elkhorn Creek to help represent spatiotemporal variability.

The use of a portable field instrument (BenthoTorch) enables real-time measurements of benthic algal species (green algae, cyanobacteria, and diatoms) and relative concentrations. Initial results from data collection indicate cyanobacteria and diatoms are prominent benthic species in South Elkhorn Creek. These algal carbon measurements will be paired with our continued biweekly sediment trap sampling to help assess algal contributions to fluvial sediment carbon pools and provide insights into algal and sediment carbon fluxes and isotopic ratios.

Future work will also incorporate the use of a mentoring model for undergraduate students, in which the lead of this study will guide an undergraduate throughout research in this topical area. The responsibilities of the undergraduate will include leading sampling and processing activities and assisting the primary researcher. The responsibilities of the primary researcher will be to introduce the undergraduate to topics pertaining to sediment source, fate, and transport and to provide structured support to the undergraduate's research experience. This model will enhance the quality of the research by promoting collaborative work and facilitating science communication within the field of water resource management.

The current hypothesis is that fluctuations in benthic algae stable carbon isotopic ratios will have mirroring impacts on the fluvial carbon signatures post algal stabilization. Furthermore, seasonality within algal isotopic ratio variation will be reflective of fluctuations within organic sediment pools. These trends found within the South Elkhorn Creek are expected to be representative of the inner bluegrass region.

## 15. Hydrologic Modelling to Predict Flash Flood Events and Uncertainty in the Appalachian Region in Future Decades

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Following the devastating flash flooding in Kentucky's Appalachian region in 2022 and subsequent flood events, the urgency to predict future flash floods in vulnerable areas affected by climate change has never been greater. In 2025 alone, flash floods have impacted communities from North Carolina to Texas to Nevada. While predictive efforts begin at a local level, the growing scope of these disasters highlights a national need for improved, model-based flood forecasting. Using high-resolution observations, outputs from global climate models, and watershed modeling can help simulate future flood events, aiding the region in its preparedness. We collect flow data through a sensor system in headwater streams in Southeastern Kentucky. We also use a range of climate scenarios from the Couples Model Intercomparison Project Phase 6 to demonstrate the uncertainty in future predictions. The Soil and Water Assessment Tool hydrological model and other hydrological and sediment transport models are being employed to analyze the area's hydrological conditions and to simulate event-based hydrographs.

Our primary findings show a significant change in the Kentucky's hydrology due to the projected increase in the average daily temperature of about 2.9 °C, as forecasted by global circulation models for the middle of the century (2055). Precipitation is also expected to increase by a yearly average of 125mm (+11.2%). We believe that data collected from headwater streams and the modeling efforts (hydrological and climate modeling) will enhance our ability to predict flash floods in areas with limited infrastructure. The insights gained from this work can be shared with at-risk communities to promote preventative measures and inform the public of potential disasters before they occur.

The network of sensors where flood forecasting is being carried out is comprised of 19 sites in Whitesburg, KY, 4 sites in Robinson Forest of Clayhole, KY, a site in Lexington, KY and a site in Jackson, KY monitored in conjunction with Breathitt County High School. This network of sensors in Eastern Kentucky provides insight to a different scales of flash floods, ranging from a single headwater stream of a few square km to the City of Whitesburg to a countywide or larger scale watershed. With extreme single-day flood events increasing at a rate of 0.5% per decade since 1910, the likelihood and extremity of flash flooding has and is expected to continue to increase. By adopting these precipitation trends and forecasts, we can model the impacts of average annual changes in flooding as well as events of extreme single-day flooding. With hydrological models such as the Soil and Water Assessment Tool, we can factor in precipitation data, soil data, land use, and other influential elements of a flood event to test these changes in order to estimate the runoff process, flood extents and levels, and areas most prone to flooding.

These results may be compared to sediment erosion and transportation, compounding the knowledge about the flood event and gaining more insight to model calibration.

The sensor site located in Jackson, KY will be monitored together with the University of Kentucky and Breathitt County High School. This collaboration will span from high school to post graduate students, to facilitate learning about flooding. We will establish a sensor site in Jackson where students from Breathitt will be taught how to collect the flowrate data and its impact. We will be mentoring undergraduate

students at the University of Kentucky as we construct the model to incorporate the flowrate data from Breathitt and the rest of the network to contribute to the advancements of flash flooding research and developments.

## 16. Investigation of Turbulence Parameters in a Karst Cave System in the Inner Bluegrass Region, Kentucky, USA

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Turbulence theory is well-developed in controlled lab settings, i.e. in flume research. This theory has been used in many applications but has not been satisfactorily applied to karst systems. The objective of this research is to apply laboratory results to velocimeter data taken from the Royal Springs karst basin in Lexington, KY. This watershed begins in central Lexington and flows northwest towards Scott County. Water passes through the Kentucky Horse Park in an estimated 8m x 1.4m conduit before daylighting as a spring in Georgetown.

KGS installed monitoring wells into this karst system, allowing probes to be inserted from the surface. This research used an Acoustic Doppler Velocimeter Profiler (ADVP), specifically the Nortek Vectrino Profiler. The ADVP was lowered into the well with a series of aluminum tubes attached to a wench, followed by a series of PVC pipes used to prevent rotation. QAQC was performed on velocimetry data using the MITT toolbox, an open-source software on MATLAB. Noise was found to be a major component of the velocity signals, so Proper Orthogonal Decomposition (POD) was used for denoising.

The results were expected to resemble pipe flow, i.e. flat flow near the center of the conduit with sharp changes near the boundary and a peak at the center. Initial results indicate a velocity profile with two distinct peaks, each about  $\frac{1}{4}$  of the way from the top/bottom of the conduit, with the lower peak being consistently larger than the upper. Reynold's stresses were expected to follow rough pipe flow, i.e. linear from a max at the boundaries to zero near the center. The velocimetry results show an S-shaped curve to the stress distribution, rather than the V-shaped curve that was expected. A major component of the research going forward will be analyzing spectral results, to see how well they fit the known laws. The current results show that flow patterns in the conduit do not match lab results. If the above-described velocity profile is accurate for much of the conduit system, models for flow through the system may need to take it into account. It is also possible that the results could be explained by boundary effects, which could be discovered by a rudimentary mapping of the cave.

Future research will involve investigation of the energy of the spectral regions under rough-bed pipe flow conditions. There are four spectral regions typically recognized: the 0, -1, -5/3, and -7/3 power regions. We hypothesize these regions would exist in the conduit due to the rough boundary conditions, with similar scaling to the "large" roughness elements found in our lab, which are cobbles on the scale of  $\sim 15$ cm. Video imagery of the cave bottom has shown roughness elements of at least this magnitude. Scaling of the spectral regions will be done in accordance with the work of Ghesemi and Fox, i.e. optimization applied to the slope of the spectra. We hope to connect the work done in the conduit to results obtained in the lab.

As a component of this research, we will be mentoring an undergraduate in the topical area, i.e. karst features, turbulence, and ADV data collection and QAQC. This student will help with data collection in the field and in the lab and will learn about data analysis techniques. These techniques are both general to turbulence research (spectrum analysis, velocity profiles, Reynolds stresses) and specific to ADV data (despiking, noise filtering). The hope is that the undergraduate could become a leader in this area in the future and would begin with a head start in future graduate research.

## 17. What's in the Air and Water? Understanding Per- and Polyfluoroalkyl Substances (PFAS) and Potential Vapor Intrusion Risks in Kentucky

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Per- and polyfluoroalkyl substances (PFAS) are a group of man-made chemicals that have raised significant environmental and public health concerns due to their persistence in the environment and the human body. PFAS have been widely used in industrial processes and can be found in various consumer products, and for years, PFAS have been subject to numerous uncontrolled environmental releases without formal federal regulations. While recent scientific and policy efforts have focused on reducing PFAS exposures via the drinking water pathway, PFAS exposures via the vapor intrusion (VI) pathway remain understudied. VI occurs when vapor-forming chemicals from subsurface sources (i.e., contaminated groundwater and soil plumes) migrate into indoor spaces. Given the diversity of PFAS, several of these chemicals meet the USEPA (US Environmental Protection Agency) threshold for VI contaminants of concern, indicating that PFAS can enter indoor environments through this pathway. A contributing factor to PFAS VI may be the uncertainty regarding the physicochemical properties relevant to modeling and site assessment.

This research addresses this uncertainty by examining Henry's constants and vapor pressures of 30 PFAS compounds. The study compiled 424 Henry's constant values and 563 vapor pressure values from multiple aggregate sources by developing a semi-automated data collection, integration, and curation tool that includes both manual and programmatic steps. Data collection involved a three-step approach: the manual collection of physicochemical properties, followed by semi-automated digital curation for cross-validation and expansion of the manual curation, and finally, manual inspection of the programmatic results. These steps revealed that approximately 80% of Henry's constant values and 34% of vapor pressure values for the included compounds exceeded USEPA VI criteria, suggesting the importance of VI as a PFAS exposure pathway. This study also highlighted the significant variability within the dataset, which can be categorized as compound-specific, PFAS subclass-specific, or method-specific (e.g., experimental or computational). Furthermore, this analysis utilized the data collected for these 30 compounds to examine areas in Kentucky that may be of concern for PFAS VI, based on historical contamination data, current industry landscapes (i.e., location and presumed PFAS use), and publicly available PFAS sample data.

## 18. Filtering the Future: Evaluating Constructed Wetlands in Rural Water Treatment

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Excess nitrogen, particularly in the form of nitrate, is a leading contaminant in surface water, primarily due to agricultural runoff. This issue is especially critical in rural areas of Kentucky, where 95% of the drinking water is sourced from surface water and conventional treatment infrastructure is often limited. This experiment investigates the effectiveness of constructed wetlands as a natural system for reducing nitrate concentrations. The experimental design consists of nine wetland mesocosms with 2-year-old plants (EST), 1-year-old plants (NEW), no plants (SED) and three open water controls (CTRL) at a mesocosm scale. Monitored water quality parameters include nitrate-N, dissolved oxygen, pH, temperature, conductivity, oxidation-reduction potential (ORP), and a range of anions. By day 7, EST wetlands achieved the highest nitrate removal, followed by NEW, then SED, with no reduction in CTRL. Greater efficiency in EST is attributed to the maturity of vegetation and more established microbial communities. These results contribute to the evidence supporting nature-based solutions for water quality improvement and highlight constructed wetland systems as a practical method to mitigate nitrate pollution in Kentucky and other rural areas.

## 19. Water Quality Modeling and Variability Among Nested Watersheds in Eastern Kentucky Data Deserts

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Many people in Eastern Kentucky rely on surface bodies of water for their drinking water supply. However, these bodies of water are affected by the surrounding land use and can leave nitrate-nitrite, sulfate, and *E. Coli* levels high in the water which causes illness and harm to human health when ingested. Therefore, this study is designed to improve data available around Kentucky where there is a lack of funding, analysis, and knowledge on contaminants found in surface waters. These areas are called “data deserts”. In these data deserts, the study aims to better understand how land use characteristics affect the contaminants found in surface water. To do this, the study aimed to 1) Identify data deserts in Kentucky that meet criteria and 2) Quantify contaminants and identify correlations between land use and water quality in these data deserts using t-tests and statistical inferencing following field sampling in two nested watersheds. We hypothesize to find more nitrate-nitrite in predominantly agriculture regions due to run off from animal waste and fertilizer application on crop pasture, *E. Coli* levels highest in developed urban areas due to fecal contamination from large populations of humans and pets in the area, and sulfate levels highest in mining regions caused by the weathering of sulfide minerals exposed during mining operations and acid mine drainage. Understanding these patterns can help areas in Eastern Kentucky implement best management practices to reduce the concentrations of these contaminants and prioritize human health in these regions.

## 20. Analyzing Factors of Harmful Algal Blooms in Old Lake: a Geospatial Study with Implications for Distilleries

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Harmful algae blooms (HABs) in lakes have ecological consequences and economic impacts on industries, such as distilleries, that rely on surface water sources. Excess nutrients, which can occur from runoff or released from sediment, can cause rapid algae growth. As the algae dies, it releases toxins and depletes oxygen in the water causing fish kills. The distillation process uses water from source lakes and HABs may cause the products to have an altered taste. Predicting HABs and implementing preventative actions could benefit lake ecosystems as well as industries that rely on source water lakes. This study investigated how geospatial factors contribute to the likelihood of HABs occurring in Old Lake. We hypothesize that the large watershed contributing to Old Lake and the proximity to highly developed areas likely increase the amount of nutrient runoff. Understanding geospatial relationships between HABs and the surrounding environment could allow for more accurate prediction and development of prevention strategies that would benefit both the ecosystem and distillery industries.

## 21. Restoration Without Reconstruction: Hydraulic Function in Urban Riparian Areas

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Streams in urban areas frequently experience erosion and downcutting due to high flow rates and volumes of water flowing from impervious surfaces. As a result, these urban streams experience downstream nutrient loss, temperatures that are uninhabitable, and high flow volumes and peak flows. Stream restoration is a practice which has objectives of restoring some or all of these functions of streams; however, it requires significant design, construction, and cost. While this is sometimes necessary, simply reforesting the riparian area, the vegetated buffer adjacent to the stream, may provide the same benefits at a lower environmental and financial cost. Thus, stakeholders such as local governments, environmental agencies, and municipalities could save time, money, and effort by replacing stream restoration with a lower impact option - reforesting and replanting the riparian area. This project compares the hydrologic function of reforested and restored riparian areas, as well as the connecting mowed green space. The physical and hydrologic properties of soil, as well as stream hydraulic and nutrient dynamics are being examined to assess the effectiveness of reforested riparian areas in enhancing ecosystem function. Currently, SATURO dual-head infiltrometers are being utilized to collect infiltration rate data at 9 restored streams, 9 reforested streams, and corresponding adjacent lawn spaces across Lexington, Kentucky. The overall goal of this project is to assess the potential hydrologic improvement of reforested riparian areas compared to mowed green space, unrestored riparian area, and intensively restored streams. This project will focus on two primary objectives: 1) Investigate how reforested riparian areas function hydrologically to adjacent green space, non-reforested/restored riparian areas, and more intensively restored stream riparian areas; and 2) Determine the impact of reforested riparian areas on stream function (quality and quantity).

## 22. Modeling Subsurface Sediment Transport Through Macropores in Heterogeneous Fine-textured Soils: Importance of Preferential Flow Dynamics and Macropore Connectivity

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Subsurface sediment transport of fine sediments is an important source of particulate bound nutrients in both karst and tile drained agroecosystems where preferential flow through macropores and sinkholes are a significant contributor to water budgets. A physically based modeling framework is presented to simulate preferential flow and subsurface sediment transport through macropores in landscapes with fine-textured soils. The model is developed to support field to watershed scale applications evaluating erosion and deposition dynamics. This study leverages a previously published database of a rainfall simulation study conducted on ten in-tact soil lysimeters. Eleven simulations were performed, each producing fixed rainfall volumes at varying intensities, and antecedent moisture conditions (Williams et al., 2023). Leachate was collected in approximately 250 mL increments from each lysimeter and were analyzed for a suite of hydrologic and water quality properties including discharge, stable water isotopes, specific conductance, sediment concentration, and sediment particle size distribution. Following rainfall simulations, a dye injection was applied at the surface, and images were collected at 5cm intervals using a destructive method.

The primary objectives of this research are to: (1) quantify the variability in preferential flow paths using dye tracing and image analysis (DTIA) method; (2) develop and apply a black-box model to assess how preferential flow variability influences detachment/filtration of sediments transported through macropores, and (3) develop a vertically distributed hydrologic model (e.g., HYDRUS) and couple with a vertically distributed sediment model in order to improve predictions of hydrologic connectivity on subsurface sediment leachate.

Regarding objective 1, dye tracer images obtained from lysimeters at 5 cm depth intervals were analyzed using GNU Image Manipulation Program (GIMP) to quantify macropore area. Results showed a decreasing trend in macropore area with increasing soil depth, ranging from approximately 40–60% in the surface layer (0–5 cm) to less than 10% beyond 10 cm. The vertical profiles of the photographs indicated that macropores were primarily continuous throughout the 0–10 cm depth range, while they became increasingly disconnected at greater depths. These findings highlight the importance of surface-connected macropores in tile-drained landscapes for increasing subsurface sediment transport and fostering preferential flow.

Regarding objective 2, a model presented in Majdalani et al. (2007) was adapted to simulate sediment transport using a black-box approach. Model calibration indicated that sediment detachment and attachment coefficients significantly influence peak sediment leachate. Simulated sediment fluxes showed general agreement in magnitude with observed values. Preliminary model calibration for a lysimeter with the greatest sediment loading yielded Nash-Sutcliffe Efficiency (NSE) values ranging from 0.3 to 0.4 and the coefficient of determination ( $R^2$ ) also between 0.3 and 0.4, indicating moderate predictive capability.

The ongoing work to improve the model (Objective 3) is focused on incorporating spatial variability in connected preferential flow dynamics and macropores (Objective 1) with a vertically discretized version of the sediment transport model.

## 23. Reforested Stormwater Basins: A help or a hindrance to stormwater management in Lexington, KY?\*

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Stormwater basins are perhaps one of the most important components of the typical urban stormwater management infrastructure. Normally, stormwater detention basins are constructed as regularly mowed sites with no intention for development of complex plant communities and little to no focus on the potential role plant communities could play in stormwater management services. However, increasing ecological awareness in urban planning has led to a desire for greener infrastructure. Retrofitting stormwater basins as “pocket forests” by planting trees and adjusting maintenance operations presents a potential greening opportunity. In addition to providing urban forest benefits such as temperature reduction, biodiversity, wildlife habitat, and carbon sequestration, establishing forest patches in stormwater basins may provide stormwater management benefits through increasing infiltration and evapotranspiration. Conversely, these forests may increase maintenance costs by producing leaf litter and clogging outflows, and growing trees may take up basin volume needed for stormwater management. This project was initiated to evaluate whether forest establishment in stormwater basins presents a net benefit or net cost for stormwater management by considering effects of forest establishment on 1) infiltration, 2) effective treatment volume, 3) maintenance costs, and 4) water table depth. To test this, five forested and five control basins were selected based on detention capacity and volume. Within these basins, groundwater wells were installed and equipped with Level Loggers to collect data on water depth, SATUROs were used to test infiltration rates, tree biomass was assessed, maintenance costs were estimated, and basin volume was determined through surveying. Analysis is ongoing, but we anticipate that results from this study will clarify whether planting trees in stormwater basins is likely beneficial or problematic for stormwater management. We also anticipate that these results will highlight key questions remaining unanswered, such as the role of basin vegetation on nutrient and sediment retention.

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## 24. Storm Event Nitrate Source Tracking Using $\delta^{15}\text{N}$ and $\delta^{18}\text{O}$ at Edge-of-Field Water Quality Monitoring Stations in Western Kentucky\*

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Storm-driven nitrate transport poses a growing challenge for water quality management, particularly in regions vulnerable to extreme weather events such as flooding and heavy storms. Elevated nitrate levels in surface waters can contribute to eutrophication, harmful algal blooms, and public health risks. In agricultural regions such as western Kentucky, intense rainfall can quickly mobilize surface-applied fertilizers. In addition to economic losses to agricultural producers, nutrient runoff can lead to seasonal nitrate enrichment of local waterways. Given the region's agricultural land use, understanding nitrate loading to local waterways is critical for building agricultural resilience, protecting drinking water supplies, and maintaining ecosystem health.

This project aims to identify the sources of nitrate entering surface waters during storm events in a highly managed agricultural landscape. Isotopic fingerprinting using  $\delta^{15}\text{N}$  and  $\delta^{18}\text{O}$  in nitrate is a powerful tool for distinguishing among potential nitrate sources in the environment. Synthetic fertilizers, animal manure, soil organic nitrogen, and atmospheric deposition each exhibit characteristic isotopic signatures. By analyzing these stable isotope ratios in storm runoff samples, it is possible to infer the dominant sources of nitrate contributing to surface waters at different stages of a storm event. This method allows for greater resolution of source dynamics than concentration data alone, providing insight into how land use, hydrologic flow paths, and timing influence nitrate transport.

This study will be conducted at three existing, long-term University of Kentucky Blue Water Farms edge of field monitoring network stations in the lower Green River watershed. Monitored watersheds are in a no-till corn and soybean field where nutrient and sediment losses have been monitored since 2018. The stations are instrumented with flumes, ultrasonic sensors, and automated ISCO samplers to monitor storm runoff and nutrient export under realistic land management conditions. Nutrient applications at these monitored watersheds this growing season which are representative of cropping systems in the Lower Green River watershed, include a poultry litter application prior to spring corn planting and a side-dress nitrogen application in early corn growth stages.

We implemented a flow-triggered, discrete sampling strategy using ISCO autosamplers at three flume stations along the agricultural field. Each autosampler (ISCO 6712) was programmed to initiate sampling once discharge exceeded 1,000 gallons at which time 500 mL samples will be collected in separate bottles. This approach provides flow-weighted, time-resolved data across the storm hydrograph, enabling isotopic analysis of nitrate ( $\delta^{15}\text{N}$  and  $\delta^{18}\text{O}$ ) to detect temporal shifts in source contributions and transport mechanisms throughout the event. We anticipate collecting storm runoff from a late summer or early fall precipitation event prior to a late October or early November corn harvest.

We expect that nitrate concentrations and isotopic signatures will vary throughout an individual storm event, reflecting changing hydrologic pathways.

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## 25. The Role Soil Spatial Complexity and Resource Patterning Play in Greenhouse Gas Emissions from Mineral Soil Wetlands\*

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Wetland soils have been shown to be spatially complex environments at small spatial scales (e.g., meter to sub-meter). However, very little is known about whether generalizable patterns of spatial complexity exist across all wetland types and how the spatial complexity and patterning of resources alter net microbial functions, such as the production and consumption of greenhouse gases (GHGs). We are currently (1) investigating spatial variation in GHG fluxes (i.e., carbon dioxide - CO<sub>2</sub>, methane - CH<sub>4</sub>, and nitrous oxide - N<sub>2</sub>O) from hydric mineral soils during simulated flooding events; (2) testing whether the spatial patterning of carbon resources and microtopography predictably alter N<sub>2</sub>O emissions during flooding; and (3) testing whether spatial patterning of carbon resources predictably alter CH<sub>4</sub> emissions via diffusion and ebullition during hydric soil inundation. In a preliminary study (n = 3 cores per environment) we found that GHG fluxes appear higher in bottomland hardwood floodplain soils compared to bottomland slough sediments. Further, N<sub>2</sub>O fluxes, which peaked within the first few hours after flooding, were more spatially variable in our bottomland hardwood floodplain (mean ± s.d. = 12,981 ± 15,221 μmol N<sub>2</sub>O m<sup>-2</sup> integrated across 10 hours) compared to our slough environment (3,437 ± 1,357 μmol N<sub>2</sub>O m<sup>-2</sup> integrated across 10 hours). To gain a more robust sample, we are collecting GHG flux measurements from 30 soil cores incubated with nitrate enriched flood waters for 24 hours. Cores are being collected using a spatially explicit sampling design from a small-scale plot (10 x 10 m) of our bottomland hardwood floodplain. Further, to explore the N<sub>2</sub>O dynamics more specifically, we are building mesocosms (1.8 m<sup>2</sup>) that isolate microtopographic and resource patch distribution to capture N<sub>2</sub>O flux dynamics. In a previous mesocosm study (n = 4 per treatment), we found significant differences in CH<sub>4</sub> emissions from the diffusive flux pathway between clumped and uniformly distributed carbon resource patches across a 6-month incubation period. However, CH<sub>4</sub> ebullition, an important pathway of CH<sub>4</sub> release, was not quantified during these measurements. As such, we will be comparing CH<sub>4</sub> emissions via diffusion and ebullition in new incubation trials. To capture ebullition, we will use image processing techniques coupled with an empirical model that relates bubble size (or surface area) and CH<sub>4</sub> concentration. Collectively, this work will shed light on the importance of soil spatial complexity and resource patterning in shaping bottomland hardwood forests and their role in GHG flux dynamics.

*\*This presentation is based upon work supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G21AP10631-03, WRRRA 104B Annual Grant Program*

## 26. Analysis of Soil Quality Dynamics Under No-Till and Conventional Tillage Practices

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The study aimed to assess the short-term effects of no-till and conventional tillage practices on soil physical properties, highlighting implications for water retention and runoff which are critical to water resources management. A total of 24 soil samples, both disturbed and undisturbed, were collected using a systematic sampling technique at Pullen Farm across three gardens (Mable Garden, Cut Flower Garden, and Community Garden) and three crop fields (Corn, Soybean, and Corn Maize). The outcome variables were soil health indicators. Bulk density (BD), porosity, and soil water-holding capacity were determined by oven-drying the soil samples, while soil pH was measured after dissolving the soil in distilled water for 30 minutes. The data were entered into and analyzed using MS Excel version 2016. Out of the six fields, soil organic matter (SOM) was highest (24.34%) in the Cut Flower Garden and lowest (5.5%) in the Corn field. Similarly, bulk density was highest (1.47g/cm<sup>3</sup>) in the Corn field and lowest (1.33g/cm<sup>3</sup>) in the Cut Flower Garden. Likewise, Mable Garden had the highest porosity (52.58%), while the Corn field had only 44.44%. Regarding pH, the Cut Flower and Community Gardens had a pH of 6.3, while the Corn field had a pH of 5.4. Soil water-holding capacity was highest (37.41%) in the Corn Maize field and lowest (17.84%) in the Community Garden. The study highlighted that no-till practices in gardens resulted in better soil health indicators, such as lower BD, higher SOM, and higher porosity, improving water infiltration and reducing potential runoff, while conventional tillage in crop fields led to poorer soil quality. These findings demonstrate the significant impact of tillage practices on soil physical properties and their role in sustainable soil and water resource management.

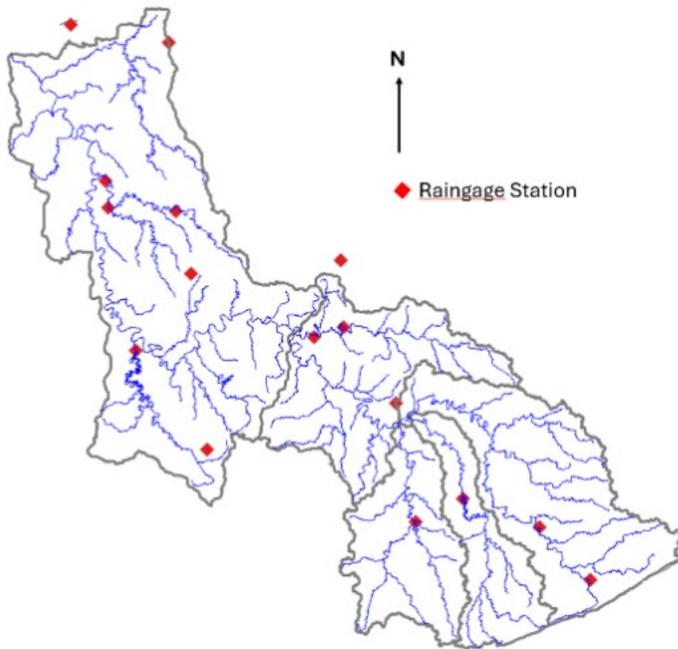
## 27. Examining Long Term Trends of Precipitation-Based Climate Indices for Kentucky River Basin

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Long term trends of precipitation provide valuable insights for a watershed management plan and helps in optimal resource utilization. This research was conducted in the Kentucky River basin, which is a tributary to Ohio River System. This river flows in a southeast to northwest direction through central Kentucky. The Kentucky River watershed drains 31 counties (fully or partially) and includes cities such as Lexington, Richmond and Frankfort, KY.

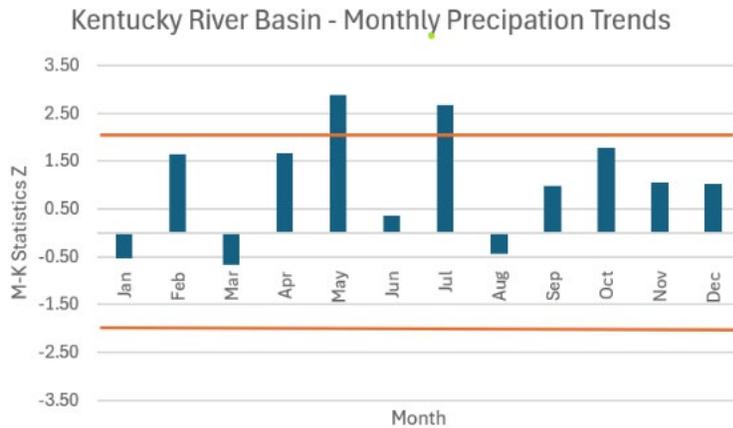


**Figure 1. Kentucky River Watershed (HUC: 051002) with Rain Gages Considered**

Daily data from 17 rain gauge stations (Figure 1) from January, 1900, to April, 2025, were considered for this analysis (Data source: SWAT meteorological database based on NOAA Climatic Data Center as well as iClimate website maintained by Purdue University). Even though the analyses were done on monthly scale, daily data were used for calculating the precipitation based climate indices such as Monthly rainfall, maximum one day precipitation (RX1), maximum five day precipitation (RX5), days with rainfall more than 10 mm (R10), days with more than 20 mm (R20), consecutive dry days (CDD), Consecutive wet days (CWD) and similar indices (Pongrácz et al, 2009).

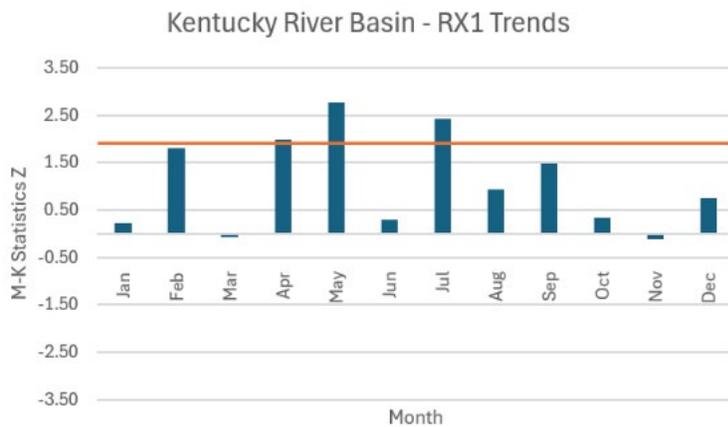
During initial data preparation missing daily rainfall data for different rain gauges were interpreted using correlation-based method recommended by Teegavarappu and Chandramouli (2005). After that, the mean areal precipitation for the entire watershed was estimated using traditional Thiessen Polygon Method for finding zone of influence of each station ([https://www.weather.gov/abr/c/map#thiessen\\_polygon](https://www.weather.gov/abr/c/map#thiessen_polygon)). After finding daily mean aerial precipitation, climate indices were calculated for performing the monthly trend analysis.

Trend analysis was conducted using the non-parametric Mann-Kendall Test method (Sanjeev Kumar et al (2009), Lettenmaier et al., 1994). For the monthly sum, statistically significant trends were observed in two months (May and July) at 95% confidence level (Figure 2). No other months displayed statistically significant trends over the 125-year study period even though many of them showed positive trends.



**Figure 2. MK Test Results for Monthly Precipitation (Years: 1900 to 2025)**

RX1 trends showed significant increase in three months (April, May and July) (Figure 3). Interestingly, except two months, all other months showed increasing trends and similar observations were made with other climate indices.



**Figure 3. RX1 Monthly Trends (Years: 1900 to 2015)**

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## **28. Preliminary Investigation on Stream Flow Variations in the Black Canyon Complex, Roppel Section of the Mammoth Cave System**

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Scallops are asymmetrical, scoop-like indentations with a steep slope on the upstream side and a gentler slope on the downstream side, bound by crests that are also angled in the downstream direction. These features can vary greatly from the millimeter to the decameter in scale. Work done by Rane L. Curl in 1974 showed that these features were not only directional but could be used to calculate flow velocity. Scallops were measured throughout the Black Canyon passage and surrounding area named the Black Canyon Complex in the Roppel section of Mammoth Cave System. Here, scallops vary in size but show multiple flow regime velocities. Furthermore, the localized stratigraphy of the passage also seems to be a controlling factor. Measurements were taken of both base and high flow stage scallops and input into the program ScallopEx (Woodward and Sasowsky, 2009) with the following parameters: scallop length, temperature, and average passage width. Our analysis yielded four different velocity calculations representing high flow and base flow from measurements taken in an upper and lower bed. Preliminary observations reveal multiple regimes that formed the Black Canyon passage that appear to be partially stratigraphically controlled with some perching layers. Scallop velocity data coupled with discharge estimates of the passages in relation to one another suggest that a preliminary conclusion of this study is that this area is evidence of drainage via to the north, towards Pike Spring, and is indicative of a shift from southward drainage towards Turnhole Bend Spring.

## 29. Effects of Organic and Inorganic Fertilizers on Soil Properties and Tomato Yield

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The overuse of inorganic fertilizers in intensive agriculture can impact soil health by altering structure, organic matter, and biological activity. Organic fertilizers offer an alternative, but their effects on soil physical and hydraulic properties and crop yield, especially in tomato (*Solanum lycopersicum* L.) systems, remain unclear. Therefore, a field experiment was conducted in Bowling Green, KY to evaluate the effects of organic and inorganic fertilizer application on soil physical, chemical and hydraulic properties, and tomato yield. Study treatments included organic fertilizer application (OF), inorganic fertilizer application (IF), and a control (CK) with neither organic nor inorganic fertilizer application, established in a randomized complete block design with three replications. Preliminary findings showed that both OF and IF treatments increased average soil nitrogen levels ( $p=0.004$ ), with no major differences in crop yield or bulk density compared to the CK treatment. Saturated hydraulic conductivity varied substantially among the treatments; however, the results were not statistically significant. The preliminary results indicated that fertilizer type affected soil parameters differently and underscore the importance of long-term research to understand how fertilizer inputs influence both productivity and soil sustainability.

### 30. Rapid and Field-Ready System for Fecal Matter Contamination Detection in Water Resources

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The unmet need for technologies that detect fecal contamination in water sources is significant, driven by the global challenge of waterborne diseases and the increasing demand for safe drinking water. Water contaminated with fecal matter can introduce harmful pathogens such as *E. coli*, cholera, and typhoid, leading to illness or even death, particularly in developing regions where access to clean water and sanitation infrastructure is limited. Traditional methods for detecting fecal contamination in water, such as culturing techniques (e.g., testing for coliform bacteria), are often time-consuming, require trained personnel, and may not provide real-time results. These delays can exacerbate health risks, especially in emergencies or in regions lacking infrastructure. Therefore, a rapid, automated, and accessible testing unit that can replace current protocols is highly desirable.

This work offers a rapid, inexpensive, and easy-to-use nucleic acid extraction and identification platform to detect pathogenic organisms in environmental samples such as surface and groundwater, and wastewater. Our system utilizes Immiscible Filtration Assisted by Surface Tension (IFAST) and magnetic beads to isolate nucleic acids (NAs). Then, loop-mediated isothermal amplification (LAMP) is employed to amplify *E. coli* and CrAssphage NAs as biomarkers for fecal contamination. This portable system allows for on-site and real-time testing, with an estimated sample-to-answer time of approximately 40 minutes. While this technology was originally developed for public health disease monitoring via wastewater testing, it can also serve as a powerful tool for detecting harmful fecal contamination in drinking water sources.