



**USGS 104(b) Grant Program:
Kentucky's FY 2018 Projects**

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Prepared by:

- Emily Koyagi, Research Analyst, Kentucky Water Resources Research Institute, University of Kentucky, Lexington, Kentucky, Emily.Koyagi@uky.edu.
- Steve Evans, Assistant Director, Kentucky Water Resources Research Institute, University of Kentucky, Lexington, Kentucky, Steve.Evans@uky.edu.
- Lindell Ormsbee, Director, Kentucky Water Resources Research Institute, University of Kentucky, Lexington, Kentucky, Lindell.Ormsbee@uky.edu.

Authors' Note:

The Kentucky Water Resources Research Institute (KWRRRI) is one of 54 federally authorized water resource institutes or centers throughout the United States and its territories. It operates under the authority of the Water Resources Research Act of 1964 (P.L. 88-379 codified at 42 U.S.C. 10301 et seq.) through the Water Resources Research Institutes Program administered by the United States Geological Survey (USGS). KWRRRI's annual base grant program under section 104(b) supports the following objectives specified in the Water Resources Research Act:

1. Plan, conduct, or otherwise arrange for competent applied and peer reviewed research that fosters:
 - a. improvements in water supply reliability;
 - b. the exploration of new ideas that address water problems and/or expand understanding of water and water-related phenomena;
 - c. the entry of new research scientists into water resources fields; and
 - d. the dissemination of research results to water managers and the public.
2. Cooperate closely with other colleges and universities from the State that have demonstrated capabilities for research, information dissemination, and graduate training in order to develop a statewide program designated to resolve State and regional water and related land problems.
3. Cooperate closely with other institutes and other organizations in the region to increase the effectiveness of the institutes and for the purpose of promoting regional coordination.

Each year, proposals are submitted to further these objectives and promote the national mission and objectives of the USGS, which are focused on providing water quality and quantity information, understanding water availability, addressing the influence of climate on water resources, and responding to water-related emerging needs. This report summarizes the projects funded in FY 2018 through the section 104(b) annual base grant program.

The findings and conclusions in this document are those of the authors and do not necessarily represent the views of the University of Kentucky, the Kentucky Water Resources Research Institute, or the United States Geological Survey.

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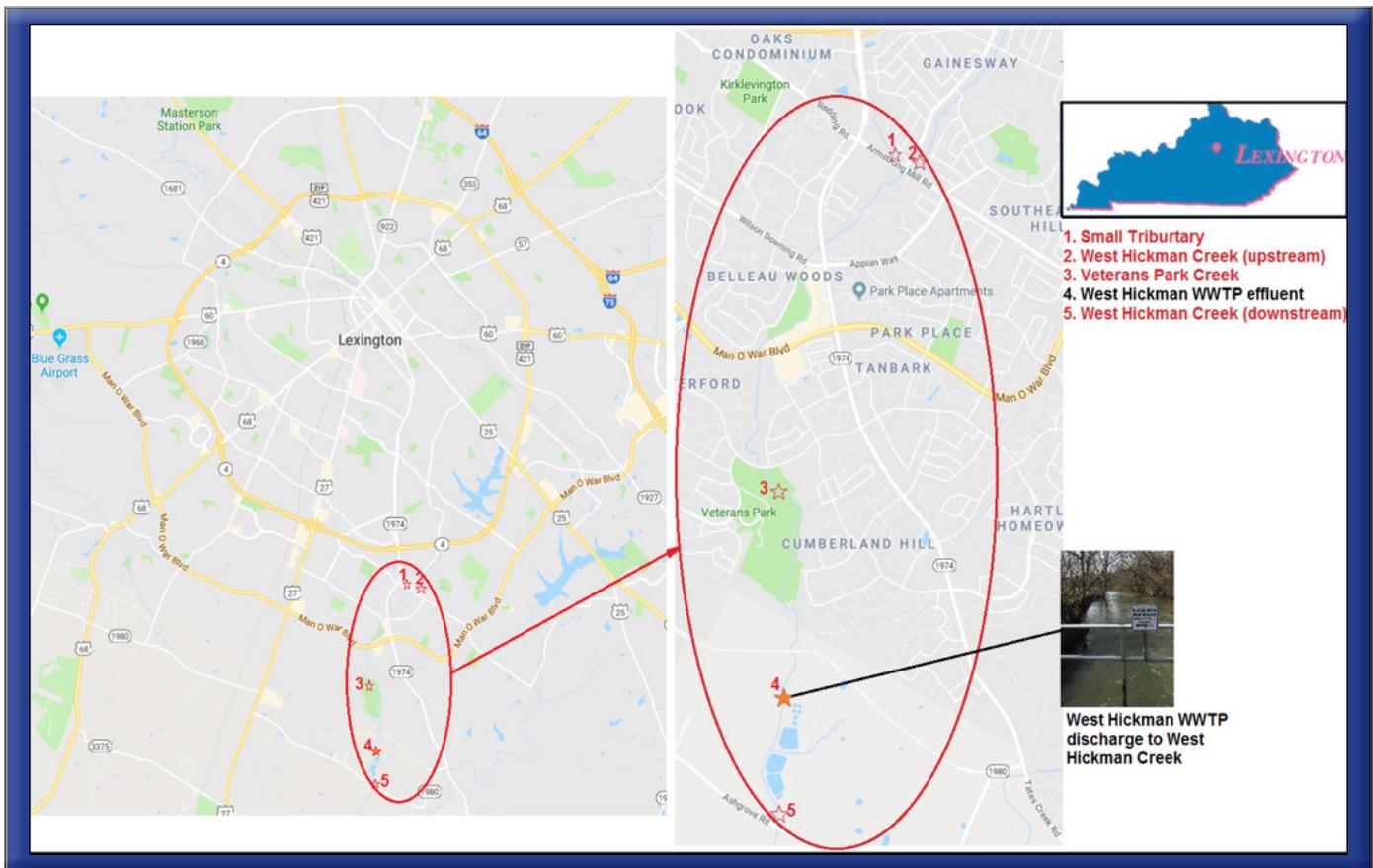
Assessment of MRSA Presence in Suburban WWTPs Effluent in Lexington, Kentucky

PI: Dr. Gail Brion, College of Engineering, University of Kentucky.

Co-PI: Atena Amirsoleimani, PhD Student, College of Engineering, University of Kentucky.

The incidence of infections caused by methicillin-resistant *Staphylococcus aureus* (MRSA) in healthy individuals exposed outside of clinical settings has been increasing at alarming rates globally, but limited studies have focused on environmentally related MRSA infections, their sources, reservoirs, and transmission routes. This research study assessed the prevalence and typing of isolates of MRSA and methicillin-susceptible *Staphylococcus aureus* (MSSA) in wastewater effluent and stream sediment in West Hickman Creek in Lexington, Kentucky.

The chlorinated effluent from the West Hickman WWTP was sampled seven times over six months. Both MRSA and MSSA were negative in all samples showing effective removal from plant discharges. Stream sediment was sampled at four locations: three locations upstream of the WWTP on tributaries in suburban areas, including Veterans Park and one location downstream of the WWTP in a rural area. Both MRSA and MSSA isolates were frequently detected in all locations. MSSA and MRSA were more prevalent in sediments upstream of the WWTP. The characteristic odor of raw sewage was detected during multiple sampling events, indicating untreated sewage as the primary source of both MRSA and MSSA. Presence of MRSA at Veterans Park, irrespective of weather conditions, is suggestive that sediment may serve as a bacteria reservoir. The ratio between MRSA and MSSA populations was 7:1 regardless of location, suggesting sediment assisted survival of attached bacteria and transport downstream via stream flow. Whole genomic sequencing and identification of a subset of the presumptive *S. aureus* isolates found during the study confirmed that MRSA and MSSA were found in the sediments from Veterans Park, above the WWTP, but not in plant effluent or in the sediments below the WWTP.



Map showing the four locations where stream sediment was sampled. Three locations were upstream of the WWTP on tributaries in suburban areas and one location was downstream of the WWTP in a rural area. (Source: Dr. Gail Brion)

Evaluation of Untreated Karst Groundwater as Community Water Sources, Barren and Monroe Counties, Kentucky

PI: Dr. Chris Groves, Crawford Hydrology Lab, Western Kentucky University.

Co-PIs: Cayla Baughn, MS Student, Lee Anne Bledsoe and Autumn Singer, Crawford Hydrology Lab.

Residents of Amish, Mennonite, and Quaker communities in several southcentral Kentucky counties rely on karst springs and cave water with limited, individual treatment strategies, and in some cases, none. This study sought to assess the risks, evaluate solutions, and develop relationships to understand lifestyle choices associated with water supply sources in these communities.

Four locations in Barren and Monroe counties were sampled monthly for a year, including a family of nine's two raw water sources (spring house and box) and home faucet treated by reverse osmosis and an untreated karst spring formerly used by a family of 10. Sampling included total coliforms, E. coli, turbidity, nitrate, and ammonia as well as field measurements. All untreated water was positive for total coliforms (436 to > 2,420 colonies / 100 mL) and E. coli (2 to 920 colonies/ 100 mL), indicating every sample of non-treated water was polluted and had high gastrointestinal health risk. Nitrate did not exceed MCLs in any samples. The reverse osmosis system performed well with no E. coli detected, two single-digit total coliform samples, and one high total coliform associated with a filter overdue for changing.

Similar results were found in another nearby community where several homes and a church were supplied by a karst spring and treated by in-home filter systems. Future work is expanding to an Allen County Mennonite family who does not use electricity that recently contracted Hepatitis A from an untreated spring. Creative solutions and educational approaches are continuing to be evaluated.



Mr. Daniel Showalter assists graduate student Cayla Baughn in sampling at the family's water supply spring. (Photo credit: Chris Groves)

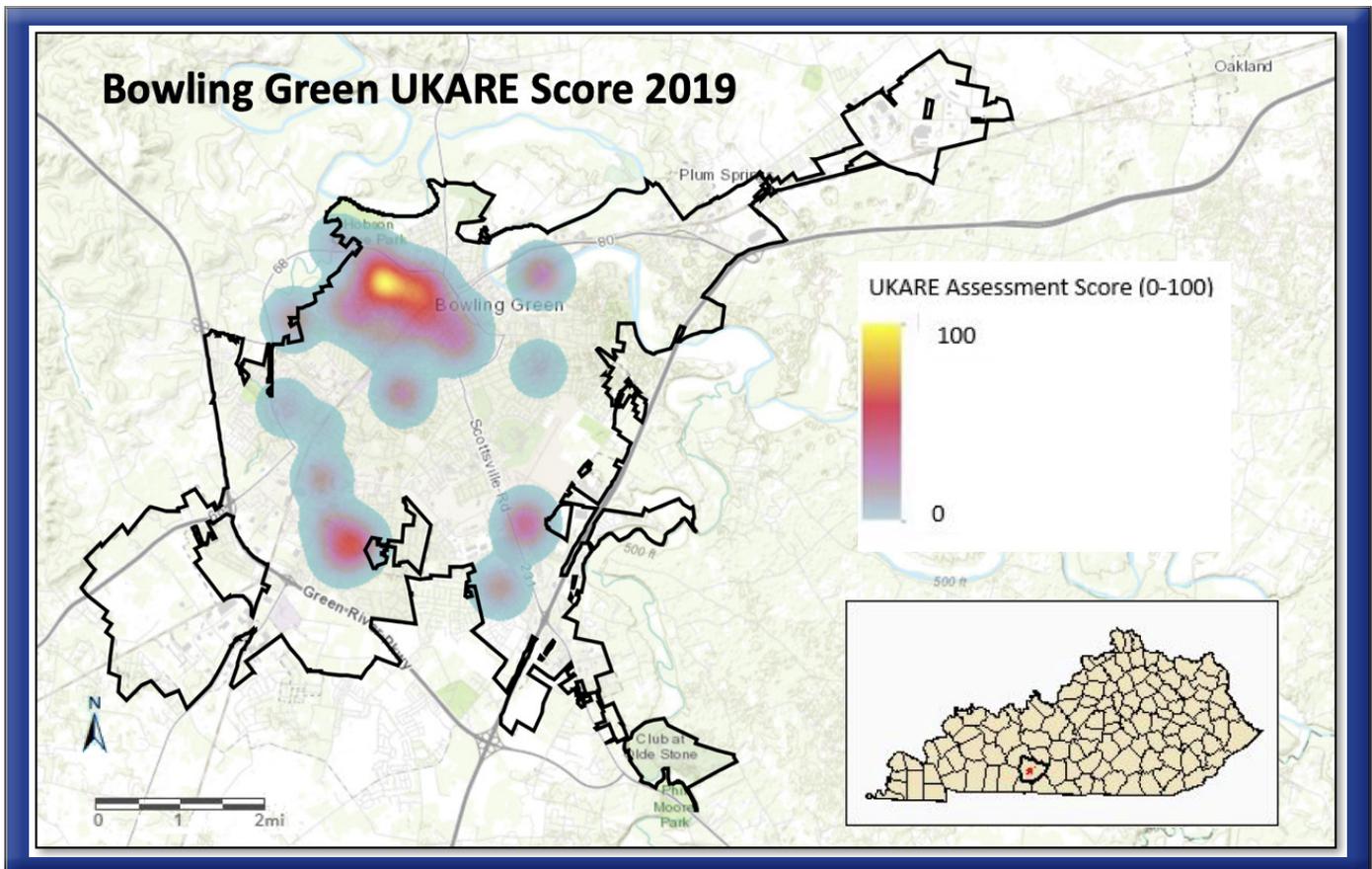
Developing A Threat Assessment and Monitoring Framework for Urban Karst Groundwater Management

PI: Dr. Jason Polk, Department of Geography and Geology, Western Kentucky University.
 Co-PI: Rachel Kaiser, MS Student, Department of Geography and Geology, Western Kentucky University.

The Urban Karst Aquifer Resource Evaluation toolbox (UKARE), developed under this study, is a universal and user-friendly tool for any urban karst systems that can be utilized to determine the most 1) vulnerable, 2) threatened, and 3) suitable locations for monitoring urban karst groundwater and what should be monitored to protect groundwater quality. Preexisting indices were evaluated and developed into toolboxes for threats (24 tools), vulnerability (9 tools), and monitoring (18 tools). The UKARE was then validated using data collected weekly from 10 karst sampling sites in Bowling Green, Kentucky for almost a year. Sites (5 prioritized and 5 controls for model validation) were chosen from 55 potential locations by applying the UKARE to a compiled karst inventory geodatabase.

Monitoring validated the prioritization of UKARE scoring, with more frequent exceedances of health criteria for arsenic and lead among other parameters in higher risk drinking water source areas. Lead, antimony, selenium, iron, thallium, nitrate, and E. coli were seen throughout the entire aquifer indicating a need for management throughout the area. All sampling sites also routinely tested positive for bacteria resistant to ESBLs (serious threat), KPC (urgent threat due to resistance to nearly all antibiotics), and to generic antibiotic strengths. The bacteria resistance indicates a need to regulate the disposal of personal care products and pharmaceuticals and improve sewage infrastructure.

The UKARE toolbox, along with this study, provide guidelines and a starting point for the development of urban karst groundwater management plans and collection of primary data for effective groundwater management.



2019 UKARE Results for Bowling Green Application. (Source: Rachel Kaiser)

Water and Solute Movement in a Fragipan Soil as Modified by Ryegrass

PI: Dr. Christopher Matocha, Department of Plant and Soil Sciences, University of Kentucky.
Co-PI: Keegan Smith, MS Student, Department of Plant and Soil Sciences, University of Kentucky.

Fragipan horizons are cement-like layers in soils common in western Kentucky which can affect crop yields due to limitations on the vertical movement of water and nutrients. This study investigated whether a ryegrass cover crop may promote the breakdown of fragipan horizons through root exudates in combination with root drilling.

Twelve fragipan soil cores were collected from Princeton, KY. Three were kept as controls, and nine were seeded with three annual ryegrass varieties.. The soil water solution was extracted from ports above and below the fragipan horizon throughout the eight-week growing period and analyzed for silica, aluminum, iron (implicated in cementing the fragipan) as well as water soluble organic carbon (WSOC) extracts. Non-invasive X-ray computerized tomography (CT) scanning in combination with pseudocolored, multimasked volume renderings were used to visualize whether annual ryegrass roots breakdown the fragipan horizon.

Dissolved Fe(II) concentrations in planted cores were greater during certain periods than the control cores at the top rhizon, suggesting the possible involvement of iron in dissolution. The role of silica and aluminum are still being evaluated. Liquid-chromatography mass spectra showed a peak which appeared in the planted core, which is being further investigated as a root extrudate that may assist in solubilizing fragipan material. CT renderings are being analyzed to determine if new ryegrass roots are penetrating the fragipan. Results demonstrating annual ryegrass's success in the breakdown of the fragipan were shared with over 150 farmers during the 2018 Fragipan Field Day.



Soil cores were collected from a site in Princeton, KY, and after being fertilized, were seeded with annual ryegrass. All cores were wrapped in Reflectix insulated bubble wrap to prevent unrealistic soil warming and algae growth. (Photo Credit: Dr. Christopher Matocha)

Phosphorus Contributions to Urban Runoff from Non-Anthropogenic Animal Waste

PI: Dr. Brad Lee, Department of Plant and Soil Sciences, University of Kentucky.

Co-PIs: Dr. Dwayne Edwards, Department of Biological and Agricultural Engineering, and Dr. Gregg Munshaw, Department of Plant and Soil Sciences, University of Kentucky.

Phosphorus (P) is a key contributor to water quality impairments such as algal blooms, and animal waste is a significant source. In Kentucky, the dog population is approximately one-third of the size of the human population, however, few studies have examined the quantity of P in domestic canine manure and potential runoff from turfgrass with manure.

To quantify the nutrient content in canine manure, 1,005 dog manure samples were collected from dog parks and apartment complexes within urbanized areas of the Bluegrass physiographic region. Each sample was dried at 50 degrees C for 48 hours, ground, and analyzed for total P and total N. The percentage dry mass of these samples was found to be $3.89 \pm 0.76\%$ (SD) total P and $3.14 \pm 1.00\%$ total N.

To quantify the runoff concentration, 24 plots were installed at the University of Kentucky Spindletop Farm to simulate rainfall according to the SERA-17 protocols. However, runoff could not be generated without exceeding the 500-year storm event rainfall. Therefore, the rainfall simulator was moved indoors. The runoff simulations will be completed in 2019.

Soils with low phosphorus content were collected, dried, ground and packed into shallow (15 cm deep) 1 m^2 boxes. Turfgrass will be grown on top of boxes after which dog manure will be applied and rainfall simulations will commence. Total N, nitrate-N, Total P and Ortho-P will be analyzed in the runoff. This process will be repeated and compared to another soil from the Bluegrass area with a high P content.



(L) Preliminary test of the rainfall simulator on soil box with straw cover. (Photo Credit: Dr. Brad Lee)

(R) Once turfgrass has been grown on top of the boxes, dog manure will be applied and rainfall simulations will begin.

Modeling Impacts of Seasonal Land Cover Change on Fluvial Sediment Loads of the Upper Floyds Fork Watershed, Kentucky

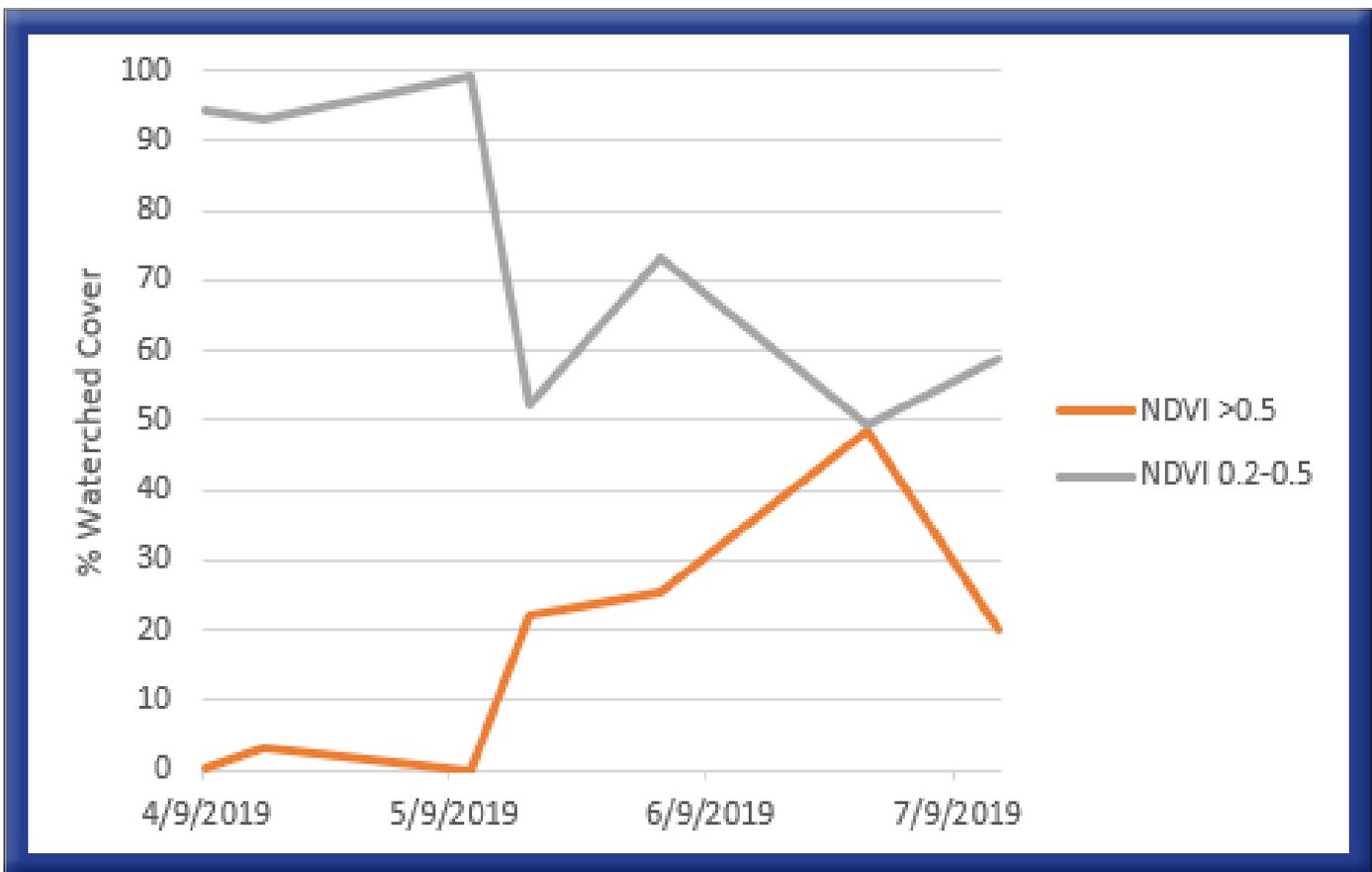
PI: Dr. Andrew Day, Department of Geography and Geosciences, University of Louisville.

Co-PIs: Aimee Downs, USGS, and Jonah Liebman, Department of Geography and Geosciences, University of Louisville.

To improve source prioritization for sedimentation, one of the leading causes of water pollution in Kentucky, continuous turbidity measurements were correlated using linear regression to suspended sediment concentration (SSC) samples collected over a range of flow conditions from the Upper Floyds Fork in Pewee Valley, Kentucky. This correlation, still being refined as data collection continues, provides an estimate of annual sediment volumes leaving the watershed.

Once data collection is completed, the linear regression model will be validated and then input into an ArcSWAT GIS-model. An extensive database of surface physical characteristics (including 10-meter resolution elevation, slope and soil data) and daily hydro-meteorological variables has been compiled to support the model. To identify potential sediment sources from seasonal land cover changes, a 14-day normalized difference vegetation index (NDVI) and supervised classification procedure were applied to 30-meter resolution Landsat imagery from the USGS. Current results clearly show vegetation cover increasing in the spring season before dropping off in summer as a function of crop harvesting and drier conditions. The Kentucky Pollutant Discharge Elimination System was queried to identify construction sites as potential non-seasonal sediment point sources.

Data collection will continue in the fall of 2019. The ArcSWAT will then be utilized to identify possible sites of sediment pollution due to seasonal land cover changes throughout the year. This information will help target land management practices to limit pollution from these sources in the future.



Normalized Difference Vegetation Index (NDVI) coverage for Upper Floyds Fork Watershed. (Source: Dr. Andrew Day)

Kentucky Water Resources Research Institute’s Information Transfer Project

PI: Dr. Lindell Ormsbee, Kentucky Water Resources Research Institute, University of Kentucky.

Each year, a portion of the 104b grant funds are used to support Kentucky Water Resources Research Institute’s information transfer activities. In 2018, KWRRI launched a new website, <https://www.research.uky.edu/kentucky-water-resources-research-institute>, to better meet the needs of its stakeholders. KWRRI also established a repository for KWRRI’s reports, <https://uknowledge.uky.edu/kwrri/>. The repository includes historical KWRRI reports, annual symposium proceedings, technical reports, and the Water Distribution System Research Database. During the FY 2018 grant reporting period, KWRRI produced two editions of its semi-annual newsletter (Spring 2018 and Winter 2019). The newsletter provides updates, facilitates information sharing, and increases communication among those in the Kentucky water community.

The 2019 Kentucky Water Resources Annual Symposium was held on March 25, 2019, in Lexington, Kentucky. Conference registration fees for this annual symposium are kept low through partial subsidy of expenses using USGS 104(b) technology transfer and matching funds. The day-long symposium, attended by nearly 170 people, opened with a plenary session where panelists discussed policy and management challenges associated with drinking water and wastewater systems. This was followed by two concurrent platform sessions featuring 24 oral presentations, two poster sessions featuring 33 poster presentations, and an awards luncheon. Recipients of the FY 2018 USGS 104(b) student research enhancement grants funded through the Institute presented their results at the symposium.



Pictures from the 2019 Kentucky Water Resources Annual Symposium which featured a plenary session with expert panel (upper left), poster sessions (upper right), platform presentations (lower left), and the presentation of the annual KWRRI awards (lower right). (Photo credit: Eric Sanders, College of Engineering)

Publications from FY 2018 104b Projects

Atena, A. & Brion, G.M. (2019, August). The Impact of WWTP on MRSA Prevalence in Creek Sediments. Poster Presentation at the 2019 KY/TN Water Professionals Conference, Louisville, KY.

Atena, A., & Brion, G.M. (2019, March). Assessment of MRSA Presence in Suburban WWTPs Effluent and Receiving Streams in Lexington, Kentucky. Poster Presentation at the 2019 Kentucky Water Resources Annual Symposium, Kentucky Water Resources Research Institute, Lexington, KY. Retrieved from https://uknowledge.uky.edu/kwrri_proceedings/2019/.

Baughn, C. (2019, March). Evaluating Potential Health Threats from Untreated Karst Springs as Community Drinking Water Sources, Monroe County, Kentucky. In Proceedings of the 2019 Kentucky Water Resources Annual Symposium, Kentucky Water Resources Research Institute, Lexington, KY, p. 33. Retrieved from https://uknowledge.uky.edu/kwrri_proceedings/2019/.

Cagle, L. & Agouridis, C. (2019, March). Evaluating and Addressing Climate Awareness and Water in Kentucky. In Proceedings of the 2019 Kentucky Water Resources Annual Symposium, Kentucky Water Resources Research Institute, Lexington, KY, p. 27. Retrieved from https://uknowledge.uky.edu/kwrri_proceedings/2019/.

Kaiser, R. (2019). An Urban Karst Aquifer Resource Evaluation and Monitoring Toolbox. Master's Thesis, Western Kentucky University, Department of Geography and Geology.

Kaiser, R., J. Polk, M. Parise, L. North, M. Powell, & Shelley, J. (2019, August). Developing an Urban Karst Groundwater Evaluation and Monitoring Toolbox. Poster Presentation at the 2019 KY/TN Water Professionals Conference, Louisville, KY.

Kaiser, R., Polk, J., Powell, M., & Agga, G. (2019, June). Monitoring BMPs and Emerging Threats to Stormwater Management. Kentucky Stormwater Association Annual Conference, Berea, KY.

Kaiser, R. (2019, March). Developing an Urban Karst Groundwater Evaluation and Monitoring Toolbox. In Proceedings of the 2019 Kentucky Water Resources Annual Symposium, Kentucky Water Resources Research Institute, Lexington, KY, p. 31. Retrieved from https://uknowledge.uky.edu/kwrri_proceedings/2019/.

Kaiser, R., & Polk, J. (2019, January). Developing a Threat Assessment and Monitoring Framework for Urban Karst Groundwater Management. Invited Presentation for the Florida Geological Survey Office, Tallahassee, FL.

Kaiser, R., J. Polk, M. Parise, L. North, M. Powell, & Shelley, J. (2018, December). Developing a Threat Assessment and Monitoring Framework for Urban Karst Groundwater Management. Oral Presentation at the National Groundwater Association Groundwater Week, Las Vegas, NV.

Kaiser, R., J. Polk, M. Parise, L. North, M. Powell, & Shelley, J. (2018, November). Developing a Threat Assessment and Monitoring Framework for Urban Karst Groundwater Management. Oral Presentation at the Geological Society of America Annual Meeting, Indianapolis, IN.

Kaiser, R., J. Polk, M. Parise, L. North, M. Powell, & Shelley, J. (2018, July). Developing a Threat Assessment and Monitoring Framework for Urban Karst Groundwater Management. Poster Presentation at the Water Professionals Conference, Nashville, TN.

Lee, B. (2019, March). Canine Nutrient Contributions to the Urban Environment. In Proceedings of the 2019 Kentucky Water Resources Annual Symposium, Kentucky Water Resources Research Institute, Lexington, KY, p. 12. Retrieved from https://uknowledge.uky.edu/kwrri_proceedings/2019/.

Matocha, C. (2018, October). What Breaks Down the Fragipan (laboratory discoveries). Oral Presentation at Fragipan Field Day, Princeton, KY.

Smith, K. & Matocha, C. (2019, March). The Impact of Ryegrass Root Exudates on Element Release in a Fragipan Soil. Poster Presentation at the 2019 Kentucky Water Resources Annual Symposium, Kentucky Water Resources Research Institute, Lexington, KY. Retrieved from https://uknowledge.uky.edu/kwrri_proceedings/2019/.

Kentucky Water Resources Research Institute
233 Mining and Mineral Resources Building
504 Rose Street
Lexington, KY 40506-0107