

# Kentucky Groundwater Monitoring Network Annual Report July 2019–June 2020

## Background

Groundwater is a vital natural resource used extensively throughout Kentucky for domestic, public, agricultural, commercial, and industrial purposes. Because of its connection with rivers, lakes, and wetlands, groundwater is also essential to the sustainability and health of the state's surface-water resources and aquatic ecosystems. Systematic monitoring of groundwater quality and quantity is therefore of critical importance to the commonwealth and its citizens. Moreover, improved access to and understanding of collected groundwater data are critical to Kentucky's economic development and proper management of the state's vital environmental and water-related resources.

In 1998, the Kentucky General Assembly enacted KRS 151.625, which directed the Kentucky Geological Survey at the University of Kentucky to establish a long-term groundwater monitoring network for the state. That same year, the General Assembly also established, through KRS 151.629, an Interagency Technical Advisory Committee on Groundwater, to advise and assist KGS in the development, coordination, and implementation of the monitoring network. Agencies represented on ITAC are:

- Kentucky Department for Environmental Protection
- Kentucky Department for Natural Resources
- Kentucky Department of Agriculture, Division of Environmental Services
- Kentucky Division of Conservation
- Kentucky Division of Forestry
- Kentucky Division of Public Health Protection and Safety
- Kentucky Division of Waste Management
- Kentucky Division of Water
- University of Kentucky, College of Agriculture, Food and Environment

- University of Kentucky, Kentucky Geological Survey
- University of Kentucky, Kentucky Water Resources Research Institute
- U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center

Working cooperatively with KGS, the participating agencies have contributed significantly to the collection of groundwater and related environmental data. Annual reports summarizing their individual and collaborative activities since 1999 are available on the [KGS website](#).

## 2019-20 Activities and Accomplishments

All ITAC member agencies faced special challenges this year because of the unprecedented COVID-19 pandemic. Nevertheless, significant advances were made in groundwater monitoring, and especially increasing and improving public access to the resulting data by way of the internet. The following sections of this report summarize groundwater monitoring, resource evaluation, and data dissemination activities conducted by KGS and other ITAC member agencies during fiscal year 2019-20.

## Active Kentucky Groundwater Monitoring Network Sites

In early 2020, KGS released an [interactive web map](#) to display all active groundwater-monitoring sites in the state and provide easier access to collected data (Fig. 1). Information about the monitoring sites, such as well location and depth, and links to other available data, such as water-level hydrographs or water-quality analyses, are provided in a pop-up window that appears when any symbol displayed on the map is clicked (Fig. 2). For display purposes, the monitoring sites are grouped

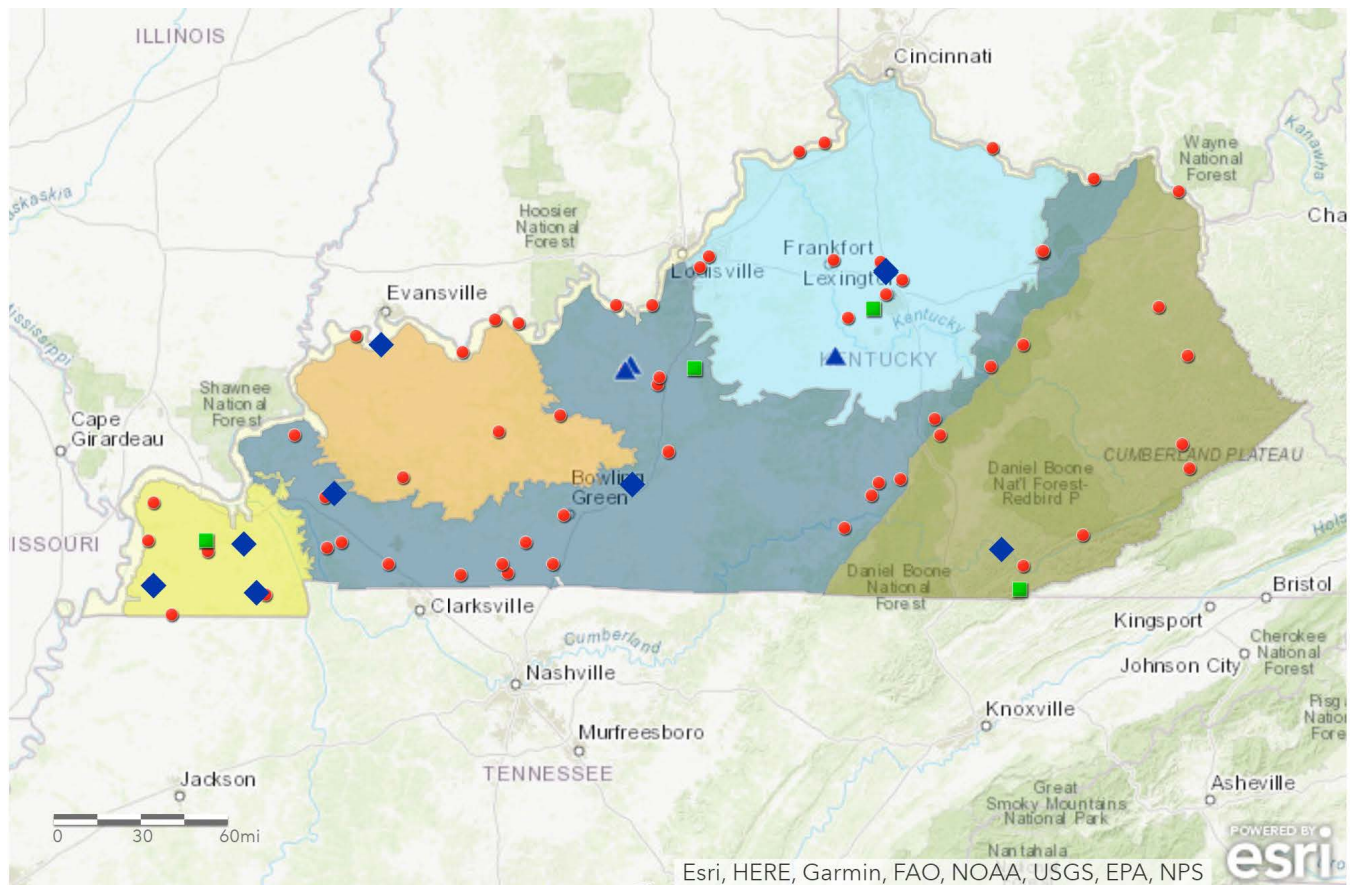


Figure 1. Interactive groundwater monitoring network web map shows locations of active monitoring sites maintained by KGS (blue diamond symbols), USGS (green squares), and Kentucky Division of Water (red dots).

into three categories, or subnetworks, defined by the principal agency responsible for site selection and maintenance, and the purpose of the monitoring activity. They are:

- KGS Kentucky Groundwater Observation Network sites, consisting of 10 observation wells used to collect long-term continuous or periodic water-level measurements, and two water-supply springs used to collect stage-discharge data. KGON sites track short-term and longer-term variations in water levels and groundwater availability in the state's major aquifers; the already large withdrawals from these aquifers for drinking-water, irrigation, and industrial uses are expected to increase because of anticipated growth in population, agriculture, and economic development.
- U.S. Geological Survey Climate Response Network sites, consisting of four wells that are part of a larger federally funded national network established to monitor water-level changes in shallow aquifers not affected by groundwater withdrawals or interactions with nearby surface waters, but which might be responsive to longer-term changes in climate. The four Kentucky sites are one well located in each of the climate divisions designated by the [National Oceanic and Atmospheric Administration](#) in the state. Data from these wells are accessible from the [KGS Groundwater Monitoring web map](#), through the [USGS National Water Information System](#) webpage, and the [National Climate Response Network](#) webpage.
- Kentucky Division of Water Groundwater-Quality Monitoring Sites comprise a statewide network of springs and water wells sampled at various intervals to track groundwater quality and establish baselines and trends in different aquifers and physiographic regions of Kentucky. Detailed information about the opera-



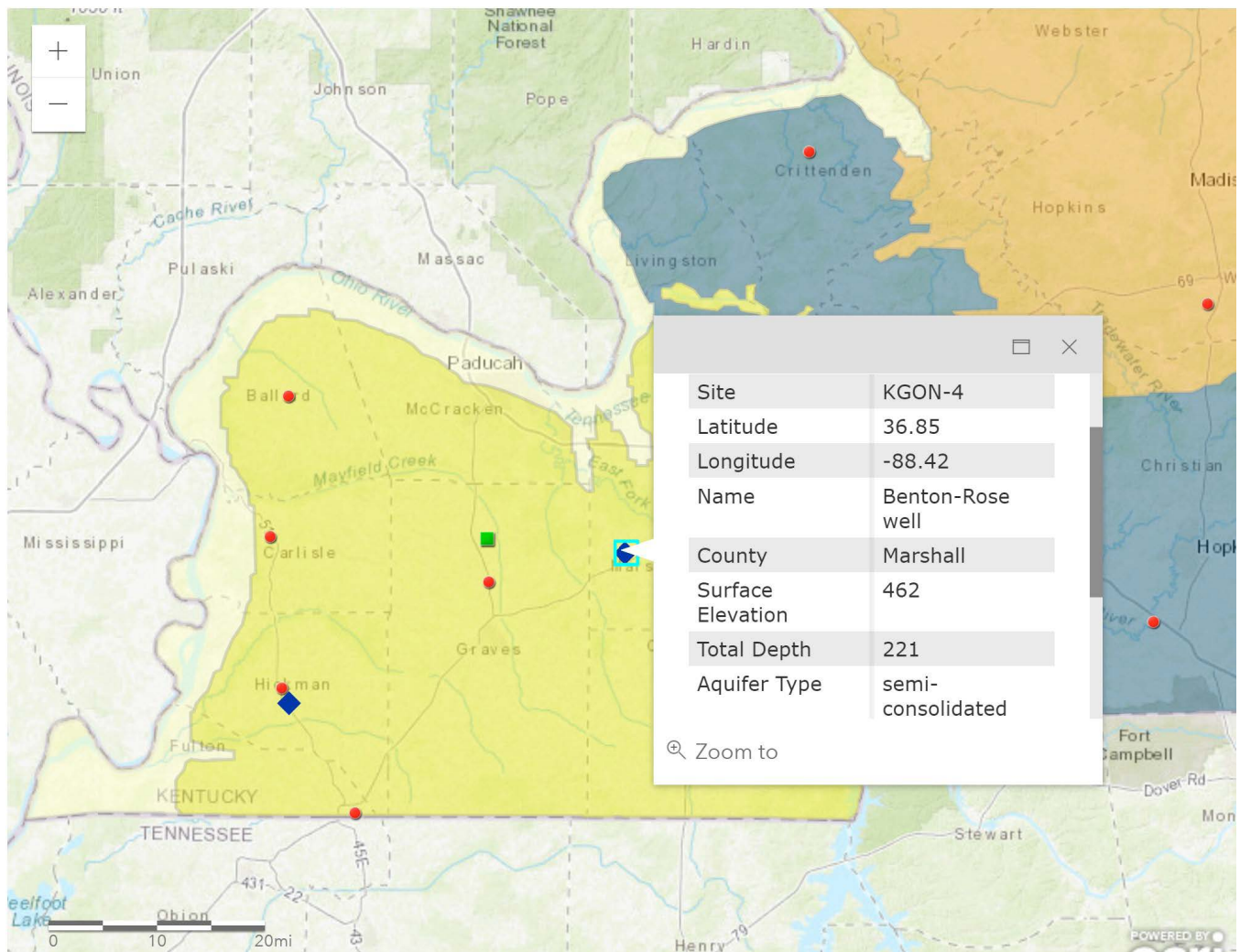


Figure 2. A pop-up window used for accessing data available for a well site selected on the interactive groundwater monitoring network web map.

tion of this subnetwork and data available for each site since initial monitoring began in about 1995, including changes in sampling frequency and analytical constituents, are documented at the [Kentucky Groundwater Monitoring Network](#) website. Routine groundwater monitoring this fiscal year included 151 samples collected from 53 permanent monitoring stations (26 wells and 27 springs) across the state. Twenty of these monitoring stations are public water suppliers, consisting of 15 water wells and five springs. Results of all water-quality analyses available for each site are accessible in a pop-up window on the [KGS Groundwater Monitoring web map](#).

### Web-Based Accessibility to Groundwater Use and Characterization Data

In addition to the groundwater monitoring web map, an “Aquifer Designation” webpage has been added to the “Water” section of the KGS website (Fig. 3).

The [Aquifer Designation](#) webpage will eventually house a series of interactive web maps and other digital content designed to help researchers, state and federal resource managers, and the public retrieve information and a better understanding about the distribution, availability, and use of the state’s groundwater resources. The first web map posted there, “Kentucky Permitted Water-

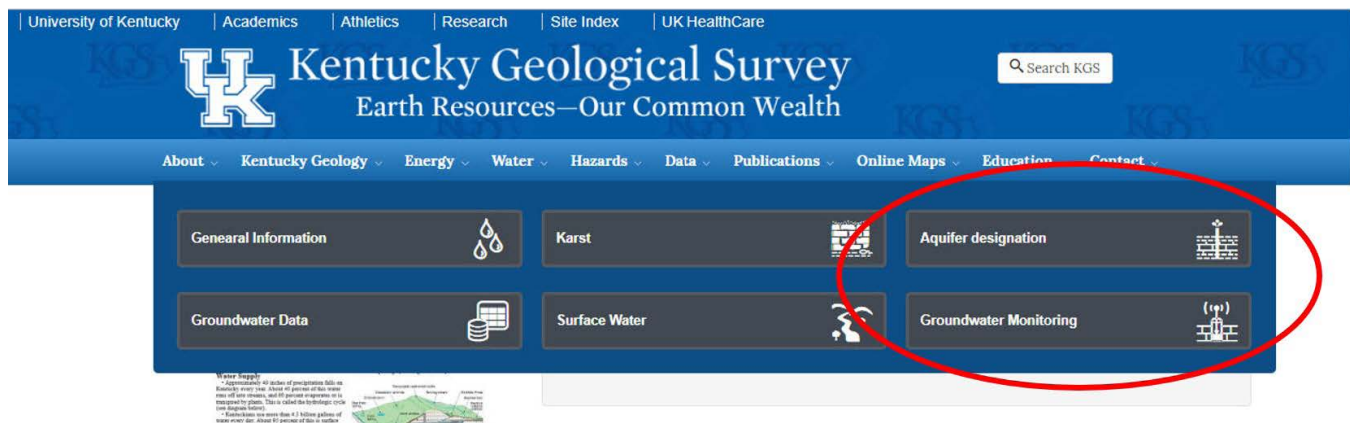


Figure 3. Dropdown menu containing links to groundwater-monitoring and aquifer-designation web maps and other topics available in the “Water” section of the Kentucky Geological Survey’s website.

Supply Wells and Springs,” depicts the locations of wells and springs that withdraw at least 10,000 gallons per day from groundwater sources and are regulated under the state’s water-withdrawal permit program (Fig. 4). The web map also shows locations of more than 1,000 agriculture irrigation wells; withdrawals from these wells are currently exempt from regulation. Pop-up windows summarize available site information, such as a water well’s location, total depth, yield, and designated aquifer source, and provide a link to automatically search and retrieve electronic data records stored in the [Kentucky Groundwater Data Repository](#) (Fig. 5).

Additional content under development for the Aquifer Designation webpage will include an interactive map that presents data about local and regional aquifer characteristics in the Ohio River alluvium, and a digitized contour map showing the mapped altitude of the fresh water–saline water interface—a hydrologic boundary defined by the depths at which drilling encounters groundwater having very high concentrations of total dissolved solids, which limits the availability of fresh groundwater in many parts of the state. Much of the content being created for the Aquifer Designation webpage is being derived by resynthesizing previously collected and published data in new ways that enhance its usefulness. For example, the interactive map under development for the Ohio River alluvium will provide seamless digital access to a series of hydrogeologic framework maps previously published during the 1960s and

’70s by the USGS but previously available only as printed maps and low-resolution, scanned PDF files.

The work done to compile data and create the Aquifer Designation webpage was conducted from 2017 to 2019 by KGS in collaboration with the Kentucky Division of Water, and supported through a cooperative grant from the U.S. Geological Survey’s Water Availability and Use Science program and Water Use Data and Research program.

## Additional Groundwater Research Activities

### KGS Projects

**Collaborative Research: Data Fusion for Characterizing and Understanding Water Flow Systems in Karst Aquifers.** The National Science Foundation has awarded funding to KGS to lead a team of collaborative researchers from the University of Kentucky, the University of Arizona, and the University of Iowa in an innovative project to study groundwater flow in karst aquifers. Karst aquifers underlie much of Kentucky and are characterized in part by rapid flow of groundwater through complex underground networks of fractures and solution conduits (caves). The project will develop and field test new and innovative hydrologic and hydraulic investigative methods to map and create 3-D models of the complex internal geologic structure of karst aquifers and groundwater flow



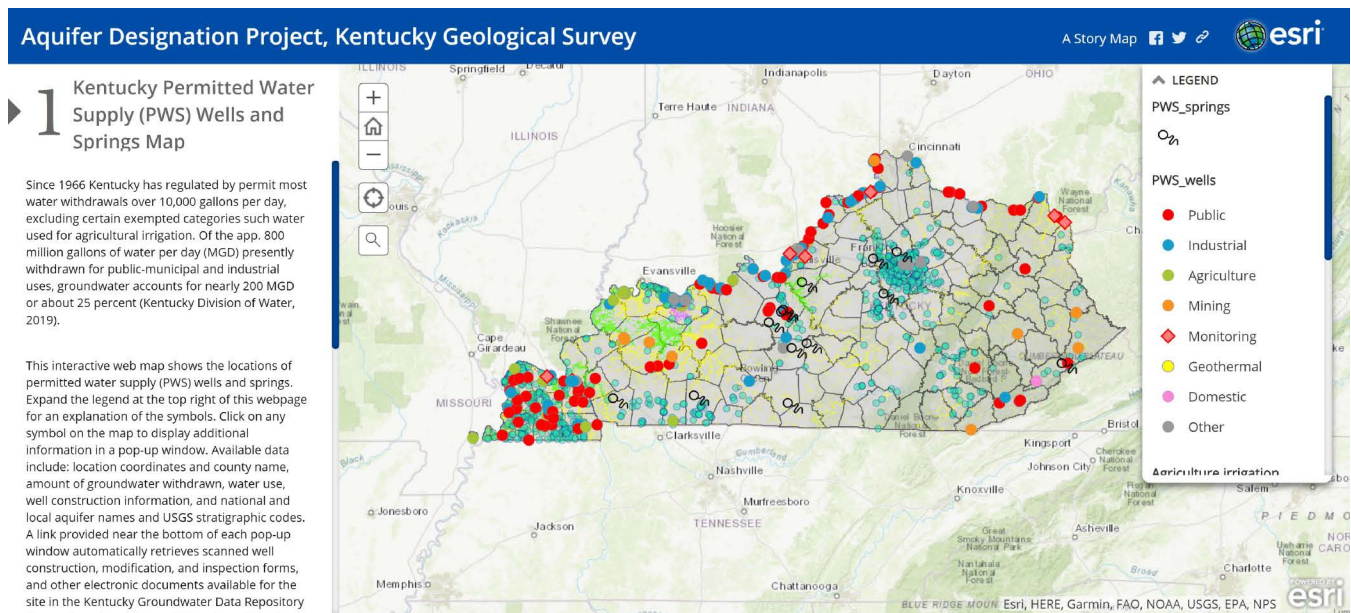


Figure 4. The user interface for the interactive map created for Kentucky permitted water-supply wells and spring sites, now available under the [Aquifer Designation](#) webpage

paths through them. In many ways, the methods used for the project will be analogous to performing a medical CT scan to image internal structures and functions of the human body. The study area includes the Cane Run–Royal Spring karst aquifer, located in Fayette and Scott Counties, which serves as the primary source of drinking water for Georgetown. **Junfeng Zhu**, a hydrogeologist with KGS, is the co-principal investigator, along with **James Fox**, professor of civil engineering at UK. Funding for the project was awarded in early 2020, but field work has been postponed until late 2020 or early 2021 because of restrictions imposed by the COVID-19 pandemic.

**Kentucky Geological Survey Groundwater Observation Wells—Support for Inclusion in the USGS National Groundwater Monitoring Network.** KGS obtained a grant from the U.S. Geological Survey to become a new data provider to the National Groundwater Monitoring Network. The two-year project, which began in late 2019, will establish web services and data-transfer processes to support collection of water-level data from seven KGON wells to the national network. The national network provides access to groundwater data collected from multiple dispersed

databases in a web-based mapping application that compiles and serves water-level and -quality data from wells in selected federal, state, and local groundwater monitoring networks across the nation. The KGON wells to be included in the national network are in Calloway, Edmonson, Fayette, Henderson, Hickman, and Marshall Counties.

**Monitoring Groundwater Levels in Response to Pivot Irrigation in Hickman County.** **Glynn Beck**, a hydrogeologist at KGS, is tracking and evaluating groundwater-level changes related to pumping withdrawals typical of an active center-pivot irrigation well in the Jackson Purchase Region. The well under study is in east-central Hickman County and is withdrawing groundwater from the Middle Claiborne aquifer. Collection of groundwater-elevation data began in January 2017, along with pumping discharge data. The fluctuations in water levels being monitored in this well will be compared with background water-level data collected simultaneously from two KGON wells in the area. This research will help evaluate the local effects of the pivot-irrigation withdrawals on natural fluctuations in groundwater levels in the aquifer.

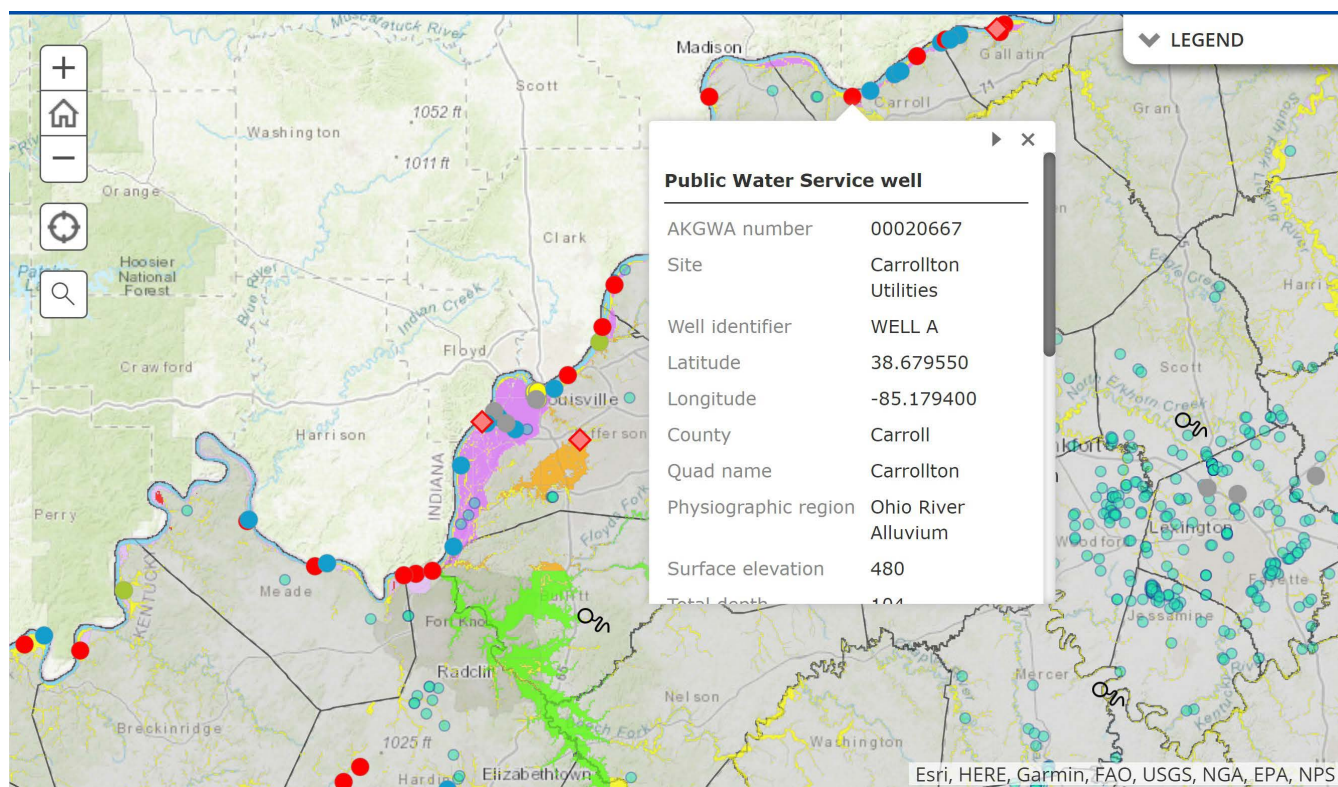


Figure 5. Example of data summarized in a pop-up window for a selected well depicted on the web map shown in Figure 4.

**Adding Lithologic Units Data From Water-Well Logs to the Kentucky Groundwater Data Repository.** The goal of this project, funded by the USGS National Geological and Geophysical Data Preservation Program, is to enter a backlog of lithologic information contained in more than 17,000 scanned water-well records into the [Kentucky Groundwater Data Repository](#) in order to make the data available online. Electronic capture of these data, which requires manual review and tabulation of the information written on water-well construction forms submitted to the Kentucky Division of Water under the Kentucky Certified Water Well Drillers Program, was discontinued by the Division of Water in 2002 because of budget cuts. In 2019-20, a KGS student employee working under the supervision of **Sarah Arpin**, the manager of the Repository, reviewed and entered 31,430 lines of lithologic data compiled from 7,602 scanned well-construction forms. Compilation of these data is critical for, among other objectives, identifying the depths and geologic units associ-

ated with Kentucky's major aquifer zones, determining targeted depths for successful water-well drilling, and determining well-construction and screening needs to optimize groundwater withdrawals.

## U.S. Geological Survey Projects

**Monitoring of Groundwater Resources of the Northeast Portion of the Ohio River Alluvial Aquifer, Near Louisville, Jefferson County.** USGS, in cooperation with the Louisville Water Co., monitors groundwater levels in the northeastern part of the alluvial aquifer near Louisville, in Jefferson County. Tasks and field activities are designed to improve understanding of the various aspects of groundwater and surface-water interaction, especially riverbank infiltration. USGS collects groundwater-level data and infiltration rates for the water company's riverbank filtration system, monitors groundwater quality to ensure proper wellhead protection planning, evaluates



groundwater-level data to estimate the contributing areas to the riverbank filtration system, measures streambed permeability, and develops groundwater flow-modeling capabilities.

**West Point Well Field Monitoring, Hardin and Meade Counties.** Water-treatment facilities at Fort Knox receive source water from drinking-water supply wells located along the Ohio River near West Point, Kentucky. The alluvial deposits in this area are typically 100 feet thick and are underlain by bedrock formations known to contain natural gas and high chloride concentrations. Previous investigations by USGS and the U.S. Army have determined that improperly abandoned gas wells have provided a means for brines, under pressure within the underlying bedrock, to migrate upward and affect the groundwater in the alluvial deposits. USGS is collecting data in the well field to monitor groundwater conditions

(Fig. 6). Researchers are measuring groundwater levels and chloride concentrations, monitoring active and abandoned gas wells, collecting geophysical information to monitor chloride movement, and simulating groundwater flow to devise strategies to protect wellheads.

**Monitoring Groundwater Levels for a U.S. Army Corps of Engineers Earthen Dam Restoration Project at Rough River Lake, Breckinridge and Grayson Counties.** The Louisville District of the U.S. Army Corps of Engineers is rehabilitating a large-scale earthen dam at Rough River Lake in Breckinridge and Grayson Counties. To track the progress of the restoration, USGS monitors groundwater levels in 60 piezometers equipped with continuously recording pressure transducers. Changes in pressure are also monitored with vibrating-wire transducers grouted in place



Figure 6. USGS scientists Catherine Fargen, Moriah Will, and Dayle Hoefling collect a groundwater sample from a well near West Point, Kentucky.

at 60 sites throughout the dam. The Corps uses these data to determine priorities for repair and to monitor groundwater-level changes related to construction.

## USGS 104(b) Grant

### Facilitation of Groundwater Research and Information Exchange

Under Section 104(b) of the Water Resources Research Act of 1984, the U.S. Geological Survey provides the Kentucky Water Resources Research Institute at the University of Kentucky with annual base grants for Kentucky-focused applied water-resource research, education, training, and outreach. Each year, projects are awarded through a competitive peer-reviewed process. For fiscal year 2020, 10 projects were awarded, five of which focus on groundwater research. The groundwater research awards are:

- *Analysis of Contaminated Karst Groundwater Supplying "Off the Grid" Religious Communities in South-Central Kentucky.* Chris Groves, Margaret Gripshover, Pat Kambesis, and Lee Anne Bledsoe, Western Kentucky University.
- *Geophysical Imaging of Ridgetop Wetland-Perched Groundwater Systems.* Jonathan Malzone, John White, and Rebecca Moskal, Eastern Kentucky University.
- *A Comparison of Sedimentation Rates and Hydrological Regimes in Floodplain Wetland Easements and Natural Bottomland Forested Wetlands of Western Kentucky.* Jessica B. Moon, Murray State University.
- *Examining Hydrogeological Dynamics of Flooding and Flow Reversals of the Green River and Major Springs of Mammoth Cave, Kentucky.* Jason Polk and Matthew Cecil, Western Kentucky University.
- *In-situ 3-D Electrical-Resistivity Method for Understanding Water Dynamics in Shallow Karst Features.* Junfeng Zhu, James Fox, and Bronson McQueen, University of Kentucky.

## Kentucky Water Resources Research Symposium

The 2020 Kentucky Water Resources Annual Symposium was scheduled to be hosted on March 23, 2020, in Lexington, Kentucky. Because of the overarching concern for the health and safety of attendees, the symposium had to be postponed indefinitely because of COVID-19. The following groundwater-related presentations were planned for the event:

### Speaking Presentations

Alice Turkington, Department of Geography, University of Kentucky, and Carmen Agouridis, Department of Biosystems and Agricultural Engineering, University of Kentucky. *Kentucky Climate Consortium: Transforming Tomorrow by Connecting Kentuckians to Address Climate Concerns.*

Jason Polk, Center for Human GeoEnvironmental Studies and HydroAnalytical Lab, Western Kentucky University. *Investigation and Remediation of an Urban Karst Gasoline Leak at Lost River Cave, Bowling Green, Kentucky.*

Nolan Bunnell, Department of Biosystems and Agricultural Engineering, University of Kentucky. *Nitrogen Fate and Transport Dynamics in Karst Agroecosystem Bedrock Channels of Central Kentucky: Insight From Numerical Modeling and High-Resolution Sensors.*

Jonathan Malzone, Department of Geosciences, Eastern Kentucky University. *Normalized Hydrograph Recession Analysis of Ridgetop Perched Groundwater-Vernal Pool Systems in the Daniel Boone National Forest: Preliminary Insights from Three Years of Data.*

Rob Blair, Kentucky Division of Water. *Evaluation of Kentucky Community Drinking Water for Per- and Poly-Fluoroalkyl Substances.*

Chuck Taylor, Kentucky Geological Survey, University of Kentucky. *Recent Efforts to Improve Usefulness of and Access to Kentucky Groundwater Data.*



Sarah Arpin, Kentucky Geological Survey, University of Kentucky. *Improving Groundwater and Karst Data Content and Curation.*

Benjamin Tobin, Kentucky Geological Survey, University of Kentucky. *Patterns in Kentucky Groundwater Geochemistry: Utilizing Multivariate Statistics to Assess Groundwater Systems.*

Kenton Sena, Lewis Honors College, University of Kentucky. *Forty Years of Data: Challenges and Opportunities Afforded by Long-Term Data Sets.*

## Poster Sessions

Nabil Al Aamery, Department of Civil Engineering, University of Kentucky. *Climate Change Impacts on Surface and Subsurface Water Pathways in a Mature Karst System, Cane Run–Royal Spring Basin.*

Cristopher Alvarez, Department of Earth and Environmental Sciences, University of Kentucky. *Causes and Extent of Elevated Groundwater Methane Concentrations in Eastern Kentucky.*

Leonie Bettel, Department of Civil Engineering, University of Kentucky. *Source, Fate, and Transport of Sediment Using Stable Carbon and Nitrogen Isotopes in Mature and Immature Karst Systems.*

Le Cao, State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences. *Monitoring of Suspended Sediment Load and Runoff-Plots Soil Loss in an Agroforestry Watershed at Karst Plateau, Southwest of China.*

Daniel Draper, Department of Geosciences, Eastern Kentucky University. *Quantifying Climatic Controlled Variation of Groundwater Recharge With a Water Budget Approach for Isolated Ridgetops in the Daniel Boone National Forest.*

Robert Engleman, Department of Geosciences, Eastern Kentucky University. *Hydrogeomorphic Classification of Ridgetop Wetlands in the Daniel Boone National Forest.*

Pedro Martin, Department of Civil Engineering, University of Kentucky. *Agricultural Runoffs in Karst Landscapes: Assessment of Glyphosate Concentration in Kentucky Watersheds.*

Cory Radcliff, Department of Biosystems and Agricultural Engineering, University of Kentucky. *Quantifying the Dissolved Reactive Phosphate Dynamics in Karst Drainage of the Inner Bluegrass Using Oxygen Isotopes.*