

# **Kentucky Interagency Groundwater Monitoring Network**

## **Annual Report**

**July 2007–June 2008**

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# **Kentucky Interagency Groundwater Monitoring Network Annual Report July 2007–June 2008 Executive Summary**

Kentucky's citizens, businesses, industries, and ecosystems depend on adequate supplies of clean groundwater. Regional and temporal variations in groundwater quantity and quality are not adequately known, however. For this reason, the 1998 Kentucky General Assembly directed the Kentucky Geological Survey to establish a long-term groundwater monitoring network (KRS 151.620 and 151.625). The network was directed to collect groundwater data, characterize groundwater quality, distribute groundwater information, improve coordination between agencies that use groundwater data, and facilitate data sharing (Interagency Technical Advisory Committee, 1996). These activities were to be conducted in coordination with an Interagency Technical Advisory Committee composed of representatives from 15 State and Federal agencies and the University of Kentucky. The Kentucky Geological Survey was also charged with annually reporting network activities to the governor's office and the Legislative Research Commission. This report summarizes activities during the 2007–08 fiscal year.

From July 2007 through June 2008, 16 data collection programs were under way, and seven major groundwater characterization reports were published. Groundwater information was communicated to the scientific and regulatory communities and to the public through 22 presentations and publications, as well as postings on Web sites. Quarterly meetings of the Interagency Technical Advisory Committee provided an opportunity to coordinate groundwater-related efforts and share information among agencies. Exchange of groundwater data, including electronic transfer of analytical results, between Division of Water and Kentucky Geological Survey databases, has proceeded through close cooperation between the two agencies.

The Kentucky Interagency Groundwater Monitoring Network has been in existence for 10

years. During this time, significant progress has been made. Important work remains, however. Among the critical issues facing Kentucky are:

- determining recharge areas for sampled wells and springs so water supplies can be protected
- establishing monitoring sites in areas that are currently not represented or are expected to have increased groundwater demand
- optimizing sampling frequency to account for natural variations in groundwater flow systems throughout the state
- monitoring the rate of intrusion of nonpoint-source contaminants into groundwater systems so effective prevention and remediation can be implemented
- establishing standard procedures for assessing whether compromised well integrity is allowing surface contamination to reach groundwater supplies
- standardizing reporting information about sampling methods, field measurements, and sample-site descriptions to promote data sharing
- developing a water-level monitoring network to track long-term land-use and climate effects on groundwater supplies
- standardizing reporting procedures and database structures to facilitate electronic data sharing
- providing increased public access to groundwater-quality data to increase awareness
- determining sources and amounts of bacteria and other pathogens in regional groundwater flow systems
- investigating the amount of pharmaceutical and personal-care-product chemicals in water systems
- evaluating amounts and effects of pesticide metabolites in groundwater
- increasing the use of stable isotopes, caffeine, and other tracers to indicate contaminant sources and quantify groundwater ages and flow rates

- quantifying the role of groundwater in the quality and quantity of water in streams as related to water-quality standards, total maximum daily loads, and designated uses.

The Kentucky Interagency Groundwater Monitoring Network will continue to address these issues. Significant progress has been hampered by staff and funding limitations, however, which are increasing. Recent advances have been the result of

substantial agency commitment of State executive budget funds; one-time, competitive grants to the Kentucky Division of Water's Groundwater Branch, the Division of Pesticide Regulation, and the Kentucky Geological Survey; and voluntary cooperation between agencies. An effective groundwater monitoring network requires sustained, recurring funding to maintain the long-term effort.

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## Introduction

Groundwater is used extensively throughout Kentucky for domestic, agricultural, commercial, and industrial purposes. Because of its connection with rivers, lakes, and wetlands, groundwater is also essential to the health of surface-water ecosystems. Determining the quality of this resource and protecting it from contamination are important to the future of the commonwealth and its citizens.

Information provided by the Kentucky Division of Water indicates that more than 300,000 citizens rely on water from private wells and springs for drinking, cooking, and washing. Public water systems serving more than 1.25 million people also rely on groundwater as a source of drinking water. This dependence on groundwater resources will continue and may increase. Many public water-supply systems are considering switching from surface-water to groundwater sources because the required treatment and monitoring are less extensive and less expensive. Recently, the cities of Louisville, Hardinsburg, and Salyersville, and the Greater Fleming Regional Water Supply were considering either switching to groundwater sources or supplementing surface-water supplies with groundwater. Furthermore, many people who now rely on private wells or springs for domestic water supplies will remain dependent on groundwater because of the cost of extending public water-supply systems to rural areas and because groundwater supplies are more than sufficient in some areas of the commonwealth.

Significant quantities of groundwater are used for commercial and industrial applications, crop irrigation, livestock watering, mining, and thermoelectric power generation. Groundwater also sustains valuable ecosystems by providing base flow to streams, lakes, and wetlands. This is particularly important during moderate to severe

droughts such as those that occurred in 1999–2001, 2005–2006, and 2007. In the absence of precipitation, groundwater base flow is the only source of water to maintain stream flow and lake levels and to preserve riparian and wetland ecosystems.

Recognizing the importance of groundwater, the 1998 Kentucky General Assembly directed the Kentucky Geological Survey to establish a long-term, interagency groundwater monitoring network to characterize the quality, quantity, and distribution of groundwater in Kentucky. The 1998 General Assembly also established an Interagency Technical Advisory Committee to assist the Kentucky Geological Survey in the development, coordination, and implementation of a groundwater monitoring network (KRS 151.629). The following agencies and organizations were asked to appoint a representative to the Interagency Technical Advisory Committee:

- Kentucky Department for Environmental Protection
- Kentucky Department for Natural Resources
- Kentucky Department for Surface Mining Reclamation and Enforcement
- Kentucky Department of Agriculture, Division of Pesticide Regulation
- Kentucky Department of Mines and Minerals
- Kentucky Division of Conservation
- Kentucky Division of Environmental Health and Community Safety
- Kentucky Division of Forestry
- Kentucky Division of Waste Management
- Kentucky Division of Water
- University of Kentucky, Kentucky Geological Survey
- University of Kentucky, College of Agriculture
- University of Kentucky, Kentucky Water Resources Research Institute

- U.S. Geological Survey, Louisville office.

The 1998 legislation directed the Kentucky Geological Survey to provide an annual summary of groundwater monitoring activities to the governor and the Legislative Research Commission. This is the ninth annual report of the Kentucky Interagency Groundwater Monitoring Network. Previous reports are posted at [www.uky.edu/KGS/water/gnet/](http://www.uky.edu/KGS/water/gnet/).

## 2007-08 Activities and Accomplishments

Brief summaries of work performed by the ITAC agencies during the 2007-08 fiscal year show how the major goals of the network are being addressed. Additional information regarding these projects can be obtained by contacting the responsible agency.

Statewide and regional ambient monitoring programs evaluated groundwater that is not affected by point-source contamination, and determined whether nonpoint-source chemicals such as sewage, pesticides, fertilizers, and volatile organic compounds have had an impact on groundwater quality. These large-scale studies are conducted in basin management units (Fig. 1), which were established by the Kentucky Division of Water (1997) and include one or more major river watersheds. Site-specific studies were conducted in smaller watersheds or other, more restricted regions. These were designed to evaluate the effects of particular land uses or unique hydrologic conditions, or the quality of unregulated public water supplies such as roadside springs.

### Groundwater Data Collection

Drilling wells, collecting and analyzing water samples, measuring water levels in wells, and mapping recharge and discharge areas of karst systems provide the fundamental data needed to determine current groundwater quality, detect changes over time, and evaluate hydrogeologic hazards.

### **Kentucky Division of Water— Groundwater Branch**

The Groundwater Branch maintains an active groundwater collection and analysis program. Dur-

ing the past year, staff collected 135 samples from 58 wells and springs statewide for the Ambient Groundwater Monitoring Program, 112 samples from 30 sites in Pike and Letcher Counties for the Elkhorn Creek nonpoint-source study of basin management unit 5 (round 2), 16 samples from four sites for the Pesticides Memorandum of Agreement Project with the Department of Agriculture, and 63 samples from 63 sites in response to requests for assistance or complaints.

Groundwater Branch staff also conducted 26 dye traces for karst mapping projects and groundwater technical assistance investigations, assisted eight county health departments with dye traces as part of local contamination investigations, and coordinated with the Kentucky Department for Surface Mining Reclamation and Enforcement on one investigation in relation to a “Lands Unsuitable for Mining” petition in Pulaski County and a second investigation into a mining-related complaint in Pike County.

### **U.S. Geological Survey**

**Louisville Water Company, Ohio River Alluvial Aquifer, Jefferson County.** The USGS, in cooperation with the Louisville Water Company, maintains a network of 18 water-level observation wells in the northeastern part of the Ohio River alluvium in Jefferson County. Seven of the wells are equipped with continuously recording pressure transducers that measure depth to water and water temperature. Water-level measurements are taken at the other nine observation wells on a quarterly basis. These data assist the Louisville Water Company’s efforts to design and implement riverbank infiltration using a network of water-supply wells constructed to draw and naturally filter river water through the sand and gravel aquifer near the Payne water-treatment plant.

### **Regional Karst Hydrology Initiative Project.**

The USGS Ground-Water Resources Program is participating in a regional study of the karst aquifers in Kentucky, Alabama, Illinois, Indiana, and Tennessee. During the first phase of the project (FY 2004–06), special emphasis was placed on developing geographic information system technology to improve the utilization and integration of karst geospatial and time-series data, and on new

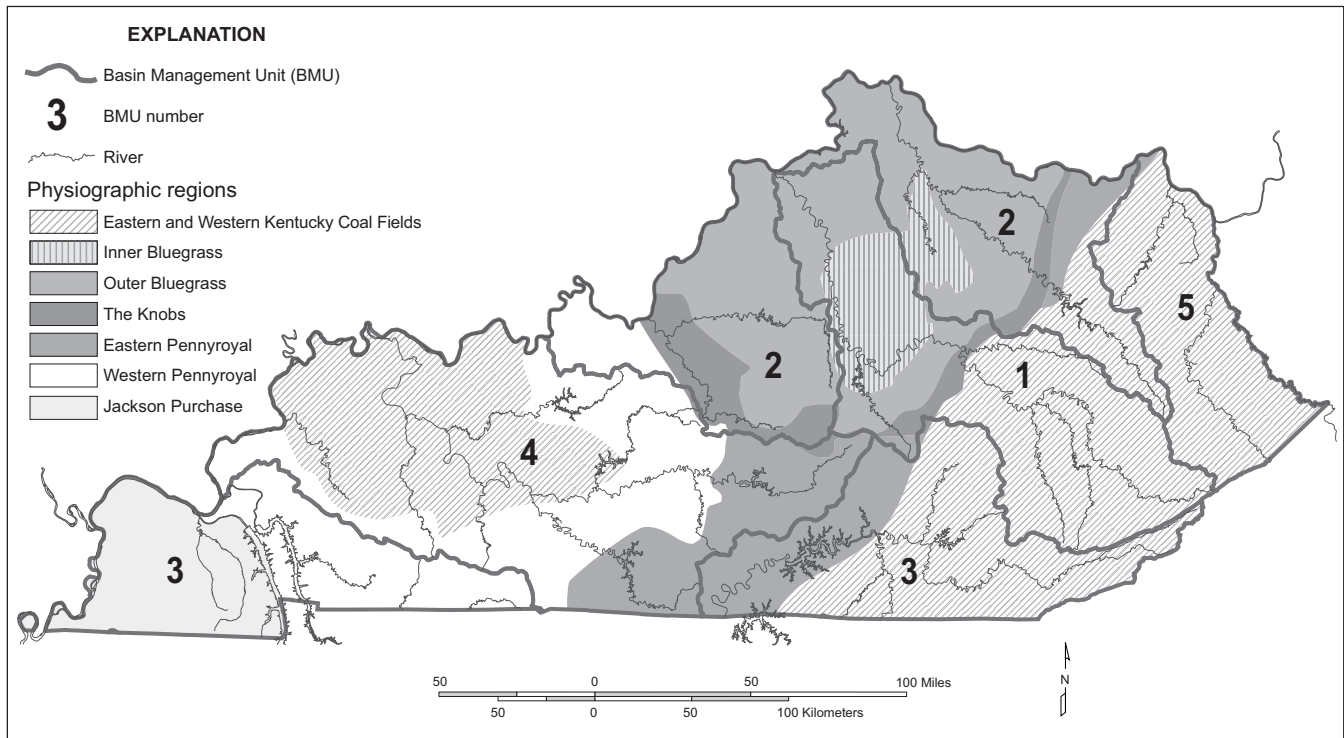


Figure 1. Locations of major rivers, basin management units, and physiographic regions in Kentucky.

methods to improve the estimation of karst water budgets. A number of spring basins in Kentucky, including the McCracken Spring Basin in Meade County, the Graham Springs Basin in Warren and Edmonson Counties, and a spring basin at the UK Agricultural Research Farm in Woodford County, were used as demonstration sites. A variety of available data about karst springs in other parts of Kentucky was collected and synthesized, along with spring data from the other states, as part of the regional study. Additional information about the project can be obtained at [ky.water.usgs.gov/projects/cjt\\_karst/](http://ky.water.usgs.gov/projects/cjt_karst/).

**Maxey Flats Low-Level Radioactive Waste Repository, Fleming and Rowan Counties.** USGS continues to provide technical assistance to the Kentucky Division of Waste Management in regard to oversight of the closure of the Maxey Flats repository. USGS maintains continuous water-level data recorders in 15 monitoring wells at the site. Five of these wells are also sampled semiannually for tritium concentrations. Water levels are measured periodically in 14 other monitoring wells. Of

these, two are sampled quarterly for tritium, and the remaining 12 are sampled annually.

**Groundwater-Level Data Collection.** USGS collects real-time continuous water-level measurements from an observation well in Graves County that is included in the USGS National Groundwater Climate Response Network—a network of wells intended to monitor the effects of droughts and other climate variability on the nation’s groundwater resources. The water-level data for this well can be accessed at [groundwaterwatch.usgs.gov/](http://groundwaterwatch.usgs.gov/) or [ky.water.usgs.gov/](http://ky.water.usgs.gov/). Two observation wells in downtown Louisville maintained by the USGS collect continuous water-level data from the Ohio River alluvial aquifer. These data, historical water-level data from other observation wells, and additional information about the activities of the USGS–Kentucky Water Science Center are available at [ky.water.usgs.gov/](http://ky.water.usgs.gov/).

**Well-Integrity Survey of Abandoned Gas Wells near West Point.** Abandoned and unrecorded natural gas wells may act as conduits for the contamination of groundwater supplies by brines from



oil and gas fields and other pollutants. The casings of abandoned wells may eventually develop leaks, which, if not properly plugged, can allow pollutants to reach freshwater aquifers that supply drinking water. Such is the situation in the Fort Knox well field near West Point. Many of the wells supplying drinking water for Fort Knox have chloride concentrations in excess of the secondary maximum contaminant level of 250 mg/L; some are as high as 800 mg/L. USGS, in cooperation with the U.S. Army Corps of Engineers and the Army installation at Fort Knox, is conducting a geophysical and hydrologic assessment to further locate sources of chlorides and characterize the alluvial aquifer.

### ***Kentucky Department of Agriculture***

The Kentucky Department of Agriculture continued monitoring in four watersheds: Little River in Christian and Trigg Counties, Sinking Creek in Breckinridge and Meade Counties, Rough River Basin in Grayson and Hardin Counties, and Bayou de Chien in Hickman and Fulton Counties. These are primarily surface-water monitoring efforts; however, some sites at Little River and Sinking Creek are in karst. The Little River, Sinking Creek, and Rough River monitoring sites are continued from previous programs with the USGS and Western Kentucky University. These water samples are being analyzed using immunoassay test kits for the herbicides atrazine, simazine, 2,4-D, and alachlor. The Little River, Sinking Creek, Rough River, and Bayou de Chien samples are being used to determine if the strong demand for corn for biofuel is resulting in increased detections of triazine herbicides from increased crop production. Bayou de Chien is being monitored for the presence and increased use of atrazine. Sampling of the four watersheds started in April 2007 and should continue through September 2008.

The Technical Support Branch of the Department of Agriculture continued to receive monitoring data from the Division of Water under its memorandum of agreement. The memorandum covers 16 samples yearly from four sites and is supplemented by the Division of Water's Ambient Groundwater Monitoring Program.

The Technical Support Branch continues to receive atrazine and simazine data from Syngenta's Stewardship Community Drinking Water System

efforts in Marion and Crittenden Counties, Dixon and Webster Counties, and the Leitchfield water system in Grayson County. In addition, Syngenta is sampling for simazine in the Rough River Basin at the Livemore Community System.

### ***Kentucky Geological Survey***

**Identifying Water Supplies.** The Kentucky Geological Survey continued work in conjunction with funding from the Kentucky Infrastructure Authority to identify water for public supplies for small communities and rural neighborhoods. The Survey directed the drilling and completed hydraulic testing of two wells and hydraulically tested an existing well for the city of Evarts in Harlan County. In addition, KGS sited a new well for the community of Wallins in Harlan County, and has designed hydraulic tests for the city of Campton in Wolfe County. All of these sites target sandstone units of Early Pennsylvanian age. In the central and western parts of the commonwealth, KGS has collaborated with Greenville (Muhlenberg County) in their initial efforts to drill high-yield wells. At present, the city is waiting to find out if there is fresh water above the producing zone in a petroleum exploration well. KGS is also providing information to Marion in Crittenden County about the use of abandoned underground fluorspar mines as potential water supplies.

**Groundwater Conditions in the Cumberland Gap Tunnel.** KGS, in coordination with the Cumberland Gap Tunnel Authority, the Federal Highways Administration, the Kentucky Transportation Cabinet, the University of Kentucky Transportation Center, and Vaughn and Melton Engineers Inc., completed dye tracing, monitoring-well installation and programs, and installation of groundwater flow meters to determine groundwater flow path, levels, and velocities in the sub-base gravels and bedrock beneath the road surface in Cumberland Gap Tunnel. Hydrogeochemical data collection and analysis indicate that groundwater dissolving the limestone aggregate that makes up the road base is a principal cause of road-surface subsidence in five major zones in both the northbound and southbound tunnel bores. Remediation measures are being considered by the Kentucky Transportation Cabinet.

**Cane Run Watershed.** In 2006, the Kentucky Division of Water named Cane Run watershed one of four focus watersheds for clean-up under the State's nonpoint-source pollution program. This watershed begins in Lexington (Fayette County) and ends in Scott County where Cane Run discharges into North Elkhorn Creek. Because it is located in karst bedrock, Cane Run only flows during times of sufficient rainfall, usually in the spring of the year. The remainder of the time, most water is recharged to an underground conduit system that leads from Lexington to Royal Springs, the major water supply for Georgetown in Scott County. The Kentucky Geological Survey is leading an effort to locate sites to monitor the underground conduit that carries groundwater from the Lexington area to Royal Springs. Electrical-resistivity and spontaneous-potential geophysics are being used to help pinpoint the location of the active conduit at three locations. An initial round of 15 exploratory boreholes was drilled to help interpret the geophysical results. This work is being carried out in cooperation with the University of Kentucky's College of Agriculture and Department of Earth and Environmental Sciences.

**Selenium Concentrations in the Aquatic Environment.** In cooperation with the Kentucky Division of Water, which has provided funding, the Kentucky Geological Survey is developing a database of selenium concentrations in water and fish tissue from the Eastern Kentucky Coal Field. The operating hypothesis is that groundwater moving through bedrock and areas of coal-mine spoil dissolves selenium concentrated in the coals during their formation. The groundwater eventually discharges to surface waters, where selenium may metabolize and bioaccumulate into toxic forms and concentrations in the food chain. Fourteen of the proposed 15 surface-water sites have been sampled. The total number of samples includes 37 water samples and 29 fish tissue samples for which seven forms of selenium were analyzed, along with standard chemical analyses to help define the hydrogeochemical environment. The data will be interpreted in the latter part of 2008.

**Karst Activities.** KGS staff completed a project to delineate karst groundwater basins in Radcliff in Hardin County; continued cooperation with the

Division of Water to produce karst groundwater basin maps; conducted further research into a demonstration project for developing maps showing the probability of cover-collapse sinkholes; and continued to develop an indexing methodology for the degree of karst development in the state.

**Health Conditions Associated with Domestic Well Water Use.** This work examines the health of citizens in western Kentucky who rely on groundwater for their drinking-water supply. Results from a survey designed to record health conditions will be combined with water-quality data from the domestic wells used. The resulting data set will be analyzed for health effects related to nitrate-nitrogen, herbicides, and bacteria in the drinking water. This is a joint project between the University of Kentucky College of Public Health and the Kentucky Geological Survey. The project began in May 2008 and runs until January 2009.

**Characterizing Contaminants in Shallow Groundwater in Marshall County.** This study samples 20 to 30 private wells in conjunction with local health laboratory officials. The objectives are to better characterize groundwater quality in Marshall County and investigate relations between coliform bacteria, nitrate-nitrogen, and pesticides in shallow groundwater. The project began in March 2008 and extends until February 2009.

**EPSCoR (Experimental Program to Stimulate Competitive Research) Projects.** Four groundwater sampling projects are under way.

1. *Groundwater Sampling for Fecal Contamination in Hickman County.* KGS is sampling 50 domestic wells in Hickman County for the presence of bacteria. Samples will be analyzed for total coliform, *E. coli*, and somatic coliphages at the Environmental Research and Training Laboratory at the University of Kentucky. This project will allow a UK student to fulfill requirements in the University of Kentucky College of Public Health and receive training to successfully test for total coliform, *E. coli*, and somatic coliphages.
2. *Groundwater Sampling for Metals in Hickman County.* KGS and Murray State University researchers previously sampled approximately 300 domestic water wells in Marshall, Calloway, Carlisle, Graves, and Ballard Counties for metals

and anions. This project expands that effort to Hickman County by sampling 50 domestic water wells for metals. Samples will be analyzed at the Environmental Research and Training Laboratory at the University of Kentucky.

3. *Determination of Selected Inorganic Anions by Ion Chromatography as an Indicator of Groundwater Quality in Hickman County.* The concentrations of common anions such as nitrate, sulfate, chloride, fluoride, and bromide are good indicators of water quality. Although there are numerous methods for the determination of these anions, ion chromatography is a single instrumental technique that can be used for rapid and sequential measurement. In conjunction with a separate EPSCoR proposal, these wells will be sampled for total metals and analyzed at the Environmental Research and Training Laboratory. This joint effort will result in a better understanding of the overall groundwater quality in Hickman County.
4. *Physical-Chemistry Characterization of Karst Waters in the Vadose Zone of Diamond Caverns, Mammoth Cave National Park – Phase II.* This is an extension of preliminary investigations at Diamond Caverns, a private show cave near Mammoth Cave National Park, initiated in conjunction with Drs. Angel Fernandez Cortes and Chris Groves of the Hoffman Environmental Research Institute at the Western Kentucky University Department of Geography and Geology. The research initially focused on evaluating the environmental conditions in tourist caves in Kentucky and Spain, with the immediate intention of devising sustainable management strategies. This research will be primarily a hydrogeochemical study of the H<sub>2</sub>O-CO<sub>2</sub>-Ca-Mg system in the vadose zone of Diamond Caverns. These specific data and the resulting karst water model will contribute to the effective study and management of parameters influencing the microclimatic and geochemical aspects of Diamond Caverns. Data from this project will be incorporated into the larger data set from the other caves in order to characterize the physical and chemical characteristics of the vadose zone of these show caves, and add to the regional understanding of vadose zone geochemistry.

## Groundwater-Quality Characterization

Uninterpreted results of data collection programs are of little value to most citizens, agencies, and organizations that are concerned with regional groundwater quality and supply. Placing results of such investigations into the context of natural conditions, regional variations in bedrock type and land use, potential impact of human activities, and the possible health effects of some chemicals in water is therefore a very important activity of the Kentucky Interagency Groundwater Monitoring Network. This section lists major interpretive reports that have been published after data-collection studies were completed.

Davidson, B., and Fisher, R.S., 2007, Groundwater quality in Kentucky: 2,4-D: Kentucky Geological Survey, ser. 12, Information Circular 18, 4 p. A statewide map showing sampled sites, ranges of concentrations of the pesticide 2,4-D, statistical summaries of 2,4-D concentrations, and information regarding sources of 2,4-D, as well as potential health effects of drinking water containing 2,4-D.

Davidson, B., and Fisher, R.S., 2007, Groundwater quality in Kentucky: Atrazine: Kentucky Geological Survey, ser. 12, Information Circular 16, 4 p. A statewide map showing sampled sites, ranges of concentrations of the pesticide atrazine, statistical summaries of atrazine concentrations, and information regarding sources of atrazine, as well as potential health effects of drinking water containing atrazine.

Davidson, B., and Fisher, R.S., 2007, Groundwater quality in Kentucky: Manganese: Kentucky Geological Survey, ser. 12, Information Circular 14, 4 p. A statewide map showing sampled sites, ranges of concentrations of manganese, statistical summaries of manganese concentrations, and information regarding natural and man-made sources of manganese, as well as potential health effects of drinking water containing manganese.

Fisher, R.S., and Davidson, B., 2007, Groundwater quality in Kentucky: Iron: Kentucky Geological Survey, ser. 12, Information Circular 13, 4 p. A statewide map showing sampled sites,

ranges of concentrations of iron, statistical summaries of iron concentrations, and information regarding natural and man-made sources of iron, as well as potential health effects of drinking water containing iron.

Fisher, R.S., Davidson, B., and Goodman, P.T., 2007, Groundwater quality in watersheds of the Kentucky River, Salt River, Licking River, Big Sandy River, Little Sandy River, and Tygarts Creek (Kentucky basin management units 1, 2, and 5): Kentucky Geological Survey, ser. 12, Report of Investigations 16, 133 p. ([www.uky.edu/KGS/water?RI\\_16](http://www.uky.edu/KGS/water?RI_16)). Summary and interpretation of groundwater quality in basin management units 1, 2, and 5, located in the Eastern Kentucky Coal Field, Eastern Pennyroyal, Knobs, Outer Bluegrass, and Inner Bluegrass physiographic regions. Concentrations of 38 important water-quality parameters and analytes were investigated and potential impacts of nonpoint-source contamination were evaluated.

Fisher, R.S., Davidson, B., and Goodman, P.T., 2007, Regional groundwater quality in watersheds of the Upper Cumberland, Lower Cumberland, and Lower Tennessee Rivers, and the Jackson Purchase Region (Kentucky basin management unit 3): Kentucky Geological Survey, ser. 12, Report of Investigations 15, 105 p. ([www.uky.edu/KGS/water/RI\\_15](http://www.uky.edu/KGS/water/RI_15)). Summary and interpretation of groundwater quality in basin management unit 3, located in the Eastern Kentucky Coal Field, Eastern Pennyroyal, Western Pennyroyal, and Jackson Purchase physiographic regions. Concentrations of 38 important water-quality parameters and analytes were investigated and potential impacts of nonpoint-source contamination were evaluated.

Fisher, R.S., Davidson, B., and Goodman, P.T., 2008, Groundwater quality in watersheds of the Big Sandy River, Little Sandy River, and Tygarts Creek (Kentucky basin management unit 5): Kentucky Geological Survey, ser. 12, Report of Investigations 19, 94 p. ([www.uky.edu/KGS/water/RI\\_19/](http://www.uky.edu/KGS/water/RI_19/)). Summary and interpretation of groundwater quality in basin management unit 5, located in the Eastern Kentucky Coal Field. Concentrations

of 38 important water-quality parameters and analytes were investigated, and potential impacts of nonpoint-source contamination were evaluated.

## Distribution of Groundwater Information

One of the most important functions of the Groundwater Monitoring Network is translating analytical data from water-level measurements and groundwater sample analyses into readily available, useful information, and presenting the results to the public. During the 2007-08 fiscal year, groundwater information was communicated via short reports, oral and poster presentations at meetings and conferences, and placement on Web sites.

## Publications

Beck, E.G., Dinger, J.S., and Kotter, D.L., 2007, The influence of water well construction and land use on rural drinking water supplies in the Jackson Purchase Region, Kentucky: Concurrent Session Proceedings of the 2007 U.S. Department of Agriculture Cooperative State Research, Education, and Extension Service Southern Region Water Quality Conference, p. 11.

Beck, E.G., Dinger, J.S., Grove, J.H., and Pena-Yewtukhiw, E., 2007, Groundwater contamination associated with abandoned animal feedlots in western Kentucky: Poster Proceedings of the 2007 U.S. Department of Agriculture Cooperative State Research, Education, and Extension Service Southern Region Water Quality Conference, p. 9.

Beck, E.G., Vendrell, P., Dozier, M., Branch, B., Dennis, S., Kizer, M., and Hodges, W., 2007, Down-well camera highlights from the Southern region: Proceedings of the 2007 New England Private Well Water Symposium, p. 13.

Blacketter, L.L., Fannin, H.B., Beck, E.G., and Kotter, D., 2007, Determination of selected inorganic anions as an indicator of groundwater quality in Hickman County, Kentucky: Proceedings of the 13th Annual Kentucky Experimental Program to Stimulate Cooperative Research Conference, poster 12.

Blair, R.J., Blanset, J.M., Ray, J.A., and Webb, J.S., 2008, Assessment of nonpoint source impacts

- on groundwater quality in South Elkhorn Creek Basin, central Kentucky [abs.]: Kentucky Water Resources Research Institute Annual Symposium, Abstracts with Program, p. 25.
- Currens, J.C., and Paylor, R.L., 2008, Feasibility study of cover-collapse rate in the Western Pennyroyal karst of Kentucky [abs.]: Kentucky Water Resources Research Institute Annual Symposium, Abstracts with Program, p. 27–28.
- Davidson, B., and Fisher, R.S., 2007, Kentucky groundwater-quality data search engine [abs.]: Kentucky Water Resources Research Institute Annual Symposium, Abstracts with Program, p. 37–38.
- Davidson, B., and Fisher, R.S., 2008, Recent enhancements to the Kentucky groundwater quality data search engine [abs.]: Kentucky Water Resources Research Institute Annual Symposium, Abstracts with Program, p. 63–64.
- Dinger, J., Currens, J., Paylor, R., Fisher, S., and Rister, B., 2008, Hydrogeologic investigations of pavement subsidence in the Cumberland Gap tunnel [abs.]: Kentucky Water Resources Research Institute Annual Symposium, Abstracts with Program, p. 35–36.
- Dinger, J.S., Zourarakis, D.P., and Currens, J.C., 2007, Spectral enhancement and automated extraction of potential sinkhole features from NAIP imagery – Initial investigations: *Journal of Environmental Informatics*, v. 10, no. 1, p. 22–29.
- Fisher, R.S., and Davidson, B., 2007, Kentucky groundwater-quality mapping service [abs.]: Kentucky Water Resources Research Institute Annual Symposium, Abstracts with Program, p. 35–36.
- Thom, W., Beck, E.G., and Gumbert, A., 2007, Seeing is believing: University of Kentucky Cooperative Extension Service DVD DEI-0083.
- Vendrell, P., Beck, E., Dozier, M., Branch, B., Dennis, S., Kizer, M., and Hodges, W., 2007, Look down inside water wells across the Southern region: Concurrent Session Proceedings of the 2007 U.S. Department of Agriculture Cooperative State Research, Education, and Extension Service Southern Region Water Quality Conference, p. 12.
- Vendrell, P., Beck, E., Dozier, M., Branch, B., Dennis, S., Kizer, M., and Hodges, W., 2007, Southern region down-well camera team: Proceedings of the 2007 New England Private Well Water Symposium, p. 44.
- Vendrell, P., Beck, E., Dozier, M., Smith, J.W., Kizer, M., Branch, B., Dennis, S., and Hodges, W., 2007, Look down inside water wells across the Southern region: Proceedings of the American Society of Agronomy–Crop Science Society of America–Soil Science Society of America 2007 International Annual Meetings.

### **Presentations**

- Davidson, B., and Fisher, R.S., 2007, Kentucky groundwater-quality data search engine: Kentucky Water Resources Research Institute Annual Symposium, Lexington, Ky., March 26.
- Davidson, B., and Fisher, R.S., 2008, The Kentucky Groundwater Data Repository and Groundwater Monitoring Network: Kentucky Geological Survey Workshop, Lexington, Ky., October 24.
- Fisher, R.S., and Davidson, B., 2008, Searching the groundwater-quality database: Kentucky Geological Survey Annual Seminar, Lexington, Ky., April 20.
- Fisher, R.S., and Davidson, B., 2008, Kentucky groundwater-quality mapping service: Kentucky Water Resources Research Institute Annual Symposium, Lexington, Ky., March 26.
- Lyne, K.L., and Blair, R.J., 2008, Efficiently locating and repairing damaged sewer lines in a karst terrane: Kentucky Water Resources Research Institute Annual Symposium, Lexington, Ky., March 17.
- Ray, J.A., Blair, R.J., and Webb, J.S., 2008, Karst groundwater infiltration of the sanitary sewer within the Beargrass Creek watershed, Jefferson County, Kentucky: Kentucky Water Resources Research Institute Annual Symposium, Lexington, Ky., March 17.

### **Web Site Information**

The Kentucky Geological Survey provides online access to information about water wells and springs at [kgsweb.uky.edu/DataSearching/Water/WaterWellSearch.asp/](http://kgsweb.uky.edu/DataSearching/Water/WaterWellSearch.asp/). The information is useful to the public, well drillers, consultants, and researchers. KGS also maintains a Web site for the Kentucky Interagency Groundwater Monitoring Network at [www.uky.edu/kgs/water/gnet/gnet.htm/](http://www.uky.edu/kgs/water/gnet/gnet.htm/). This site contains maps and data summaries

of measurements of nitrate-nitrogen, fluoride, mercury, selenium, arsenic, pH, and hardness; a location map showing wells and springs that have been analyzed for various water-quality parameters; and previous annual reports of the network. The site also has links to the Web sites of the ITAC agencies and organizations. The Kentucky Geological Survey has compiled information about hydrology, geology, topography, water supply, and water quality from maps, reports, and data collected from 1940 to 2000 and posted them for public access at [www.uky.edu/kgs/water/library/webintro.html/](http://www.uky.edu/kgs/water/library/webintro.html/).

In 2007-08, the Kentucky groundwater-quality data search engine was updated and enhanced, and a new graphical groundwater-quality comparison Web site was introduced. Users can select individual or multiple parameters of interest, view search results, download the data to delimited text files for use in spreadsheets or various GIS software packages, and generate graphs comparing groundwater-quality data by physiographic region or watershed basin. Currently, 38 parameters in five major categories (water properties, volatile organic compounds, nutrients, pesticides, and inorganic solutes) can be searched either as an entire group or by individual analyte. Each analyte also has associated text files with descriptive information about the substance, possible health hazards, and EPA drinking-water standards. Users can display a detailed groundwater-quality map of each analyte showing the range of values on a statewide base map showing physiographic regions.

The new graphical groundwater-quality comparison Web site allows users to choose an analyte, limit data by date or data reliability, and generate three types of graphs: cumulative plots of analyte values, analytical values versus well depth, and box-and-whisker diagrams, which help explain the data distribution.

For more information on groundwater-quality or water-well or spring data, contact the Survey at (859) 257-5500 x 162 or x 158. The enhanced water-quality search engine can be accessed online at [kgsweb.uky.edu/DataSearching/Water/WaterQualSearch.asp/](http://kgsweb.uky.edu/DataSearching/Water/WaterQualSearch.asp/) and the newly released graphical groundwater-quality data comparison site is located at [kgsmap.uky.edu/website/KGSWaterPlot/WaterQualityPlot.asp/](http://kgsmap.uky.edu/website/KGSWaterPlot/WaterQualityPlot.asp/).

## Interagency Coordination

Cooperation among agencies and research organizations that collect, analyze, and use groundwater data reduces monitoring costs, improves program efficiency, and promotes data sharing. The Kentucky Interagency Technical Advisory Committee on Groundwater provides a forum for organizations that participate in ITAC to meet quarterly and discuss groundwater issues.

Many programs benefit from the Division of Water's willingness to collect and analyze groundwater samples to support various projects. Recent examples include the DOW coordinating with the Kentucky Geological Survey to collect groundwater samples at a drilling site in Salyersville, and DOW's regular sampling of Royal Spring, the focus of a Kentucky Geological Survey travel-time study. DOW also samples groundwater and surface water for nonpoint-source constituents in support of projects for the Division of Pesticide Regulation. The Division of Water and the Kentucky Geological Survey regularly answer inquiries from the public and communicate with staff of the Kentucky Rural Water Association. KGS staff have been meeting with County Extension Service agents and Area Development District staff throughout the commonwealth to promote awareness of hydrogeologic issues. Many of the ITAC agencies are also members of the Kentucky Agricultural Water Quality Authority, or cooperate with the Authority and participate in their meetings. Members of both the Division of Water and Kentucky Geological Survey regularly participate in meetings of State and Federal agencies and citizens' groups that have interests in groundwater resources.

## Groundwater Data Sharing

Sharing data is an essential function of the Interagency Groundwater Monitoring Network. Data transfers between agencies provide each group access to a larger database than any agency could develop independently, thereby improving evaluations of groundwater quality and suitability for various uses, threats to groundwater quality, and the effects of mining, logging, agricultural practices, urbanization, waste disposal, and oil and gas production. Sharing data also reduces the overall expense and increases the efficiency of monitoring efforts.

Data have been transferred electronically between the Division of Water groundwater database and the Kentucky Groundwater Data Repository, and between the Kentucky Geological Survey analytical laboratory and the Groundwater Branch since 1992. There has also been a high level of collaboration and data sharing between the Kentucky Geological Survey and the Groundwater Branch during the reporting period, as the agencies are jointly reporting on groundwater quality throughout the state. During 2007, electronic data files of groundwater-quality data, as well as well-construction information, were transferred from the Division of Water to the Survey.

## Other Activities

ITAC agencies are involved in many activities dealing with surface-water quality and public education about water resources. Although these projects do not directly address issues raised by the 1998 Kentucky General Assembly, they are important contributions because of the close interconnection of groundwater and surface-water systems in Kentucky.

### ***Division of Water–Groundwater Branch***

1. In January 2008, changes were made to the Ambient Groundwater Monitoring Program that will allow for increased sampling frequency at four karst springs to better capture temporal water-quality variations.
2. Documents dealing with regulations for water well drillers' certification and well-construction practices and standards were revised and filed with the Legislative Research Commission. Among other documents, the certification regulation, updates to water-supply well-construction standards, a separate regulation for monitoring well-construction practices, and a new definitions regulation were revised.
3. Recent groundwater-quality studies in Kentucky's karst regions have integrated approaches to surface- and groundwater quality assessments to better define the interrelationships between the two flow systems (surface water and groundwater are connected systems, particularly in karst terrains). Surface-water assessments (sec-

tion 305b report) in the well-developed karst areas, such as the Sinkhole Plain and Bluegrass regions, are limited because of a relative lack of flowing surface streams. Particularly in the Sinkhole Plain of south-central Kentucky, karst spring basins represent large areas of contribution to the Green River that are not assessed for water quality. Conduit flow that drains these basins can only be assessed via discharges to surface waters at discrete springs. Any adequate strategy for assessing these flows must meet the requirements for surface-water assessment protocols.

- An integrated approach attempts to address the deficiencies of inadequately assessed stream segments and provide needed information on spring conditions relative to nonpoint-source impacts to both surface and groundwater in Kentucky. Such assessments have implications for listing and removing springs as water bodies in the section 305(b)/303(d) integrated report, total maximum daily loads, watershed planning, and the availability of grant funds (e.g., section 319(h)) for watershed projects in these areas. Two separate study areas in the Kentucky River and Green River Basins served as locations for pilot projects for this holistic watershed approach. Water-quality samples (for major ions, nutrients, total organic carbon, total suspended solids, total dissolved solids, pH, alkalinity, metals, volatile organic compounds, and pesticides) were collected monthly for a year from each spring. Total coliform and *E. coli* bacteria samples were also collected monthly from May through October. Of the 10 springs assessed in the Green River Basin, nine were "not supporting" for primary contact recreation and one was "partially supporting" for primary contact recreation. Five of these springs were "fully supporting" for aquatic life use; the other five were "partially supporting." In the South Elkhorn watershed, 18 springs were "not supporting" for primary contact recreation, and three were "fully" supporting for primary contact recreation. Aquatic life use was not determined for springs in the South Elkhorn watershed.
4. Comparison of hydrologic maps developed using dye-trace data to the USGS 11- and 14-digit hydrologic unit code boundaries indicates that

a significant amount of mapped karst groundwater basins deviate from hydrologic boundaries based on topographic divides. Accurate hydrologic mapping is necessary to calculate water budgets and develop watershed models for total maximum daily loads, to implement watershed-based solutions to water quality and quantity problems, and to aid first responders to hazardous material releases.

### **University of Kentucky Cooperative Extension Service—Environmental and Natural Resource Issues Task Force**

**Kentucky Water Awareness Month.** Each May, citizens across Kentucky celebrate Water Awareness Month. This program first began in 1996 as an educational tool of the University of Kentucky Cooperative Extension Service to promote water awareness. Each year, program materials are developed by a committee at the state level, and distributed to each of the 120 County Extension offices. Counties across the commonwealth celebrate Kentucky Water Awareness Month by participating in activities such as after-school programs, environmental day camps, and homemaker club meetings. In March 2008, packets were distributed and included radio scripts and short media articles, fact sheets, brochures, activities, and program evaluations on groundwater, stormwater, and watersheds. Many materials included in the 2008 packet are available online at [www.ca.uky.edu/enri/KWAM.HTM/](http://www.ca.uky.edu/enri/KWAM.HTM/).

**Seeing Is Believing Video.** “Seeing Is Believing” is a 15-minute video developed by the University of Kentucky Cooperative Extension Service and the Kentucky Geological Survey. The video informs well owners on how to maintain existing water wells and reminds viewers of the importance of water testing. The video can be ordered online at [dept.ca.uky.edu/agc/distrib/index.asp/](http://dept.ca.uky.edu/agc/distrib/index.asp/).

**Consumer Radio Tips.** The following 60-second radio tips were recorded by the University of Kentucky Agricultural Communications Service; they were developed and read by Amanda Gumbert, UK Water Quality Liaison, and Ashley Osborne, UK ENRI Extension Associate:

- Caring for Your Drinking Water Well
- Testing Your Water
- Safe Chemical Storage
- What Is Karst?
- Stormwater Sewer Drains
- Groundwater Awareness Week.

**ENRI Web Site ([www.ca.uky.edu/enri/](http://www.ca.uky.edu/enri/)).** The ENRI Web site contains information on groundwater ([www.ca.uky.edu/enri/groundwater/](http://www.ca.uky.edu/enri/groundwater/)). The Web site is routinely updated and maintained by Ashley Osborne, ENRI Extension Associate. Also included on the Web site is information about watersheds, stormwater, the Kentucky Agriculture Water Quality Plan, and the Kentucky Water Awareness Month packet. In addition, an Upcoming Events page provides information on current events such as Groundwater Awareness Week.

**ENRI Quarterly Newsletter ([www.ca.uky.edu/ENRI/news.htm/](http://www.ca.uky.edu/ENRI/news.htm/)).** The ENRI newsletter provides information to County Extension agents and other natural-resources professionals in Kentucky about current research, events, and materials (e.g., new videos, publications, links, etc.).

**Displays.** The ENRI Task Force developed a display on basic stormwater information for the Stormwater Education Toolkit. The toolkit was coordinated by the Kentucky Transportation Cabinet for all Kentucky coordinators of phase II of municipal stormwater sewer systems.

**Cane Run Watershed Project.** The University of Kentucky has received two grants from the EPA’s 319(h) program to address water-quality problems in the Cane Run watershed. Segments of the Cane Run watershed, which includes the Royal Spring aquifer (a drinking-water source for the city of Georgetown) have been identified as having high levels of sedimentation/siltation, pathogens, and nutrient/organic enrichment. The stream has been placed on Kentucky’s list of impaired streams. UK will focus its efforts in the upper 15,000 acres of the watershed. Phase I of the Cane Run project is the development and approval of a watershed-based plan with some initial implementation. Phase II will continue implementation of the plan. Implementation includes best management practices, restoring parts of the stream channel, and conducting an education and outreach campaign. Cooperators



on the project include the Agricultural Experiment Station, Kentucky Horse Park, Lexington-Fayette Urban County Government, Kentucky Division of Conservation, Fayette County Conservation District, Lexmark, Friends of Cane Run, and many others. For additional information, please contact Amanda Gumbert, UK Water Quality Liaison, at [amanda.gumbert@uky.edu](mailto:amanda.gumbert@uky.edu).

### ***Kentucky Division of Forestry***

The primary objective of the Kentucky Division of Forestry's Timber Harvest Compliance Program is to protect water from nonpoint-source pollution by utilizing best management practices in commercial timber-harvesting operations. This program enforces the minimum performance standards of BMP's mandated by the Agriculture Water Quality State Plan.

For the fiscal year of July 1, 2007, to June 30, 2008, a total of 5,877 harvest inspections were performed, resulting in 571 enforcement actions. A BMP monitoring study from a recent statewide survey indicated that 68 percent of the applicable BMP's were implemented on the sites examined.

The Kentucky Division of Forestry Stewardship Program is also proactively involved with mitigating water-quality concerns by providing technical assistance in practice plans for riparian buffer development under the auspices of the U.S. Department of Agriculture-Natural Resources Conservation Service's Conservation Reserve Program. Riparian buffer development (conservation practice 22) is also a major component of the Conservation Reserve Enhancement Program in the Green River watershed, in which the Kentucky Division of Forestry continues to play a key role. In this targeted project area, the Division of Forestry completed 164 CREP practice plans involving 1,287 acres for fiscal year 2007-08.

The Division of Forestry is also beginning the promotion of the new "agroforestry" concept of strategically incorporating trees into the agricultural landscape to protect water resources and meet landowner objectives. This integrated watershed approach is very effective in promoting water quality, and many times economical to the landowner when implemented.

Mitigating stormwater issues is a component of the Division of Forestry's Urban Forestry Pro-

gram. The Division's urban forestry specialists are involved with educating community leaders about the many benefits of trees in the urban setting, including phytoremediation (the use of trees to decontaminate soils or water). The urban forestry specialists are also working with the Cane Run focus watershed management group to address water-quality concerns for that important urban landscape of the Bluegrass Region. Division of Forestry personnel are assigned to work collaboratively with local groups in four of the Kentucky Division of Water's five focus watersheds.

### ***Division of Mine Reclamation and Enforcement***

This past fiscal year was busy for the Technical Support Section of the DMRE. Water samples were collected during an investigation of possible mining-related impacts to groundwater in both the Eastern and Western Kentucky Coal Fields. An extended drought in eastern Kentucky dropped groundwater levels and caused a significant increase in requests for inspections of dry wells. Numerous complaints of methane production from domestic water wells in the eastern coal field were associated with lowered groundwater levels.

DMRE received 92 requests for inspection related to groundwater issues and, of the 79 investigations close during the 2007-08 fiscal year, 17 found that groundwater quality or quantity had been affected by mining operations. The remaining investigations resulted in a finding of no impact or impacts by natural causes.

## **Summary**

The Kentucky Interagency Groundwater Monitoring Network was established by the Kentucky General Assembly to increase knowledge and awareness of groundwater resources. For 10 years, the network has met the obligation of collecting and interpreting data, communicating findings, sharing data, and promoting interagency cooperation. Significant progress has been made over this period, particularly over the past fiscal year; however, critical questions remain to be addressed.

Most of the activities during the reporting period were investigations of identified or suspected

groundwater-quality problems and were possible only because the agencies involved were able to obtain funding from outside sources. As noted in previous annual reports, the availability of these funds is decreasing. A stable source of recurring funding is essential if groundwater issues are to be addressed proactively, which will best serve the needs of citizens, resource managers, and environmental regulators.

## **References Cited**

- Interagency Technical Advisory Committee on Groundwater, 1996, Framework for the Kentucky Groundwater Monitoring Network: A report of the Interagency Technical Advisory Committee: University of Kentucky, Kentucky Water Resources Research Institute, 29 p.
- Kentucky Division of Water, 1997, Kentucky watershed management framework: Kentucky Division of Water, 53 p.