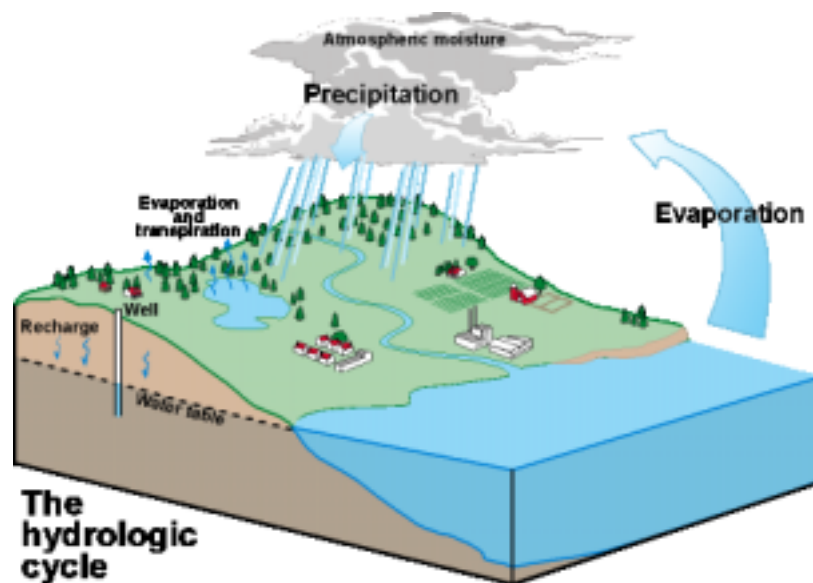


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GROUND-WATER RESOURCES OF BOURBON COUNTY, KENTUCKY



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Foreword

This report on the ground-water resources of the county was prepared for the Water Resource Development Commission by the Kentucky Geological Survey. Reports were prepared for each of Kentucky's 120 counties. These reports complement other county planning reports of the Commission, including Strategic Water Development Plans and Strategic Wastewater Treatment Plans, and the Division of Water's County Water Supply Plans.

Each ground-water resource report is a compilation of information on hydrology, geology, topography, water supply and water quality taken from maps, reports, and data collected from 1940 to 2000. The primary mode of access to the information is via links from the report to the internet--for example, by linking to the KGS internet library of ground-water research. The digital form of the report, and its ability to link to data anywhere on the internet, makes it a dynamic tool for gathering information.

The current compilation is by no means exhaustive: no doubt valuable data have been overlooked. As new or more-detailed information becomes available, it can be easily linked into this report.

While this report may be of value to planners and geologists for strategic planning and feasibility-level studies, it cannot replace field investigation for the development or assessment of site-specific ground-water resources.

DISCLAIMER STATEMENT

The Kentucky Geological Survey (KGS) is constantly gathering data from multiple sources, interpreting the data it gathers, and reflecting its interpretations on maps such as those in this report. Reasonable efforts have been made by KGS to verify that these maps and the digital data provided thereon accurately interpret the source data used in its preparation; however, these maps may contain omissions and errors in scale, resolution, rectification, positional accuracy, development methodology, interpretations of source data, and other circumstances. As additional data becomes available to KGS, and as verification of source data continues, these maps may be re-interpreted or updated by KGS. These maps are designed at a designated scale and should not be enlarged. Further, these maps should not be used for navigation, engineering, legal or any other site-specific use. Nothing contained herein shall be deemed an expressed or implied waiver of the sovereign immunity of the Commonwealth or its duly authorized representatives, agents, or employees.

Introduction

This report is intended to provide both a basic understanding of ground-water resources in the county and links to more in-depth sources of information, maps, and data. Links are highlighted in [blue](#). Most of the links are to document files or maps in Adobe PDF files. The PDF may be viewed with the free [Acrobat Reader](#). Some of the files are large and, depending on your system, you may prefer to download the files to your system overnight. A few maps may be in MrSid file format. These files are viewable with the free [MrSid Viewer](#), with ESRI GIS software, and with any other MrSid-compatible software.

Acknowledgments

Many individuals and several agencies provided information and assistance in the preparation of this atlas. The GIS students at the Federal Prison Camp, Lexington, Ky., prepared index maps and created spatial data from historical well maps. Staff members of the [Kentucky Natural Resources Information System](#) provided technical and programming assistance. Reports from the [Kentucky Division of Water](#), the U.S. Geological Survey, the [Kentucky Geological Survey](#), the Water Resource Development Commission, the [U.S. Census Bureau](#), and other agencies were used. And finally, the atlas would not have been completed at this time if the Water Resource Development Commission had not promoted the project and provided both financial and technical support.

Overview

About 3,300 residents of Bourbon County rely on private domestic water supplies: 1,000 use wells and 2,300 use other sources. In the valleys of the South Fork of the Licking River, Stoner and Hinkston Creeks and their major tributaries, most drilled wells will produce enough water for a domestic supply at depths of less than 100 feet. Wells located in the upper reaches of the larger creek valleys will produce enough water for a domestic supply except during dry weather. In the upland areas of eastern and southern Bourbon County, 30 percent of the county, most drilled wells will not produce enough water for a dependable domestic supply; some wells along drainage lines may produce enough water, except during dry weather. Throughout the county ground water is hard or very hard and may contain salt or hydrogen sulfide, especially at depths greater than 100 feet.

Water Use

Bourbon County had an estimated population of 19,231 (7,737 households) in 1999; projected population is 18,822 (8,202 households) in 2020. Public water is provided to about 83 percent of the county's residents. In areas not served by public water, about 30 percent of the households use wells and 70 percent use other sources. About 380 customers will be added to public water service through new line extensions from 2000 to 2020. If all proposed water line extensions are made, about 12 percent of the county will still rely on private water supplies in the year 2020.

The Water Resource Development Commission has prepared a report on [water supply infrastructure in the county](#).

It is estimated that there are over 200,000 water wells in Kentucky. The Ground-Water Data Repository, maintained by the Kentucky Geological Survey, has information on over 50,000 of these wells. The locations of wells and springs in the county for which data is available is shown on the [map of wells and springs in the county](#). A map of [certified well drillers in Kentucky](#) has been prepared by the Kentucky Division of Water.

Topography of the County

Discussion from McGrain and Currens (1978)

Bourbon County is located in the Inner Blue Brass region of Kentucky. Topographically, it is a rolling limestone upland, slightly to moderately dissected. Even though this is a limestone terrain, karst features are not abundant.

[View elevation map](#)

Elevations between 900 and 1,000 feet are common; the maximum elevation of 1,050 feet is on a ridge about 1 1/2 miles northeast of North Middletown. Cane Ridge, east of Paris, has ridgetop elevations between 950 and 1,000 feet. Similar high elevations are found on the ridge along the Bourbon-Scott and Bourbon-Fayette County boundaries; this ridge is also the dividing line between the drainage basins of the Kentucky and Licking Rivers. Another high area is the drainage divide between some of the tributaries of Hinkston and Stoner Creeks in southeastern Bourbon County, where a number of hilltops have elevations between 1,000 and 1,030 feet.

The greatest local reliefs are found adjacent to the major streams: Licking River and Hinkston, Houston, Silas, Stoner, Strodes, and Townsend Creeks. Here differences in elevation between the valley flats and the adjacent uplands range from 60 to 120 feet in most areas. The lowest elevation in the county is about 715 feet, at the point where Licking River leaves the county.

Elevations of communities in the county are Austerlitz, 920 feet; Centerville, 931 feet; Clintonville, 992 feet; Millersburg, 803 feet; North Middletown, 916 feet; Paris, the county seat, 843 feet; and Shawhan, 835 feet.

The 7.5-minute topographic quadrangle maps that cover the county are shown, by name and by index code (Kentucky Natural Resources and Environmental Protection Cabinet) on the [index map](#).

Geology of the County

In Bourbon County water is obtained from consolidated sedimentary rocks of Ordovician age and unconsolidated sediments of Quaternary age. The oldest rocks found on the surface in Bourbon County are the Lexington Limestones, deposited in shallow seas 490 million years ago during the Middle Ordovician Period. In the Late Ordovician the seas became relatively shallow, as indicated by the amounts of mud (shale) in the sediments. When the waters were clear and

warm, a profusion of animal life developed, particularly brachiopods and bryozoa. Over the last one million years the unconsolidated Quaternary sediments have been deposited along the larger streams and rivers.

Geologic Formations in the County

Unconsolidated deposits

ALLUVIUM (Qa)

Limestones

UPPER PART OF LEXINGTON LIMESTONE (O1) (Strodes Creek , Millersburg, Tanglewood Limestone, Devils Hollow, Stamping Ground, Sulphur Well, Brannon Members)

LOWER PART OF LEXINGTON LIMESTONE (O1) (Grier, Logana, Curdsville Members)

Interbedded clay shales, siltstones and sandstones

GARRARD SILTSTONE (Okc)

Interbedded limestones and shales

ASHLOCK FORMATION, CALLOWAY CREEK LIMESTONE (Oaf)

CLAYS FERRY FORMATION (Okc) and KOPE FORMATION (Ok)

For more information, see the definitions of [geologic terms](#) and [rock descriptions](#), [a geologic map of the county](#), a summary of the [geology of Kentucky](#), and a discussion of [fossils and prehistoric life in Kentucky](#).

Ground Water Availability

Alluvium (Qa)

Topography

Alluvium forms valley flats and flood plains. Flats are dissected by short, steep-sided gullies near tributaries.

Hydrology

The alluvium is too thin and fine-grained to yield large amounts of water. Water is hard.

Ashlock Formation, Calloway Creek Limestone (Oaf)

Topography

These rocks form gently to moderately rolling uplands away from major streams, more highly dissected where shale content increases. Small sinkholes, minor underground drainage, and broad, flat valleys occur where limestone predominates.

Hydrology

These formations yields 100 to 500 gal/day to drilled wells in broad valleys and along streams in upland; yield almost no water to drilled wells on hillsides or ridgetops; yield water to small springs. Water is hard and in valley bottoms may contain salt or hydrogen sulfide. Where thick limestone beds with little shale occur below stream level in valley bottoms or on uplands, they may have undergone solutional enlargement of fractures and bedding-plane openings. Wells drilled into these limestone beds may produce more than 500 gal/day. These thick beds also yield water to some large springs.

Garrard Siltstone (Okc)

Topography

The Garrard has prominent ledges in steep slopes and bluffs along large streams.

Hydrology

The Garrard yields 100 to 500 gal/day to drilled wells in valley bottoms, but almost no water to wells on hillsides or ridgetops and almost no water to springs. The well-cemented siltstone and fine-grained sandstone do not provide many openings for water. Water is hard.

Clays Ferry Formation (Okc) and Kope Formation (Okope)

Topography

These formations form a rugged topography of narrow, steep-sided ridges with narrow V-shaped valleys of dendritic drainage. Shales on steep slopes erode easily and are covered with thin limestone slabs in many places. In the lower part of the formation topography becomes more gently to moderately rolling uplands with small sinkholes, and some underground drainage where limestone predominates.

Hydrology

These rocks yield 100 to 500 gal/day to drilled wells in large valley bottoms along streams, but almost no water to drilled wells on hillsides or ridge tops. They yield water to small springs and

seeps. Water is hard in valley bottoms and may contain salt or hydrogen sulfide. Shale has small, poorly connected openings, and ground-water circulation is slow; as a result, little water is available to wells and springs. On ridgetops the shale prevents downward percolation of water, and creates small semiperched water bodies in lower part of soil and upper part of weathered bedrock.

Upper Part of Lexington Limestone (Ol) (Strodes Creek , Millersburg, Tanglewood Limestone, Devils Hollow, Stamping Ground, Sulphur Well, Brannon Members)

Topography

The upper Lexington forms broad flat valleys in uplands; well-developed subsurface drainage and many sinkholes; gently sloping hillsides adjacent to small streams in uplands. The resistant shale and soft bentonite-rich beds form a subdued benchlike topography along hillsides and streams.

Hydrology

The upper Lexington yields 100 to 500 gal/day to wells in valley bottoms and along streams in uplands; yields as much as 300 gal/min in some places where thick limestone beds occur at or below stream level along large streams; yields water to springs in the Tanglewood Limestone and Brannon Member. Generally, the upper part of the Lexington Limestone contains more shale and yields less water in contrast to the lower part which is mostly limestone in many places. Water is hard and may contain salt or hydrogen sulfide in some places. Water from wells near fault zones may contain objectionable amounts of salt.

Lower Part of Lexington Limestone (Ol) (Grier, Logana, Curdsville Members)

Topography

The Lower Lexington is characterized by rolling to dissected uplands. Sinkholes are very common; the large ones occur in the Grier Limestone. Underground drainage is well developed. Natural outcrops are rare in the rolling upland, but the resistant limestone beneath hillslopes is evident from the subdued benchlike or terrace-like appearance of the slopes.

Hydrology

The limestones yield more than 500 gal/day to wells in valley bottoms and along streams in uplands; yield up to 150 gal/min from thick limestone beds in the Curdsville along large streams; and yield water to many small and large springs. The amount of water available in rocks of the Lexington Limestone depends on the amount of shale. Generally, the upper part of the Lexington

Limestone contains more shale and yields less water, in contrast to the lower part which is mostly limestone in many places. Water is hard and may contain salt or hydrogen sulfide in some places. Water from wells near fault zones may contain objectionable amounts of salt.

The U.S. Geological Survey's [Hydrologic Atlas Series](#), published cooperatively with the Kentucky Geological Survey, provides hydrologic information for the entire state.

Exploration for Ground Water

Ground water is precipitation that has drained through the soil into the gravels and bedrock fractures and faults below. It is found nearly everywhere, but useable, reliable quantities can only be tapped in sand, gravel, and rock formations that have sufficient void space to hold and conduct water. These formations are known as aquifers. Most ground water used for domestic supply comes from relatively shallow wells (less than 150 feet in depth) in fractured bedrock or unconsolidated materials. The bedrock may be shale, sandstone, siltstone, limestone, or coal. Water can be stored in all these rocks, but rapid movement of water is primarily controlled by secondary fractures--joints or faults that penetrate the rock near the land surface (Wyrick and Borchers, 1981; Kipp and Dinger, 1991).

Joints and faults in the earth's crust may extend for tens of feet up to several miles in length. The more lengthy of these features, called linear terrain features, fracture traces, or lineaments, can be seen on different types of aerial photographs and satellite imagery. These features may collect, store, and transport large amounts of ground water that can provide sufficient water to communities and industry.

Little effort has been made in the past to determine the ground-water resource potential as it relates to high-yield wells. Recent efforts in the upper Kentucky River Basin in which satellite imagery was used to locate wells resulted in three out of four wells producing more water than 90 percent of the recorded wells in the area, and having enough water to supply from 50 to 250 homes per well.

Exploiting geologic features such as fracture traces and lineaments is a common technique used for the exploration of subsurface fluids, including ground water (Siddiqui and Parizek, 1971; Mabee and others, 1994) and petroleum (Driscoll, 1986). Fracture traces are linear expressions on the earth's surface that are less than 1 mile in length; those greater than a mile are termed lineaments. Linear features that are not readily apparent on the ground can often be distinguished at high altitudes. Currently, private vendors as well as foreign agencies have made high-resolution satellite photos and radar images available. These data can be used in detailed surficial analysis for linear features that can be related to high-production ground-water zones.

Karst

(by James C. Currens, Kentucky Geological Survey)

A karst landscape has sinkholes, sinking streams, caves, and springs. Kentucky is one of the most famous karst areas of the world. Much of the state's beautiful scenery, particularly the horse farms of the Inner Blue Grass, results from the development of karst landscape. Karst underlies regions of major economic importance to the state. Many of Kentucky's cities, such as Frankfort, Louisville, Lexington, Bowling Green, Elizabethtown, Munfordville, Hopkinsville, Russellville, Princeton, Lawrenceburg, Georgetown, Winchester, Paris, Somerset, Versailles, and Nicholasville, are partly or entirely underlain by karst. Springs and wells in karst areas supply water to thousands of homes. Much of Kentucky's prime farmland is underlain by karst. A substantial portion of the Daniel Boone National Forest, with its important recreational and timber resources, is underlain by karst. Caves also provide recreational opportunities and contain unique ecosystems. Mammoth Cave, with over 350 miles of passages, is the longest surveyed cave in the world. Two other caves in the state are over 30 miles long, and 10 Kentucky caves are among the 50 longest in the United States.

[View state karst map](#)

Although maps that show in detail where the karst terrane of Kentucky occurs have never been made, the areas underlain by rocks on which karst can develop have been mapped. The 1:500,000-scale geologic map (Noger, 1988) can be used to estimate the percentage of karst terrane in the state. Ninety-two of Kentucky's 120 counties contain at least some areas of karst. About 40 percent of the state is underlain by rocks with the potential for at least some karst development, recognizable on topographic maps, and 20 percent of the state has well-developed karst features.

Karst Regions

The karst of Kentucky occurs in five principal regions, but also in many scattered locations.

- The largest area is the Western Pennyroyal, arching from the Ohio River north of Elizabethtown southward, then westward through Bowling Green and Hopkinsville, then

northward again back to the Ohio River. Many of the state's longest caves, and terrane most densely pocketed with sinkholes, are in this region.

- The next largest expanse is the Inner Blue Grass, surrounding Lexington and including Georgetown, Versailles, Winchester, and several other cities.
- The Eastern Pennyroyal lies east of the Inner Blue Grass and reaches from the Ohio River south-southwest to the Tennessee border. The Eastern Pennyroyal includes the communities of Mount Vernon, Somerset, and Monticello.
- The Carter Caves region, east-northeast of Winchester is the fourth region, but it is sometimes considered part of the Eastern Pennyroyal. Although no large communities are located on this karst, Carter Caves State Park, an important tourist attraction, is located here.

The last major karst area lies along the crest of Pine Mountain in southeastern Kentucky, where geologic forces have thrust the limestone from deep beneath the coal field to the surface. No communities occupy this karst area, but it is a significant recreational and ecological resource, and springs draining from it are important water supplies.

Karst terrane affects the lives of many Kentuckians every day. Most people don't realize they are affected because the costs are hidden in the form of higher taxes and increased cost of living. Often enough, the consequences of living in a karst terrane directly affects people's lives. Of vital concern is protection of ground-water resources. For example, many communities in Kentucky were established near karst springs to take advantage of the reliable water supply. Because of pollution, most of these town springs have long since been abandoned as water supplies. Factories and homes built over filled sinkholes may be damaged as the fill is transported out of the sinkhole and the soil cover collapses. Also, structures built in sinkholes are often vulnerable to flood damage.



Flooding in a karst area.

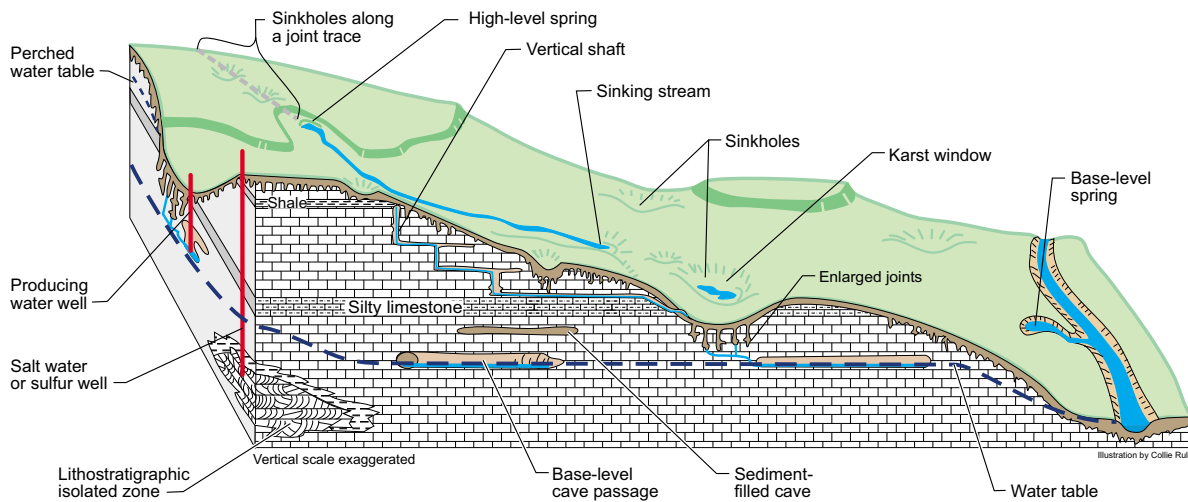
Features of a Karst Landscape

The term "karst" is derived from a Slavic word that means barren, stony ground. It is also the name of a region in modern Slovenia near the border with Italy that is well known for its sinkholes and springs. The name has been adopted by geologists as the term for all such terrane.

A karst landscape most commonly develops on limestone but can develop on several types of rocks, such as dolomite, gypsum, and salt. The karst terranes of Kentucky are mostly on limestone and formed over hundreds of thousands of years. As water moves underground, from hilltops toward a stream through tiny fractures in the limestone bedrock, the rock is slowly dissolved away by weak acids found naturally in rain and soil water.

Generalized Block Diagram of the Inner Blue Grass Karst

James C. Currens



Inner Blue Grass karst:

Karst occurs where limestone or other soluble bedrock is near the earth's surface, and fractures in the rock become enlarged when the rock dissolves. Sinkholes and sinking streams are two surface features that indicate karst development. In karst areas most rainfall sinks underground, resulting in fewer streams flowing on the surface than in non-karst settings. Instead of flowing on the surface, the water flows underground through caves, sometimes reemerging at karst windows, then sinks again to eventually discharge at a base-level spring along a major stream. The development of karst features is influenced by the type of soluble rock and how it has been broken or folded by geologic forces. There are four major karst regions in Kentucky: the Inner Blue Grass, Western Pennyroyal, Eastern Pennyroyal, and Pine Mountain. This diagram depicts the Inner Blue Grass karst.

In the Inner Blue Grass, insoluble impurities within the limestone, such as shale, result in a perched or isolated water table that discharges ground water at high-level springs or may locally isolate pockets of saltwater or sulfur water. In some locations, vertical fractures in the rock, called joints, may increase the rate of water flowing toward base level. The joints and impurities also influence the location and development of vertical shafts and caves. As erosion on the surface continues over geologic time, the major stream draining a karst terrane cuts its channel deeper. In response, deeper conduits increase their flow to the major stream, and new springs develop at lower elevations along the stream's banks. Older, higher flow routes are left as dry cave passages, some of which become sediment filled. To produce significant amounts of water, wells drilled into karst aquifers must intersect a set of enlarged fractures, a dissolution conduit, or a cave passage with an underground stream.

For information on obtaining copies of this chart and other Kentucky Geological Survey maps and publications call:
Publications Sales
(606) 257-3899
View the KGS World Wide Web site at:
www.uky.edu/KGS/

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Schematic diagram showing some of the important features of karst terrane. Other types of karst features are not illustrated.

An aquifer is any body of rock from which important quantities of drinkable water may be produced. Springs are sites where ground water emerges from an aquifer to become surface water. Springs occur along creeks and rivers where the water table meets the land surface. They also occur where rocks that do not allow water to flow easily, such as shale, underlie or have been faulted against permeable rock. The impermeable rock blocks the flow of the ground water, again forcing it to the surface. Karst springs occur where the ground-water flow has concentrated to dissolve a conduit or cave in soluble rock. The ground-water basin of a karst spring collects drainage from all the sinkholes and sinking streams in its drainage area. The water flowing from each sinkhole joins together underground to form ever-increasing flow in successively larger passages, which discharge at the spring. Karst springs or "cave springs" can have large openings and discharge very large volumes of water. The soil cover, narrow fractures, small conduits, and larger cave passages collectively form a karst aquifer.

A sinkhole is any depression in the surface of the ground into which rainfall is drained. Karst sinkholes form when a fracture in the limestone bedrock is preferentially enlarged. Sinkholes form in two ways. In the first way, the bedrock roof of a cave becomes too thin to support the weight of the bedrock and the soil material above it. The cave roof then collapses, forming a collapse sinkhole. Bedrock collapse is rare, and the least likely way a sinkhole can form, although it is commonly assumed to form all sinkholes. The second way sinkholes form is much more common and much less dramatic. As the rock is dissolved and carried away underground, the soil gently slumps or erodes into a dissolution sinkhole. Once the underlying conduits become large enough, insoluble soil and rock particles are carried away too. Dissolution sinkholes form over long periods of time, with occasional episodes of soil or cover collapse.

All of the dissolved limestone and soil particles eroded from the bedrock to form a sinkhole pass through the sinkhole's "throat" or outlet. The throat of a sinkhole is sometimes visible, but is commonly roofed by soil and broken rock and can be partly or completely filled with rubble. This opening can vary from a few inches in diameter to many feet. Normally, water flows out of the sinkhole throat to a conduit that drains to a spring. When sinkhole throats are totally blocked and little water can flow out, a "sinkhole pond" may form, a common sight in the Pennyroyal. Sinkhole ponds are temporary features and last only as long as the throat is tightly plugged.

Swallow holes are points along streams and in sinkholes where surface flow is lost to underground conduits. Swallow holes range in diameter from a few inches to tens of feet, and some are also cave entrances. Swallow holes are often large enough to allow large objects such as tree limbs and cobble-size stones to be transported underground. This means that waste dumped into sinkholes can easily reach underground streams. It is not uncommon for discarded automobile tires and home appliances to be found deep within caves with flowing streams. Likewise, sewage, paint, motor oil, pesticides, and other pollutants are not filtered from water entering a karst aquifer.

Karst windows are a special type of sinkhole that gives us a view, or window, into the karst aquifer. A karst window has a spring on one end, a surface-flowing stream across its bottom, and a swallow hole at the other end. The stream is typically at the top of the water table. Karst windows develop by both dissolution and collapse of the bedrock. Many karst windows originated as collapse sinkholes.

[Karst locations are shown on a map of karst in the county.](#)

[More information on karst](#) is available on the KGS Web site.

Water Quality

"Groundwater is a vital, renewable natural resource that is widely used throughout Kentucky. Wells and springs provide approximately one-third of public domestic water supplies in the state. Surface streams, the major source of Kentucky's water supply, are primarily sustained during base flow by groundwater discharge from adjacent aquifers. This resource is susceptible to contamination from a variety of activities at the land surface. Once contaminated, groundwater can be difficult or impossible to remediate."---Kentucky Division of Water, Groundwater Branch.

Quality of Ground Water in the County

The quality of ground water in the Blue Grass region varies considerably from place to place and is determined by its geologic source. In Bourbon County ground water is hard to very hard and may contain salt or hydrogen sulfide. The two most common natural constituents that make water in the Blue Grass region objectionable for domestic use are common salt and hydrogen sulfide. The hydrogen sulfide-bearing water is usually satisfactory for domestic use since the hydrogen sulfide escapes as a gas upon exposure of the water to the air.

At a time when surprisingly little information is available on ground-water quality, ground-water contamination has become one of the major environmental issues. Reliable information about water quality is necessary in order to develop plans for protecting ground water. The absence of accurate and broad perspectives on ground-water quality may lead to inappropriate and ineffective regulatory policies. Because ground water supplies a large percentage of rural drinking water and water for agricultural use, rural landowners have become increasingly concerned about the quality of ground water. The Kentucky Farm Bureau, Kentucky Division of Conservation, University of Kentucky Cooperative Extension Service, and the Kentucky Geological Survey conducted a water-quality survey of nearly 5,000 rural domestic wells. The results are discussed in "[Quality of Private Ground-Water Supplies in Kentucky.](#)" Additional references are contained in the [Kentucky Geological Survey Internet Water Research library.](#)

Salt Water

Salt water (saline water) is found below fresh ground water at variable depths throughout the entire state of Kentucky. Depths to the saline groundwater range from 50 feet or less, down to 2,000 feet below land surface in Kentucky. "Salinity" is defined as a measure of the quantity of

dissolved mineral matter or total dissolved solids (TDS) in water, reported in parts per million (ppm) or milligrams per liter (mg/L); The two forms of measurement usually are equivalent. The term “salt” or “table salt” as used by most people is pure sodium chloride. Sodium and chloride are generally the major component of saline waters in Kentucky, but are not the only constituents. Water having a TDS concentration of less than 1,000 ppm is classified as fresh and water having a TDS concentration of 1,000 ppm or more is classified as saline.

Recommendations by the U.S. Public Health Service for drinking water suggest that total dissolved solids should not exceed 500 ppm, but less than 1,000 ppm may be used. In agriculture, the recommended TDS levels vary with uses, as shown in the following table, which was taken in part from "[Fresh-Saline Water Interface Map of Kentucky](#)" (Hopkins, 1966).

Upper limits of total dissolved-solids concentration in water to be consumed by livestock or used for crops.	
Crop	ppm
All crops, including forage	525
Most fruit and vegetable crops	1,400
Poultry	2,860
Pigs	4,290
Horses	6,435
Cattle (dairy)	7,150
Cattle (beef)	10,000
Adult sheep	12,900

Being aware of the depth to saline ground water is valuable when planning a water-supply well. Drilling a well too deep through the freshwater interval may cause a good well to be unsuitable for various uses. Care must be taken to prevent contamination of the freshwater zones by the deeper saline waters. Properly constructed water wells will screen the production zone in the targeted aquifer and isolate all other zones by casing and properly grouting and cementing the space outside the casings in the boreholes.

In Bourbon County the fresh-saline interface ranges from elevations of less than 600 feet mean sea level along the South Fork of the Licking River and Hinkston Creek to 900 feet in the higher elevations within the county. Generally, salt water is found at depths greater than 100 feet below the level of the principal valley bottoms.

Sensitivity of Ground Water to Pollution

According to the Kentucky Division of Water, Groundwater Branch, Bourbon County has areas of low-moderate to high sensitivity to ground-water pollution (see "[Report and Map on Ground-Water Sensitivity](#)," adapted from the Kentucky Division of Water, 1994). The hydrogeologic sensitivity of an area is defined as the ease and speed with which a contaminant can move into and within a ground-water system. The sensitivity assessment addressed only the naturally occurring hydrogeologic characteristics of an area. Possible impacts of human activity upon ground water, such as mining, logging, industry, and the use of pesticides, injection wells, and landfills, were not considered in the production of this map. Because of its small scale and generalized nature, this map is not intended for site-specific use, such as detailed land-use planning for city, county, or state agencies. The map should prove useful as a broad-scale management, educational, and planning tool, however.

Maps and Data

More information may be found at the following Web sites:

[Index to 7.5' Topographic and Geologic Quadrangle Maps](#)

[Download site for Geologic Quadrangle Maps](#)

[Download site for Topographic Maps](#)

[Download site for Aerial Photos \(DOQQs\)](#)

[Download site for Digital Elevation Models](#)

[GIS Data](#)

Additional Readings

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Definitions of Geologic Terms

Alluvial deposits: Stream-sediment deposits of comparatively recent age.

Aquifer: Stratum or zone below the surface of the earth capable of producing water, as from a well.

Bedding plane: The division planes that separate the individual layers, beds, or strata of rock.

Bedrock: Solid rock underlying soils and unconsolidated materials.

Faults: Fractures in the earth's crust along which displacement has occurred. The presence of faults may be very important in the success of large-capacity wells. In general, faulting enhances the permeability of bedrock aquifers because the bedrock is broken and pulverized along the zone bordering the fault plane. This is especially true in limestone areas, where fracturing is enhanced by subsequent solution. High-capacity wells are commonly located in fault zones.

Joints: Widely spaced vertical cracks in the bedrock.

Limestone: Layered rock composed of grains of calcite cemented together; may contain fossils.

Sandstone: Layered rock composed of grains of sand cemented together.

Shale: Thin-layered rock composed of clay minerals.

Soil: Loose materials occurring between the ground surface and underlying bedrock.

Rock Descriptions

(Noger, 1988; Carey and others, 1994)

Limestone: Limestones are characterized by solution-enlarged joints and bedding planes that channel water into conduits. The majority of ground water flows through the conduits and discharges at springs along major, permanent streams. Wells drilled in these areas may produce only a little water, or hundreds of gallons per minute, depending on the chance intersection of an enlarged joint or other opening. Little water moves through the unaltered bedrock. Ground water flowing through fractures and solution openings is easily contaminated. These rocks are generally very hard, requiring blasting or heavy equipment for excavation, and the depth of soil coverage is highly variable. In some areas of Kentucky underlain by limestones, soils more than 30 feet thick have been reported.

Sandstone: These rocks are generally very hard, requiring blasting or heavy equipment for excavation. Sandstones tend to form thin soils and steep slopes. Ground water flows through openings between sand grains and along fractures (widely spaced cracks).

Unconsolidated deposits: These deposits consist of noncemented clay, sand, and gravel and are found primarily in stream valleys. West of Lake Cumberland, these deposits occur both in stream valleys and upland areas. They are easily eroded during rainstorms. West of Lake Barkley, these deposits include loess, a fine-grained material deposited by wind. These deposits yield large volumes of water where aquifers are extensive. Areas of terrace deposits and alluvium in upper stream reaches may be too small to sustain high rates of production.

Fractured shales: Fresh exposures of fractured shale are hard and require heavy machinery for excavation. Although jointing and bedding planes in these brittle shales allow ground-water movement, there is little storage in the unfractured material. Wells in these rocks typically produce little water.

Clay shales: These shales are easily excavated and restrict ground-water movement. The high clay content can produce slippage and workability problems. Joints and bedding planes tend to heal or become clogged, although clay minerals have large intergranular storage of water, there is little or no permeability to allow its movement. Wells in these rock are generally dry.

Interbedded shales and limestones: Bedrock composed of 80 percent or more shale and 20 percent or less limestone. Limestone layers are usually 2 inches or less thick. These rocks are

easily excavated and generally restrict ground-water movement. Oversteepened banks and artificial cuts are subject to slippage. These formations have some limited potential as aquifers, but the high clay content generally blocks small conduits in the limestone. Wells in these rocks are generally dry.

Interbedded clay shales and sandstones: Where clay shales are dominant, successful water wells are difficult to obtain. In areas where the unit is sandy, wells more commonly yield sufficient water for a domestic supply.

Interbedded limestones and shales: Contains more than 20 percent limestone. Where limestone exceeds 60 percent, wells may yield adequate water for a domestic supply.

Interbedded limestones, sandstones, and shales: A vertical sequence of alternating limestones, sandstones, and shales.

Coals, sandstones, and shales: This unit consists of a vertical sequence of coals, sandstones, and shales that is generally horizontally discontinuous. Wells that penetrate a section composed of more than 50 percent sandstone have better than average yields, and almost all wells will produce enough water for domestic supplies. Many wells will produce sufficient supplies for small industries. Wells completed in coals, or obtaining flow from coals, are high productive, but may be of marginal or poor water quality. Wells completed in shales are commonly adequate for domestic supplies, depending upon the occurrence of weathered fractures in the shale.