Kentucky Geological Survey
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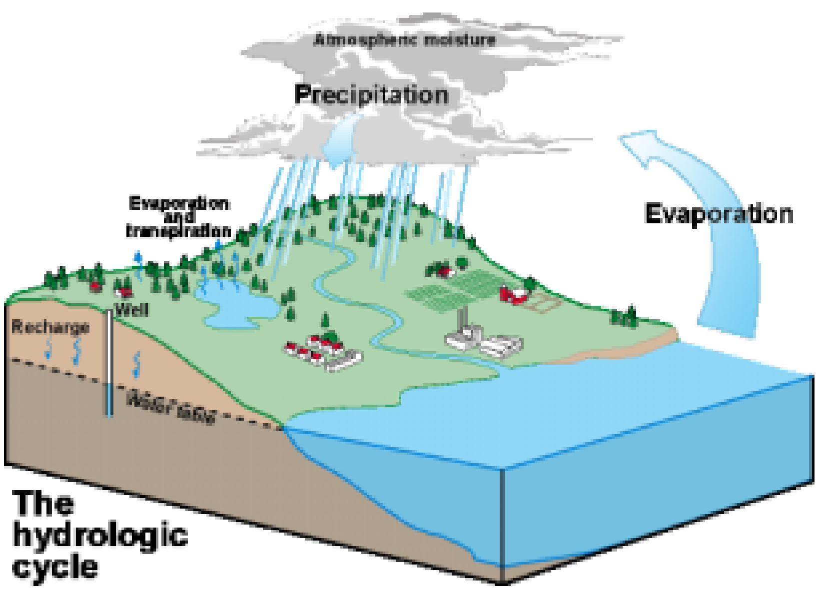
GROUND-WATER RESOURCES

OF

MARTIN 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 at dynamic tool for gathering information.

The current compilation is by no mains 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 3,900 people, 33 percent, in Martin county rely on private domestic water supplies: 3,800 use wells and 100 use hauled water, cisterns and other sources. Most wells drilled in valley bottoms are adequate for a modern domestic supply. Nearly three-quarters of the wells drilled on hillsides are adequate for a domestic supply, except in the northern third of the county where only half of drilled wells on hillsides produce enough water for domestic use. Wells on hilltops and ridges yield smaller quantities of water. In the central and southern two-thirds of the county, drilled wells more than 200 feet deep in valleys may yield enough water for small municipal or industrial supplies. Ground water from most drilled wells in this area is moderately to extremely hard and contains noticeable amounts of iron. Salty water may be found in wells drilled less than 100 feet below the level of the principal valley bottoms, except in the northern third of the county where salty water can be found as shallow as 50 feet. A few springs supply enough water for domestic use. Almost all springs yield less than 5 gal/min.

Water Use

Martin County had an estimated population of 11,939 (4,319 households) in 1999. Some 2,920 households (approximately 67 percent) were served by public water. The remainder relied primarily on wells. It is projected that the population of Martin County will be 10,600 (4,302 households) in the year 2020. Proposed water line extensions from 2000 to 2020 will serve another 600 households, so that public water will be provided to about 81 percent of the county's population 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)

Martin County is in the easternmost part of the Eastern Kentucky coal field. Tug Fork of Big Sandy River marks the eastern boundary of both Martin County and the Commonwealth of Kentucky. The lowest elevation in the county, approximately 550 feet, is on Tug Fork at the northern boundary of the county.

View elevation map

The terrain is mountainous. Practically no flat areas may be found except in the valleys, and these are limited. Highest elevations are in the southern part of the county where many of the mountaintops exceed 1,400 feet. Elevations generally decline northward and are between 1,000 and 1,200 feet at the northern border. Chestnut Knob, 3 miles east-northeast of the junction of Martin, Floyd, and Pike Counties, has an elevation of 1,600 feet, and a mountain above the headwaters of Hobbs Fork in the southeastern corner of the county is 1,606 feet. Local reliefs range from 400 feet in the northern part of the county to 600 feet in the southern area.

The communities are located in valleys. The elevation of Inez, the county seat, is 640 feet. Other elevations are Beauty, 640 feet; Hode, 620 feet; Lovely, 625 feet; Milo, 635 feet; and Warfield, 620 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 Martin County, water is obtained from consolidated sedimentary rocks of the Breathitt Formation, which is Pennsylvanian Age, and from unconsolidated sediments of Quaternary age. The sediments of the Pennsylvanian were deposited 320 million years ago. The warm climate of the Pennsylvanian grew extensive forests and great coastal swamps at the edges of water bodies. Marine waters advanced and receded many times, which produced many layers of sandstone, shale, and coal. Vegetation of all sorts fell into the water and was buried under blankets of sediments, which over long geologic time were compressed into coal. The non-vegetative sediments such as sand, clay and silt were compressed into sandstone and shale. Over the last one million years unconsolidated Quaternary sediments have been deposited along the larger streams and rivers.

Geologic Formations in the County

Unconsolidated deposits

ALLUVIUM (Qa)

Coals, sandstones, and shales

BREATHITT GROUP (Pbu, Pbm, Pbl) (Princess Formation, Four Corners Formation, Hyden Formation, Pikeville Formation)

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

The alluvium forms terraces and narrow flood plains of varying width along streams. At least one well-developed terrace is generally present.

Hydrology

The alluvium yields more than 100 gal/day to most dug wells. Probably will yield as much as 20 or 25 gal/min to wells drilled and screened in the alluvium of the lower sections of the Tug and Levisa Forks. Water is soft or moderately hard; may contain large amounts of iron at depth.

Breathitt Group (Pbu, Pbm, Pbl) (Princess Formation, Four Corners Formation, Hyden Formation, Pikeville Formation)

Topography

The Breathitt underlies valleys and forms the rugged hills. Sandstone forms narrow valleys and cliffs or steep slopes on hillsides and shale forms wide valleys and moderate or gentle slopes on hills. Tops of hills and ridges commonly are capped by sandstone.

Hydrology

The Breathitt yields more than 500 gal/day to most of the wells drilled in valley bottoms and half of the wells on hillsides, and smaller quantities of water to wells on hilltops. Most common aquifers are sandstone and shale, but coal supplies water to a few wells. Near-vertical joints and openings along bedding plains yield most of the water to wells. Waters are highly variable in chemical character. Ground water may contain salty water at depths less than 100 feet below the principal valley bottoms.

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.

Mined-Out Areas as Sources of Water

Conservative estimates indicate that water from abandoned underground coal mines could provide water for a population of millions. Generalized areas of underground mining have been compiled for several important coal beds as part of the U.S. Geological Survey's National Coal Assessment Program. Two of the six seams that have been mapped in eastern Kentucky represent 160 billion gallons of potential water storage. Initial studies of abandoned underground coal mines in Johnson, Martin, Knott, and Letcher Counties show that there are favorable sites, but they need to be proved.

Although preliminary investigations have apparently confirmed the value of this resource at several locations, the feasibility of using abandoned underground coal mines as municipal water supplies throughout Appalachia needs further study. Underground mines that have potential for development as water supplies, which are also near population centers with the greatest water demands, must be identified. The following questions need to be addressed for the region:

- Are underground mines a viable source for major water supplies?
- What water-quality problems may inhibit use of mine water (such as poor quality or abrupt changes in quality?
- What are the challenging issues for existing water supplies that currently use mine water?
- What difficulties might inhibit an accurate determination of water-supply conditions in underground mines?
- Can hydrogeologic data and mine information obtained from existing mines be extrapolated to untested sites?
- What impacts will future land uses, including mining have on the water supply?

A map showing mined-out areas of selected seams in the county in is included in this report.

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

Ground water obtained from most drilled wells contains noticeable amounts of iron and is considered moderately hard too extremely hard in the northern third of the county. The main naturally occurring contaminants that may be present in objectionable amounts in the ground water are sulfate, salt (sodium chloride), iron (Fe) and manganese (Mn). In some locations old abandoned oil and gas wells are responsible for contamination of shallow fresh water aquifers by salt water brought up from much deeper formations. High iron and manganese levels are found in the ground water in many wells, which can produce objectionable taste and staining of laundry and porcelain fixtures. Often, coal mining aggravates these problems by increasing the amount of fresh surface area of the rocks exposed to oxidation, which can increase the sulfate and metals concentrations in the ground water.

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 Martin County the fresh-saline interface ranges from 700 feet mean sea level, down to 500 feet along the larger streams and rivers. In most areas of the county, saline water may be found in wells tapping formations less 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, Martin County has areas of moderate 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

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Water-resource publications of the Kentucky Geological Survey may be viewed on the internet at the Kentucky Geological Survey Internet Water Research library.

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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 space 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, an 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.