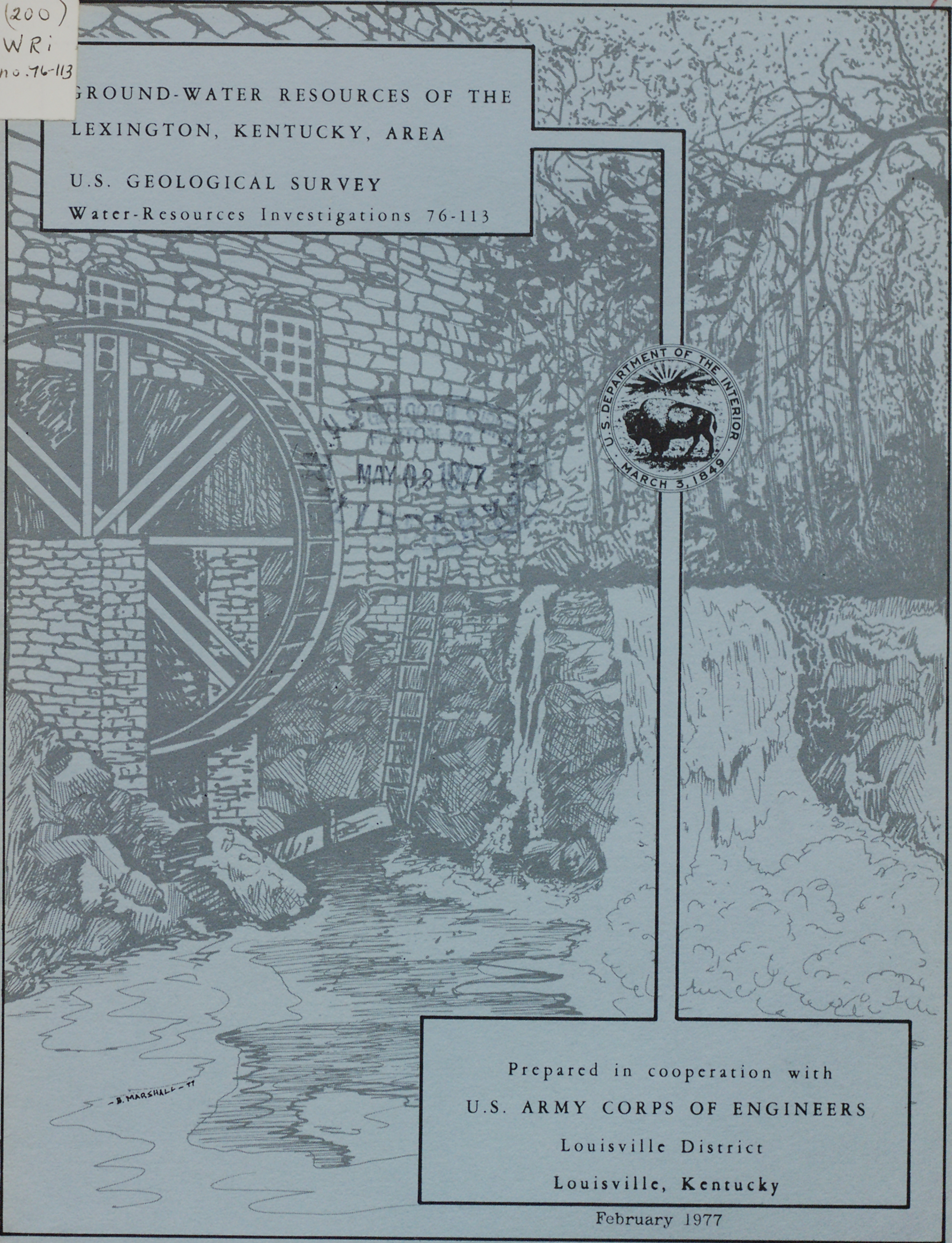
GROUND-WATER RESOURCES OF THE LEXINGTON, KENTUCKY, AREA

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations 76-113



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Ground water in the Lexington area occurs in Ordovician limestones in which cavity development is generally limited to about 100 feet (30 meters) below land surface. Some wells produce about 300 gallons per minute (19 liters per second) in some of the large stream valleys, about 50 gallons per minute (3 liters per second) in the rolling upland and small stream valleys, and about 5 gallons per minute (0.3 liters per second) on hilltops and steep slopes. Many wells throughout the area do not furnish adequate water for domestic supplies because no significant water-bearing openings are penetrated during drilling. Ground-water use is limited mostly to domestic and stock supplies and a few small public supplies. Ground water is generally a calcium bicarbonate type and in places contains sodium chloride and (or) hydrogen sulfide. Bacterial pollution of ground water is widespread because of direct recharge of polluted runoff and streamflow to cavernous limestones.

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UNITED STATES DEPARTMENT OF THE INTERIOR

Cecil D. Andrus, Secretary

GEOLOGICAL SURVEY

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Open-File Report

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Louisville, Kentucky 40202

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(Plates are in pocket)

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CONVERSION FACTORS

The following are factors used for converting English units to metric units in this report. However, in the text the metric equivalents are shown to the number of significant figures consistent with the values for the English units.

English	Multiply By	Metric
feet (ft)	0.3048	meters (m)
gallons (gal)	3.785	liters (l)
square miles (mi^2)	2.590	square kilometers (km^2)
cubic feet per second (ft^3/s)	0.02832	cubic meters per second (m^3/s)
gallons per minute (gal/min)	0.06309	liters per second (l/s)
million gallons per day (Mgal/d)	0.04381	cubic meters per second (m^3/s)

GROUND-WATER RESOURCES OF THE LEXINGTON, KENTUCKY, AREA

ABSTRACT

Ground water in the Lexington area occurs in Ordovician limestones in which cavity development is generally limited to about 100 feet (30 meters) below land surface. Some wells produce about 300 gallons per minute (19 liters per second) in some of the large stream valleys, about 50 gallons per minute (3 liters per second) in the rolling upland and small stream valleys, and about 5 gallons per minute (0.3 liters per second) on hilltops and steep slopes. Many wells throughout the area do not furnish adequate water for domestic supplies because no significant water-bearing openings are penetrated during drilling. Ground-water use is limited mostly to domestic and stock supplies and a few small public supplies. Ground water is generally a calcium bicarbonate type and in places contains sodium chloride and (or) hydrogen sulfide. Bacterial pollution of ground water is widespread because of direct recharge of polluted runoff and streamflow to cavernous limestones.

INTRODUCTION

Purpose and Scope

Population growth and urban expansion increase the demand for water while causing water-related problems that tend to degrade water supplies. Urban runoff, disposal of large volumes of sewage and garbage, leakage from sewers, and pollution from septic tanks are some of the factors associated with population growth that can cause water problems. These problems are generally more severe in areas of limestone terrane where pollutants can enter cavernous limestone directly and move rapidly to discharge points. This is true of the Lexington area in the Blue Grass region of Kentucky.

The U.S. Army Corps of Engineers is conducting a regional water-resources-management study of the Lexington area, which includes the counties of Bourbon, Clark, Fayette, Jessamine, Scott, and Woodford (fig. 1); this study will examine and present alternative solutions to water problems of the area. The present report, which is a part of the study, describes the ground-water resources of the area and was prepared by the U.S. Geological Survey in cooperation with the U.S. Army Corps of Engineers.

The objectives of this report were to summarize the ground-water resources of the six counties in terms of location, quantity, quality, and present use. Other goals were to delineate ground-water gradients and outline recharge areas of selected discharge points.

Previous Investigations

Many reports have been published about the Blue Grass region of Kentucky. Matson (1909) described the ground-water resources of the region. His report covered 30 counties and contained a chapter on chemical quality by Chase Palmer. McFarlan (1943) discussed geologic formations and mineral resources of the State. Hamilton (1950) described areas and principles of occurrence of ground water in Bourbon, Fayette, Jessamine, and Scott Counties. Public and industrial water supplies of the Blue Grass region were described by Palmquist and Hall (1953). The availability of ground water was described by Hall and Palmquist (1960a and b) and Palmquist and Hall (1960). The availability of water in the Lexington-Fayette County area was discussed by Hopkins (1963). The geochemistry of natural waters of the region was described

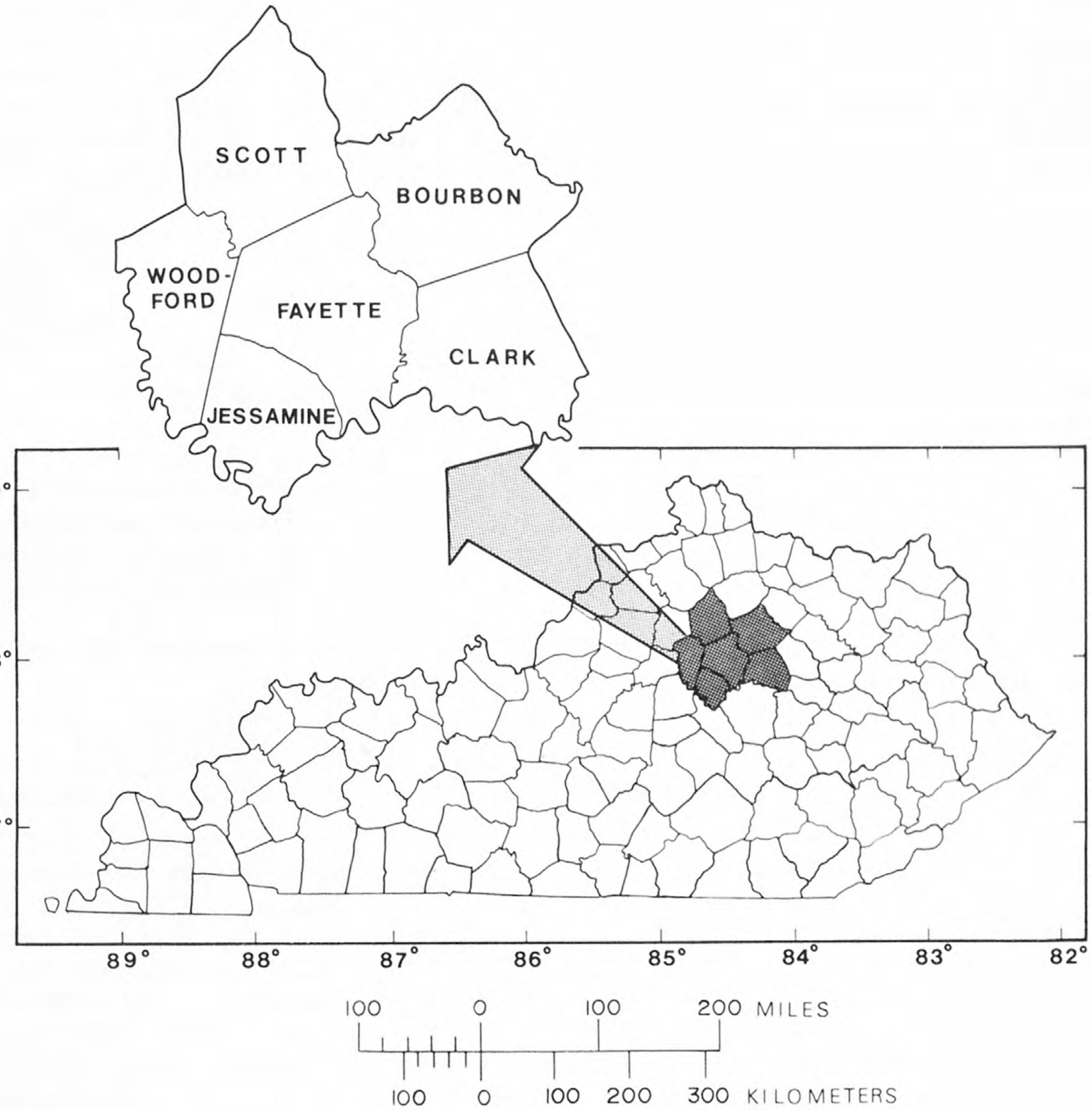

Figure 1.--Map of Kentucky showing study area and county boundaries.

by Hendrickson and Krieger (1964). The hydrology of the Lexington-Fayette County area was discussed by Mull (1968). The U.S. Army Corps of Engineers (1974) published an inventory of the environmental resources of the study area. This report is a compilation of available data on the biological, cultural, and physical features of the area. Detailed geologic maps at the scale of 1:24,000 are being published by the U.S. Geological Survey. Most of the quadrangles for the six counties have been published and all are scheduled for completion by 1978.

Method of Investigation

The field work for this report was done in 1975 and consisted of updating the well inventory, collecting water samples for analyses, and making discharge measurements. In updating the well inventory only those wells were selected in which the water level could be measured or wells were selected in areas of sparse data. Water samples were collected for routine chemical analyses and for pesticide and metal analyses. Discharge measurements were made to evaluate runoff from the project area and to help delineate reaches of streams that gain or lose water.

Published ground-water-availability maps were combined and updated using additional data collected for this report.

Physiography

The physiographic subdivisions in the study area are the Inner Blue Grass, Eden Shale Belt, Outer Blue Grass, and the Knobs (fig. 2). The Inner Blue Grass is surrounded by concentric belts of the other subdivisions. Most of the study area lies in the Lexington Plain of the Interior Low Plateau physiographic province (Fenneman, 1938). The Inner Blue Grass occupies most of the six counties of this report. It is a gently rolling upland that contains abundant sinkholes, and is underlain by soluble limestone in which an extensive subsurface drainage system occurs. Because of the subsurface drainage system, small streams are not extensively developed but large streams such as the Kentucky River are entrenched 200-500 ft (60-150 m).

The Eden Shale Belt surrounds the Inner Blue Grass and is characterized by narrow valleys and steep-sided hills. It is underlain by interbedded shale and limestone and contains few sinkholes. There is runoff of precipitation and very few perennial streams exist in this

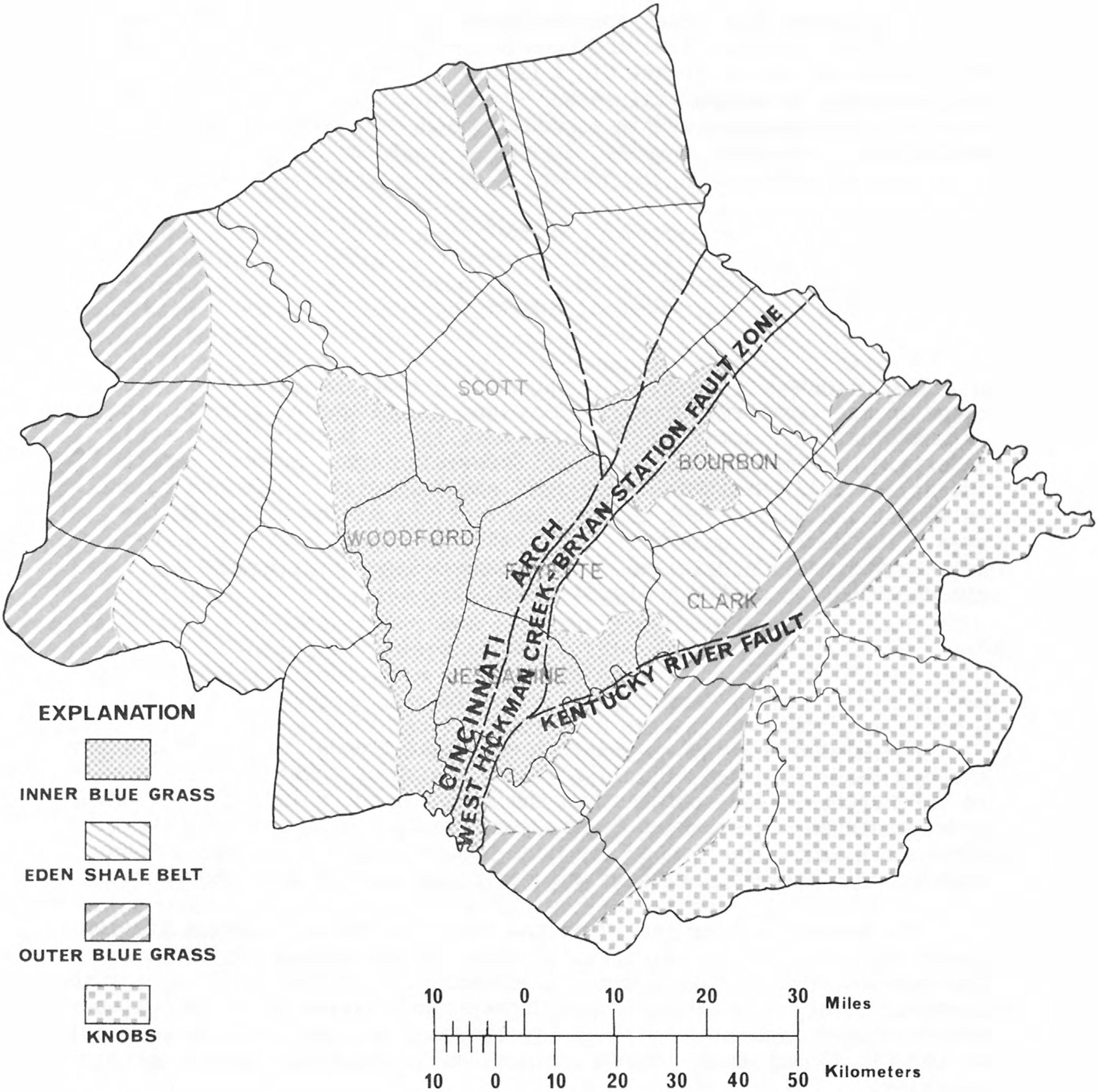

Figure 2.--Physiographic subdivisions and major structural features of study area and vicinity. Named counties represent study area.

area. The Outer Blue Grass and the Knobs physiographic subdivisions occur in belts outward from the Eden Shale Belt. In the report area, they occur only in southeast Clark County. Here the topography is characterized by narrow valleys and steep-sided hills. The area is underlain by limestone and interbedded shale, and contains very few sinkholes.

GEOLOGY

General Stratigraphy

Consolidated rocks in the study area are sedimentary in origin and range in age from Ordovician to Devonian. Small unconsolidated deposits of Quaternary age occur in some stream valleys. Most of the area is underlain by limestone and shale of Ordovician age. Several reports (McFarlan, 1943; Hamilton, 1950; Hall and Palmquist, 1960a and b, and Palmquist and Hall, 1960) contain descriptions of the strata in the area. The geologic quadrangle maps being published by the U.S. Geological Survey provide detailed descriptions of the stratigraphy and show the distribution of the geologic units.

Structure

The Cincinnati arch is a major fold that trends north-northeastward through the study area (fig. 2). Rocks dip about 40 ft (12 m) per mile to the northwest and southeast on the limbs of the fold. The Jessamine dome, centered in Jessamine County, represents a high point on the Cincinnati arch. Erosion of the dome has exposed older rocks in the center and concentric belts of younger rocks outward from the center.

The Kentucky River fault and the West Hickman Creek-Bryan Station Fault zone are the two major faults that cut across the project area. The Kentucky River fault occurs in Jessamine and Clark Counties near the Kentucky River. The West Hickman Creek-Bryan Station Fault zone trends northeastward through Jessamine, Fayette, and Bourbon Counties parallel to the Cincinnati arch. Several minor faults occur throughout the six counties.

GROUND WATER

Ground water occurs mostly in solution openings along joints and bedding planes of Ordovician limestones in the Lexington area. The distribution of these openings and the movement, quantity, and quality of water in them are discussed in the following sections of this report.

The availability of ground water from shallow aquifers only is described in this report. Deeper geologic units, such as the St. Peter Sandstone of Middle Ordovician age and Knox Dolomite of Early Ordovician and Late Cambrian age are potential aquifers. However, the sparse data available indicate these units generally yield only small quantities (less than 25 gal/min or 1.6 l/s) of mineralized water in the Lexington area. A more detailed description of the water-bearing characteristics of these deeper units would require additional data.

Topographic Position of Wells

Wells with known and reported yields were tabulated in three general groups based on their topographic position: (1) hilltop or steep slope, (2) narrow valley or draw, and (3) gently rolling upland or flat plain (fig. 3). The relationships shown by this grouping are probably somewhat biased toward low-capacity wells as an area of poor ground-water yield may be represented by several wells, because one or more wells failed to yield a sufficient supply, whereas an area of abundant ground water may be represented in the data by a single well. Nevertheless, some generalizations are suggested by the relationships shown in figure 3.

One obvious relationship is the large percentage of low-capacity wells associated with hilltops and steep slopes. Only about one of four wells produce more than 4 gal/min (0.25 l/s). Another relationship is that about one-third of the wells in the other two groups are in the 0 to 4-gal/min (0 to 0.25-l/s) range. This means that even in more favorable topographic positions some wells produce very little water. This is typical of limestone terrane areas where the size and number of water-bearing openings penetrated by wells are variable in short lateral distances. Finally, there is little difference in well capacities in the gently rolling uplands or flat plains and in the narrow valleys or draws.

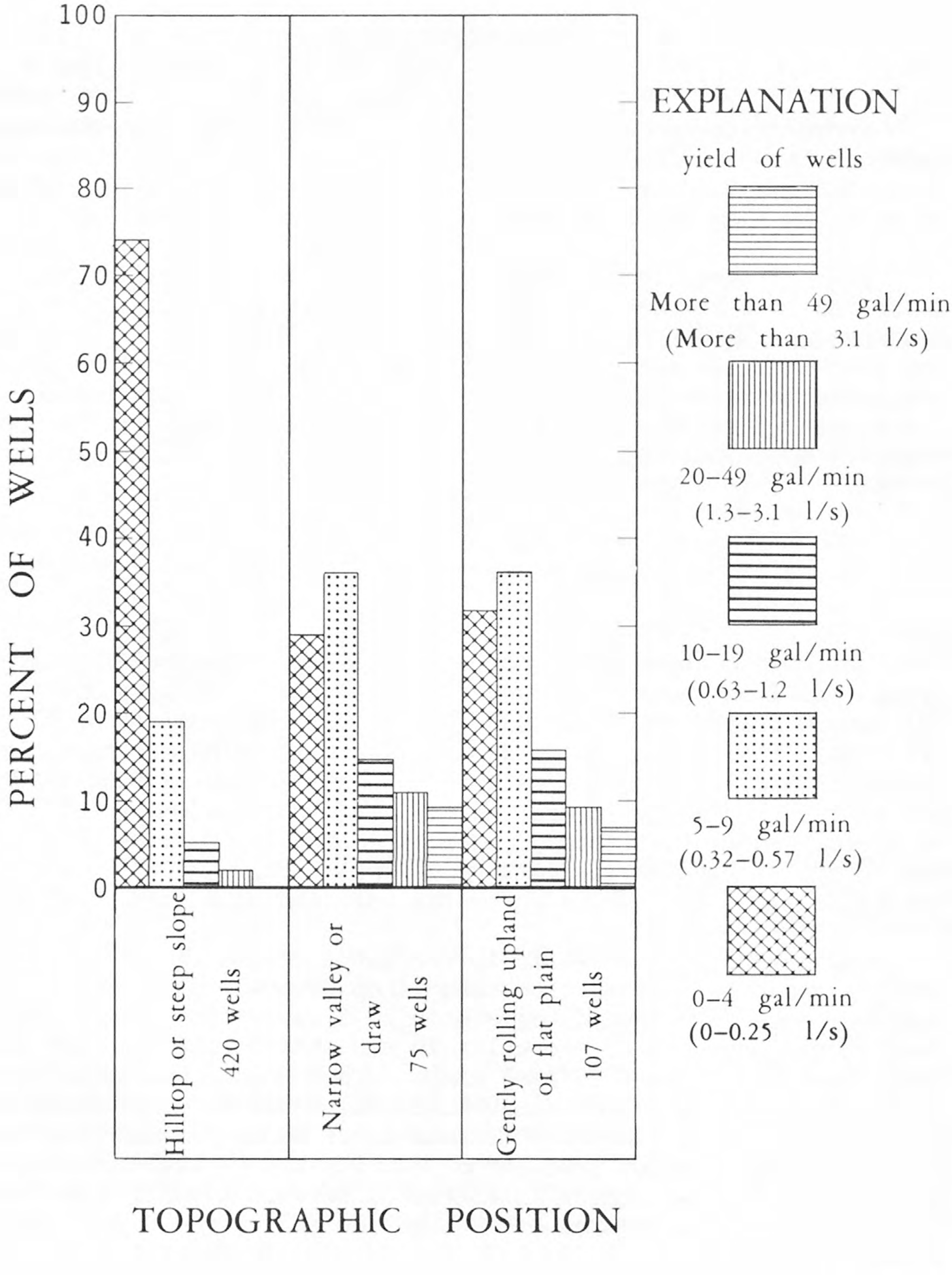

Figure 3.--Relationship between well capacities and topographic position.

Depth of Wells

Most wells in the study area are completed at relatively shallow depths. A cumulative curve based on about 500 well depths is shown in figure 4. About 64 percent of the wells are 100 ft (30.5 m) or less in depth and about 90 percent are 150 ft (45.7 m) or less. Two factors account for the shallow depths. First, the presence of shales and bentonites prevent or retard downward percolation of water and cavity development at depth. Hamilton (1950, p. 28) suggested that very little cavity development occurs below 90-100 ft (27-30 m). Second, deeper wells are more likely to produce poor quality water. Hendrickson and Krieger (1964, p. 15) indicated that saline or sulfurous water is likely to occur at depths greater than 50-200 ft (15-60 m) below the level of local streams.

Water Levels and Movement

Water levels from more than 500 wells were used to prepare the cumulative curve in figure 5 and to prepare the water level contours on plate 1. Figure 5 shows that water levels are relatively shallow in the study area. About 69 percent are 50 ft (15 m) or less and 95 percent are 100 ft (30 m) or less.

Ground water moves from points of recharge to points of discharge or from uplands to lowlands. Flow lines drawn at right angles to the contour lines on plate 1 show the general direction of ground water movement. They show that ground water moves away from the Lexington area to the surrounding lowlands. Lexington is high topographically and structurally and much of the surface and subsurface drainage from the urban area passes through the drainage basins of South Elkhorn Creek and North Elkhorn Creek.

Ground water moves through and enlarges openings along joints and bedding planes in carbonate rock. Eventually roofs over some of the enlarged openings collapse to cause sinkholes. In many places in the Inner Blue Grass, sinkholes are alined northwest-southeast indicating that ground water enlarged openings along the prominent northwest-southeast joint system. Some of these alined sinkholes are delineated on plate 2. Ground water probably moves through conduit type openings along some of these linear features.

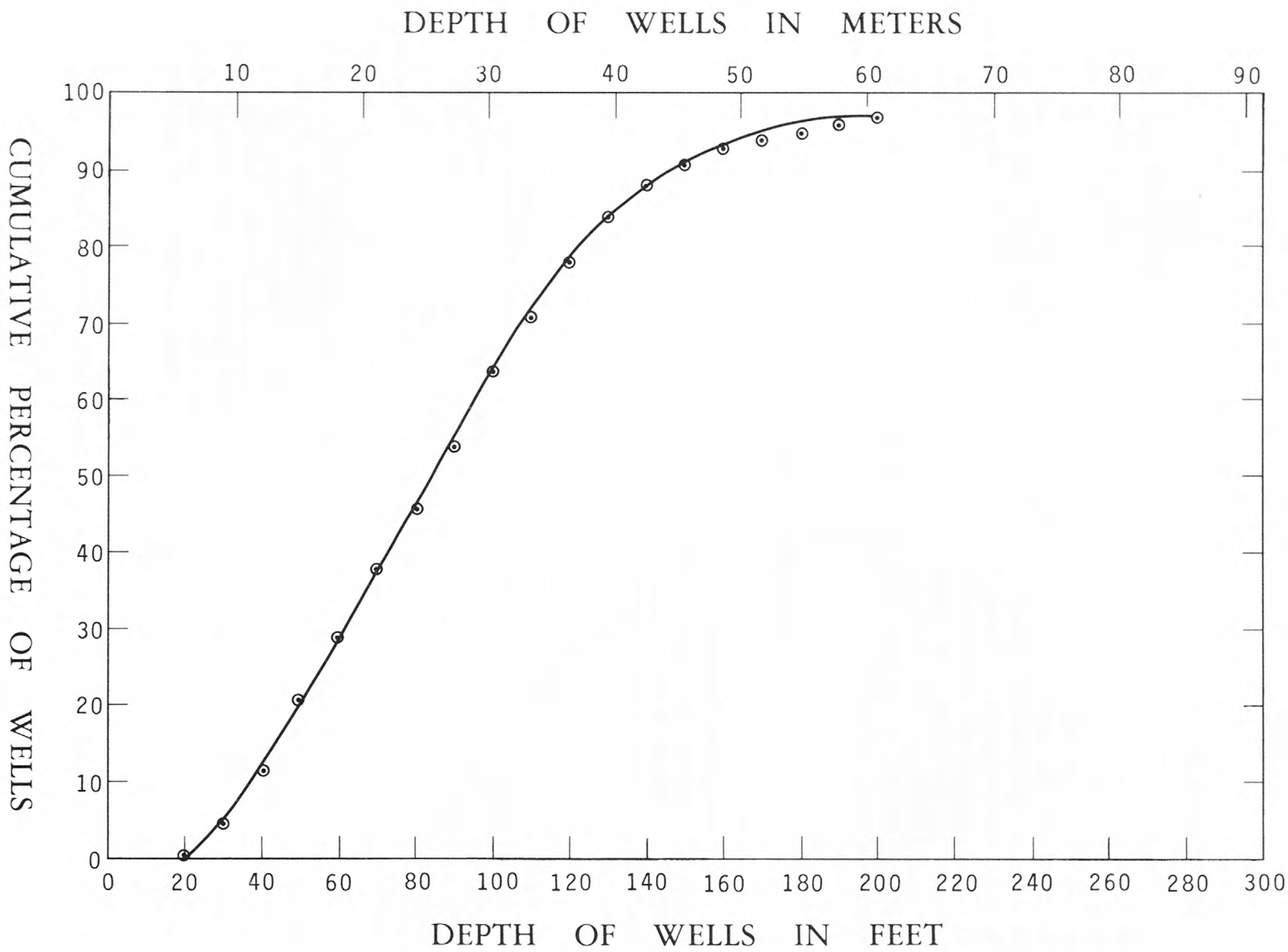

Figure 4.--Cumulative distribution by depth of 504 drilled wells-curve indicates percent of wells having depth equal to or less than indicated amount.

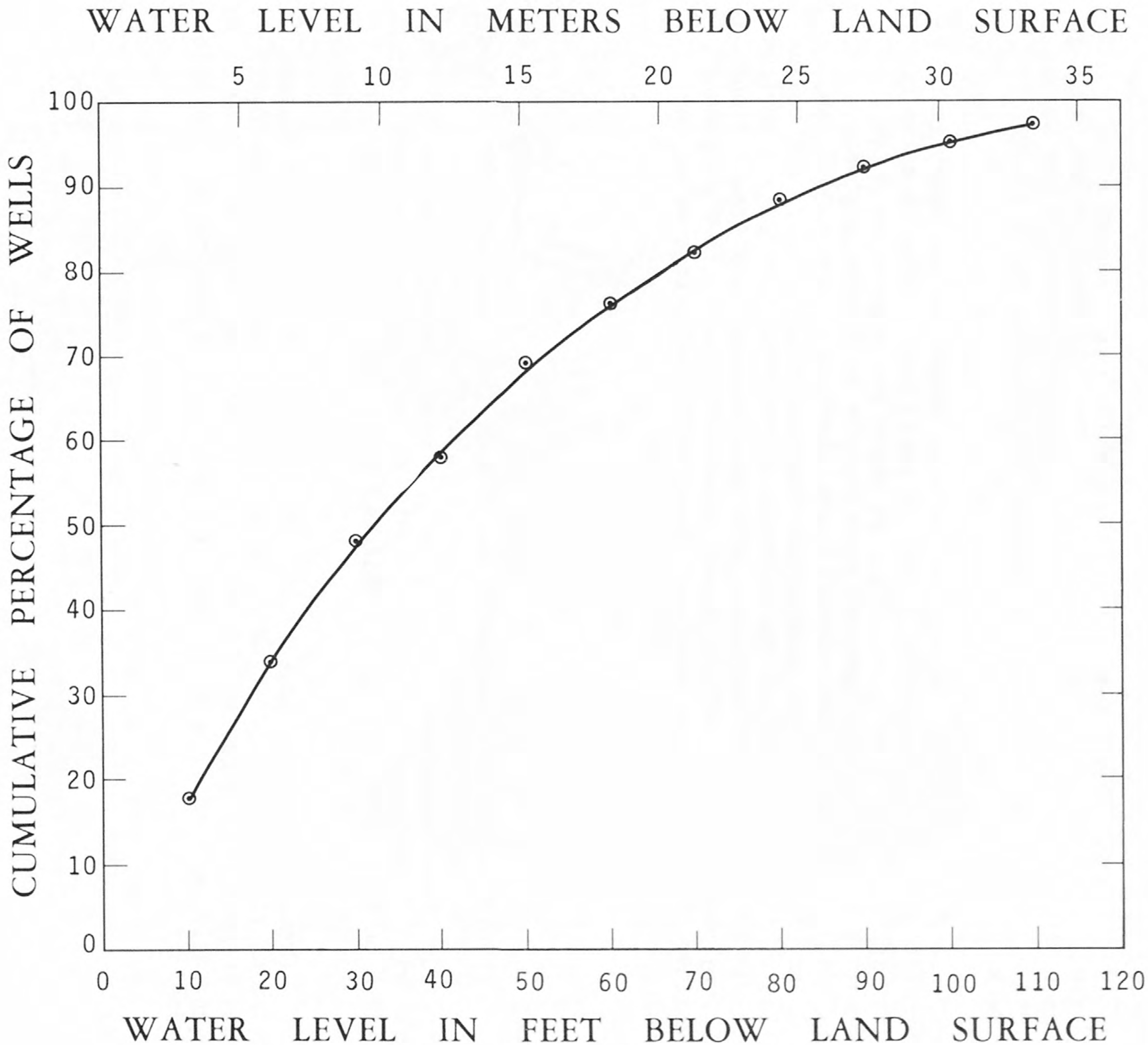

Figure 5.--Cumulative distribution of 537 water-level measurements-curve indicates percent of water levels having depth below land surface equal to or less than indicated amount.

Recharge Areas

Ground-water levels and topography were used to delineate recharge areas for selected discharge points in the six counties (fig. 6). Generally surface-drainage upstream from discharge points roughly coincide with recharge areas. However, the recharge area of Royal Spring, near Georgetown, probably includes part of the Cane Run drainage basin (Mull, 1968, p. 17). This means the recharge area of the spring cuts across the drainage divide between Cane Run and North Elkhorn Creek.

Land-use planning, in aquifer recharge areas, is necessary to protect ground-water supplies. This is particularly true in areas of limestone terrane with a thin regolith where pollutants can enter directly into cavity systems and move rapidly to discharge points. Landfills, sewage lagoons, septic tanks, feedlots, urban runoff, and sewage-plant effluent are some common sources of pollution. Any pollution that affects water in the streams, of the study area, is a serious threat to ground-water supplies. Discharge measurements (table 1 and pl. 3) show that most of the larger streams lose water to underground drainage systems in some reaches. Thus, polluted surface water can enter directly into the ground-water system.

Availability

Hydrologic Investigations Atlases HA-19 (Hall and Palmquist, 1960a), HA-24 (Hall and Palmquist, 1960b), and HA-25 (Palmquist and Hall, 1960) contain ground-water availability maps covering the six counties of this report. These maps are generally still applicable, but they were combined on one sheet (pl. 2) and modified to reflect interpretation of additional well data.

Ground-water availability in limestone terrane depends on factors such as topography, stratigraphy, structure, amount and depth of cavity development, and regolith thickness. The more productive wells are generally developed where several of these factors occur in a favorable combination.

FIGURE 6. RECHARGE AREAS FOR SELECTED DISCHARGE POINTS IN BOURBON, CLARK, FAYETTE, JESSAMINE, SCOTT, AND WOODFORD COUNTIES.

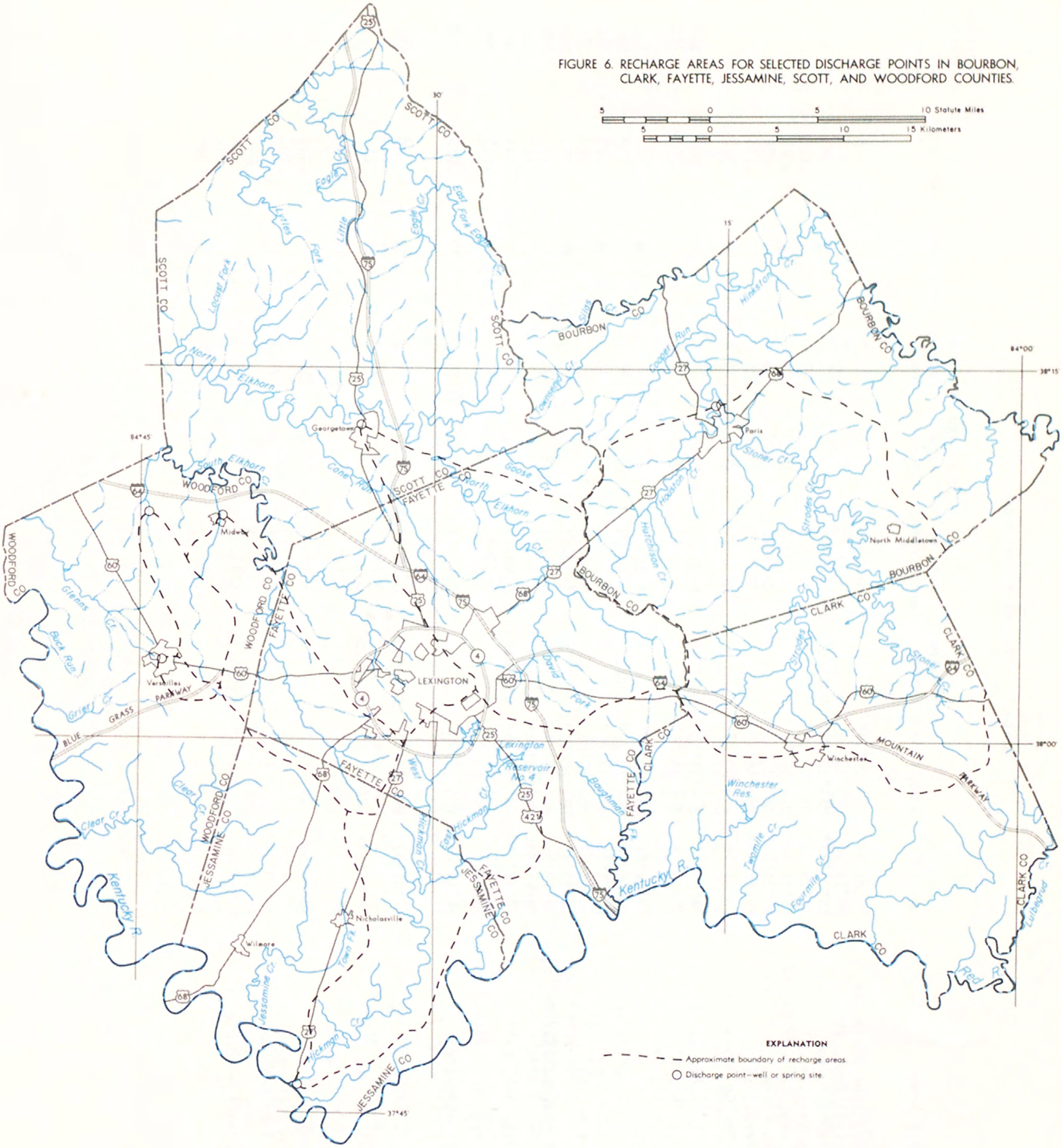

Table 1.--Discharge measurements

Station name	Latitude	Longitude	Station number	Date of measurement	Drainage area (mi^2)	Drainage area (km^2)	Discharge (ft^3/s)	Discharge (m^3/s)	Specific conductance (micromhos per cm at 25°C)	T (°C)
East Fork Eagle Cr. near Davis, Ky.	38°21'18"	084°29'12"		6-23-75	9.34	24.2	0.65	0.018		27.0
Eagle Cr. near Turkey Foot, Ky.	38°21'43"	084°30'38"		6-23-75	17.0	44.0	1.12	.032		27.0
Eagle Cr. at Sadieville, Ky.	38°23'22"	084°32'36"	03291000	6-23-75	42.9	111	3.28	.093		25.5
Eagle Cr. near Sadieville, Ky.	38°24'08"	084°34'39"		6-23-75	49.5	128	3.64	.103		
Little Eagle Cr. near Sadieville, Ky.	38°24'08"	084°34'43"		6-23-75	14.0	36.3	.66	.019		31.0
Rays Fork near New Columbus, Ky.	38°25'58"	084°36'42"		6-23-75	14.9	38.6	.71	.020		26.5
Eagle Cr. near Porter, Ky.	38°25'52"	084°36'47"		6-23-75	86.7	225	6.57	.186		26.0
Lytles Fork near New Columbus, Ky.	38°25'54"	084°38'12"		6-23-75	30.3	78.5	2.08	.059		26.0
North Elkhorn Cr. at Montrose, Ky.	38°04'35"	084°24'48"	03287600	6-24-75	21.5	55.7	.22	.006	340	24.5
Unnamed Tributary to North Elkhorn Cr. near Muir, Ky.	38°06'14"	084°23'54"		6-23-75	21.2	54.9	.12	.003	370	24.5
Russell Cave Spring	38°07'44"	084°26'04"		6-24-75			1.59	.045	520	16.5
North Elkhorn Cr. near Mattoxtown, Ky.	38°09'10"	084°26'28"	03287700	6-24-75	62.7	162	4.82	.136	380	26.0
Goose Cr. near Newtown, Ky.	38°11'36"	084°29'01"		6-24-75	17.3	44.8	.96	.027	350	27.0
Boyd Run near Newtown, Ky.	38°12'47"	084°28'51"		6-24-75	13.8	35.7	.77	.022	350	26.5
Marshall Spring	38°13'15"	084°30'25"		6-23-75			.49	.014	360	20.0
North Elkhorn Cr. near Georgetown, Ky.	38°12'20"	084°30'49"	03288000	6-23-75	119	308	12.5	.354	380	26.0
Royal Spring	38°12'30"	084°33'44"		6-23-75			18.6	.527	430	25.5
Cane Run near Georgetown, Ky.	38°12'35"	084°36'39"	03288260	6-23-75	45.5	118	1.70	.048	380	29.0
North Elkhorn Cr. at Great Crossing, Ky.	38°12'57"	084°36'21"		6-23-75	155	401	15.0	.425	360	27.0
Lecomptes Run near Stamping Ground, Ky.	38°16'07"	084°43'00"		6-23-75	15.0	389	.53	.015	300	31.0
South Elkhorn Cr. at Fort Spring, Ky.	38°02'35"	084°37'35"	03289000	6-24-75	24.0	62.2	3.61	0.102	380	25.5
South Elkhorn Cr. at Faywood, Ky.	38°06'12"	084°38'28"		6-24-75	57.3	148	6.12	.173	360	27.0
Town Br. at Yarnallton, Ky.	38°06'13"	084°35'17"	03289200	6-24-75	30.0	77.7	42.3	1.20	380	31.5
South Elkhorn Cr. near Paynes Depot, Ky.	38°09'37"	084°38'38"		6-23-75	113	293	64.9	1.84	580	25.5
Lee Br. near Midway, Ky.	38°09'43"	084°41'12"		6-23-75	22.8	59.0	1.72	.049	440	28.5
Spring near Spring Station, Ky.	38°09'27"	084°44'35"		6-23-75			3.79	.107	280	14.5
Beals Run nr. Spring Station, Ky.	38°09'34"	084°44'39"		6-23-75			0	0		
Beals Run nr. Woodlake, Ky.	38°10'28"	084°44'47"		6-23-75	10.4	26.9	.02	.001		32.0
South Elkhorn Cr. near Woodlake, Ky.	38°11'07"	084°44'16"	03289410	6-23-75	156	404	50.8	1.44	440	25.5

Versailles Spring	38°03'08"	084°43'55"		6-24-75			0.68	0.019	480	15.0
Glenns Cr. near McKees Crossroads, Ky.	38°05'48"	084°47'37"		6-23-75	19.2	49.7	4.76	.135	350	28.0
Glenns Cr. near Millville, Ky.	38°08'55"	084°51'04"		6-23-75	35.0	90.6	5.61	.159	360	28.0
East Fork near Keene, Ky.	37°54'00"	084°42'15"		6-23-75	17.2	44.6	.29	.008	325	26.5
Clear Cr. near Keene, Ky.	37°55'37"	084°42'14"		6-23-75	28.8	74.6	1.20	.034	380	25.0
Clear Cr. near Mortonsville, Ky.	37°56'37"	084°45'53"	03287130	6-23-75	61.6	160	3.30	.093	300	22.5
Jessamine Cr. near Willmore, Ky.	37°50'33"	084°38'43"		6-23-75	32.3	83.7	4.47	.126	375	24.5
Hickman Cr. near Sulphur Well, Ky.	37°50'46"	084°30'32"		6-24-75	77.1	200	11.7	.331	430	23.0
Hickman Cr. near Camp Nelson, Ky.	37°47'13"	084°35'09"		6-23-75	97.6	253	12.9	.365	410	23.5
Boone Cr. near Locust Grove, Ky.	37°55'03"	084°20'28"	03284100	6-24-75	41.8	108	1.02	.029	350	23.5
Lower Howard Cr. at Lisletown, Ky.	37°55'07"	084°16'24"		6-24-75	19.4	50.2	.52	.015	390	22.5
Fourmile Cr. near Winchester, Ky.	37°52'47"	084°12'40"		6-24-75	27.4	71.0	.72	.020	290	23.0
Upper Howard Cr. near Winchester, Ky.	37°52'43"	084°07'22"		6-24-75	35.6	92.2	1.42	.040	320	23.5
Stoner Cr. near Winchester, Ky.	38°01'57"	084°10'41"		6-24-75	17.6	45.6	0	0		
Strodes Cr. near North Middletown, Ky.	38°06'35"	084°10'41"	03251790	6-23-75	53.6	139	3.11	.088		27.0
Pretty Run near North Middletown, Ky.	38°06'23"	084°09'01"		6-23-75	6.20	16.1	.91	.026		27.0
Stoner Cr. near North Middletown, Ky.	38°06'51"	084°08'17"	03251665	6-23-75	51.6	134	8.90	.252		26.0
Strodes Cr. near Escondida, Ky.	38°08'03"	084°09'41"		6-23-75	64.0	166	4.34	.123		26.0
Green Cr. near Escondida, Ky.	38°08'39"	084°12'01"		6-23-75	14.4	37.3	.49	.014		26.0
Houston Cr. near Paris, Ky.	38°10'59"	084°17'32"		6-23-75	30.3	78.5	.82	.023		28.5
Houston Cr. at Paris, Ky.	38°12'55"	084°14'55"		6-23-75	45.6	118	2.93	.083		25.0
Stoner Cr. at Paris, Ky.	38°13'45"	084°15'22"	03252000	6-23-75	239	619	12.0	.340	380	28.0
Cooper Run near Shawhan, Ky.	38°16'32"	084°16'27"		6-24-75	18.6	48.2	.52	.015		
Flat Run near Shawhan, Ky.	38°16'39"	084°15'06"		6-24-75	13.0	33.4	.16	.004		
Stoner Cr. near Shawhan, Ky.	38°18'11"	084°14'58"		6-24-75	284	736	9.64	.273		
Hinkston Cr. near Carlisle, Ky.	38°14'33"	084°39'48"	03252300	6-24-75	154	399	1.70	.048		
Hinkston Cr. at Millersburg, Ky.	38°17'44"	084°09'04"		6-24-75	212	549	6.26	.177		
Hinkston Cr. near Shawhan, Ky.	38°18'17"	084°14'17"		6-24-75	260	673	9.05	.256		
Townsend Cr. near Shawhan, Ky.	38°17'43"	084°18'39"		6-24-75	17.0	44.0	1.79	.050		

The Inner Blue Grass of this study area has a more favorable combination of the above factors than the other physiographic subdivisions. Its topography is less rugged and it has a thicker regolity than the rest of the study area. It is underlain by a fairly thick soluble limestone near land surface whereas the rest of the area is underlain by rocks containing more interbedded shale. Most of the Inner Blue Grass is on the northwest limb of the Cincinnati arch (fig. 2) where the rocks dip gently to the northwest roughly parallel to the slope of the land surface. Ground water moving with the dip of the rocks from the crest of the arch has developed an extensive cavity system that extends to about 100 ft (30 m) below land surface on the northwest limb of the arch. Faulting on the southeast limb of the arch moved less soluble rocks near land surface and resulted in less favorable conditions for cavity development.

In northern Scott, eastern Bourbon and Fayette, and all of Clark Counties shale or shale with interbedded limestone are the dominant rock types near land surface. Cavity development is generally limited to the limestone underlying stream valleys. In the uplands between the stream valleys ground water probably is present only in joints and fractures in the rocks.

Area 1, of plate 2, has the most potential for ground-water development. This area comprises the larger stream valleys in the Inner Blue Grass and one small area along the Kentucky River. Wells with the highest reported yields (as much as 300 gal/min or 19 l/s) and the largest springs are in area 1. Probably other wells could be developed that would produce as much as 300 gal/min (19 l/s). Water moving through conduit-type openings that are recharged by streamflow would support large-capacity wells. However during extended dry periods, when streamflow ceases, well yields would decline.

Area 2 includes the rolling upland of the Inner Blue Grass, most of the small stream valleys, and small discontinuous areas of the Kentucky River floodplain. Wells in area 2 generally produce adequate water for domestic supplies and some produce as much as 50 gal/min (3 l/s).

Area 3 consists mostly of steep-sided hills and ridges and narrow valleys. It is underlain by interbedded limestone and shale and cavity development is limited. Generally, wells do not produce adequate water for domestic supplies.

Favorable areas for developing ground-water supplies, in terms of quantity, are probably along the alined sinkholes in large valleys of the Inner Blue Grass. However, some of these cavity systems are recharged directly by streamflow which contains bacterial pollution (Foree, 1974).

Use

Water-use data for the six counties are tabulated in table 2. The list includes water systems that generally withdraw at least 10,000 gal/d (38 m^3/d). It also includes an estimate of water used for private supplies. The total water used was about 29 Mgal/d (1.27 m^3/s in 1974. This was about 100 gal/d (380 l/d) per capita consumption.

Ground water accounted for only about one-tenth of the water used in 1974. Georgetown, which obtains water from Royal Spring, was the single largest ground-water user. Midway and the Kentucky Female Orphan School, Inc., used lesser amounts from wells. Many of the private supplies in rural areas are developed from ground-water sources.

Table 2.--Water use

County and system name	Average water use in 1974 [1/] Mgal/d	m^3/s	Source of water
Bourbon County			
Paris Municipal Water Works	1.386	0.061	SW
Millersburg Municipal Water Works	.105	.004	SW
North Middletown Municipal Water Works	.051	.002	SW
Clark County			
Winchester Municipal Utilities	1.344	.059	SW
Tennessee Gas Pipeline Company	.022	.001	SW 2/
Fayette County			
Kentucky-American Water Company	20.334	.891	SW
Lexington Blue Grass Army Depot	.313	.014	GW 3/
Jessamine County			
Nicholasville Municipal Water Works	1.085	.048	SW
Asbury College Water Company	.202	.009	SW
Scott County			
Georgetown Municipal Water Works	1.293	.056	GW
Stamping Ground Municipal Water Works	.015	.001	SW
West Scott County Water District	.287	.012	SW 4/
Woodford County			
Versailles Municipal Water Works	.832	.036	SW
Midway Municipal Water Works	.093	.004	SW 5/
Kentucky Female Orphan School, Inc.	.019	.001	GW
Total	27.381	1.200	
Estimated water use by remaining population who use private supplies	1.6	.070	Wells, springs, and cisterns
Grand total	About 29	About 1.270	

1/ From withdrawal permits of Dept. for Natural Resources and Environmental Protection--Division of Water Resources.
2/ Used only in July, August, September, and October.
3/ January-June 1974--now supplied by Kentucky American Water Company.
4/ Now supplied by Kentucky American Water Company.
5/ Well used as supplemental supply.

Quality

Several previous reports contain information on the chemical quality of ground water in the Blue Grass region. A report by Palmquist and Hall (1953) presented data on public and industrial supplies of the region. Reconnaissance reports by Palmquist and Hall (1960, 1961) contained information on chemical quality of ground water. Hendrickson and Krieger (1964) studied the geochemistry of natural waters of the Blue Grass region. Mull (1968) reported on the hydrology of the Lexington and Fayette County area.

Data published in the preceding reports are representative of the quality of ground water in the study area, thus very few additional samples were collected. Three samples for standard chemical analyses were collected in Bourbon County because of limited data in that county. Some additional samples were collected in an arc around the western side of the Lexington area and analyzed for pesticides and metal concentrations. Sampling was done in this area because the availability of ground water is greater and also because this area receives most of the runoff from the Lexington urban area. Results of these analyses are tabulated in tables 3 and 4. Results of standard chemical analyses are presented in table 5 to show the concentrations of constitutents in ground water. Locations of wells and springs listed in tables 3, 4, 5 are shown on plate 4. Also shown on plate 4 are locations of wells and springs that have high concentrations of chloride, nitrate, sulfate, and (or) a high specific conductance.

Shallow water is a calcium magnesium bicarbonate type and deeper water is saline or a sodium chloride type. Many water supplies also contain noticeable amounts of hydrogen sulfide. Hendrickson and Krieger (1964, p. 69) indicated that saline water occurs at depths 50-200 ft (15-60 m) below the altitude of local streams, but they also noted that, in places, saline water occurs in shallow wells above local streams. Hamilton (1950, p. 21) associated the occurrence of saline water with faults and associated joints. However, saline water occurs at shallow depths in places where faults are not mapped.

Pesticide contamination of ground water was present in only one sample (table 3) taken in an arc west of Lexington urban area, but this was within the recommended limit for public water supplies (National Academy of Science-National Academy of Engineering, 1972, p. 77).

Table 3.--Pesticide analyses of water from selected wells and springs

[Concentration of constituents in whole water samples, in micrograms per liter]

No. on fig. 10	Owner or name	Depth of well (ft)	Discharge (ft^3/s)	Date of collection	Temperature (°C)	Specific conductance (micromhos per cm at 25°C)	Aldrin	Chlordane	DDD	DDE	DDT	Diazinon	Dieldrin	Endrin	Ethion	Heptachlor	Heptachlor epoxide	Lindane	Malathion	Methyl parathion	Methel trithion	Parathion	PCB	Polychlorinated napthalenes	Toxaphene	Trithion	2,4-D	2,4,5-T	Silvex
2	Royal Spring	-	11	July 25, 1975	17.0	360	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	-	0.00	0.00	0.00	0.00
8	Midway	200	-	.....do......	15.0	420	.00	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.0	-	-	.00	.00	.00	.00
9	Versailles Spring	-	.47	.....do......	19.5	420	.00	.0	.00	.00	.00	.01	.01	.00	.00	.00	<.01	.00	.00	.00	.00	.00	.0	.00	-	.00	.0	.00	.00
10	Thomas Tipton	65	-	.....do......	19.0	430	.00	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.0	.00	-	.00	.00	.00	.00
20	Cecil Cooley	85	-	.....do......	18.0	590	.00	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.0	.00	-	.00	.00	.00	.00

Table 4.--Metal analyses of water from selected wells and springs

[Total concentration1/ of constituents, in micrograms per liter]

No. on fig. 10	Owner or name	Depth of well (ft)	Discharge (ft^3/s)	Date of collection	Temperature (°C)	Specific conductance (micromhos per cm at 25°C)	Aluminum (Al)	Barium (Ba)	Beryllium (Be)	Bismuth (Bi)	Boron (B)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Cobalt (Co)	Gallium (Ga)	Germanium (Ge)	Iron (Fe)	Lead (Pb)	Lithium (Li)	Manganese (Mn)	Molybdenum (Mo)	Nickel (Ni)	Silver (Ag)	Strontium (Sr)	Tin (Sn)	Titanium (Ti)	Vanadium (V)	Zinc (Zn)	Zirconium (Zr)
2	Royal Spring	-	11	July 25, 1975	17.0	360	1,500	-	-	-	30	-	2	-	-	<1	<2	940	-	-	60	3	-	-	140	<2	90	<3.0	10	<4
8	Midway	200	-	.....do......	15.0	420	15,000	300	-	-	60	-	20	50	-	<2	<4	1,400	20	20	1,600	5	20	-	150	<6	1,100	15	260	90
9	Versailles Spring	-	.47	.....do......	19.5	420	170	-	-	-	40	-	<2	-	-	0	<3	150	-	-	80	2	-	-	170	<2	10	<2.0	30	<3
12	Danada Farm	135	-	.....do......	19.5	590	150	-	-	-	80	-	<3	-	-	<1	<3	170	-	10	10	5	-	-	580	<3	6	<3.0	200	<5
15	Clayton Curd	53	-	Aug. 6, 1975	15.0	465	1,400	-	-	-	40	-	<2	-	-	0	<3	1,000	20	-	70	2	-	-	370	<2	150	<2.0	290	4

1/ No. 8 is dissolved concentration, in micrograms per liter.

Table 5.--Chemical analyses of water from selected wells and springs

[Chemical constituents in milligrams per liter except where noted]

No. on fig. 10	Owner or name	Depth of well (ft)	Date of collection	Silica (SiO_2)	Iron (Fe) ug/1	Manganese (Mn) ug 1	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos per cm at 25°C)	pH	Temperature (°C)	Color
								Wells														
3	Julius Kessler Distillery	-	July 24, 1957	8.7	240	40	45	24	26	4.6	260	28	18	1.2	-	282	210	0	512	7.6	-	3
4	D. T. Phillips	65	Sept. 19, 1972	16	80	32	53	36	690	27	300	77	1,100	1.9	0.10	2,050	280	30	3,820	8.2	13.5	5
5	Virgil Smith	80	May 27, 1968	8.7	50	20	60	42	170	12	330	25	310	.7	1.6	789	320	54	1,440	7.6	-	2
6	Clay B. Crain	109	July 29, 1975	-	160	20	50	33	220	16	430	2.2	280	2.0	-	822	260	0	1,600	7.3	14.5	0
7	Bob Gateskill	97	......do......	-	160	40	48	22	18	5.4	280	11	15	1.2	-	394	210	0	480	7.6	17.0	0
12	Danada Farm	135	May 28, 1968	7.1	70	0	72	16	17	7.8	260	33	25	.5	17	330	250	31	566	7.8	-	2
13	U.S. Army	150	......do......	6.6	100	70	85	14	30	2.3	270	46	52	.7	1.9	394	270	52	650	7.5	-	2
14	H. E. Madden	92	June 3, 1968	7.7	110	20	72	12	5.6	1.3	240	32	8.5	.4	.5	258	230	32	446	7.7	-	2
16	C. P. Hammond	101	May 28, 1968	7.7	120	10	88	8.4	20	1.9	210	58	28	.2	33	348	250	78	572	7.8	-	-
17	D. B. Chair	85	Mar. 25, 1954	-	390	-	-	-	-	-	390	190	330	1.4	15	-	420	-	2,000	-	13.8	-
18	Ms. S. Skidmore	38	Mar. 24, 1954	-	130	-	-	-	-	-	240	30	12	0	16	-	250	-	490	-	10.0	-
19	Nicholasville	175	Sept. 19, 1951	6.6	470	0	82	14	5.3	2.1	260	49	9.5	.2	1.7	-	260	49	507	8.0	13.3	1
22	Camp Nelson	125	Aug. 23, 1951	11	170	360	86	12	8.5	2.2	310	26	9.0	.2	5	307	260	13	526	7.4	14.4	0
								Springs														
1	H. Marshall Spring	-	May 27, 1968	8.9	240	70	58	4.1	2.1	2.1	150	24	4.0	.4	19	209	160	36	331	7.5	13	15
2	Royal Spring	-	Aug. 13, 1975	6.9	-	60	93	8.5	22	2.8	240	59	36	1.0	7.1	370	270	73	570	-	19.5	6
9	Versailles Spring	-	Oct. 31, 1956	7.7	20	0	89	15	8.5	1.4	280	42	16	.2	13	320	280	54	541	7.3	13.3	3
11	Russell Cave Spring	-	May 27, 1968	7.6	140	40	66	5.9	5.5	2.1	170	39	10	.3	17	247	190	52	395	7.4	13.0	15
21	Woods Spring	-	Sept. 17, 1958	7.3	20	40	92	4.5	1.9	1.0	280	14	4.0	.1	13	280	250	20	472	7.4	14.4	3

Metal concentrations in ground water (table 4) in the same area were generally within acceptable limits. Concentrations of aluminum, iron, and manganese were high enough in water from well 8 to cause problems for certain water uses.

Bacterial pollution is a serious problem in ground-water supplies. Mull (1968, p. 19) reported that bacterial pollution occurred in about 70 percent of ground-water supplies in the Lexington-Fayette County area. The Environmental Protection Agency (1972, p. 121) did a study of three counties one of which adjoins the study area of this report. They reported that, in 540 rural individual water supplies checked, 70 percent had coliform bacteria contamination and about 66 percent had fecal coliform contamination. The percentage of polluted water supplies in the study area is unknown, but it is probably as high as reported in the above studies. It could be even higher in areas receiving most of the runoff from the Lexington urban area such as the drainage basins of the South Elkhorn Creek and North Elkhorn Creek.

Pollution of ground water by polluted streamflow is also a major problem. A study by the Corps of Engineers (Foree, 1974) showed that most streams contain bacterial pollution, and discharge measurements show that some reaches of the larger streams lose water to cavern systems (pl. 3).

SUMMARY

Ground water in the Lexington, Kentucky area occurs in Ordovician limestones in which cavity development is generally less than 100 ft (30 m) below land surface.

Some wells produce about 300 gal/min (19 l/s) in some of the large stream valleys; about 50 gal/min (3 l/s) in the rolling upland of the Inner Blue Grass, small stream valleys, and small areas of the Kentucky River floodplain; and about 5 gal/min (0.3 l/s) on hilltops and steep slopes.

Typical of most limestone terranes, many wells in all topographic settings fail to penetrate any significant water-bearing openings and fail to furnish adequate water for domestic supplies.

The Lexington urban area is high topographically and structurally. Ground-water gradients indicate that water moves from the urban area to the surrounding lowlands. Much of the surface and subsurface drainage from the urban area passes through the drainage basins of South Elkhorn Creek and North Elkhorn Creek.

Ground-water recharge areas, based on ground-water gradients and topography, generally coincide with surface drainage areas above discharge points. Much of the Lexington urban area is in the recharge areas of aquifers that have the most potential for ground-water development.

Ground water is a calcium bicarbonate type and, in places, contains sodium chloride and (or) hydrogen sulfide. Generally it is more mineralized with increasing depth below land surface. Bacterial pollution occurs in a high percentage of ground-water supplies.

Ground water provides about one-tenth of the water used in the six counties. Problems in developing ground-water supplies include small well yields, poor chemical quality, and bacterial pollution.

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