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GEOLOGY AND WATER AVAILABILITY OF

CULLMAN COUNTY, ALABAMA

By R. J. Faust and P. O. Jefferson

ABSTRACT

The Pottsville Formation of Pennsylvanian age underlies most of Cullman County. It consists mostly of interbedded sandstones and shales that dip southward about 40 feet per mile. The Bangor Limestone of Mississippian age underlies the Pottsville and crops out in a few valleys along the northern boundary of the county.

The principal source of ground water in the county is the Pottsville Formation. Sandstones of the Pottsville Formation underlying low topographic areas will yield as much as 200 gpm (gallons per minute) to individual wells 200 feet deep or less in the southeastern part of the county and 25-100 gpm in other parts of the county. Those underlying high topographic areas generally yield less than 5 gpm.

The average flow of streams in and adjoining Cullman County is about 1,500 mgd (million gallons per day) which includes about 780 mgd that originates in the county. Discharge from ground-water storage is small, and most streams cease to flow during extended dry periods. Sipsey Fork and Mulberry Fork are the only streams in and adjoining Cullman County that have median annual 7-day low flows that exceed 2 mgd.

Chemical analyses of water in the county indicate the water is suitable for most uses, but iron concentrations in ground water exceed 0.3 mg/l (milligrams per liter) in many places.

Water use in Cullman County was estimated to average 5.6 mgd in 1967.

INTRODUCTION

The U.S. Geological Survey, in cooperation with the Geological Survey of Alabama is conducting studies of the geology and availability of water resources of Alabama. For these studies the State was divided in groups of counties that approximately coincide with seven major river basins; however, the work is being conducted and the reports resulting from the studies are to be published by county units. The boundaries of the seven areas and the status of the studies are shown in figure 1.

Figure 1 (caption on next page) belongs near here.

This report for Cullman County is part of the upper Tombigbee-Black Warrior River basin. ~~(Ala-6-C).~~

Figure 1. --Status of geologic and water-availability studies in Alabama.

The purposes of this report are: (1) present general information on water availability in such a way that a quick visual appraisal and comparison with other county areas can be made, and (2) provide a geologic map of sufficient detail to aid in evaluating ground-water and mineral resources of Cullman County. The geologic map is also part of the long-range plan of the U. S. Geological Survey and the Geological Survey of Alabama to update the geologic map of the State.

This report utilizes information contained in earlier reports listed in selected references. In addition, it contains water-availability maps and other water-resources information not previously published.

Topography and Drainage

Most of Cullman County is in the Cumberland Plateau section of the Appalachian Plateaus province. A few square miles along the northern boundary of the county is in the Highland Rim section of the Interior Low Plateaus province.

The topography of the county is characterized by narrow, steeply sloping interfluvial areas and deeply entrenched stream valleys. Altitudes of the upland areas range from about 1,100 feet above mean sea level in the northern part of the county to about 600 feet in the southern part. The larger streams are entrenched from 200 to 400 feet below the upland areas.

Drainage is mostly southward and southwestward to Mulberry and Sipsey Forks of the Black Warrior River. The Highland Rim section drains northward to the Tennessee River.

GEOLOGY

Sedimentary rocks exposed in Cullman County are Mississippian and Pennsylvanian in age and consist mostly of sandstone and shale but include several seams of coal. Limestone is exposed in a few valleys along the northern boundary of the county. The rocks dip uniformly to the south about 40 feet per mile except along the southeastern boundary where they are abruptly folded on the southern extension of the Sequatchie anticline. The distribution of the formations is shown on figure 2.

Figure 2 (caption on next page) belongs near here.

Bangor Limestone

The Bangor Limestone received its name for exposures of limestone near the community of Bangor in Blount County, Alabama. These exposures are less than 1 mile from the southeastern boundary of Cullman County. The Bangor Limestone is overlain by the Pottsville Formation in Cullman County except in a few valleys along the northern boundary of the county (fig. 2).

The thickness of the formation underlying Cullman County, based on well logs and exposures in Blount and Morgan Counties, ranges from about 375 to 600 feet.

Figure 2. --Geologic map of Cullman County, Alabama.

The Bangor is mostly medium- to dark-gray, thin- to thick-bedded limestone. Fine- to coarse-grained bioclastic limestone and oolitic limestone comprise most of the formation, but dense, argillaceous, and cherty limestones are commonly present. Most of the limestones have a fetid odor when freshly broken. Shale partings occur in the limestones and several feet of dark-gray to black carbonaceous shale forms the basal part of the formation in southwestern Blount County. The formation is very fossiliferous and the bryozoan <u>Archimedes</u> weathers in relief on many surfaces.

An interval of about 100 feet of gray shale, maroon and green shales and mudstones, and interbedded limestones occur at the top of the Bangor Limestone in Cullman County. This interval has generally been mapped as the Pennington Formation, but, for this report, the interval is included with the Bangor Limestone. The interval is not mapped separately because the shales and mudstones are not laterally extensive and the interbedded limestones are similar to limestones of the Bangor.

The Bangor Limestone is overlain unconformably by the Pottsville Formation. The contact between the two units was mapped at the base of the lowest quartzose or conglomeratic sandstone of the Pottsville Formation.

Pottsville Formation

The Pottsville Formation received its name from the town of Pottsville in eastern Pennsylvania. It is the youngest formation exposed in Cullman County and its outcrop area extends over most of the county. It ranges in thickness from about 300 feet in the northern part of the county to about 1,000 feet in the southern part. The greater thickness to the south results mostly from preservation of younger beds because the southward dip of the formation is slightly greater than the southward slope of land surface.

The Pottsville consists of sandstone, shale, siltstone, conglomeratic sandstone, pebble conglomerate, and several bituminous coal beds. Some sandstones are tan to brown, thick-bedded to massive, and orthoquartzitic; others are gray to greenish-gray and thin- to thick-bedded. Some shales are gray to greenish-gray, but others are black, carbonaceous, and fissile. Pebble conglomerates or conglomeratic sandstones are common at the base of the Pottsville but conglomeratic sandstones also occur at other horizons.

Several efforts have been made to subdivide the Pottsville. Culbertson (1962, p. E51-E57) summarized several of these subdivisions and proposed a nomenclature for units of the formation in northwest Georgia.

A section that includes the lower part of the Pottsville and the upper part of the Bangor occurs at the Cullman County-Morgan County boundary along State Highway 157.

Geologic section on west side of State Highway 157 in secs. 30 and 31, T. 8 S., R. 4 W.

	Thickness (feet)
Pottsville Formation:	
Sandstone, gray, fine- to medium-grained, thin- to thick-bedded, weathers yellowish brown.	75
Shale, dark-gray, fissile, carbonaceous.	7
Sandstone and thin shale partings, gray fine- to medium-grained, thick-bedded, weathers yellowish brown	61
Sandstone interbedded with siltstone and shale	10
Sandstone, gray, fine- to coarse-grained, thick-bedded, weathers yellowish brown.	10
Shale, dark-gray, carbonaceous, interbedded with dark-gray sandstone	5
Sandstone, gray, medium- to coarse-grained, thin- to thick-bedded, carbonaceous; contains quartz pebbles; weathers yellow to reddish brown.	42

Geologic section--Continued

	Thickness (feet)
Bangor Limestone:	
Shale, greenish-gray, micaceous, silty	7
Limestone, light-gray, dense, thin-bedded, argillaceous; contains abundant bryozoan fragments.	1
Shale, gray, fissile.	10
Covered interval.	7
Shale, gray- to light-green.	3
Covered interval.	15
Limestone, gray, dense, beds 3 inches to 1 foot in thickness, cherty near top of unit; contains brachiopod and bryozoan fragments	7
Shale, greenish-gray.	7
Limestone, medium-gray, dense, massive, weathers light gray; contains brachiopod and bryozoan fragments.	10
Covered interval.	36
Shale, greenish-gray with streaks of red	3
Limestone, medium-gray, dense, massive, weathers light gray; contains nodules and layers of chert and few brachiopods.	7
Shale, greenish-gray.	1

Geologic section--Continued	Thickness (feet)
Bangor Limestone--Continued	
Limestone, gray, dense, massive, argillaceous; weathers light tan	4
Limestone, medium-gray, medium-grained, massive, crystalline, weathers light gray; contains small veins of calcite	10
Covered interval	2
Limestone, gray, dense, massive, argillaceous; weathers light tan	4

WATER AVAILABILITY

All fresh water in Cullman County is derived from precipitation which averages about 56 inches per year. About three-fifths of the precipitation returns to the atmosphere by evapotranspiration and the other two-fifths runs off as streamflow or percolates through the soil to ground-water reservoirs.

Ground Water

The evaluation of the availability of ground water shown on figure 3 is based on well data in table 1 and on interpretations of subsurface geology. The Pottsville Formation is the only geologic unit evaluated as an aquifer because it exceeds 300 feet in thickness in most of Cullman County and most of the available data are from shallow wells. The few wells that have been drilled below the base of the Pottsville have not penetrated any significant water-bearing openings in the Bangor Limestone.

Topography is an important factor in evaluating the availability of water from the Pottsville. Wells drilled in lowlands and valleys produce as much as 200 gpm, whereas wells drilled on the uplands and ridges generally produce less than 5 gpm and some fail to supply sufficient water for domestic or stock use. Wells developed in low topographic areas produce more because the rocks are more permeable near land surface and the water table is generally shallow in these areas. Thus, a greater thickness of the more permeable rocks near land surface is saturated with water. In high topographic areas the water table is at greater depths in generally less permeable rocks.

The relationship of well yield to local topography cannot be practically shown on an illustration because of the great local variation. However, maximum expected yields of wells in low topographic areas differ in the county and these differences are outlined in three general areas in figure 3.

Figure 3 (caption on next page) belongs near here.

Figure 3. --Availability of ground water in Cullman County, Alabama.

The northern area of the county (fig. 3) is underlain mainly by gently dipping beds of sandstone. Yields of as much as 100 gpm to individual wells can be expected in some of the lowlands and valleys.

The southeastern area (fig. 3) is a shallow syncline of sandstones and interbedded thin shales. The sandstones, by receiving recharge from both limbs of the syncline, yield more water to wells than the flat-lying sandstones in the northern area. Yields of as much as 200 gpm, or about 0.3 mgd, to individual wells can be expected in some lowlands and valleys along the axis of the syncline.

The southwestern area (fig. 3) is underlain by gently dipping beds of shale and sandstone. Generally, yields to individual wells are less than 25 gpm in the lowlands and valleys because of the high percentage of shale.

The permeability of the Pottsville Formation generally decreases with depth. Significant increases in yield are rarely obtained at depths greater than 200 feet, and wells drilled to a depth of 100 feet generally produce as much as deeper wells.

Surface Water

Average Flow

The average flow of streams is the parameter of streamflow selected to show the availability of surface water because it represents the water yield of the drainage basin. The average flow of all streams in and adjoining Cullman County is about 1,500 mgd of which about 780 mgd or about 1.0 mgd per square mile originates in the county. Average flow of streams, adjusted to the base period 1940-65, are shown on figure 4 by width between lines along individual streams.

Figure 4 (caption on next page) belongs near here.

Figure 4. --Availability of surface water in Cullman County, Alabama.

Variability of Streamflow

Streamflow from direct runoff of rainfall may be many times greater than the average flow, but it is available for only a brief period after rainfall. Streamflow during long rainless periods is dependent on discharge from ground-water storage. The discharge, referred to as base flow of a stream, is generally much less than the average flow. A hydrograph (fig. 5) of Mulberry Fork near Garden City, Alabama,

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Figure 5 (caption on next page) belongs near here.

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illustrates seasonal variability of streamflow which is typical of streams in the county.

Figure 5. --Hydrograph of average monthly flows of Mulberry Fork near Garden City, Alabama.

Flow-duration data also help to illustrate variability of streamflow. The flow-duration curve for Mulberry Fork (fig. 6), which drains a large

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Figure 6 (caption on next page) belongs near here.

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part of Cullman County, indicates highly variable streamflow and small discharge from ground-water storage. The curve for Tallahatchee Creek near Wellington (Calhoun County), Alabama, which illustrates less variable streamflow, has been plotted (fig. 6) to provide a comparison.

Because of the variability of streamflow, the availability of surface water fluctuates from periods of high flow to periods of low flow. The following sections on low flow and storage requirements are presented to aid in evaluating the availability of surface water during periods of low flow, and to estimate storage requirements for specified draft rates.

Figure 6.--Flow-duration curves for Mulberry Fork near Garden City, Alabama and Tallahatchee Creek near Wellington, Alabama.

Low flow.--A streamflow parameter that provides useful information in appraising the low flow of Alabama streams is the median value of the annual 7-day minimum flows--hereafter referred to as the 7-day Q_2. For streams that are not regularly gaged, this parameter can be satisfactorily evaluated from a relatively small amount of streamflow data. As a median value, it is a fairly stable parameter, being the average only of position in an array of items and hence unaffected by extreme values. Also, as a median, it is a good measure of normal conditions. The recurrence interval for a median value in a series of annual events is always known, being equal to 2 years in any form of frequency distribution. Finally, the 7-day period of low flow is short enough to represent flow that is available for the most part without storage, yet is long enough to suppress the effects of abnormally low transient flows of little hydrologic significance that might result from occasional regulations or from natural causes of an accidental nature.

The approximate range of the 7-day Q_2 for streams in Cullman County is shown by color on figure 4. Values for 7-day Q_{10}, 7-day Q_2, and average flow are given at network gaging stations.

Storage requirements.--Surface-water storage is necessary if low flows of streams are less than the required draft rate. Storage requirements to provide draft rates from 25 to 50 percent of the average flow can be estimated from average flow and 7-day Q_2 by using figure 7.

Figure 7 (caption on next page) belongs near here.

Storage figures selected from the diagram will be adequate to provide the selected draft rate 9 of every 10 years on the average. Storage requirements can be estimated from figure 7 by using only average flow but use of low-flow data where available improves the estimate. Where the 7-day Q_2 in million gallons per day per square mile is unknown, it can be assumed to be zero or the area average of 0.06 mgd per square mile can be used for large streams.

The following example illustrates the use of figure 7. The average flow at station 02450000, Mulberry Fork at Garden City, is 418 mgd and the 7-day Q_2 is about 5.4 mgd (fig. 4) or about 0.015 mgd per square mile. A draft rate of 209 mgd, or 50 percent of the average flow, is assumed to be needed at the site. These values when applied to figure 7 (dashed line) give an estimated storage requirement of 118,000 acre-feet.

Figure 7 is intended for preliminary selection of sites where desired draft rates could be obtained by providing storage. The effects of evaporation, seepage, and sedimentation would require adjustments for final design purposes.

Figure 7. --Storage required for sustained draft rates.

Chemical Quality of Water

Water from the Pottsville Formation, except for iron content, is generally of good chemical quality. About two-thirds of the chemical analyses listed in table 2 indicate iron concentrations of more than 0.3 mg/l. However, there is no discernable pattern of the distribution of iron in water from the Pottsville in the county. Concentrations above and below 0.3 mg/l occur throughout the county and in water from various depths. Water from the Pottsville Formation ranges from soft (less than 60 mg/l) to very hard (more than 180 mg/l) but generally is soft. The water is commonly acidic.

Water from streams in the county is of relatively uniform quality and suitable for most uses. Generally, the water contains less than 100 mg/l dissolved solids and is soft. Results of chemical analyses of water from streams are tabulated in table 3.

WATER USE

Average water use in Cullman County during 1967 was estimated to be 5.6 mgd. The principal water users, sources of supplies, and quantities used are listed below:

User	Source	Average use in gallons per day
Domestic and stock	Wells and farm ponds	2,000,000
Cullman	Lake Catoma	3,300,000
Hanceville	Well W-9	135,000
Garden City	Well Y-1	30,000
Holly Pond	Well O-4	25,000
Schools	Wells	130,000
	Total	5,620,000
1/ Birmingham	Sipsey Fork	60,000,000

1/ User is in Jefferson County but source is Sipsey Fork.

CONCLUSIONS

The following are conclusions resulting from the study in Cullman County:

1. The Pottsville Formation, consisting mostly of sandstone and shale, underlies most of Cullman County and dips gently to the south.

2. Ground water is obtained from shallow sandstones (less than 200 feet below land surface) of the Pottsville Formation. Wells tapping sandstones underlying lowlands and valleys are the most productive. Yields of as much as 200 gpm (0.3 mgd) to individual wells can be expected in some lowlands and valleys of the southeastern part of the county, as much as 100 gpm in the northern part, and as much as 25 gpm in the southwestern part.

3. The quality of water, except for iron content in ground water, is generally good in the county.

4. Runoff originating in the county is about 780 mgd or about 1.0 mgd per square mile. About two-thirds of the runoff is to Mulberry Fork along the southeastern boundary of the county and most of the remaining one-third flows into Lewis Smith Lake.

5. Sipsey Fork and Mulberry Fork are the only streams that have median annual 7-day low flows that exceed 2 mgd. Most, if not all, other streams in the county cease to flow during extended dry periods.

6. Average water use in the county was estimated to be 5.6 mgd in 1967. The city of Cullman used about 3.3 mgd from Lake Catoma, and domestic and stock use of ground water was about 2 mgd. Water in Lewis Smith Lake is used primarily for power generation and recreation but sufficient water is released to Sipsey Fork to provide 60 mgd diversion to Birmingham in Jefferson County for industrial use.

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