JOURNAL OF THE TENNESSEE ACADEMY OF SCIENCE
Volume 40, Number 1, January, 1965

AVAILABILITY OF GROUND WATER IN THE WESTERN HIGHLAND RIM OF TENNESSEE

GERALD K. MOORE AND ROY H. BINGHAM *
Water Resources Division, U. S. Geological Survey
Nashville, Tennessee

INTRODUCTION

Within the Highland Rim Physiographic Province (Fig. 1) some springs produce more than 1000 gallons of water per minute, and some wells and springs do not produce enough water for domestic use. However, the vast majority of wells and springs yield amounts of water that range between these two extremes. The purpose of this paper is to (1) describe the availability of ground water in 10 counties (Fig. 1) on the western Highland Rim, (2) explain the factors that determine the occurrence of ground water and the productivity of the aquifers (water-bearing units) in this area, and (3) discuss the significance of the quantity of water discharged by springs as an indicator of probable yields in nearby wells. Significant features of the geology of the western Highland Rim are described because the geology of the report area provides an understanding of the physical framework in which the ground water occurs and through which it moves.

The source for nearly all ground water in the western Highland Rim is local precipitation. There is little likelihood that significant amounts of water are imported by subsurface flow from adjacent areas. For all practical purposes, the drainage divides of the streams coincide with the ground-water divides. The direction of groundwater movement is from the divides toward the valleys, then down the valleys, and eventually the ground water is discharged into streams.

WATER-BEARING CHARACTER OF THE AQUIFERS

The western Highland Rim is underlain mostly by limestone, chert, and siltstone formations of Early and Middle Mississippian age. Besides the Mississippian formations, limestone formations of Ordovician, Silurian, and Devonian age underlie a few stream valleys. In addition, sands and gravels of Cretaceous age cap some of the hills, and unconsolidated deposits of Quaternary age occur as terrace deposits along many of the major streams and on some of the uplands.

The Mississippian strata have a slight regional dip to the north. However, local flexures having apparent dips from 2 to 8 degrees usually obscure the regional dip, except across considerable distances.

Throughout most of the western Highland Rim the bedrock formations are covered by a layer of cherty subsoil (a weathered zone that lies between the true organic soil above and unaltered bedrock below). The subsoil generally ranges from 30 to 150 feet in thickness on the hilltops and from 0 to 30 feet in thickness in the valleys.

During periods of ground-water recharge, the subsoil acts much like a sponge, absorbing part of each rainfall and transmitting the water slowly downward to the water table. Practically all recharge from precipitation occurs from November 1 of one year through April of the following year. In the intervening months (May through October) evapotranspiration exceeds rainfall, and nearly all rain that seeps into the ground is absorbed by the soil. Little, if any, reaches the water table. Large amounts of water are stored in the subsoil during the wet winter and spring months because the area of ground-water recharge is much larger than the area of ground-water discharge. During the dry summer and fall months, much of this stored water is discharged, and thus the flow of many streams in the Highland Rim is sustained.

Where the subsoil is underlain by a nonporous, mostly insoluble formation such as the Fort Payne Chert, only a minor amount of the ground water enters the bedrock. Most of the water flows slowly through the subsoil on top of the bedrock to areas of discharge. Trace Creek near Waverly and Buffalo River above Riverside (Fig. 1) are two examples of streams that receive large contributions of ground water from the subsoil of the Fort Payne Chert.

The subsoil from most of the Mississippian rocks exposed in the western Highland Rim has a low permeability; but where it is sufficiently thick, it yields large amounts of water. For example, some wells in Hohenwald and Waverly (Fig. 1) that penetrate 100 feet of saturated subsoil yield as much as 300 gpm (gallons per minute) of water. The specific capacity[1] of one well at Waverly is about 13.5 gpm/ft (gallons per minute per foot) of drawdown. Another well, at Summertown (Fig. 1) in Lawrence County, yields about 200 gpm and has a specific capacity of about 3.5 gpm/ft of drawdown. In most areas, however, wells in the subsoil have specific capacities of less than 1.0 gpm/ft of drawdown.

The largest amounts of ground water are found in solution cavities in the bedrock where the subsoil is underlain by fairly pure, soluble limestone (such as some beds in the Warsaw and St. Louis Limestones). In the western Highland Rim, bedding planes apparently are the major control in the formation of solution cavities because most of the cavities are elongated in a

---

* Prepared in cooperation with the Tennessee Department of Conservation, Division of Water Resources.

[1] An indicator of the relative yield of a well. Defined as the number of gallons per minute a well will yield for each foot of drawdown of the water level.

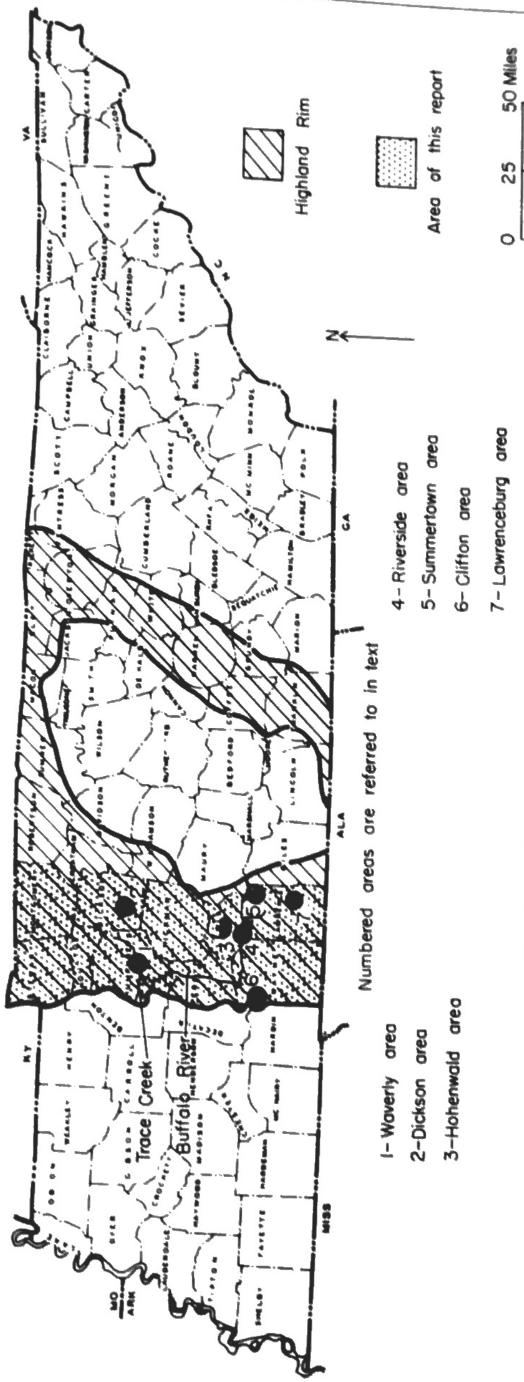

Fig. 1. Map showing location of report area, selected towns, and selected streams.

horizontal direction. Joints obviously provide the passageways for water to enter the limestone, however, and joints also exert control on cavity-system development, as evidenced by the linearity of the cavities.

GUIDES TO GROUND-WATER AVAILABILITY

The factors that determine ground-water availability in the report area are: (1) thickness of the water-saturated residuum, (2) type of bedrock, whether it is soluble or insoluble, (3) depth below land surface, (4) topography, and (5) structure. The significance of residuum thickness and of bedrock type has been discussed previously. Where most of the ground water is found in the bedrock, the factors of well depth, surface topography, and rock structure are also important.

On the western Highland Rim, solution-cavity development and thus ground-water availability decreases with depth (Fig. 2). In 66 percent of the 707 wells inventoried, water was found at a depth of less than 100 feet; in 91 percent of the wells water was found at depths less than 200 feet; and in 97 percent of the wells water was found at depths less than 300 feet. Nearly all the wells inventoried were drilled for domestic use, and drilling was stopped where adequate amounts of water for household use were obtained. The 470 wells that are less than 100 feet deep might have found additional water at somewhat greater depths. However, only 18 of the 707 wells were drilled deeper than 300 feet, and this depth seems to be the "practical" limit for water in most of the western Rim. Very few solution openings occur below a depth of 300 feet.

Topography plays an important part in determining the availability of ground water. In the highly dissected areas of the Highland Rim, most of the potential recharge in the form of precipitation runs off the steep hillsides; very little reaches the water table. In addition, the water table has a steep gradient, resulting in a fairly rapid movement of ground water toward areas of discharge. Wells in such areas show large water-level fluctuations and commonly go dry in the summer and fall.

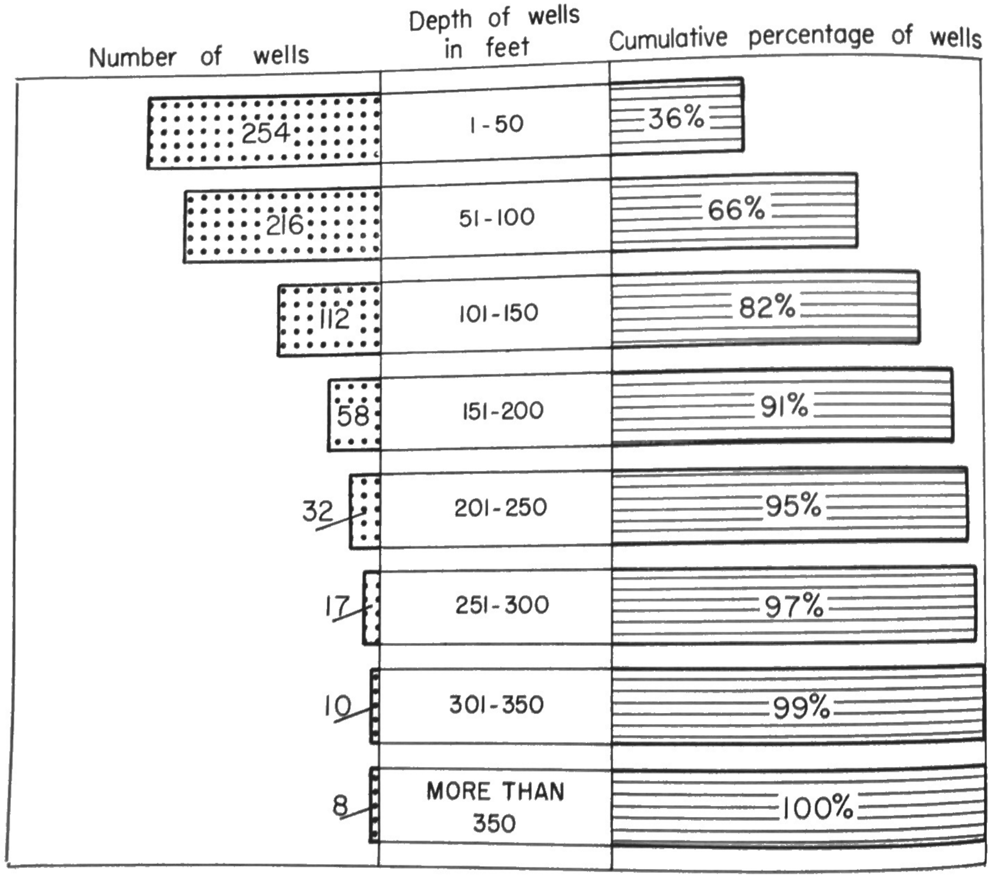

Fig. 2. Graph showing distribution of wells by depth on the western Highland Rim.

Considerably more favorable areas for ground water are the broad, relatively flat uplands. Precipitation runs off slower and more water is recharged to the aquifers in the flat upland areas than in the dissected areas. The

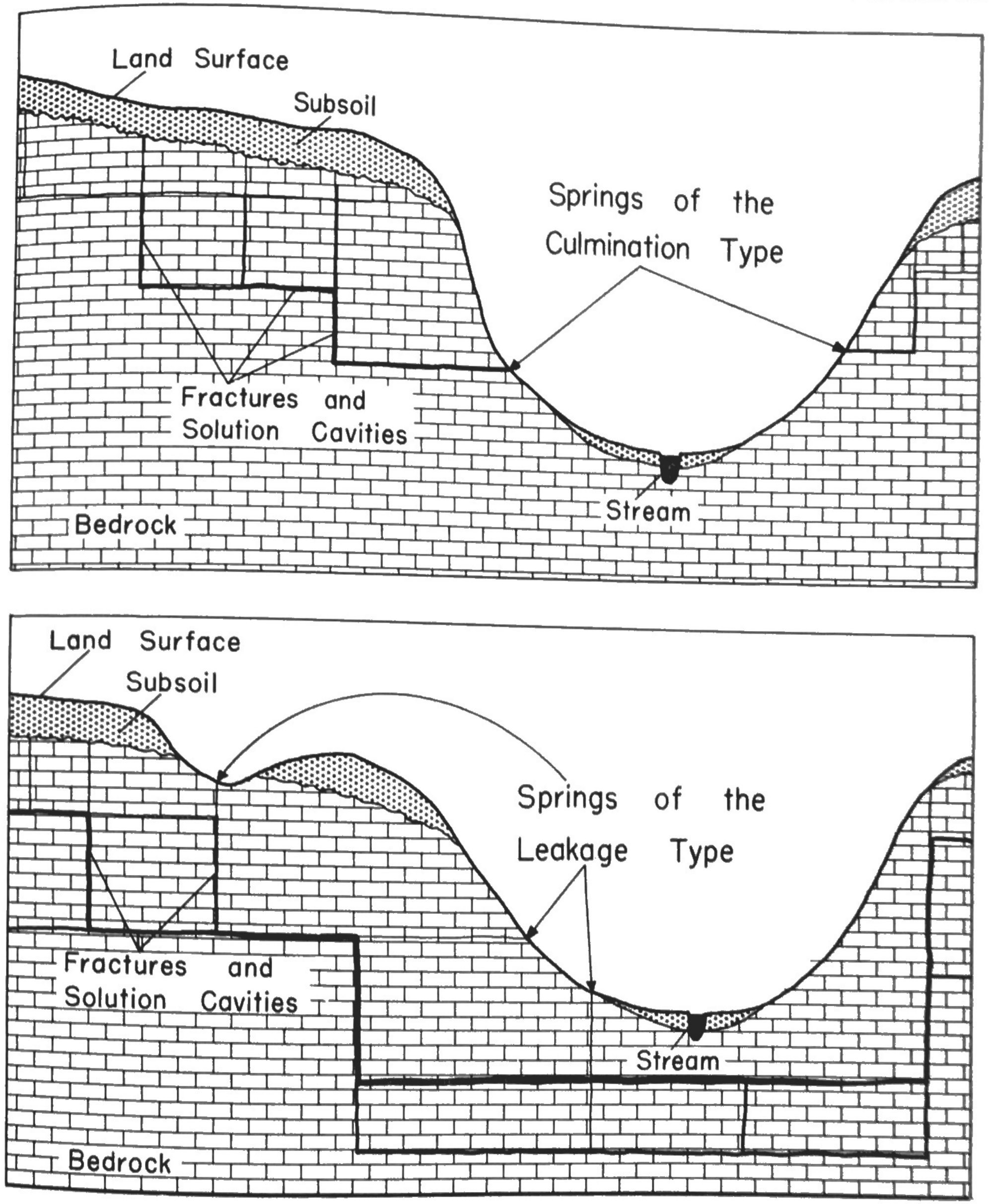

Fig. 3. Idealized cross sections showing culmination-type and leakage-type springs.

movement of ground water is also fairly slow which results in small seasonal water-level fluctuations. Moreover, the subsoil is commonly thickest on the uplands, and large quantities of water stored in the subsoil are available to wells during the dry summer and fall months. As the population of the western Rim is concentrated mainly on the uplands, most of the future increase in ground-water use is expected to be in these areas.

Probably the best potential areas for large-capacity wells are the broad flood plains bordering some of the major streams in the western Rim. The reason for this is that all ground-water movement is toward the stream valleys, and a considerable portion of the ground water eventually flows beneath the flood plains of the major streams. Drawbacks to the future development of ground-water supplies in the flood-plain areas are the threat of periodic flooding and the availability of large, nearby sources of surface water.

Another factor that probably determines aquifer productivity is local structure. Because bedding planes play a major role in solution-cavity development, movement of ground water is from the structural highs to the structural lows; the largest amounts of ground water flow through the structural lows; and this water is available to wells. Good correlations have been found between structure and ground-water productivity near Lawrenceburg (Fig. 1) and in northern Alabama, especially near Huntsville (LaMoreaux and Powell, 1961, p. 371).

SPRINGS

An excellent indicator of aquifer productivity (and one that is usually overlooked) in any particular area is the amount of water discharged from nearby springs. Some springs represent the culmination of a solution-cavity system (Fig. 3), and wells drilled into this system above the spring obviously would yield somewhat less water than the spring. Other springs, however, apparently represent a point of leakage on an extensive cavity system (Fig. 3); a few wells drilled into this system may yield more water than the spring. Springs of the leakage type, examples of which probably are Fielder Spring near Dickson (Fig. 1) and Hope Spring at Lawrenceburg, commonly are found on broad, fairly flat areas. Springs of the culmination type normally are found on steep hillsides, at or near geologic contacts.

The variability of the rate at which water is discharged by springs is also an indication of aquifer productivity. Springs with a small variability indicate that the aquifer has an extensive cavity system and a large capacity for water storage. Springs with a large variability indicate a small capacity for water storage. If an aquifer has little capacity for storage, wells may fail during the dry summer and fall months. An example of a spring with a small variability is Fielder Spring near Dickson. The discharge from this spring fluctuated between 680 and 1400 gpm from 1961 through 1963. Alley Spring near Clifton (Fig. 1) is a culmination-type spring and is much more variable; the discharge fluctuated between 45 and 3200 gpm in 1963.

The lack of large capacity springs in any particular area is not necessarily an indication that large quantities of water cannot be developed in that area. However, the presence of large springs is a positive indication of the presence of large quantities of ground water.

Two hundred eleven springs have been inventoried in the report area on the western Highland Rim. Thirty-six percent of the springs yield more than 50 gpm and 21 percent yield more than 200 gpm. Four percent yield more than 1000 gpm.

CONCLUSIONS AND SUMMARY

Ground water in amounts adequate for domestic use can be found nearly everywhere on the western Highland Rim as evidenced by the results of random drilling of wells. Larger amounts of water can be obtained but are fairly rare. Probably only 2 percent of the wells would yield more than 40 gpm as a result of random drilling. The yields of springs on the Rim indicate, however, that large amounts of water can be obtained in favorable areas by means of selective test drilling. Well production of more than 50 gpm should be possible in many areas, and well production of as much as 1000 gpm should be possible in a few areas.

The factors that determine ground-water availability are:

(1) Thickness of the subsoil—this factor has a direct relationship with the amount of water, stored in the subsoil, that is available for pumping during extended periods without rainfall. Such periods usually occur in the summer and fall.

(2) Type of bedrock—whether the rock is soluble or insoluble. If the bedrock is insoluble, most ground water will be found in the subsoil.

(3) Depth below land surface—very little potable water is found below a depth of 300 feet.

(4) Topography—broad uplands and wide stream valleys are the most productive areas for ground water.

(5) Structure—generally more water is found in structural lows than in structural highs.

These factors plus the yield, type, and variability of nearby springs can be used to select sites and determine depths for the test drilling of large-capacity wells.

LITERATURE CITED

LaMoreaux, P. E. and W. J. Powell. 1961. Stratigraphic and structural guides to the development of water wells and well fields in a limestone terrane. *Internat. Assoc. Sci. Hydrology*, 52:363-375.

DATES OF MAILING VOLUME 39 (1964)

Number 1, March 19
Number 2, May 5
Number 3, September 10
Number 4, January 4