DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

WATER RESOURCES INVESTIGATIONS REPORT 86-4121


## EXPLANATION

—300— POTENTIOMETRIC SURFACE CONTOUR -- Shows altitude at which water level would have stood in tightly cased wells. Dashed where approximately located. Contour interval 50 feet. Hachures indicate depressions. Datum is National Geodetic Vertical Datum of 1929

AQUIFER RECHARGE AREA BOUNDARY

OBSERVATION WELL -- Well in which water-level or artesian-pressure measurement was made in Fall, 1982

GRE-3 OBSERVATION WELL FOR WHICH HYDROGRAPH IS SHOWN

WITHDRAWAL RATES AT MAJOR PUMPING CENTERS (in million gallons per day)

0.25 - 0.49

0.50 - 0.99

1.00 - 1.99

≥ 2.00

## INTRODUCTION

The U.S. Geological Survey began a nationwide program in 1978, termed Regional Aquifer-System Analysis (RASA), to study a number of the major aquifer systems that provide a significant part of the country's water supply. One of the aquifer systems chosen for study was the thick and extensive sequence of sands of Cretaceous and early Tertiary age that underlies the Coastal Plain of the Southeastern United States. This system, which extends from Mississippi eastward to South Carolina, is called the Southeastern Coastal Plain aquifer system. It can be divided hydrogeologically into several separate aquifers. The map presented here, one of a series that portray the potentiometric surface, ground-water withdrawals, and recharge areas for the aquifers in Alabama that are included in the regional system, deals with the Eutaw aquifer.

## HYDROGEOLOGY

The Eutaw aquifer comprises the Eutaw Formation, which is composed of sands, clays, and sandstones of Cretaceous age. The aquifer is composed of a regionally extensive basal sand and isolated sand beds in the upper part of the formation. Conant and Monroe (1945) proposed that the lower sand be designated the McShan Formation, restricting the name Eutaw to the upper sands. This convention was followed in Alabama by Wahl (1965, 1966), but other authors (Newton and others, 1961, p. 24; Barksdale, 1976, chap. 8, p. 3; Davis and others, 1980, p. 4) followed Smith and Johnson (1887, p. 189) and included both the upper and lower sands in the Eutaw Formation because the McShan Formation is difficult to distinguish in the subsurface and has a very limited eastward extent in Alabama (Applin and Applin, 1947). For convenience, this report follows the latter convention and defines the Eutaw Formation as including all deposits underlying the Mooreville Chalk (or the Blufftown Formation in eastern Alabama), and overlying the Tuscaloosa Group.

The area of direct recharge for the Eutaw aquifer (outcrop) extends across the State from Lamar and Pickens Counties in the west to Russell County in the east in an arcuate band 2 to 20 miles wide. The updip limit of the aquifer is the outcrop of the Gordo Formation of the Tuscaloosa Group in western and central Alabama and of the Tuscaloosa Formation in the east. These formations are part of the Tuscaloosa aquifer, which underlies and has varying degrees of hydraulic connection with the Eutaw aquifer. In western and central Alabama the Demopolis and Mooreville Chalks overlie the Eutaw aquifer, while in easternmost Alabama the chalk is replaced by the Blufftown Formation. These overlying units generally form or contain confining beds that (along with clays in the upper part of the Eutaw Formation in the eastern part of the State) hydraulically separate the Eutaw aquifer from overlying aquifers. However, while the separation provided by the chalk is known to be great, that provided by confining beds in eastern Alabama is uncertain. Permeability and thickness of the sands comprising the Eutaw aquifer generally decrease from west to east.

### Potentiometric Surface

The accompanying map is a generalized depiction of the regional potentiometric surface of the Eutaw aquifer based on water-level measurements made primarily in the fall of 1982, and in some instances on stream stage. The potentiometric surface map illustrates, by means of contour lines, the altitude of the water table or the altitude to which water would rise in tightly cased wells tapping an artesian (confined) aquifer. The potentiometric surface depicted generally represents an average for the aquifer; the water-level altitude in any particular well may differ from the average to some extent depending on well depth and local geology. The orientation and shape of the contour lines are influenced by several factors, which include the geologic structure of the aquifer, the rate with which water passes through the aquifer (its transmissivity), and the location of discharge points such as wells, springs, or streams. Ground-water flow in the aquifer is approximately perpendicular to the contour lines.

### Recharge and Discharge

Recharge of the Eutaw aquifer occurs through the infiltration of water from precipitation and probably by leakage from adjacent aquifers. Discharge from the aquifer occurs in as many as four ways: water may 1) leak upward or downward into adjacent aquifers, 2) emerge at land surface as springs, 3) be withdrawn from wells, or 4) drain to streams in the recharge area.

Streams in the unconfined zone of Alabama Coastal Plain aquifers act as ground-water drains due to their low altitude relative to recharge areas. Large streams and rivers drain significant amounts of water from an aquifer, often controlling regional flow patterns. The flow patterns depicted on this potentiometric surface map and digital-computer model simulation (Gardner, 1981) suggest that most of the discharge from the Eutaw aquifer is to the Tombigbee-Black Warrior River system and to the Alabama River in the central part of the State. Where the aquifer is overlain by the Demopolis and Mooreville Chalks in the vicinity of those rivers, water from the aquifer apparently leaks to the rivers through fractures in the chalk (Gardner, 1981, p. 11). Water entering the aquifer that is not intercepted by streams or pumpage in the recharge area has a longer flow path downdip through the confined part of the aquifer. Low permeability rocks and highly mineralized water far downdip in the aquifer present a barrier to flow, causing fresh ground water recharging the deeper parts of the aquifer to either leak upward into the overlying aquifer or to move updip and eventually discharge to the rivers.

## GROUND–WATER USE

### Major Pumping Centers

The Eutaw Aquifer provides water for several municipalities and industries, as well as for a large rural area across central Alabama. Public supply systems drawing water from the aquifer at a rate of 0.25 Mgal/d (millions gallons per day) or greater are the cities of Demopolis, Linden, Marion, Selma, Montgomery, Troy, Union Springs, and the Dallas County and North Dallas County Water and Fire Protection Authorities. The total rate of withdrawal from the aquifer by all of these users was approximately 8 Mgal/d in 1982; individual rates are shown by pumpage categories on the map. Self-supplied industrial use is relatively insignificant; only a few have withdrawal rates higher than 0.25 Mgal/d. These are located near the Alabama River between Selma and Montgomery. Agricultural use of water from the Eutaw aquifer also is thought to be insignificant and relatively uniformly distributed. Self-supplied domestic use cannot be quantified with certainty, but may account for as much as 4 Mgal/d. Discharge from unregulated flowing wells is probably significant. Gardner (1981, p. 4, table 2) estimated such discharge to be more than 12 Mgal/d near river valleys in an area extending from Autauga County west to the State line.

### Water-level Fluctuations

Water-level observation wells have been monitored for several years to assess the effects of water withdrawals on the aquifer. The hydrographs shown on this map are a record of water levels measured in some of those wells. Before production wells are drilled and withdrawal begins, an aquifer is in a state of "dynamic equilibrium", where water levels in the aquifer rise and fall in an annual cycle corresponding to seasonal changes in precipitation. Water levels may also show fluctuations of longer duration due to long-term departures from normal rainfall amounts, but on the average remain nearly the same. This is because the amount of water that enters the aquifer as recharge is also naturally discharged, either to other aquifers, to the land surface as springs, or to streams in the aquifer recharge area. Pumping changes this balance, and, as shown by the hydrographs, water levels usually begin to decline near major pumping centers. They will continue to decline until either an increase in recharge or a decrease in natural discharge balances the quantity of water being pumped.

The hydrographs demonstrate that equilibrium has been reached near some pumping centers, while water levels continue to fall near others. For example, in the west Alabama counties of Greene, Hale, and Marengo, water levels in observation wells Gre-3, Hal-1, and Mag-2 have been declining steadily since monitoring began in 1952, 1961, and 1954, respectively, while Mag-1 in Marengo County, which showed a decline in water levels from 1953 to 1958, appears to have reached a new equilibrium. As the rate of withdrawal from the aquifer in the vicinity of Mag-1 has not decreased since 1958, it could be inferred that water levels ceased declining because there was a decrease in natural discharge from the aquifer. Indirect evidence, derived from mapping of the potentiometric surface along with digital modeling of the Eutaw aquifer (Gardner, 1981), suggests a connection between the aquifer and the Tombigbee and Black Warrior Rivers in the area just north of Demopolis. If the area of diversion around the pumping center widened to include such connections, it could account for the decrease in natural discharge necessary to allow the aquifer in that area to reach equilibrium.

Farther to the east, hydrographs for wells in Crenshaw, Bullock, and Montgomery Counties demonstrate a phenomenon similar to that observed in western Alabama. The water level in Crenshaw County A-3 (a domestic-use observation well) has generally declined since measurement began in 1971. The hydrograph for Bul-1, an observation well located near municipal wells in Union Springs, shows that the potentiometric surface in that area has fallen precipitously since 1960, and that the aquifer probably has not reached equilibrium to date. In contrast, observation well Mtg-3, which monitors water levels in the vicinity of the city of Montgomery's west well field, has shown no decline despite an estimated pumpage from the Eutaw aquifer of 3 Mgal/d. The apparent reason for the aquifer's attaining a new equilibrium so quickly is the close proximity to the well field of both the recharge area for the aquifer and the Alabama River, along with the absence of a major intervening confining bed to restrict inducement of additional recharge.

The significance of whether an aquifer in the area of a pumping center reaches equilibrium is that, if equilibrium is attained, the current pumping rate for that center may be considered dependable. However, if water levels continue to decline, a condition could arise where further withdrawal from the aquifer at that rate would be impossible.

### Future Ground-Water Development

The potential for future development of large public and industrial supplies in the Eutaw aquifer is probably limited, and restricted to locales near the recharge area, where induced recharge can more easily compensate for large ground-water withdrawals. Municipalities located in areas distant from potential recharge sources for the Eutaw aquifer and that are seeking large supplies are currently screening new wells in the underlying Tuscaloosa aquifer, which generally yields more water to wells.

Another factor governing future aquifer development is the chemical quality of the water. Sodium chloride, for example, can impart a salty taste to water at a chloride ion concentration above 500 milligrams per liter; and with a very high chloride content, water may even become unpotable. This is a common occurrence in water from the Eutaw aquifer, particularly in some areas of west-central and central Alabama (Scott, 1957, p. 20; Newton and others, 1961, p. 133; Wahl 1966, p. 21, fig. 10; Avrett, 1968). High fluoride concentration can cause mottling of tooth enamel, and is a problem locally in some of the same areas (Newton and others, 1961, p.134; Wahl, 1966, p. 21; Avrett, 1968; Barksdale, 1976, chap. 8, p. 20). Other water-quality conditions that may affect decisions concerning the suitability of ground water for various uses (particularly industrial) are high iron and hardness. One or both of these conditions may also be a problem in some parts of the State (Scott, 1957, p. 38, table 2, 1962, p. 30; Newton and others, 1961, p. 134; Wahl, 1965, p. 74, table 7, 1966, p. 19-21; Avrett, 1968; Barksdale, 1976, chap. 8, p. 20).


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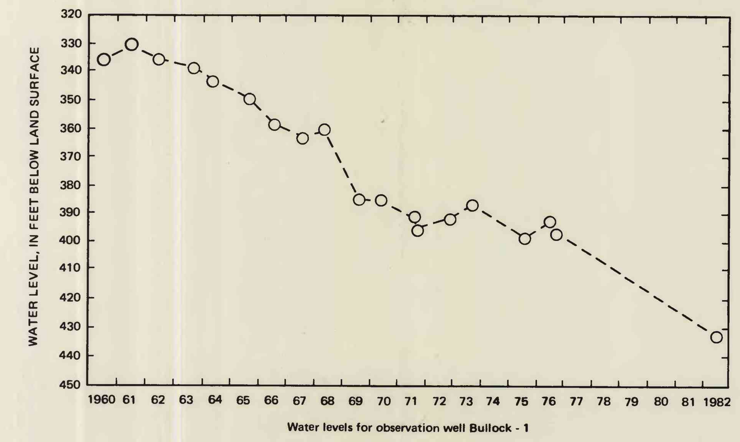
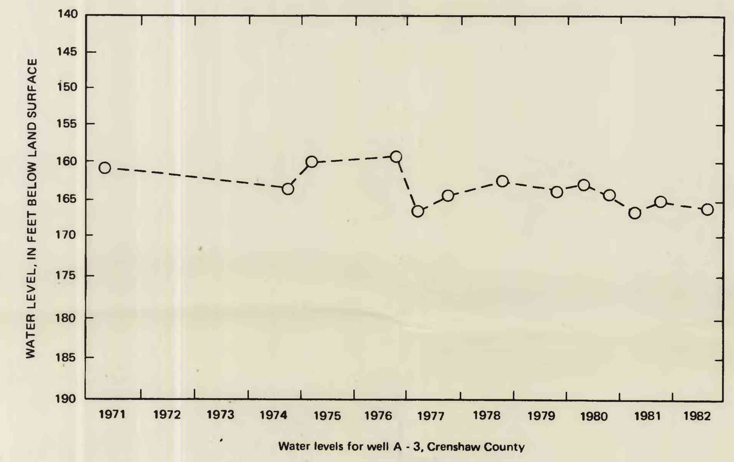
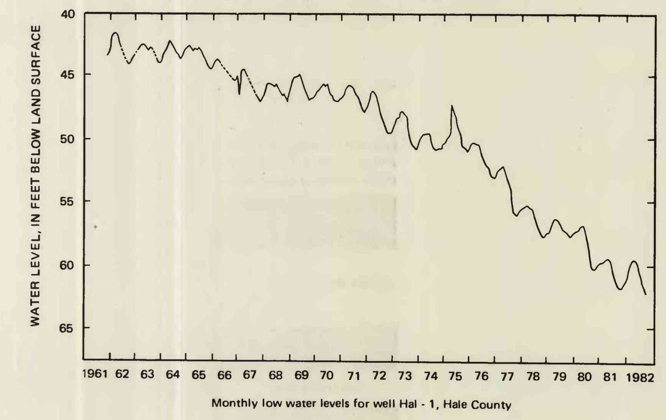
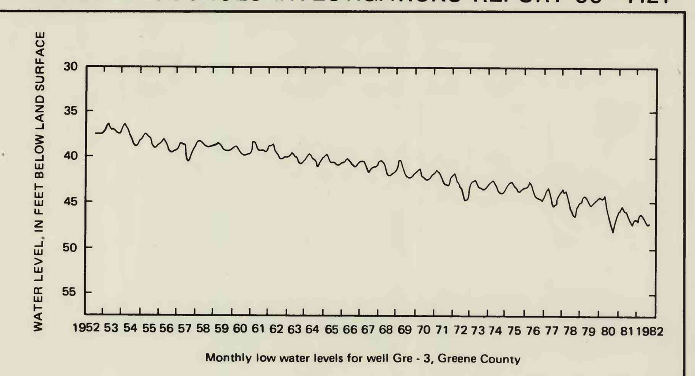
# POTENTIOMETRIC SURFACE, GROUND–WATER WITHDRAWALS, AND RECHARGE AREA FOR THE EUTAW AQUIFER IN ALABAMA, FALL 1982

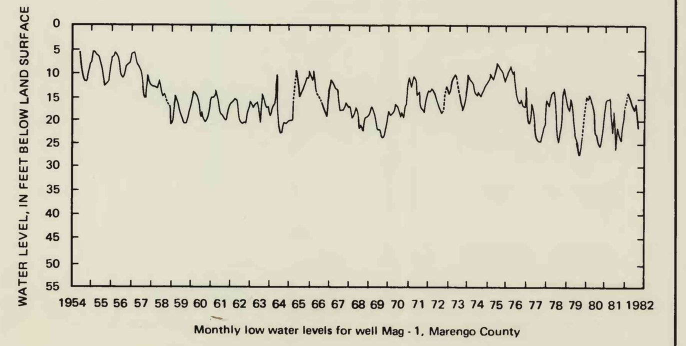
by John S. Williams, Michael Planert and Sydney S. DeJarnette

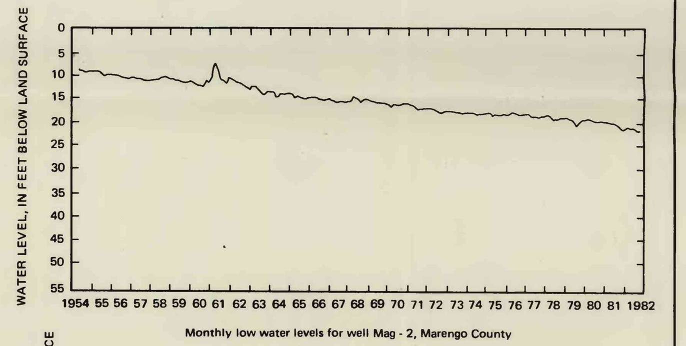


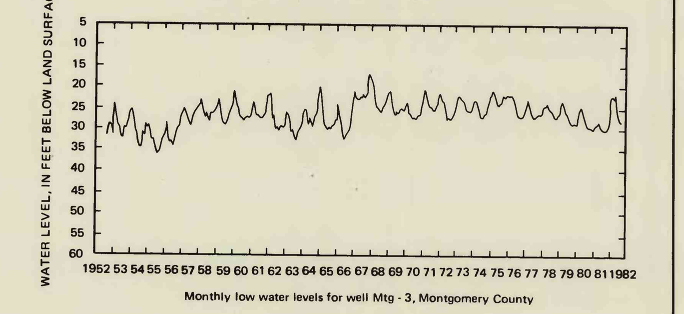




### Generalized correlation of hydrogeologic units and rock-stratigraphic units of the Southeastern Coastal Plain Aquifer System in Alabama

| Period | Epoch | Hydrogeologic Unit | Rock-Stratigraphic Unit: Western Alabama | Rock-Stratigraphic Unit: Eastern Alabama |
|---|---|---|---|---|
| Tertiary | Eocene | Confining unit | Yazoo Clay | Ocala Limestone |
| Tertiary | Eocene | Lisbon aquifer | Moodys Branch Formation<br>Gosport Sand<br>Lisbon Formation<br>Tallahatta Formation<br>Hatchetigbee Formation<br>Bashi Formation<br>Upper part of Tuscahoma Formation | Moodys Branch Formation<br>Gosport Sand and Lisbon Formations, undifferentiated<br>Tallahatta, Hatchetigbee, and Bashi Formations, undifferentiated<br>Upper part of Tuscahoma Formation |
| Tertiary | Paleocene | Confining unit | Middle part of Tuscahoma Formation | Middle part of Tuscahoma Formation |
| Tertiary | Paleocene | Nanafalia - Clayton aquifer | Lower part of Tuscahoma Formation<br>Nanafalia Formation<br>Naheola Formation | Lower part of Tuscahoma Formation<br>Baker Hill and Nanafalia Formations, undifferentiated<br>Porters Creek Formation<br>Upper part of Clayton Formation |
| Tertiary | Paleocene | Confining unit | Porters Creek Formation<br>Clayton Formation<br>Prairie Bluff Chalk | Lower part of Clayton Formation |
| Cretaceous | Late | Providence - Ripley aquifer | Ripley Formation | Providence Sand<br>Ripley Formation |
| Cretaceous | Late | Confining unit | Demopolis Chalk<br>Mooreville Chalk | Demopolis Chalk, Mooreville Chalk / Blufftown Formation |
| Cretaceous | Late | Eutaw aquifer | Eutaw Formation | Eutaw Formation |
| Cretaceous | Late | Confining unit | Upper part of Gordo Formation | Upper part of Tuscaloosa Formation[1] |
| Cretaceous | Late | Tuscaloosa aquifer | Lower part of Gordo Formation, Coker Formation (Tuscaloosa Group)<br>Unnamed Early Cretaceous rocks[3] | Tuscaloosa Formation<br>Unnamed Early Cretaceous rocks[3] |
| Cretaceous | Early | | | |
| Pre - Cretaceous | | Confining unit | Pre - Cretaceous rocks | Pre - Cretaceous rocks |

[1] May be only partially confining or absent in western Alabama
[2] May be only partially confining or absent in eastern Alabama
[3] Largely unstudied; may be locally hydraulically connected with overlying sediments