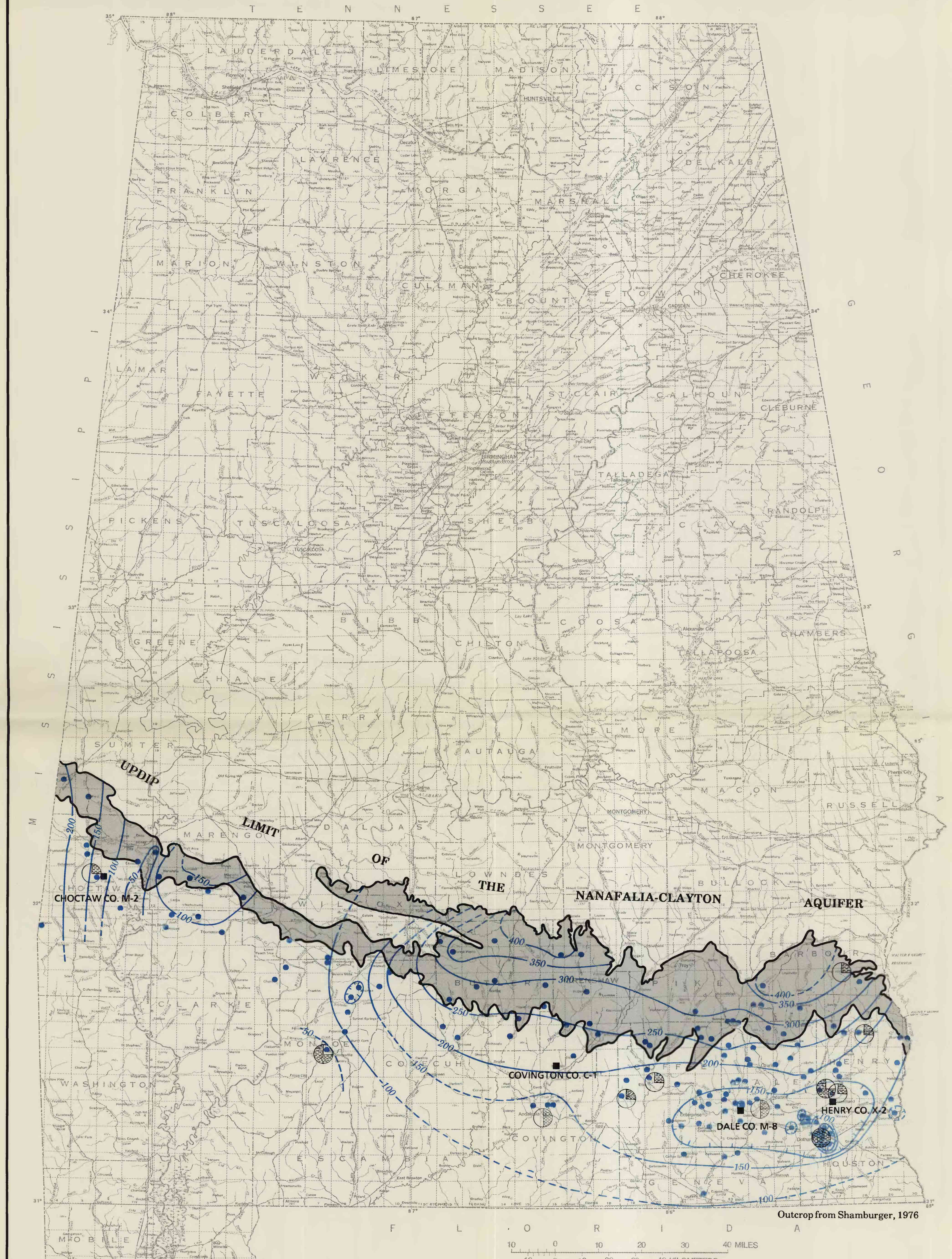


EXPLANATION

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

DALE CO.M-8 OBSERVATION WELL FOR WHICH HYDROGRAPH IS SHOWN

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

0.25-0.49 1.00-2.99
0.50-0.99 ≥3.00

POTENTIOMETRIC SURFACE, GROUND-WATER WITHDRAWALS, AND RECHARGE AREA FOR THE NANAFALIA-CLAYTON AQUIFER IN ALABAMA, FALL 1982

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

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 withdrawal, and recharge areas for the aquifers in Alabama that are included in the regional system, deals with the Nanafalia-Clayton aquifer.

HYDROGEOLOGY

The Nanafalia-Clayton aquifer is one of the more productive of Alabama's Coastal Plain aquifers, with potential well yields of 200 to 3,000 gallons per minute from large, public-supply wells (Shamburger, 1976). Highest well yields from the aquifer occur in the southeastern part of the State. The aquifer includes the basal sands of the Tuscahoma Formation, and the whole of the Nanafalia and equivalent Baker Hill (in eastern Alabama), Naheola, Porters Creek, and Clayton Formations, all of Paleocene age. However, one or more of these formations is absent at any one geographical location. The aquifer consists mostly of unconsolidated sand and clay beds, but locally includes carbonate rocks. The underlying confining bed includes the Prairie Bluff Chalk, Clayton Formation, and clays in the Porters Creek Formation in the west, and clays and limestones in the basal part of the Clayton Formation in the east. Geophysical logs and water-level data suggest that the confining bed is probably most effective in west Alabama, becoming progressively less confining eastward. The overlying confining bed is formed by clays in the middle part of the Tuscahoma Formation, with the degree of confinement by this bed increasing from west to east.

The area of direct recharge for the aquifer (outcrop) extends across the State from Barbour and Henry Counties to Sumter County in a slightly curving band that narrows from about 25 miles wide in its eastern and central extent, where the aquifer is thickest, to as little as 5 miles wide in western Alabama, where the thickness of water-bearing sands is not as great. The recharge area is bounded on the north by the Prairie Bluff Chalk or by relatively impermeable clays and limestones in the Clayton and Porters Creek Formations, and on the south by clays in the middle part of the Tuscahoma Formation.

Potentiometric Surface

The accompanying map depicts the potentiometric surface of the Nanafalia-Clayton aquifer based on water-level measurements made primarily in the fall of 1982, and in some cases 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 a tightly cased well 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 at 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 Nanafalia-Clayton aquifer occurs by the infiltration of water from precipitation in the outcrop area, and possibly by leakage from adjacent aquifers. Discharge from the aquifer occurs in as many as four ways: water may 1) leak into adjacent aquifers, 2) emerge at the 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 lower 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 map suggest that the major ground-water drains in the Nanafalia-Clayton aquifer are the Tombigbee, Alabama, Conecuh, Pea, Choctawhatchee, and Chattahoochee Rivers. Water entering the aquifer that is not intercepted in the recharge area by streams or pumpage has a longer flow path downdip through the confined part of the aquifer. Low permeability rocks and highly mineralized water far downdip present a barrier to flow, forcing fresh ground water recharging the deeper parts of the aquifer to leak upward into the overlying aquifer or to move updip and eventually discharge to the rivers.

Heavy pumpage can lower water levels locally, resulting in a depression in the potentiometric surface that causes the contours to be distorted from natural, unstressed conditions. In a graphic depiction of the potentiometric surface, the contour lines may bend around the pumping center, as near Andalusia in Covington County, or even close around it, as in the area around Dothan and the large area encompassing parts of five counties in the southeastern part of the State.

GROUND-WATER USE

Major Pumping Centers

The Nanafalia-Clayton aquifer provides water for several municipalities and industries, as well as for a large rural area across Alabama. The public-supply systems drawing water from the aquifer at an average rate of 1 Mgal/d (million gallons per day) or greater are the cities of Monroeville, Enterprise, Dothan, and the Fort Rucker military complex. Several public suppliers use more than 0.25 Mgal/d. The total rate of withdrawal from the aquifer by all of these users was approximately 12 Mgal/d in 1982; individual user rates are shown by pumpage category on the map. There are numerous industries, irrigators, and smaller public-supply systems (particularly in southeastern Alabama) which, although not individually using more than 0.25 Mgal/d and not identified on the map, cumulatively add significantly to the total amount of ground water withdrawn from the aquifer. Scott and others (1984) estimated the withdrawal rate in five southeastern Alabama counties to be 33 Mgal/d. This withdrawal rate includes pumpage from all available aquifers; however, the majority of wells in the area are screened in the Nanafalia-Clayton aquifer. Thus, the Nanafalia-Clayton aquifer probably contributes by far the greatest amount of water to this total pumpage. Self-supplied domestic use and water withdrawn for livestock are difficult to quantify with certainty, but probably total less than 4 Mgal/d.

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 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. On the average, however, the water levels remain nearly the same 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 some of 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 discharge balances the quantity of water being pumped.

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.

Hydrographs from observation wells in the central part of the Nanafalia-Clayton aquifer in Alabama (such as Covington County C-1) show little change in water levels since monitoring began, suggesting that equilibrium conditions exist in that area. However, the potentiometric surface map shows that there are areas of the State where pumpage is causing significant diversion of water from what would be the normal flow pattern in the aquifer. Water levels in some public-supply wells in those areas have declined an average of 2 to 5 feet per year. Most of those wells, with the exceptions of those in Monroeville and Beatrice in Monroe County, and Andalusia in Covington County, are in southeastern Alabama. The hydrographs of observation wells Dale County M-8 (located at Ft. Rucker Aviation Center), and Henry County X-2 illustrate these declines. The recent recovery trend in Dale County M-8 reflects a shift to new, less clustered wells for the majority of the water supply at Ft. Rucker, resulting in reduced mutual interference among the wells. At the same time, however, withdrawal rates have increased, and the potentiometric surface in the area will likely decline again (Scott and others, 1984).

Assuming that ground-water withdrawal rates are not likely to be reduced within the areas of severe water-level declines, water levels there will continue to fall indefinitely unless additional recharge can be induced into the aquifer. This might occur if the potentiometric surface is lowered sufficiently to cause increased leakage from adjacent aquifers, or by capturing water that would normally be lost to the ground-water system through evapotranspiration or discharge to streams in the recharge area.

Choctaw County well M-2, located in a pumping center, illustrates the phenomenon of declining water level in response to pumping followed by attainment of a new equilibrium. The hydrograph shows a water-level decline until 1979, at which time the water level stabilized. As withdrawal rates have not been reduced, the stabilization may indicate that the potentiometric surface was lowered sufficiently by pumping to induce additional recharge, and that the aquifer reached equilibrium as a result.

Future Ground-Water Development

The potential for future development of the Nanafalia-Clayton aquifer for public supply, industrial, or agricultural uses will depend on the proposed geographic location of the wells and on proper well placement. Except in Monroeville and Beatrice, there currently appears to be little stress on the aquifer over most of its western extent in Alabama, and further ground-water development should pose no problems in most areas. Location of new wells sufficiently distant from existing wells to avoid mutual interference probably would allow additional withdrawals in the vicinity of Monroeville, Beatrice, and Andalusia. Proper well placement will be particularly critical in southeastern Alabama due to the large areal extent of significant and continuing water-level declines. Future ground-water management plans may need to include reduced pumping rates in some wells to minimize interference with others. Any future ground-water development near existing major pumping centers is contingent upon the eventual equilibration of the aquifer in the vicinity. Failing that, future ground-water withdrawal rates would have to be reduced from current rates in areas where equilibrium cannot be attained, and alternate sources of water (other aquifers or surface water) utilized.

Another factor governing aquifer development is the chemical quality of the water. Ground water from the Nanafalia-Clayton aquifer is generally of good quality and suitable for most applications; however, excessively high levels of chloride, bicarbonate, dissolved solids, or hardness are present in areas of Marengo and western Wilcox Counties, probably due to upward movement of water from underlying aquifers through faults (LaMoreaux and Toulmin, 1959, p. 124, 141; Newton and others, 1961, p. 138). Water from the aquifer containing iron in excess of 0.3 milligrams per liter occurs sporadically across the State (Avrett, 1968; Shamburger, 1976, chap. 6, p. 31), possibly making treatment necessary for some uses.

REFERENCES CITED

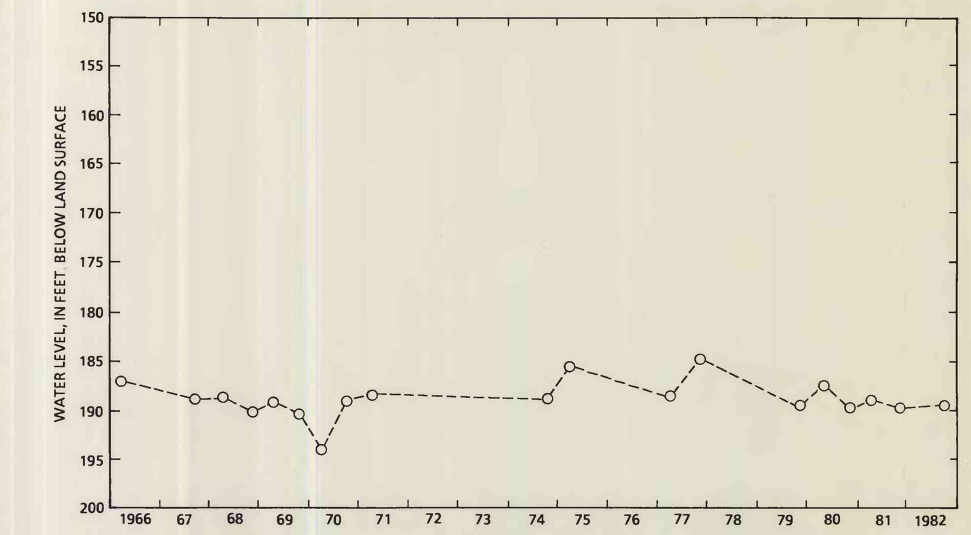
Avrett, J. R., 1968, A compilation of ground water quality in Alabama: Geological Survey of Alabama Circular 37, 336 p.

LaMoreaux, P. E., and Toulmin, L. D., 1959, Geology and ground-water resources of Wilcox County, Alabama: Geological Survey of Alabama County Report 4, 289 p.

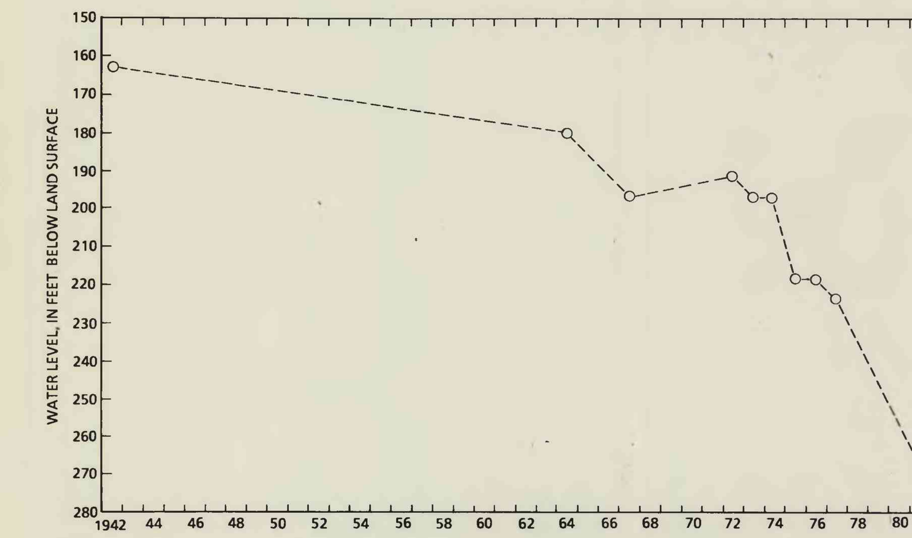
Newton, J. G., Sutcliffe, H., Jr., and LaMoreaux, P. E., 1961, Geology and ground-water resources of Marengo County, Alabama: Geological Survey of Alabama County Report 5, 443 p.

Shamburger, V. M., 1976, The Clayton-Lower Wilcox aquifer, in Barksdale, H. C. and others, Water content and potential yield of significant aquifers in Alabama: Geological Survey of Alabama Open File Report, Tuscaloosa, Alabama, 449 p.

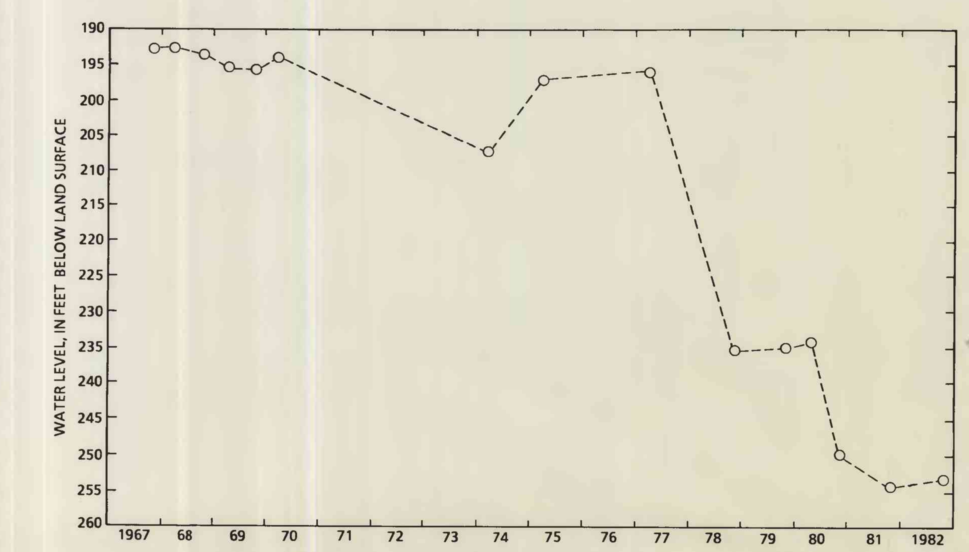
Scott, J. C., Law, L. R., and Cobb, R. H., 1984, Hydrology of the Tertiary-Cretaceous aquifer system in the vicinity of Fort Rucker Aviation Center, Alabama: U.S. Geological Survey Water-Resources Investigations Report 84-4118, 221 p.



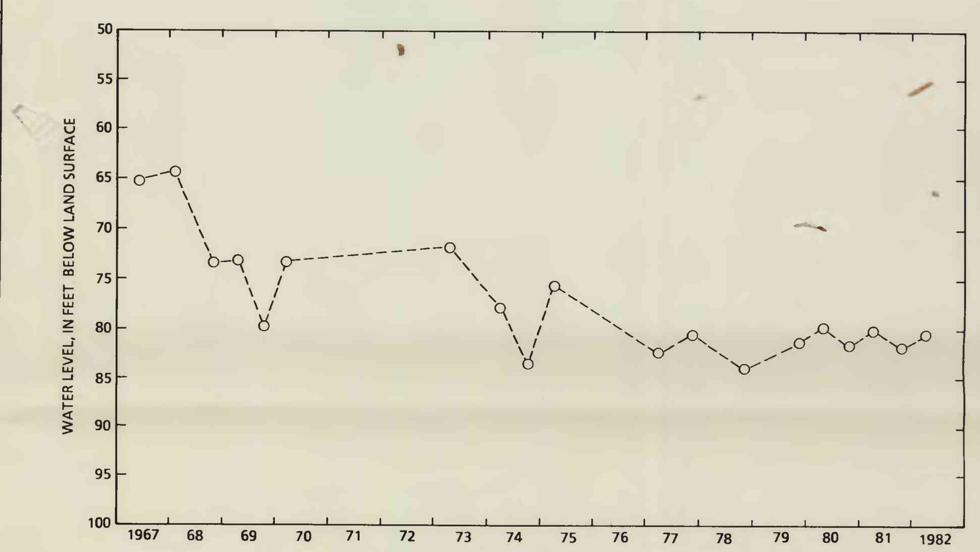
Water-level measurements for observation well Covington Co. C-1



Water-level measurements for observation well Dale Co. M-8



Water-level measurements for observation well Henry Co. X-2



Water-level measurements for observation well Choctaw Co. M-2

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
	Eocene / Paleocene	Lisbon aquifer	Moodys Branch Formation Gosport Sand Lisbon Formation Tallahatta Formation Hatchetigbee Formation Bashi Formation Upper part of Tuscahoma Formation	Moodys Branch Formation Gosport Sand and Lisbon Formations, undifferentiated Tallahatta, Hatchetigbee, and Bashi Formations, undifferentiated Upper part of Tuscahoma Formation
	Paleocene	Confining unit	Middle part of Tuscahoma Formation[1]	Middle part of Tuscahoma Formation
	Paleocene	Nanafalia - Clayton aquifer	Lower part of Tuscahoma Formation Nanafalia Formation Naheola Formation	Lower part of Tuscahoma Formation Baker Hill and Nanafalia Formations, undifferentiated Porters Creek Formation Upper part of Clayton Formation
	Paleocene	Confining unit	Porters Creek Formation Clayton Formation Prairie Bluff Chalk	Lower part of Clayton Formation[2]
Cretaceous	Late	Providence - Ripley aquifer	Ripley Formation	Providence Sand Ripley Formation
	Late	Confining unit	Demopolis Chalk Mooreville Chalk	Demopolis Chalk Mooreville Chalk; Blufftown Formation
	Late	Eutaw aquifer	Eutaw Formation	Eutaw Formation
	Late	Confining unit	Upper part of Gordo Formation	Upper part of Tuscaloosa Formation[2]
	Late / Early	Tuscaloosa aquifer	Lower part of Gordo Formation, Coker Formation } Tuscaloosa Group Unnamed Early Cretaceous rocks[3]	Tuscaloosa Formation Unnamed Early Cretaceous rocks[3]
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