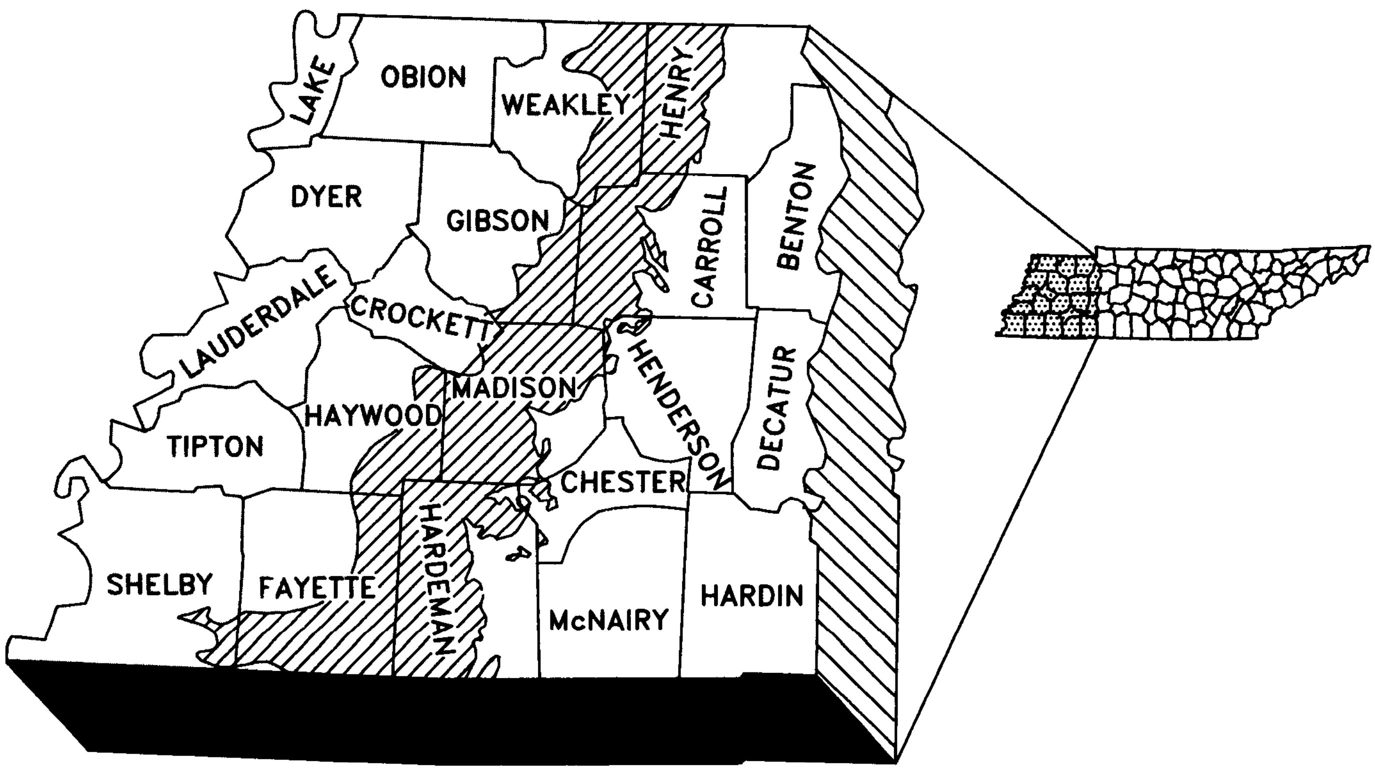
Water-Resources Investigations Report 88-4180

ALTITUDE OF POTENTIOMETRIC SURFACE, FALL 1985, AND HISTORIC WATER-LEVEL CHANGES IN THE MEMPHIS AQUIFER IN WESTERN TENNESSEE



USGS
science for a changing world

Click here to return to USGS Publications

Prepared by the
U.S. GEOLOGICAL SURVEY

ALTITUDE OF POTENTIOMETRIC SURFACE, FALL 1985, AND HISTORIC WATER-LEVEL CHANGES IN THE MEMPHIS AQUIFER IN WESTERN TENNESSEE

W. S. Parks and J. K. Carmichael

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 88-4180

Memphis, Tennessee

1990

DEPARTMENT OF THE INTERIOR

MANUAL LUJAN, JR., *Secretary*

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, *Director*

For additional information
write to:

District Chief
U.S. Geological Survey
A-413 Federal Building
U.S. Courthouse
Nashville, Tennessee 37203

Copies of this report can be
purchased from:

U.S. Geological Survey
Books and Open-File Reports Section
Federal Center, Building 810
Box 25425
Denver, Colorado 80225

CONTENTS

ILLUSTRATIONS

CONVERSION FACTORS

Factors for converting inch-pound units to International System of Units (SI) are shown to four significant digits.

Multiply inch-pound unit	*By*	*To obtain SI unit*
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.59	square kilometer (km^2)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Well-Numbering System: Wells are identified according to the numbering system used by the U.S. Geological Survey throughout Tennessee. The well number consists of three parts: (1) An abbreviation of the name of the county in which the well is located; (2) a letter designating the 7 1/2-minute topographic quadrangle on which the well is plotted; and (3) a number generally indicating the numerical order in which the well was inventoried. The symbol Dy:H-7, for example, indicates that the well is located in Dyer County on the "H" quadrangle and is identified as well 7 in the numerical sequence. Quadrangles are lettered from left to right, beginning in the southwest corner of the county.

ALTITUDE OF POTENTIOMETRIC SURFACE, FALL 1985, AND HISTORIC WATER-LEVEL CHANGES IN THE MEMPHIS AQUIFER IN WESTERN TENNESSEE

W.S. Parks and J.K. Carmichael

ABSTRACT

Recharge to the Memphis aquifer of Tertiary age is from precipitation on the outcrop, which forms a broad belt across western Tennessee, or by downward infiltration of water from the overlying fluvial deposits of Tertiary(?) and Quaternary age and alluvium of Quaternary age. In the outcrop-recharge belt, where the Memphis aquifer is under water-table conditions, the potentiometic surface is complex and generally conforms to the topography. To the west of the outcrop-recharge belt where the Memphis aquifer is confined, the potentiometric surface gently slopes westward, and water moves slowly in that direction. A major cone of depression in the potentiometric surface in the Memphis area is the result of long-term (1886-present) pumping at municipal and industrial well fields.

Data from five observation wells in the Memphis aquifer indicate that water levels have declined at average rates ranging from less than 0.1 to 1.3 feet per year during the period 1928-85. The largest declines have been in the Memphis area, where withdrawals averaged about 191 million gallons per day in 1985. The record from an observation well located near the center of the major cone of depression in the Memphis area indicates that water levels ceased to decline in about 1975 and that the center of the cone essentially has stabilized. The record from another well away from the center of the cone indicates that water levels are still declining at a low rate, and that the cone is still expanding as a result of the effects of pumping.

Water levels in large areas of western Tennessee, away from the effects of pumping, have fluctuated only in response to long-term variations in precipitation on the outcrop-recharge belt. Long-term changes in water levels in these areas have been small.

INTRODUCTION

This report shows the altitude of the potentiometric surface in the Memphis aquifer based on water levels measured in 114 wells in western Tennessee and one well in southeastern Missouri during September and October 1985, and describes historic water-level changes in the aquifer. The report was prepared by the U.S. Geological Survey as part of the Gulf Coast Regional Aquifer-System Analysis (GC RASA) program (Grubb, 1984). Other reports describing aquifers in Tertiary sediments in western Tennessee that were prepared as part of the GC RASA program include reports describing the geology and ground-water resources of the Cockfield Formation, Memphis Sand, and Fort Pillow Sand (Parks and Carmichael, in press(a), (b), (c)). A companion report showing the altitude of the potentiometric surface in the Fort Pillow aquifer for the fall of 1985 and describing historic water-level changes in that aquifer also was prepared (Parks and Carmichael, in press(d)).

Manuscript approved for publication October 5, 1988

PREVIOUS INVESTIGATIONS

Maps showing the potentiometric surface of the Memphis aquifer ("500-foot" sand) in the Memphis area for 1960 (Criner and others, 1964); 1964 (Bell and Nyman, 1968); 1886, 1960, 1970, 1975 (Criner and Parks, 1976); 1978 (Graham, 1979); 1980 (Graham, 1982) and in the Memphis urban area for 1984 (Graham and Parks, 1986) are included in reports dealing with the ground-water hydrology of the Memphis area. A map showing the potentiometric surface of the Memphis aquifer in western Tennessee for 1960 was included in a report on the geology and hydrology of the Claiborne Group (Moore, 1965).

Historic water-level changes in the Memphis aquifer are discussed in reports by Wells (1933), Kazmann (1944), Criner and Armstrong (1958), Criner and others (1964), Moore (1965), Nyman (1965), Bell and Nyman (1968), Criner and Parks (1976), and Graham (1982).

AQUIFER OCCURRENCE AND CHARACTER

The Memphis Sand of Tertiary age underlies approximately 7,400 square miles in the Gulf Coastal Plain of western Tennessee (fig. 1). The formation consists of a thick body of sand that contains subordinate lenses or beds of clay and silt at various horizons. Thin lenses of lignite occur locally, and the clay and silt locally are carbonaceous and lignitic. Sand in the Memphis Sand ranges from very fine to very coarse, but it commonly is locally fine, fine to medium, or medium to coarse.

Where the original thickness is preserved, the Memphis Sand ranges from about 400 to 900 feet in thickness. The formation is thinnest along the eastern limits of the outcrop belt in Hardeman, Madison, Carroll, and Henry Counties where it ranges from 0 to about 200 feet in thickness. The formation is thickest in southwestern Shelby County where it is about 900 feet thick. The Memphis Sand yields water to wells in most of the area of occurrence in western Tennessee and, where saturated, makes up the Memphis aquifer.

The Memphis aquifer is the principal source of water for public and industrial supplies in western Tennessee. Withdrawals in 1985 averaged about 230 million gallons per day (Mgal/d). Of this, about 191 Mgal/d were withdrawn in the Memphis area. The Memphis aquifer also provides water to many domestic and farm wells in rural areas.

RECHARGE AND POTENTIOMETRIC SURFACE

Recharge to the Memphis aquifer generally occurs along the broad outcrop or subcrop belt where the Memphis Sand is at or near the land-surface (plate 1). Recharge results from precipitation on the outcrop or by downward infiltration of water from the overlying fluvial deposits of Tertiary(?) and Quaternary age and alluvium of Quaternary age. In the outcrop-recharge belt where the Memphis aquifer is under water-table conditions (unconfined), the configuration of the potentiometric surface (plate 1), whether in the Memphis Sand or in the overlying fluvial deposits and alluvium, is complex. Except at seeps and springs, the water table is lower than the land surface, but generally conforms to the topography. In areas of some relief, perched water tables above clay or silt beds add to the complexity of the potentiometric surface. In the outcrop-recharge belt, water moves westward down the dip of the aquifer and also toward the major streams that drain the area. Part of the water that flows toward the major streams infiltrates through the alluvium, discharges along the channels, and sustains base flows.

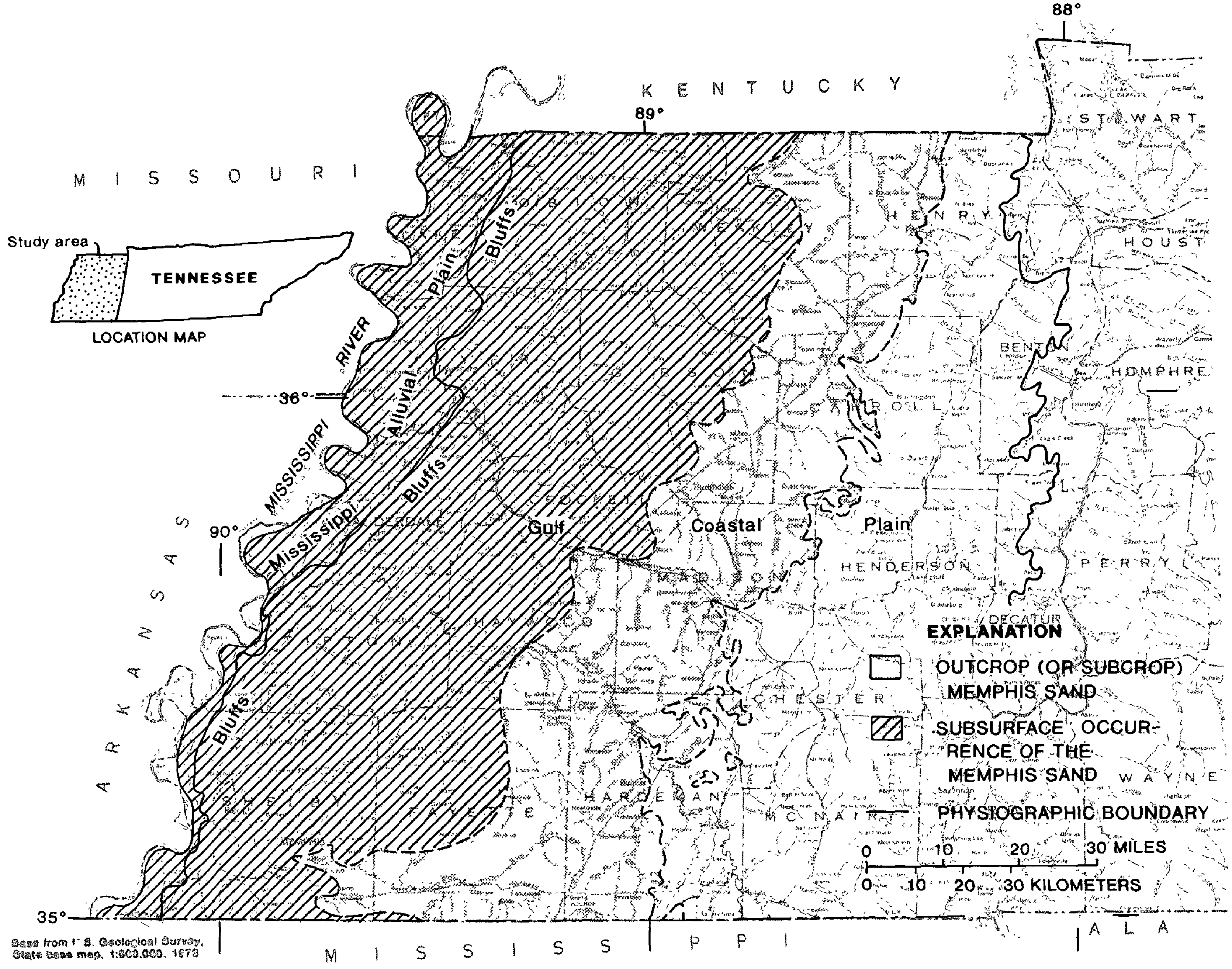


Figure 1.--Occurrence of the Memphis Sand as related to major physiographic subdivisions in western Tennessee.

In the subsurface to the west of the outcrop-recharge belt, where the Memphis aquifer is confined (artesian), the potentiometric surface gently slopes westward (plate 1) and the water moves slowly in that direction. The major cone of depression in the potentiometric surface in the Memphis area is the result of long-term (1886-present) pumping at municipal and industrial well fields.

Where confined and head differences are favorable, a component of recharge locally may enter the Memphis aquifer by downward leakage of water from the water-table aquifers (fluvial deposits and alluvium) or from the Cockfield Formation of Tertiary age. Conditions for downward leakage are particularly favorable where the Cook Mountain Formation of Tertiary age, which serves as the upper confining layer for the Memphis aquifer, is thin or sandy or where leakage through the Cook Mountain Formation has been induced by intense pumping from the Memphis aquifer, as at Memphis (Graham and Parks, 1986). Conditions for downward leakage also are favorable where the Cook Mountain Formation has been displaced by faults, leaving the Cockfield Formation and Memphis aquifer in direct hydraulic connection (Parks and others, 1985).

HISTORIC WATER-LEVEL CHANGES

Historic water-level changes in the Memphis aquifer are evident from long-term records of water levels in observation wells. Hydrographs for five observation wells in the Memphis aquifer are shown in figure 2; their locations are shown in plate 1. Well Dy:H-7, in Dyer County, is near municipal and industrial well fields at Dyersburg, and the water level in this well is affected by nearby pumping. Part of the hydrograph for well Dy:H-7 (1954-57), which shows extreme fluctuations of the monthly low water level caused by pumping of nearby wells, was not used in determining the water-level trend at Dyersburg. The water level in well Dy:H-7 has declined about 6.7 feet in 27 years (1958-85), an average rate of 0.25 foot per year (fig. 2).

Well Ld:F-4, in Lauderdale County, is in a remote area where water levels are not significantly affected by pumping in the Memphis area or by nearby municipal or industrial well fields. The hydrograph does show a definite correlation with large changes in stage of the Mississippi River, 2.5 miles away (Parks and others, 1985). This correlation is most evident during long periods of sustained high stage on the Mississippi River and backwater flooding of parts of the Mississippil Alluvial Plain. The monthly low water level in well Ld:F-4 has declined about 1.0 feet in 19 years (1966-85), an average rate of less than 0.1 foot per year (fig. 2).

Observation wells in the Memphis area show the long-term effects of pumping on water levels in the Memphis aquifer. Well Fa:R-2, in northwestern Fayette County, is the farthest well from the center of the major cone of depression in the potentiometric surface at Memphis (plate 1). The water level in well Fa:R-2 has declined about 1.75 feet in 36 years (1949-85), an average rate of less than 0.1 foot per year (fig. 2). Well Sh:Q-1, in eastern Shelby County, is at an intermediate distance between well Fa:R-2 and the center of the major cone of depression (plate 1). The water level in well Sh:Q-1 has declined about 30 feet in 45 years (1940-85), an average rate of about 0.7 foot per year (fig. 2). Well Sh:P-76, at Memphis, is near the center of the major cone of depression (plate 1). The water level in well Sh:P-76 has declined about 73 feet in 57 years (1928-85), an average rate of about 1.3 feet per year (fig. 2). This rate of decline in well Sh:P-76 is the best record of the long-term water-level decline caused by total pumping from the Memphis Sand aquifer in the Memphis area.

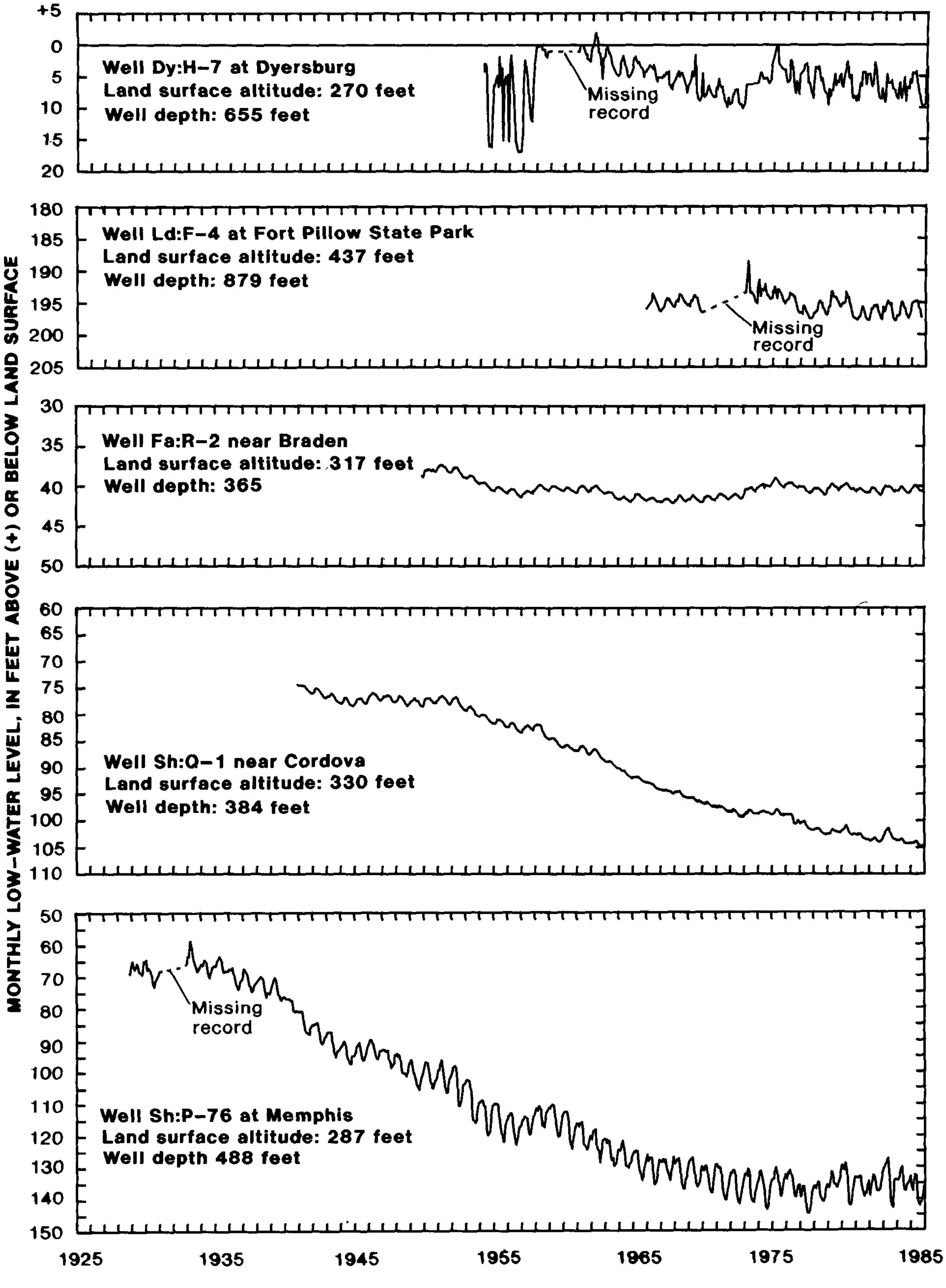


Figure 2.--Historic water-level changes in the Memphis aquifer.

CONCLUSIONS

Long-term records of water levels in observation wells in the Memphis aquifer for the period 1928-85 show that water levels have declined at average rates ranging from less than 0.1 to as much as 1.3 feet per year. The largest declines have been in the Memphis area where a major cone of depression has developed as a result of long-term (1886-present) pumping at municipal and industrial well fields. However, the hydrograph for well Sh:P-76, near the center of the major cone of depression, indicates that water levels ceased to decline after about 1975 and that the center of the cone essentially has stabilized. The hydrograph of well Sh:Q-1, in eastern Shelby County, indicates that water levels are still declining at a low rate as the cone continues to expand as a result of the effects of past pumping, and the hydrograph for well Fa:R-2, in northwestern Fayette County, indicates that water levels in that area have not been significantly affected by pumping in the Memphis area.

Water levels in large areas of western Tennessee away from the effects of pumping have fluctuated only in response to long-term variations in precipitation on the outcrop-recharge belt. Long-term changes in water levels in these areas have been small.

REFERENCES

Bell, E.A., and Nyman, D.J., 1968, Flow pattern and related chemical quality of ground water in the "500-foot" sand in the Memphis area, Tennessee: U.S. Geological Survey Water-Supply Paper 1853, 27 p.

Criner, J.H., and Armstrong, C.A., 1958, Ground-water supply of the Memphis area: U.S. Geological Survey Circular 408, 20 p.

Criner, J.H., and Parks, W.S., 1976, Historic water-level changes and pumpage from the principal aquifers of the Memphis area, Tennessee: 1886-1975: U.S. Geological Survey Water-Resources Investigations Report 76-67, 45 p.

Criner, J.H., Sun, P-C.P., and Nyman D.J., 1964, Hydrology of the aquifer systems in the Memphis area, Tennessee: U.S. Geological Survey Water-Supply Paper 1779-O, 54 p.

Graham, D.D., 1979, Potentiometric map of the Memphis Sand in the Memphis area, Tennessee, August 1978: U.S. Geological Survey Water-Resources Investigations Report 79-80, scale 1:250,000, 1 sheet.

-----1982, Effects of urban development on the aquifers in the Memphis area, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 82-4024, 20 p.

Graham, D.D., and Parks, W.S., 1986, Potential for leakage among principal aquifers in the Memphis area, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 85-4295, 46 p.

Grubb, H.F., 1984, Planning report for the Gulf Coast Regional Aquifer-Systems Analysis in the Gulf of Mexico Coastal Plain, United States: U.S. Geological Survey Water-Resources Investigations Report 84-4219, 30 p.

Kazmann, R.G., 1944, The water supply of the Memphis area, A progress report: U.S. Geological Survey, 66 p.

Moore, G.K., 1965, Geology and hydrology of the Claiborne Group in western Tennessee: U.S. Geological Survey Water-Supply Paper 1809-F, 44 p.

Nyman, D.J., 1965, Predicted hydrologic effects of pumping from the Lichterman well field in the Memphis area, Tennessee: U.S. Geological Survey Water-Supply Paper 1819-B, 26 p.

Parks, W.S., and Russell, E.E, 1975, Geologic map showing Upper Cretaceous, Paleocene, and lower and middle Eocene units and distribution of younger fluvial deposits in western Tennessee: U.S. Geological Survey Miscellaneous Investigations Map I-916, scale 1:250,000.

Parks, W.S., Carmichael, J.K., and Graham, D.D., 1985, Preliminary assessment of the ground-water resources of Lauderdale County, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 84-4104, 35 p.

Parks, W.S., and Carmichael, J.K., in press(a), Geology and ground-water resources of the Cockfield Formation in western Tennessee: U.S. Geological Survey, Water-Resources Investigations Report 88-4181.

-----in press(b), Geology and ground-water resources of the Memphis Sand in western Tennessee: U.S. Geological Survey Water-Resources Investigations Report 88-4182.

-----in press(c), Geology and ground-water resources of the Fort Pillow Sand in western Tennessee: U.S. Geological Survey Water-Resources Investigations Report 89-4120.

-----in press(d), Altitude of potentiometric surface, fall 1985, and historic water-level changes in the Fort Pillow aquifer in western Tennessee: U.S. Geological Survey Water-Resources Investigations Report 89-4048.

Wells, F.G., 1933, Ground-water resources of western Tennessee, *with a discussion of* Chemical character of the water by F. G. Wells and M. D. Foster: U.S. Geological Survey Water-Supply Paper 656, 319 p.