Prepared in cooperation with the
U.S. GEOLOGICAL SURVEY GROUND-WATER RESOURCES PROGRAM, ARKANSAS NATURAL RESOURCES COMMISSION, ARKANSAS GEOLOGICAL SURVEY, MEMPHIS LIGHT, GAS AND WATER, SHELBY COUNTY, TENNESSEE, AND THE CITY OF GERMANTOWN, TENNESSEE

SCIENTIFIC INVESTIGATIONS MAP 3014
Schrader, T.P., 2007, Sparta-Memphis aquifer—SHEET 1 of 1
Potentiometric surface in the Sparta-Memphis aquifer
of the Mississippi Embayment, spring 2007

Table 1. Hydrogeologic units and their correlation across the states within the Mississippi embayment.

ERATHEM	SYSTEM	SERIES		LOUISIANA	ARKANSAS Southern	ARKANSAS Northeastern	MISSOURI	KENTUCKY	TENNESSEE	MISSISSIPPI	ALABAMA	Hydrogeologic units
CENOZOIC	QUATERNARY	HOLOCENE / PLEISTOCENE		Alluvium and terrace deposits				Alluvium and loess deposits		Alluvium, terrace, and loess deposits	Alluvium and terrace deposits	Mississippi River Valley alluvial aquifer
	TERTIARY	OLIGOCENE	Vicksburg Group	Vicksburg Formation	Not present in study area					Vicksburg Formation		Vicksburg-Jackson confining unit
		EOCENE	Jackson Group	Jackson Group								
			Claiborne Group	Cockfield Formation							Gosport Sand	Upper Claiborne aquifer
				Cook Mountain Formation								Middle Claiborne confining unit
				Sparta Sand		Memphis Sand		Sparta Sand	Memphis Sand	Sparta Sand	Lisbon Formation	Middle CLaiborne aquifer (Sparta-Memphis aquifer)
				Cane River Formation				Tallahatta Formation		Zilpha Clay Winona Sand Tallahatta Formation	Tallahatta Formation	Lower Claiborne confining unit
				Carrizo Sand						Meridian Sand Member		Lower Claiborne aquifer
		UPPER PALEOCENE	Wilcox Group	Dolet Hills Formation	Undifferentiated	Flour Island Formation		Wilcox Formation	Flour Island	Undifferentiated	Hatchetigbee Formation	Upper Wilcox aquifer
						Fort Pillow Sand		No Wilcox deposits identified as being of Paleocene age	Fort Pillow Sand		Bashi Formation Tuscahoma Sand Bells Landing Marl Member Nanafalia Formation Grampian Hills Member Gravel Creek Sand Member	Middle Wilcox aquifer
				Undifferentiated Naborton Formation		Old Breast-works Formation			Old Breast-works Formation		Gravel Creek Sand Member	
				Midway Group								Midway confining unit

Modified from Hosman and Weiss, 1991

Explanation

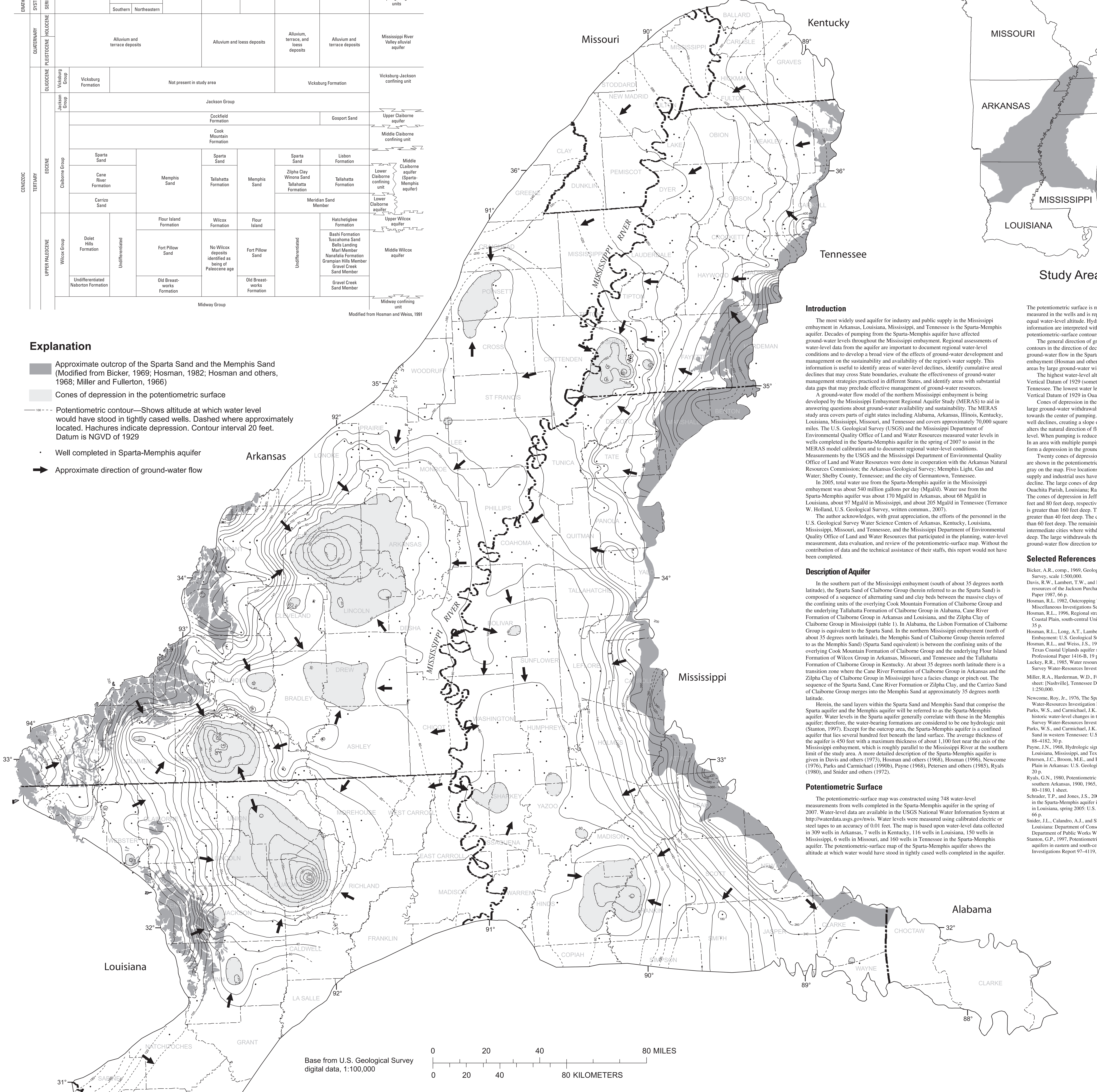
Approximate outcrop of the Sparta Sand and the Memphis Sand (Modified from Bicker, 1969; Hosman, 1982; Hosman and others, 1968; Miller and Fullerton, 1966)

Cones of depression in the potentiometric surface

Potentiometric contour—Shows altitude at which water level would have stood in tightly cased wells. Dashed where approximately located. Hachures indicate depression. Contour interval 20 feet. Datum is NGVD of 1929

Well completed in Sparta-Memphis aquifer

Approximate direction of ground-water flow



Study Area

Introduction

The most widely used aquifer for industry and public supply in the Mississippi embayment in Arkansas, Louisiana, Mississippi, and Tennessee is the Sparta-Memphis aquifer. Decades of pumping from the Sparta-Memphis aquifer have affected ground-water levels throughout the Mississippi embayment. Regional assessments of water-level data from the aquifer are important to document regional water-level conditions and to develop a broad view of the effects of ground-water development and management on the sustainability and availability of the region's water supply. This information is useful to identify areas of water-level declines, identify cumulative areal declines that may cross State boundaries, evaluate the effectiveness of ground-water management strategies practiced in different States, and identify areas with substantial data gaps that may preclude effective management of ground-water resources.

A ground-water flow model of the northern Mississippi embayment is being developed by the Mississippi Embayment Regional Aquifer Study (MERAS) to aid in answering questions about ground-water availability and sustainability. The MERAS study area covers parts of eight states including Alabama, Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee and covers approximately 70,000 square miles. The U.S. Geological Survey (USGS) and the Mississippi Department of Environmental Quality Office of Land and Water Resources measured water levels in wells completed in the Sparta-Memphis aquifer in the spring of 2007 to assist in the MERAS model calibration and to document regional water-level conditions. Measurements by the USGS and the Mississippi Department of Environmental Quality Office of Land and Water Resources were done in cooperation with the Arkansas Natural Resources Commission; the Arkansas Geological Survey; Memphis Light, Gas and Water; Shelby County, Tennessee; and the city of Germantown, Tennessee.

In 2005, total water use from the Sparta-Memphis aquifer in the Mississippi embayment was about 540 million gallons per day (Mgal/d). Water use from the Sparta-Memphis aquifer was about 170 Mgal/d in Arkansas, about 68 Mgal/d in Louisiana, about 97 Mgal/d in Mississippi, and about 205 Mgal/d in Tennessee (Terrance W. Holland, U.S. Geological Survey, written commun., 2007).

The author acknowledges, with great appreciation, the efforts of the personnel in the U.S. Geological Survey Water Science Centers of Arkansas, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee, and the Mississippi Department of Environmental Quality Office of Land and Water Resources that participated in the planning, water-level measurement, data evaluation, and review of the potentiometric-surface map. Without the contribution of data and the technical assistance of their staffs, this report would not have been completed.

Description of Aquifer

In the southern part of the Mississippi embayment (south of about 35 degrees north latitude), the Sparta Sand of Claiborne Group (herein referred to as the Sparta Sand) is composed of a sequence of alternating sand and clay beds between the massive clays of the confining units of the overlying Cook Mountain Formation of Claiborne Group and the underlying Tallahatta Formation of Claiborne Group in Alabama, Cane River Formation of Claiborne Group in Arkansas and Louisiana, and the Zilpha Clay of Claiborne Group in Mississippi (table 1). In Alabama, the Lisbon Formation of Claiborne Group is equivalent to the Sparta Sand. In the northern Mississippi embayment (north of about 35 degrees north latitude), the Memphis Sand of Claiborne Group (herein referred to as the Memphis Sand) (Sparta Sand equivalent) is between the confining units of the overlying Cook Mountain Formation of Claiborne Group and the underlying Flour Island Formation of Wilcox Group in Arkansas, Missouri, and Tennessee and the Tallahatta Formation of Claiborne Group in Kentucky. At about 35 degrees north latitude there is a transition zone where the Cane River Formation of Claiborne Group in Arkansas and the Zilpha Clay of Claiborne Group in Mississippi have a facies change or pinch out. The sequence of the Sparta Sand, Cane River Formation or Zilpha Clay, and the Carrizo Sand of Claiborne Group merges into the Memphis Sand at approximately 35 degrees north latitude.

Herein, the sand layers within the Sparta Sand and Memphis Sand that comprise the Sparta aquifer and the Memphis aquifer will be referred to as the Sparta-Memphis aquifer. Water levels in the Sparta aquifer generally correlate with those in the Memphis aquifer; therefore, the water-bearing formations are considered to be one hydrologic unit (Stanton, 1997). Except for the outcrop area, the Sparta-Memphis aquifer is a confined aquifer that lies several hundred feet beneath the land surface. The average thickness of the aquifer is 450 feet with a maximum thickness of about 1,100 feet near the axis of the Mississippi embayment, which is roughly parallel to the Mississippi River at the southern limit of the study area. A more detailed description of the Sparta-Memphis aquifer is given in Davis and others (1973), Hosman and others (1968), Hosman (1996), Newcome (1976), Parks and Carmichael (1990b), Payne (1968), Petersen and others (1985), Ryals (1980), and Snider and others (1972).

Potentiometric Surface

The potentiometric-surface map was constructed using 748 water-level measurements from wells completed in the Sparta-Memphis aquifer in the spring of 2007. Water-level data are available in the USGS National Water Information System at http://waterdata.usgs.gov/nwis. Water levels were measured using calibrated electric or steel tapes to an accuracy of 0.01 feet. The map is based upon water-level data collected in 309 wells in Arkansas, 7 wells in Kentucky, 116 wells in Louisiana, 150 wells in Mississippi, 6 wells in Missouri, and 160 wells in Tennessee in the Sparta-Memphis aquifer. The potentiometric-surface map of the Sparta-Memphis aquifer shows the altitude at which water would have stood in tightly cased wells completed in the aquifer.

The potentiometric surface is mapped by determining the altitude of the water levels measured in the wells and is represented on the map by contours that connect points of equal water-level altitude. Hydrologic principles, water-use data, and historical information are interpreted with the water-level data to delineate the potentiometric-surface contours.

The general direction of ground-water flow in an aquifer is perpendicular to the contours in the direction of decreasing hydraulic gradient. The natural direction of ground-water flow in the Sparta-Memphis aquifer is toward the axis of the Mississippi embayment (Hosman and others, 1968). The natural direction of flow has been altered in areas by large ground-water withdrawals.

The highest water-level altitude measured was 513 feet above the National Geodetic Vertical Datum of 1929 (sometimes referred to as sea level) in Madison County, Tennessee. The lowest water level measured was 225 feet below the National Geodetic Vertical Datum of 1929 in Ouachita Parish, Louisiana.

Cones of depression in the potentiometric surface usually are caused by moderate to large ground-water withdrawals. The cones of depression alter the flow of ground water towards the center of pumping. When a well is pumped, the water level in and around the well declines, creating a slope or gradient in the potentiometric surface. The gradient alters the natural direction of flow of water in the aquifer towards points of lower water level. When pumping is reduced or stops, the water level recovers to a new equilibrium. In an area with multiple pumping wells, the area of the declining water level expands to form a depression in the ground-water surface composed of multiple cones of depression.

Twenty cones of depressions (generally represented by a series of closed contours) are shown in the potentiometric surface of the Sparta-Memphis aquifer and are shaded in gray on the map. Five locations centered at cities with large withdrawals for public supply and industrial uses have large cones of depression with greater than 40 feet of decline. The large cones of depression are in Jefferson and Union Counties, Arkansas; Ouachita Parish, Louisiana; Rankin County, Mississippi; and Shelby County, Tennessee. The cones of depression in Jefferson and Union Counties, Arkansas, are greater than 100 feet and 80 feet deep, respectively. The cone of depression in Ouachita Parish, Louisiana, is greater than 160 feet deep. The cone of depression in Rankin County, Mississippi, is greater than 40 feet deep. The cone of depression in Shelby County, Tennessee, is greater than 60 feet deep. The remaining 15 depressions are mostly centered near small or intermediate cities where withdrawals have formed a cone of depression less than 40 feet deep. The large withdrawals that caused the cones of depression also alter the natural ground-water flow direction towards the cones of depression.

Selected References

Bicker, A.R., comp., 1969, Geologic map of Mississippi: [Jackson], Mississippi Geological Survey, scale 1:500,000.
Davis, R.W., Lambert, T.W., and Hansen, A.J., Jr., 1973, Subsurface geology and ground-water resources of the Jackson Purchase region, Kentucky: U.S. Geological Survey Water-Supply Paper 1987, 66 p.
Hosman, R.L. 1982, Outcropping Tertiary units in southern Arkansas: U.S. Geological Survey Miscellaneous Investigations Series I-1405, 1 sheet.
Hosman, R.L., 1996, Regional stratigraphy and subsurface geology of Cenozoic deposits, Gulf Coastal Plain, south-central United States: U.S. Geological Survey Professional Paper 1416-G, 35 p.
Hosman, R.L., Long, A.T., Lambert, T.W., and others, 1968, Tertiary aquifers in the Mississippi Embayment: U.S. Geological Survey Professional Paper 448-D, 29 p.
Hosman, R.L., and Weiss, J.S., 1991, Geohydrologic units of the Mississippi Embayment and Texas Coastal Uplands aquifer systems, South-Central United States: U.S. Geological Survey Professional Paper 1416-B, 19 p.
Luckey, R.R., 1985, Water resources of the Southeast Lowlands, Missouri: U.S. Geological Survey Water-Resources Investigation Report 84–4277, 77 p.
Miller, R.A., Harderman, W.D., Fullerton, D.S., comps., 1966, Geologic map of Tennessee, west sheet: [Nashville], Tennessee Department of Conservation, Division of Geology, scale 1:250,000.
Newcome, Roy, Jr., 1976, The Sparta aquifer system in Mississippi: U.S. Geological Survey Water-Resources Investigation Report 76–7, 3 sheets.
Parks, W.S., and Carmichael, J.K., 1990a, Altitude of potentiometric surface, fall 1985 and historic water-level changes in the Memphis aquifer in western Tennessee: U.S. Geological Survey Water-Resources Investigation Report 88–4180, 8 p.
Parks, W.S., and Carmichael, J.K., 1990b, Geology and ground-water resources of the Memphis Sand in western Tennessee: U.S. Geological Survey Water-Resources Investigations Report 88–4182, 30 p.
Payne, J.N., 1968, Hydrologic significance of the lithofacies of the Sparta Sand in Arkansas, Louisiana, Mississippi, and Texas: U.S. Geological Survey Professional Paper 569-A, 17 p.
Petersen, J.C., Broom, M.E., and Bush, W.V., 1985, Geohydrologic units of the Gulf Coastal Plain in Arkansas: U.S. Geological Survey Water-Resources Investigations Report 85–4116, 20 p.
Ryals, G.N., 1980, Potentiometric surface maps of the Sparta Sand, northern Louisiana and southern Arkansas, 1900, 1965, 1975, and 1980: U.S. Geological Survey Open-file Report 80–1180, 1 sheet.
Schrader, T.P., and Jones, J.S., 2007, Status of water levels and selected water-quality conditions in the Sparta-Memphis aquifer in Arkansas and the status of water levels in the Sparta aquifer in Louisiana, spring 2005: U.S. Geological Survey Scientific Investigations Report 2007–5029, 66 p.
Snider, J.L., Calandro, A.J., and Shampine, W.J., 1972, Water resources of Union Parish, Louisiana: Department of Conservation, Louisiana Geological Survey, and Louisiana Department of Public Works Water Resources Bulletin No. 17, 68 p.
Stanton, G.P., 1997, Potentiometric surface and specific conductance of the Sparta and Memphis aquifers in eastern and south-central Arkansas, 1995: U.S. Geological Survey Water-Resources Investigations Report 97–4119, 16 p.

POTENTIOMETRIC SURFACE IN THE SPARTA-MEMPHIS AQUIFER OF THE MISSISSIPPI EMBAYMENT, SPRING 2007

By
T.P. Schrader
2008

For additional information, contact:
Director, U.S. Geological Survey
Arkansas Water Science Center
401 Hardin Road
Little Rock, AR 72211
E-mail: dc_ar@usgs.gov
Fax: (501) 228-3601
Telephone: (501) 228-3600
Home Page: http://ar.water.usgs.gov

Copies of this report can be purchased from:
U.S. Geological Survey, Information Services
Box 25286, Denver Federal Center
Denver, CO 80225
E-mail: infoservices@usgs.gov
Fax: (303) 202-4188
Telephone: 1-888-ASK-USGS
Home Page: http://www.usgs.gov

Publishing support provided by:
Lafayette Publishing Service Center