U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
PUBLIC WORKS AND WATER RESOURCES DIVISION
WATER RESOURCES SECTION

WATER-RESOURCES INVESTIGATIONS REPORT 02-4053

Hydrogeology--(Sheet 1 of 3)

Brantly, J.A., Seanor, R.C., and McCoy, K.L., 2002, Louisiana Ground-Water Map No. 13: Hydrogeology and Potentiometric Surface of the Sparta aquifer in northern Louisiana, October 1996

INTRODUCTION

Previous investigators have determined that the Sparta aquifer is made up of several massive (major) sands. The individual sands are separated locally by layers of clay, but on a regional basis act as one unit (Payne, 1968). The Sparta aquifer serves as a source of ground water for 16 parishes in northern Louisiana, and is the principal source of ground water for Bienville, Claiborne, Jackson, Lincoln, Morehouse, Ouachita, Union, Webster, and Winn Parishes. Municipalities in the State began withdrawing water from the aquifer for public supply in the late 19th century. The withdrawal of water from the aquifer for industrial purposes began at Bastrop in 1922 and at West Monroe in 1923 (Sanford, 1973a). Since then, the demand for water has continued to increase, and water levels throughout much of the aquifer have declined steadily. In 2000, the Sparta aquifer provided a total of 77.2 Mgal/d of water for public supply, industry, power generation, rural domestic supply, livestock, irrigation, and aquaculture. This amount was a 12.6 percent increase in withdrawals since 1990 (J.K. Lovelace, U.S. Geological Survey, oral and written communs., 2000).

The decline in water levels have prompted concern about the capability of the aquifer to meet future demands for freshwater (water containing less than 250 mg/L of chloride, U.S. Environmental Protection Agency, 1994). Additional knowledge about the thickness and areal extent of major sands and the effects of water withdrawals on the Sparta aquifer is essential in assessing the aquifer's potential as a sustained source of water for present and future needs and for protection of the resource. In 1996, the U.S. Geological Survey (USGS), in cooperation with the Louisiana Department of Transportation and Development, began a study of the Sparta aquifer in northern Louisiana to develop a data base of digital geophysical logs from boreholes, to determine the thickness and areal extent of major sands, and to evaluate the potentiometric surface. The study area included all or parts of 16 parishes in northern Louisiana.

Purpose and Scope

This report describes the thickness and areal extent of the Sparta aquifer, identifies sands within the freshwater extent of the aquifer, and presents data and a map that illustrate the generalized potentiometric surface (water levels) during October 1996. The report includes a detailed geophysical log, structure contour maps, hydrogeologic sections, and hydrographs of water levels in selected wells. The potentiometric surface-map can be used for determining direction of ground-water flow, hydraulic gradients, and the effects of withdrawals on the aquifer.

Data Collection and Methods

Correlations of the sands were accomplished by selecting and analyzing geophysical and drillers' logs in the study area. The geophysical logs were selected on the basis of geographic location, log depth, and log quality. The geophysical logs from 574 water and oil wells were digitized to develop a digital data base. The wells were located in Bienville, Bossier, Caddo, Caldwell, Claiborne, Jackson, Lincoln, Morehouse, Natchitoches, Ouachita, Richland, Sabine, Union, Webster, and Winn Parishes. For quality-control purposes, the digital geophysical logs were compared with the original geophysical log printouts. When possible, the geophysical log data were used to identify the top, base, and individual sands of the Sparta aquifer, and to prepare structure contour maps of the top and base of the aquifer.

Geophysical logs from 45 wells were used in preparation of five hydrogeologic sections. The sections were constructed to represent the extent of the aquifer. Three sections were oriented west to east, and two sections were oriented north to south. Sands were determined for the wells by analyzing the geophysical log data. In general, areas of sand or shale less than 20 ft thick were not differentiated in the sections.

Water-level measurements collected during October 1996 from 55 wells were used in the construction of the generalized potentiometric-surface map. The water-level data were collected from wells located throughout the freshwater extent of the Sparta aquifer in Louisiana. The data were collected by USGS personnel in accordance with methods described by the USGS, Office of Ground Water. The data were entered into the USGS National Water Information System data base.

Previous Investigations

Reports from previous investigations of the hydrogeology in the study area were reviewed. Payne (1968) described the thickness, sand percentage, lithologic variations, and hydrologic characteristics of the Sparta aquifer in Mississippi, Louisiana, Arkansas, and Texas. Sanford (1973b) studied water use and water resources of the Ruston area, and in a similar manner, Ryals (1982) described the ground-water resources of the Arcadia-Minden area. Trudeau and Buono (1985) discussed the effects increased pumpage in the Sparta aquifer near West Monroe could have on water levels and salinity. McWreath and others (1991) modeled potentiometric responses to pumping stresses in the Sparta aquifer in northern Louisiana and southern Arkansas. The potentiometric surface of the Sparta aquifer has been previously mapped by Ryals (1980) and Smoot and Seanor (1991). Water from the Sparta aquifer is moderately hard, 61 to 120 mg/L (Stuart and others, 1994) and suitable for use without treatment, although water in some areas may require treatment to remove excess iron (Ryals, 1982; Page and May, 1964; Sanford, 1973b). Freshwater occurs throughout most of the study area. Chloride concentrations within the Sparta aquifer generally increase in a downdip direction (McWreath and others, 1991).

Acknowledgments

Special thanks are given to Zahir "Bo" Bolourchi, Chief, Water Resources Section, Louisiana Department of Transportation and Development, for assistance provided during the study and during preparation of the report; and to Dan Tomaszewski for his contribution to the analysis and interpretation of geophysical logs and the compilation of the report.

HYDROGEOLOGY

The Sparta aquifer is one hydrogeologic unit in a series of alternating aquifers and confining units within the Mississippi Embayment. The Sparta aquifer, of Eocene age, is situated between the massive marine clay layers of the overlying Cook Mountain and underlying Cane River confining units (Snider and others, 1972). For this study, the top of the Sparta aquifer is defined as the base of the overlying Cook Mountain confining unit. The base of the Sparta aquifer is defined as the top of the underlying Cane River confining unit.

The lithology of the Sparta aquifer is highly varied both laterally and vertically. The Sparta aquifer consists of very fine to medium sand, silty clay, lignite, and clay. The aquifer has beds of fine to medium sand in the lower half and beds of sand, clay, and lignite in the upper half. The existing pattern of sand concentrations in the aquifer has been attributed to deposition by constantly shifting stream channels and interlacing lakes, marshes, and swamps of a deltaic-fluvial flood plain (Payne, 1968). Individual sands within the Sparta aquifer may act locally, for short periods of time, as separate hydraulic units. However, over longer periods of time and larger areas, these sands act together as a unified aquifer (Payne, 1968). Pumpage from the basal parts of the aquifer may affect water levels in the middle and upper parts (McWreath and others, 1991). This is dependent on how well the individual sands are hydraulically connected, and the duration and rate of pumping.

The percentage of sand within individual sands of the Sparta aquifer can vary from being almost completely sand (as typified by the thick sands generally present near the base of the Sparta aquifer) to approximately 50 percent sand, as seen in well Ou-466, which contains thin sands broken with many small clays (fig. 1).

In most of the study area, the altitude of the top of the Sparta aquifer ranges from approximately 200 ft above sea level near the recharge area to approximately 300 ft below sea level near the downdip limit of freshwater (fig. 2). The top of the aquifer generally dips east and southeast at a rate of 5 to 25 ft/mi. The altitude of the top of the Sparta aquifer in southern Natchitoches and Sabine Parishes range from sea level in the recharge area to approximately 1,300 ft below sea level near the downdip limit of freshwater. In this area, the aquifer dips at a rate greater than 60 ft/mi (fig. 2).

The altitude of the base of the Sparta aquifer ranges from approximately 150 ft above sea level in the recharge area to approximately 1,000 ft below sea level near the downdip limit of freshwater (fig. 3). The base of the aquifer dips east and southeast at a rate of 25 to 50 ft/mi. The altitude of the base of the Sparta aquifer in southern Natchitoches and Sabine Parishes ranges from approximately 100 ft below sea level in the recharge area to approximately 1,400 ft below sea level near the downdip limit of freshwater (fig. 3).

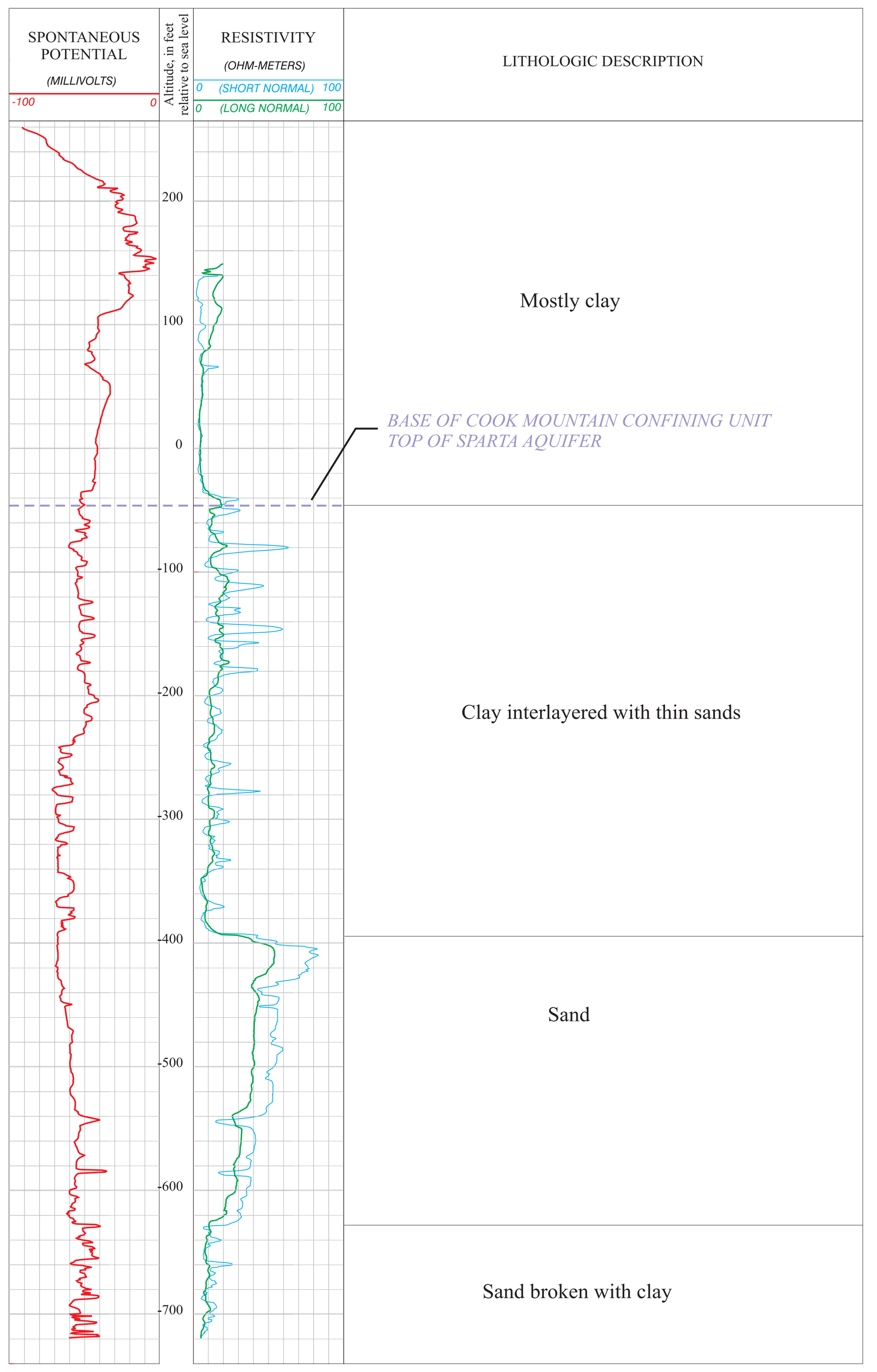

Figure 1. Geophysical log and lithologic description of well Ou-466, Ouachita Parish, Louisiana.

Adjacent to the recharge area, the Sparta aquifer is approximately 500 ft thick. The thickness of the aquifer increases to approximately 700 ft near the downdip limit of freshwater.

The concentric features shown in figure 3 are caused by the intrusion of deeply buried salt into overlying formations. As the salt rises, the overlying geologic units are pushed to higher altitudes, resulting in the creation of dome-shaped geologic structures (Clark, 1959).

The hydrogeologic sections (A-A', B-B', C-C', D-D', and E-E') illustrate the highly varied nature of the individual sands within the Sparta aquifer. Section A-A' extends from Caddo Parish to Morehouse Parish covering approximately 138 mi. Along this section, the Sparta aquifer ranges in thickness from less than 100 ft in the recharge area in northern Caddo Parish to more than 600 ft in Morehouse Parish. The thickest individual sands, more than 300 ft, are present in the lower part of the aquifer in Claiborne and Morehouse Parishes (fig. 4). No saltwater is present in the aquifer in Caddo, Bossier, Webster, and Claiborne Parishes. Saltwater is present at a depth of 534 ft below sea level in well Un-82. The elevation of the saltwater interface generally increases as the section trends eastward.

Section B'B' extends from the recharge area in Bienville Parish to western Ouachita Parish near the downdip limit of freshwater. This section illustrates that individual sands within the Sparta aquifer coalesce and diverge. Near the Lincoln-Ouachita Parish line, the borehole geophysical logs from wells L-144, L-68, and Ou-441 show where distinct sand intervals in the middle part of the aquifer have thickened and coalesced to form a single sand approximately 300 ft thick. Along this section, the aquifer ranges in thickness from 500 ft in Bienville Parish to approximately 700 ft near the downdip limit of freshwater in Ouachita Parish (fig. 5). Analysis of chloride data indicates the aquifer contains no saltwater along this section from Bienville Parish to central Ouachita Parish. Saltwater is present in the aquifer at a depth of 610 ft below sea level in well Ou-432 (fig. 5), and the elevation of the saltwater interface increases as the section moves downdip.

Section C-C' (fig. 6) extends from the recharge area in Bienville Parish to near the downdip limit of freshwater in southwest Ouachita Parish. The aquifer ranges in thickness from approximately 140 ft in the recharge area of Bienville Parish to approximately 725 ft near the downdip limit of freshwater in Caldwell Parish (fig. 6). Along this section, saltwater is only present in wells Ca-54634 and Ou-402. Wells Ca-54634 and Ou-402 contain saltwater at 704 ft and 346 ft below sea level, respectively.

Section D-D' (fig. 7) extends south from north-central Claiborne Parish to the recharge area in south-central Bienville Parish. Thickness of the Sparta aquifer along this section ranges from approximately 580 ft in Claiborne Parish to approximately 170 ft in the recharge area of Bienville Parish (fig. 7). The aquifer contains no saltwater along this section.

Section E-E' (fig 8) extends from northern Union Parish southward through Ouachita and Jackson Parishes to central Winn Parish near the downdip limit of freshwater. Borehole-geophysical logs for wells Un-61B, Ou-441, and Ou-466 show sands in the middle and lower parts of the Sparta aquifer as they thicken and coalesce and then diverge and grow thinner. Sands in the middle part of the aquifer reach a maximum thickness of 200 ft at well Un-61B. The lower sands show a maximum thickness of 240 ft at well Ou-466 (fig. 8). Saltwater is present at varying depths along much of section E-E'. At the northern end of the section, saltwater is present at a depth of 408 ft below sea level at well Un-74B, 591 ft below sea level at well Un-78, 645 ft below sea level at well Ou-466 and 684 ft below sea level at well Ja-78880. The depth of saltwater decreases from 561 ft below sea level at well W-172 to 418 ft below sea level at well W-144B.

CONVERSION FACTORS, VERTICAL DATUM AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer (km)
foot per mile (ft/mi)	0.1894	meter per kilometer
foot per year (ft/yr)	0.3048	meter per year
million gallons per day (Mgal/d)	3,785	cubic meter per day

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

Abbreviated water-quality units: milligrams per liter (mg/L)

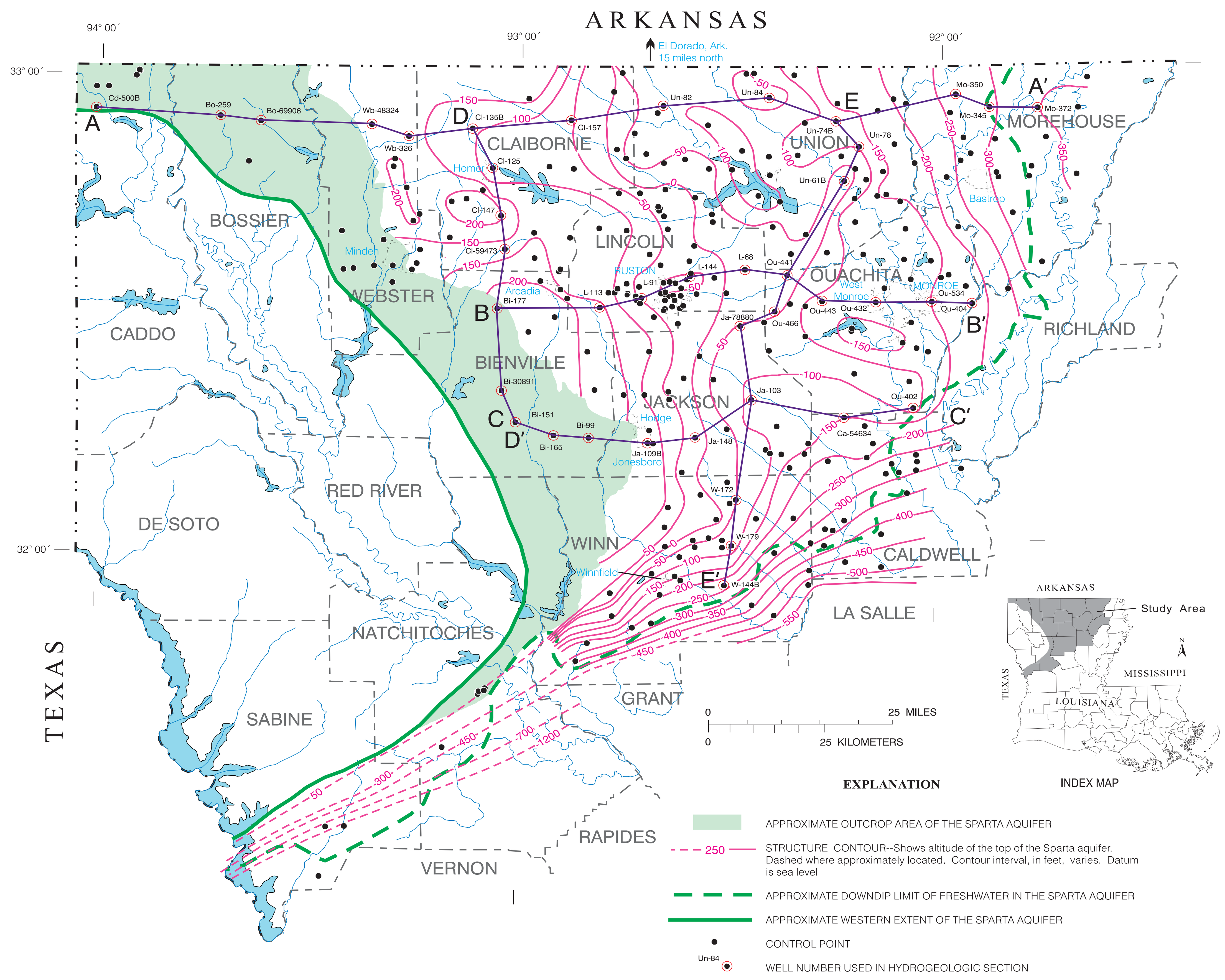

Figure 2. Altitude of the top of the Sparta aquifer in northern Louisiana.

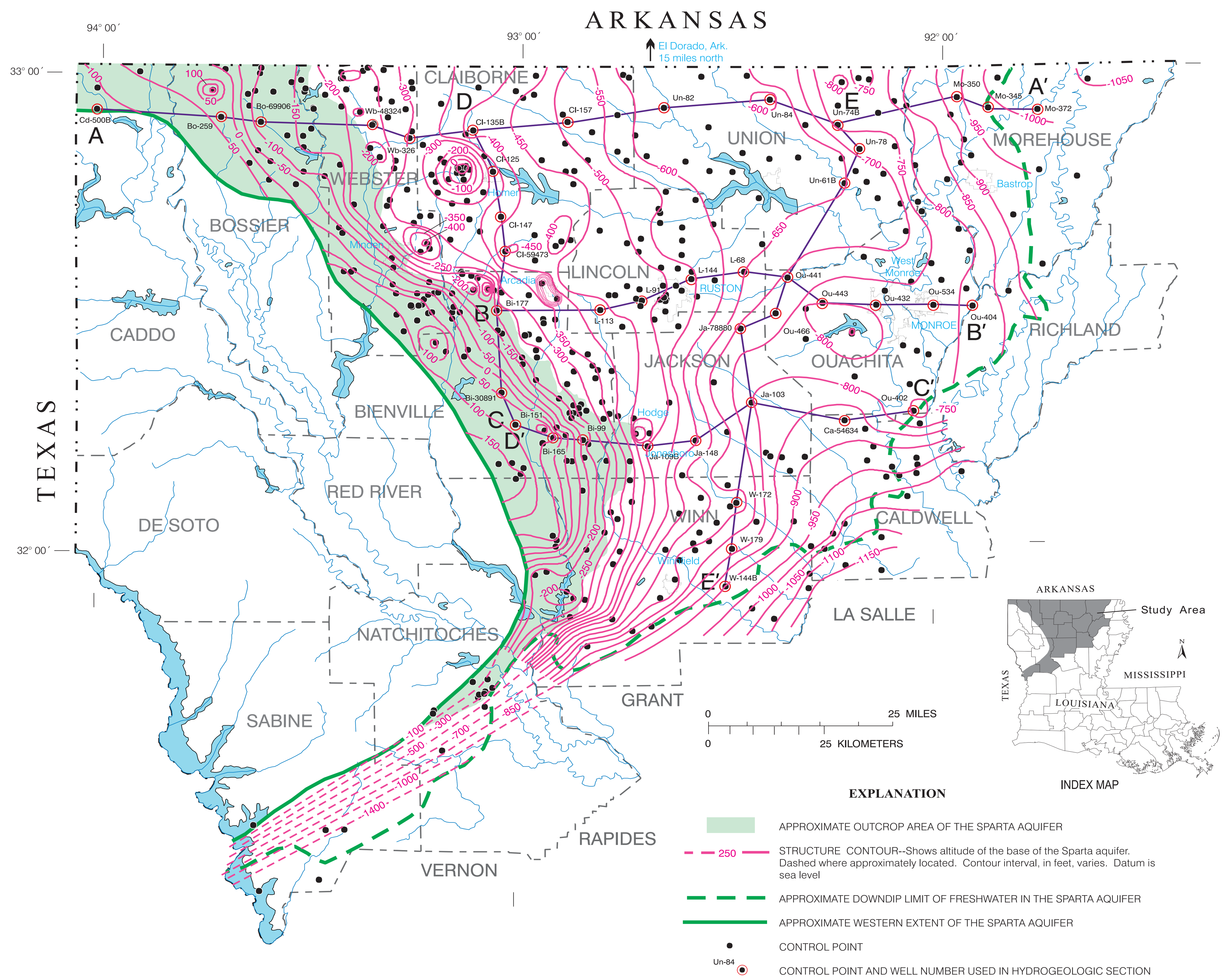

Figure 3. Altitude of the base of the Sparta aquifer in northern Louisiana.

Louisiana Department of Transportation and Development - U.S. Geological Survey Water Resources Cooperative Program

Louisiana Ground-Water Map No. 13

Hydrogeology and Potentiometric Surface of the Sparta Aquifer in Northern Louisiana, October 1996

By

Jeffrey A. Brantly, Ronald C. Seanor, and Kaycee L. McCoy

2002

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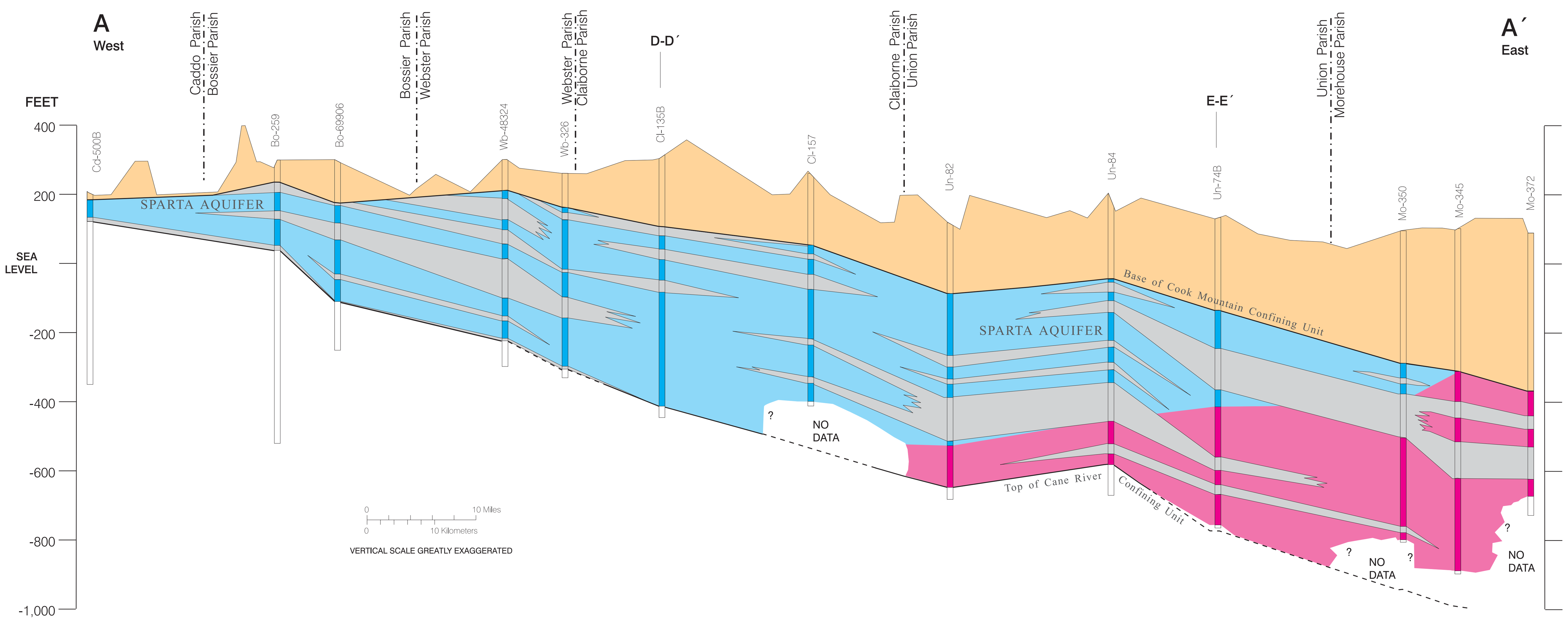


Figure 4. West-to-east hydrogeologic section (A-A′) through the Sparta aquifer in northern Louisiana.

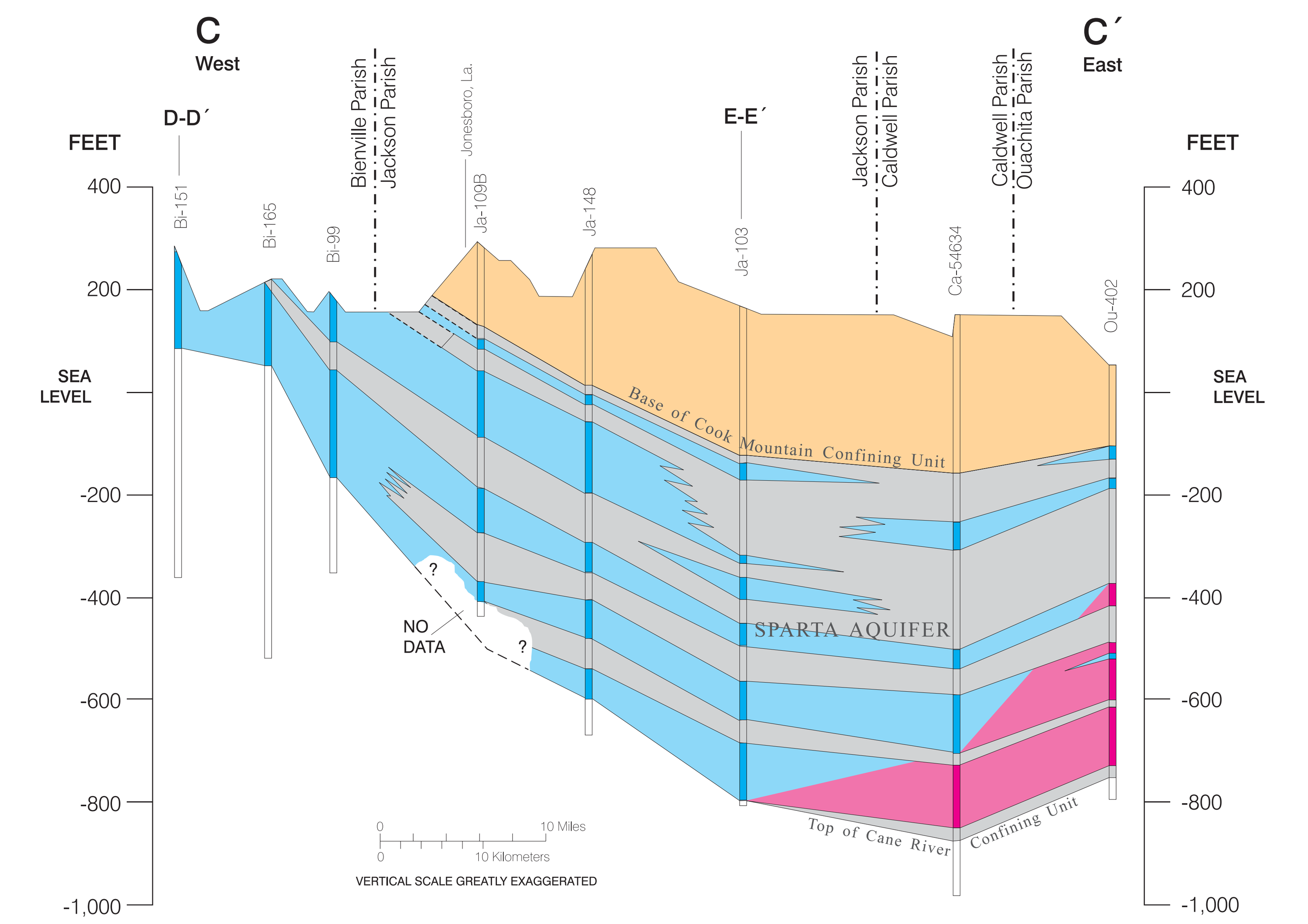


Figure 6. West-to-east hydrogeologic section (C-C′) through the Sparta aquifer in northern Louisiana.

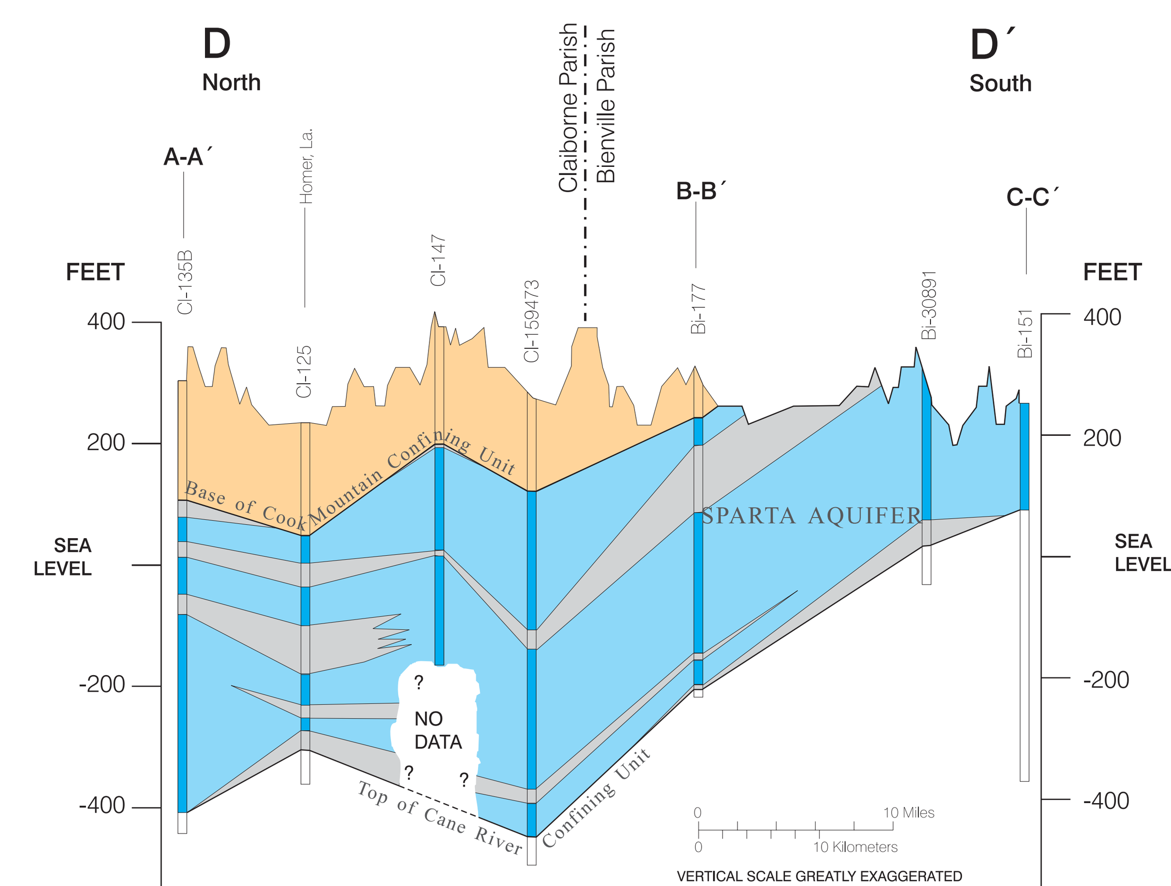
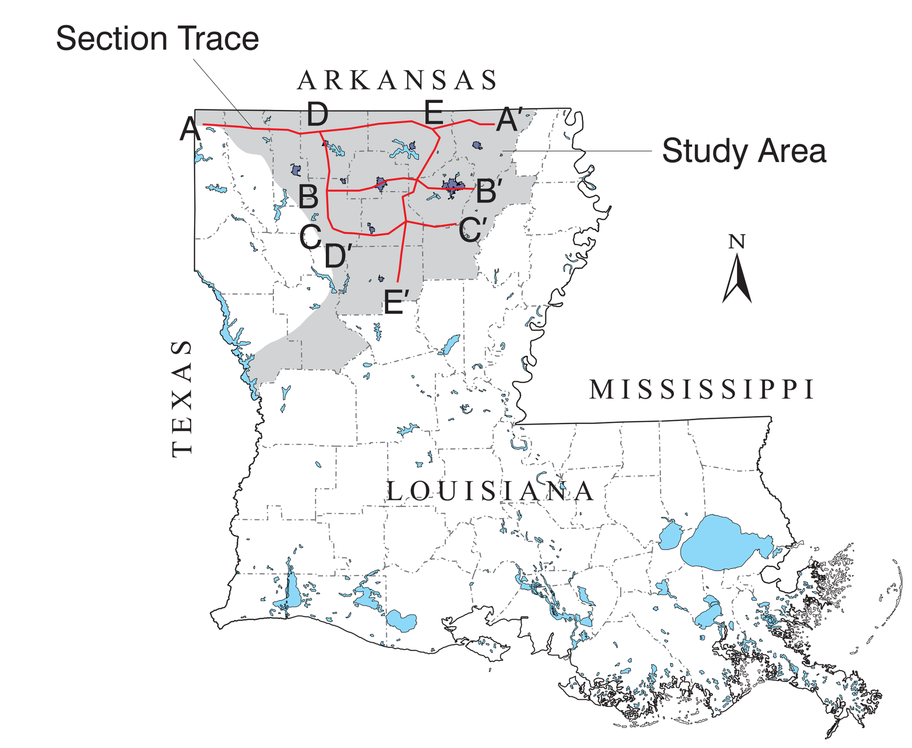


Figure 7. North-to-south hydrogeologic section (D-D′) through the Sparta aquifer in northern Louisiana.



INDEX MAP

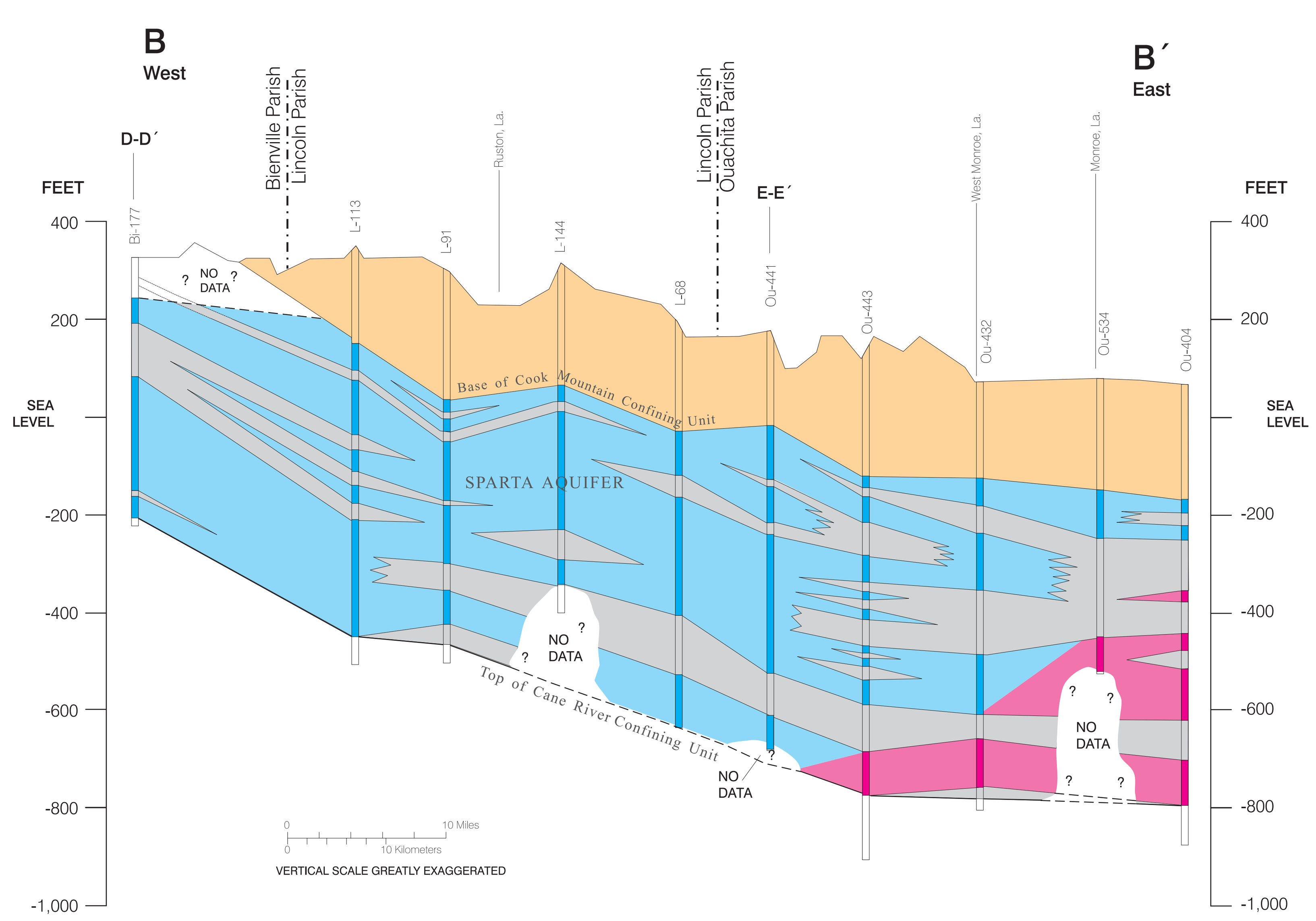


Figure 5. West-to-east hydrogeologic section (B-B′) through the Sparta aquifer in northern Louisaina.

EXPLANATION

- Overlying hydrogeologic unit
- Clay
- Freshwater bearing sand
- Saltwater bearing sand
- Underlying hydrogeologic unit
- Inferred contact

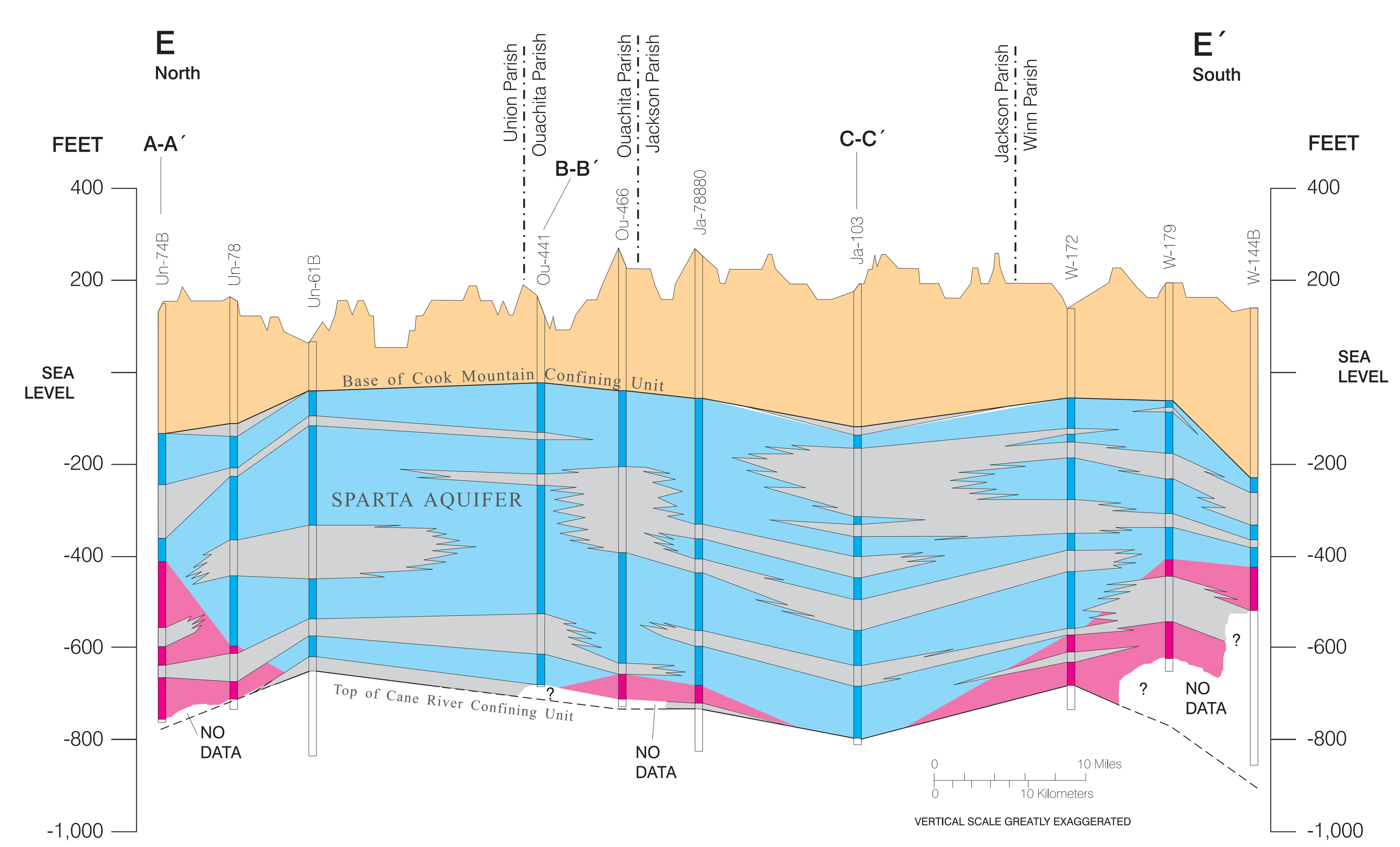


Figure 8. North-to-south hydrogeologic section (E-E′) through the Sparta aquifer in northern Louisiana.

Louisiana Department of Transportation and Development - U.S. Geological Survey Water Resources Cooperative Program

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Brantly, J.A., Seanor, R.C., and McCoy, K.L., 2002, Louisiana Ground-Water Map No. 13: Hydrogeology and Potentiometric Surface of the Sparta aquifer in northern Louisiana, October 1996

POTENTIOMETRIC SURFACE

A map of the generalized potentiometric surface of the Sparta aquifer for October 1996, was constructed using water-level measurements from 55 wells completed in the middle or lower part of the aquifer. The altitude of water level contours ranged from 220 ft above sea level in the recharge areas of Bienville and Webster Parishes to 220 ft below sea level in Ouachita Parish (fig. 9). These contours show highest water levels in the western recharge area, and lowest water levels at major pumping centers. Flow lines illustrated on the potentiometric map in figure 9 show ground-water movement is toward areas of intensive pumpage. Major pumping centers in Louisiana are located at West Monroe (20 Mgal/d), and Hodge (20 Mgal/d). The Sparta aquifer is also impacted by pumpage in the Ruston (8 Mgal/d), Minden (6 Mgal/d), and Winnfield (1 Mgal/d) areas of Louisiana, as well as pumpage from El Dorado, Arkansas (J.K. Lovelace, U.S. Geological Survey, oral and written communs., 2000). Data collected subsequent to the data used in this potentiometric-surface map seem to indicate the presence of a cone of depression around the Ruston area.

Well Wb-399 is located in the recharge area and is screened between a depth of 288 and 298 ft. The hydrograph in figure 10 shows only seasonal fluctuations in water levels for the period of record from 1979 to 2000 and no net increase or decrease. This well is typical of wells located in the recharge area of the Sparta aquifer.

Typical regional declines in water levels in the Sparta aquifer are shown by wells Cl-149 (fig. 11), located near the Louisiana-Arkansas State line, and well L-26 (fig. 12), located north of Ruston. For the periods of record, water levels in wells Cl-149 and L-26 have declined approximately 1.5 and 2.0 ft/yr, respectively. These regional declines are a result of long-term withdrawals from the Sparta aquifer.

Wells Ou-443, Ou-444, and Ou-445 are located west of West Monroe. Each well is completed in a different sand separated vertically by layers of clay which results in the wells being hydraulically isolated on a local basis. All three wells have shown an average water-level decline of about 2.0 ft/yr for the same period of record. Hydrographs for all three wells indicate water levels undergo very similar fluctuations (fig. 13). Therefore, water levels of individual sands in this area indicate a hydraulic connection between individual sands within the Sparta aquifer.

SUMMARY AND CONCLUSIONS

The Sparta aquifer serves as the principal source of ground water for Bienville, Claiborne, Jackson, Lincoln, Morehouse, Ouachita, Union, Webster, and Winn Parishes. Pumpage from the massive sands in the lower part of the aquifer may affect the upper sands. Analysis of the hydrogeologic-sections, as well as the water-level data, indicate that parts of the Sparta aquifer are well-connected hydraulically. The aquifer framework is constructed of imperfectly connected sands which may act as separate hydraulic units for short periods of time, but due to the depositional nature of the aquifer, act as one unit regionally.

In northern Louisiana, the altitude of the top of the Sparta aquifer ranges from 200 feet above sea level in the recharge areas to approximately 300 feet below sea level near the downdip limit of freshwater and dips east and southeast at a rate of 5 to 25 feet per mile. The altitude of the base of the Sparta aquifer ranges from 150 feet above sea level in recharge areas to approximately 1,000 feet below sea level near the downdip limit of freshwater and dips east and southeast at a rate of 25 to 50 feet per mile.

Hydrogeologic-sections show the thickness and linear extent of sands within the Sparta aquifer. Along the sections, the Sparta aquifer ranges in thickness from approximately 140 feet adjacent to the recharge areas to approximately 725 feet near the downdip limit of freshwater.

Water levels in the Sparta aquifer have steadily declined since the early 1920's when industrial pumpage began. The 1996 potentiometric surface shows that water levels have generally declined approximately 20 feet (2.8 feet per year) since 1989, except in the recharge areas where water levels have remained relatively constant. In 2000, the Sparta aquifer provided a total of 77.2 million gallons per day for public supply, industry, power generation, rural domestic supply, livestock, irrigation, and aquaculture. From 1990 to 2000, withdrawals from the Sparta aquifer increased 12.6 percent.

Table 1: *Water-level data used to construct the potentiometric surface of the Sparta aquifer in Louisiana, October 1996*

Well number	Well depth (feet)	Water level (feet below land surface)	Water level (feet above or below sea level)	Date measured
Bienville Parish				
Bi-76	110	50.46	229.54	10-01-96
Bi-100	90	33.21	186.79	10-16-96
Bi-112	348	115.82	99.18	10-01-96
Bi-144	630	236.42	83.58	10-01-96
Bi-166	472	181.43	78.57	10-01-96
Bi-186	216	41.97	138.03	10-16-96
Bi-192	153	74.49	210.51	10-16-96
Bi-216	300	16.70	183.30	10-01-96
Caldwell Parish				
Ca-86B	545	79.28	80.72	10-01-96
Claiborne Parish				
Cl-9	670	270.01	89.99	10-09-96
Cl-58	488	140.01	109.99	10-09-96
Cl-111	570	255.46	44.54	10-08-96
Cl-116	684	259.73	-14.73	10-10-96
Cl-148	625	196.80	-6.80	10-10-96
Cl-149	736	294.36	-64.36	10-10-96
Jackson Parish				
Ja-49	570	201.19	-41.19	10-02-96
Ja-147	703	246.47	-26.47	10-16-96
Ja-148	578	225.15	19.85	10-02-96
Lincoln Parish				
L-26	686	180.27	-25.27	10-10-96
L-68	770	249.60	-69.60	10-10-96
L-113	750	317.56	37.44	10-02-96
L-117	551	137.85	-51.85	10-15-96
Morehouse Parish				
Mo-5	860	153.52	-36.08	10-04-96
Mo-342	620	89.85	-1.51	10-03-96
Mo-350	740	105.56	6.52	10-03-96
Ouachita Parish				
Ou-80	176	283.76	-223.76	10-10-96
Ou-401A	397	106.13	-43.85	10-10-96
Ou-402	750	58.98	4.32	10-10-96
Ou-404	167	80.32	-19.43	10-15-96
Ou-406	681	157.25	-90.50	10-10-96
Ou-444	670	229.09	-111.09	10-23-96
Ou-488	255	332.73	-52.73	10-23-96
Union Parish				
Un-26	745	184.00	-50.08	10-04-96
Un-78	727	208.60	-33.60	10-24-96
Un-79	749	153.40	-35.40	10-24-96
Un-83	326	174.00	-52.00	10-16-96
Un-84	696	248.70	-38.70	10-24-96
Un-86	655	100.63	-10.63	10-16-96
Un-134	585	307.13	-87.13	10-23-96
Webster Parish				
Wb-127	408	61.37	208.63	10-21-96
Wb-164	769	64.32	155.68	10-07-96
Wb-219	136	5.17	184.83	10-08-96
Wb-271	220	84.25	193.75	10-09-96
Wb-285	608	180.68	159.32	10-08-96
Wb-326	470	114.51	145.49	10-04-96
Wb-338	425	94.89	135.11	10-04-96
Wb-349	263	70.38	109.62	10-07-96
Wb-359	687	79.68	200.32	10-09-96
Wb-399	298	45.24	159.76	10-04-96
Wb-415	544	17.20	142.80	10-09-96
Winn Parish				
W-28	606	52.14	52.86	10-01-96
W-144B	550	37.55	102.45	10-01-96
W-172	655	91.21	48.79	10-01-96
W-177	695	53.34	131.66	10-01-96
W-179	585	108.70	86.30	10-01-96

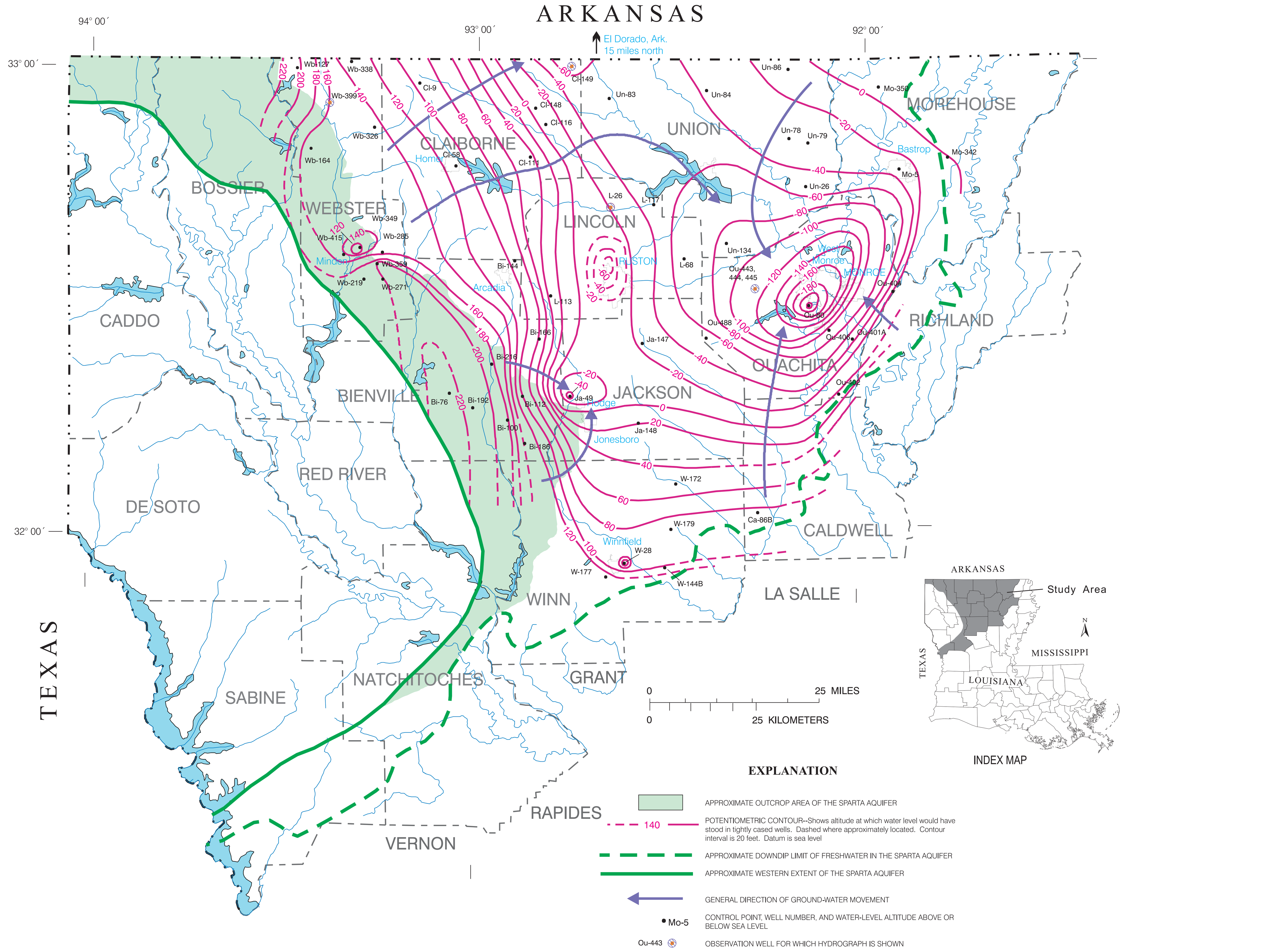

Figure 9. Potentiometric surface of the Sparta aquifer in northern Louisiana, October 1996.

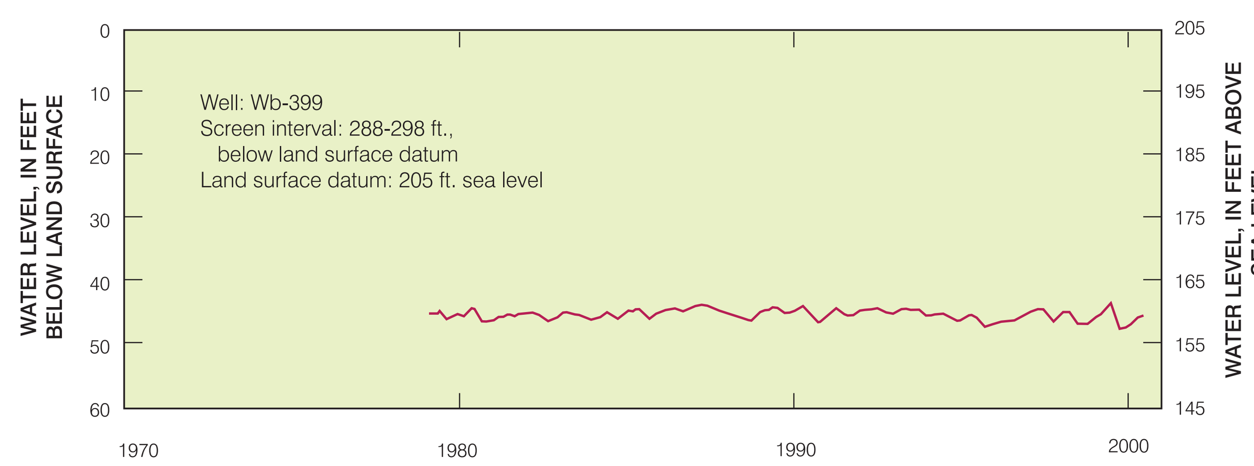

Figure 10. Water level in well Wb-399 (Webster Parish).

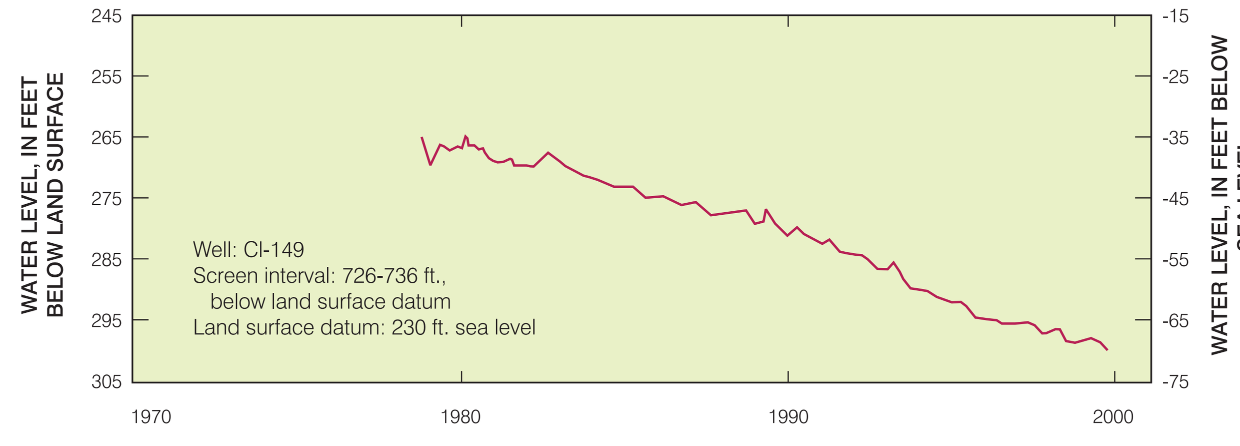

Figure 11. Water level in well Cl-149 (Claiborne Parish).

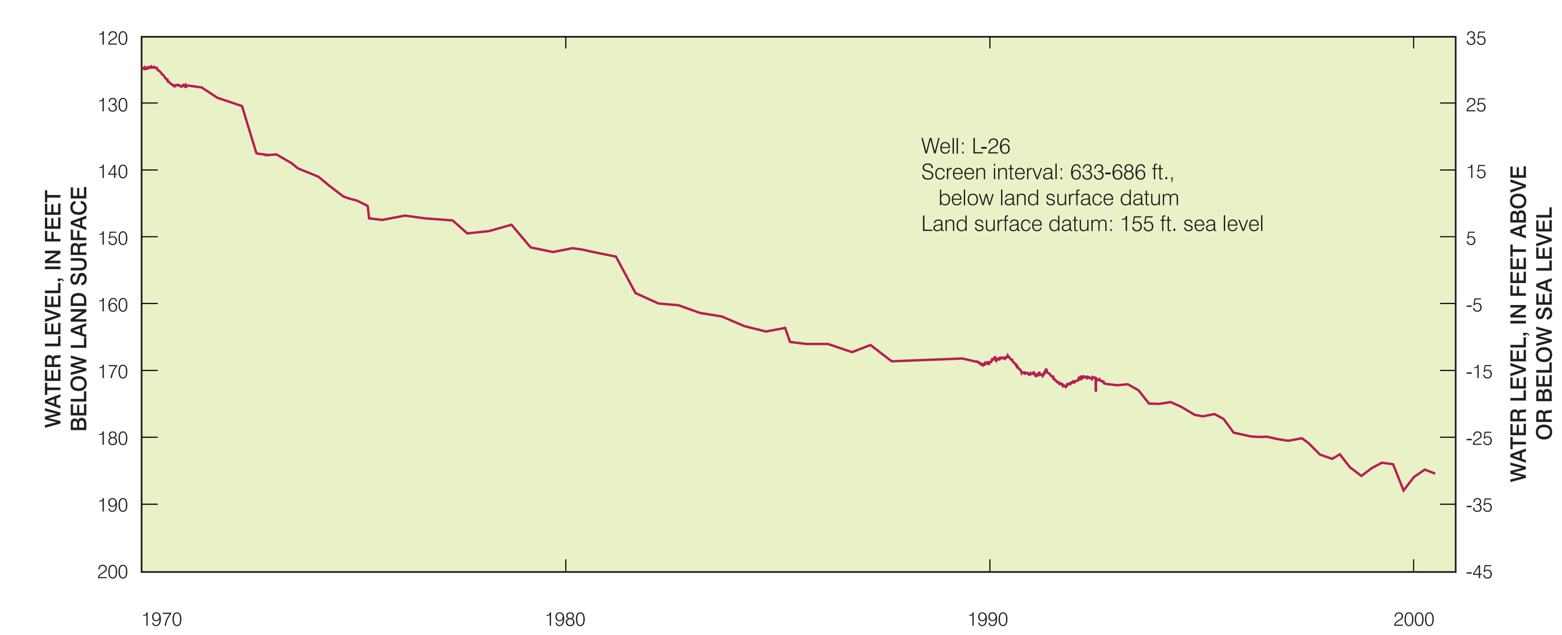

Figure 12. Water level in well L-26 (Lincoln Parish).

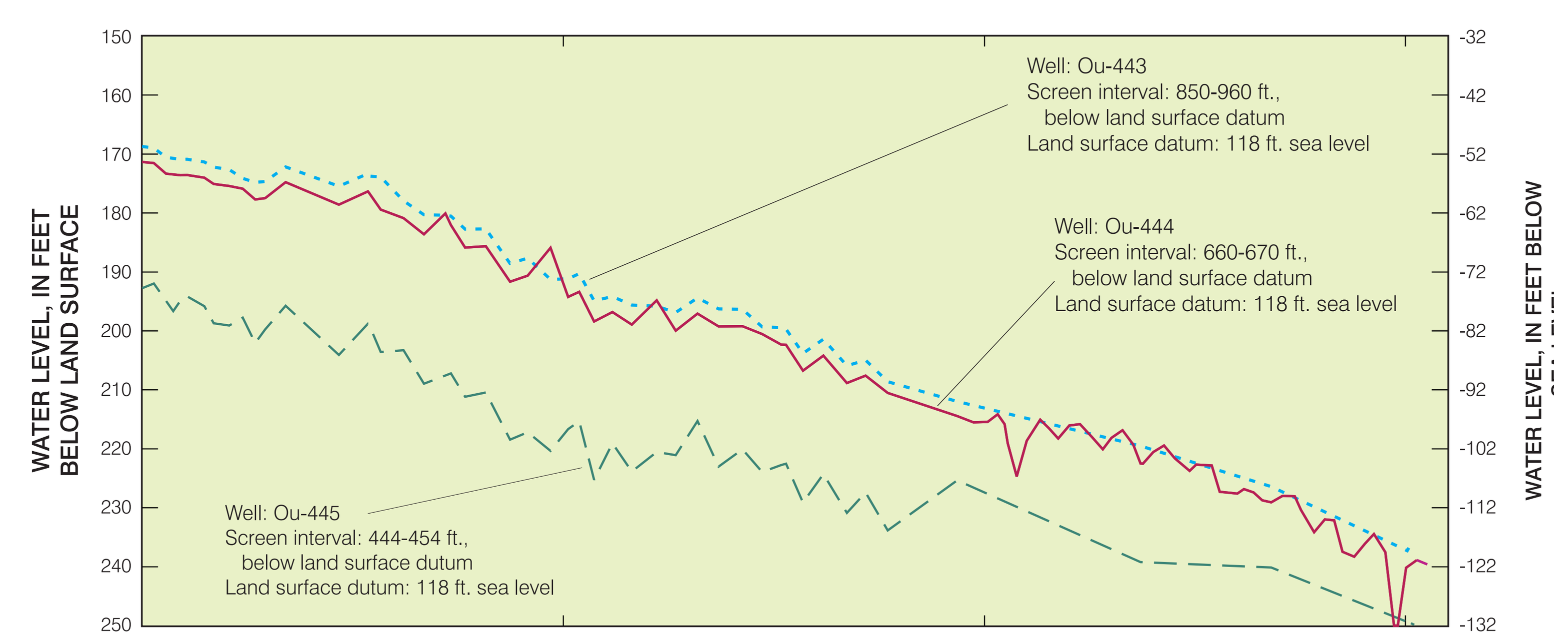

Figure 13. Water level in well Ou-443, Ou-444 and Ou-445 (Ouachita Parish).

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Louisiana Ground-Water Map No. 13

Hydrogeology and Potentiometric Surface of the Sparta Aquifer in Northern Louisiana, October 1996

By

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