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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, October 1996, of the Sparta aquifer in northern Louisiana

INTRODUCTION

The Sparta aquifer serves as a source of ground water for 16 parishes (Bienville, Bossier, Caddo, Caldwell, Claiborne, Jackson, LaSalle, Lincoln, Morehouse, Natchitoches, Ouachita, Richland, Sabine, Union, Webster, and Winn Parishes) in northern Louisiana. Of these parishes, the aquifer is the principal source of ground water for Bienville, Claiborne, Jackson, Lincoln, Morehouse, Ouachita, Union, Webster, and Winn Parishes (Lovelace and Johnson, 1996, p. 98, 100-101). Municipalities in the State began withdrawing water from the aquifer for public supply in the late 19th century. In Louisiana, the first large industrial withdrawal of water from the aquifer began at Bastrop in 1922 (Sanford, 1973a, p. 60) and at West Monroe in about 1923 (Smoot and Seanor, 1991). Since then, the demand for water has increased, and water levels throughout much of the aquifer have declined. In 2000, the aquifer provided a total of approximately 68 Mgal/d of water for public supply, industry, power generation, rural domestic supply, livestock, irrigation, and aquaculture. This amount was a 6 percent increase in withdrawals since 1990 (B.P. Sargent, U.S Geological Survey, written commun., 2000).

The decline in water levels has prompted concern about the capability of the Sparta aquifer to meet future demands for freshwater (water containing less than 250 mg/L of chloride, U.S. Environmental Protection Agency, 1994, p. 10). 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 describe the hydrogeology and potentiometric surface (water levels). The study area included all or parts of 16 parishes in northern Louisiana.

Purpose and Scope

This report presents results of the study. The report describes the extent and general lithology of the Sparta aquifer, identifies sand and clay thickness within the aquifer, and presents data and a map that describe the generalized potentiometric surface during October 1996. The report includes a detailed geophysical log, structure contour maps, hydrogeologic sections, and hydrographs of water levels in selected wells for the part of the Sparta aquifer located in Louisiana. The potentiometric-surface map can be used for determining direction of ground-water flow and hydraulic gradients. Water-level data are on file at the USGS office in Baton Rouge, La.

Previous Investigations

Previous investigators have determined that the Sparta aquifer is made up of several massive (major) sands. Payne (1968) described the thickness, sand percentage, lithologic variations, and hydrologic characteristics of the aquifer in Mississippi, Louisiana, Arkansas, and Texas. According to Payne (1968, p. 5), individual sands are separated locally by layers of clay but on a regional basis act as one unit. 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 that increased pumpage from the aquifer near West Monroe could have on water levels and salinity. McWreath and others (1991) modeled potentiometric responses to pumping stresses in the aquifer in northern Louisiana and southern Arkansas. The potentiometric surface of the aquifer has been mapped previously by Ryals (1980) and Smoot and Seanor (1991). Water from the aquifer is soft (concentrations as calcium carbonate are less than 60 mg/L; Stuart and others, 1994, p. 11) and generally suitable for use without treatment, although water in some areas may require treatment to remove excess iron (Ryals, 1982, p. 18; Page and May, 1964, p. 48; Sanford, 1973b, p. 18). Freshwater occurs throughout most of the study area. Dissolved solids concentrations within the Sparta aquifer generally increase in a downdip direction (McWreath and others, 1991, p. 8).

Acknowledgments

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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 were from 574 water and oil wells located in Bienville, Bossier, Caddo, Caldwell, Claiborne, Jackson, Lincoln, Morehouse, Natchitoches, Ouachita, Sabine, Union, Webster, and Winn Parishes. 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. The occurrence of saltwater in individual wells was determined from geophysical logs on file at USGS offices and chloride data stored in the USGS National Water Information System data base.

Geophysical logs from 42 wells were used in preparation of five hydrogeologic sections. The sections were constructed to represent the spatial extent of the aquifer. Three sections were oriented west-to-east, and two sections were oriented north-to-south. Sands were identified 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 from 55 wells during October 1996 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 input into the USGS National Water Information System data base.

HYDROGEOLOGY

The Sparta aquifer is one hydrogeologic unit in a series of alternating aquifers and confining units within the Mississippi Embayment. The Sparta aquifer, in strata of the Eocene Epoch, is situated between the massive marine clay layers of the overlying Cook Mountain and underlying Cane River confining units (Snider and others, 1972, p. 13). For this study, the top of the aquifer is defined as the base of the overlying Cook Mountain confining unit. The base of the aquifer is defined as the top of the underlying Cane River confining unit. The area where the aquifer is exposed at or near land surface is referred to as the outcrop area in this report.

The lithology of the Sparta aquifer is highly varied both laterally and vertically. 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 distribution of sand 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, p. 3-4). Figure 1, well Ou-466, contains a typical electric log (e-log) showing strata overlying the Sparta aquifer and sediments contained in the Sparta aquifer. The part of the log at about 240 to -50 ft (altitude relative to sea level) shows the thickness of the overlying sediment. The top of the Sparta aquifer is defined at -50 ft where the base of the Cook Mountain confining unit occurs. The e-log does not show the base of the aquifer, which is about 740 ft below sea level. Interpretations of e-log data indicate that the upper 350 ft (approximately -50 to -400 ft) of the Sparta is mostly clay interlayered with thin sand beds. Sand predominates from about -400 to -630 ft. Sand broken with clay predominates from about -630 to -710 ft. The base of the Sparta aquifer is below the logged part of the well.

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, p. 5). Pumping from the lower part of the aquifer may affect water levels in the middle and upper parts (McWreath and others, 1991, p. 38).

In the study area, the altitude of the top of the Sparta aquifer ranges from approximately 200 ft above sea level near the outcrop area to approximately 400 ft below sea level near the downdip limit of freshwater[1] (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 aquifer in southwestern Natchitoches Parish and southern Sabine Parish ranges from approximately sea level in the outcrop area to approximately 1,200 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).

[1] The downdip limit of freshwater is defined as the point at which the aquifer no longer has sands containing water with less than 250 mg/L of chloride.

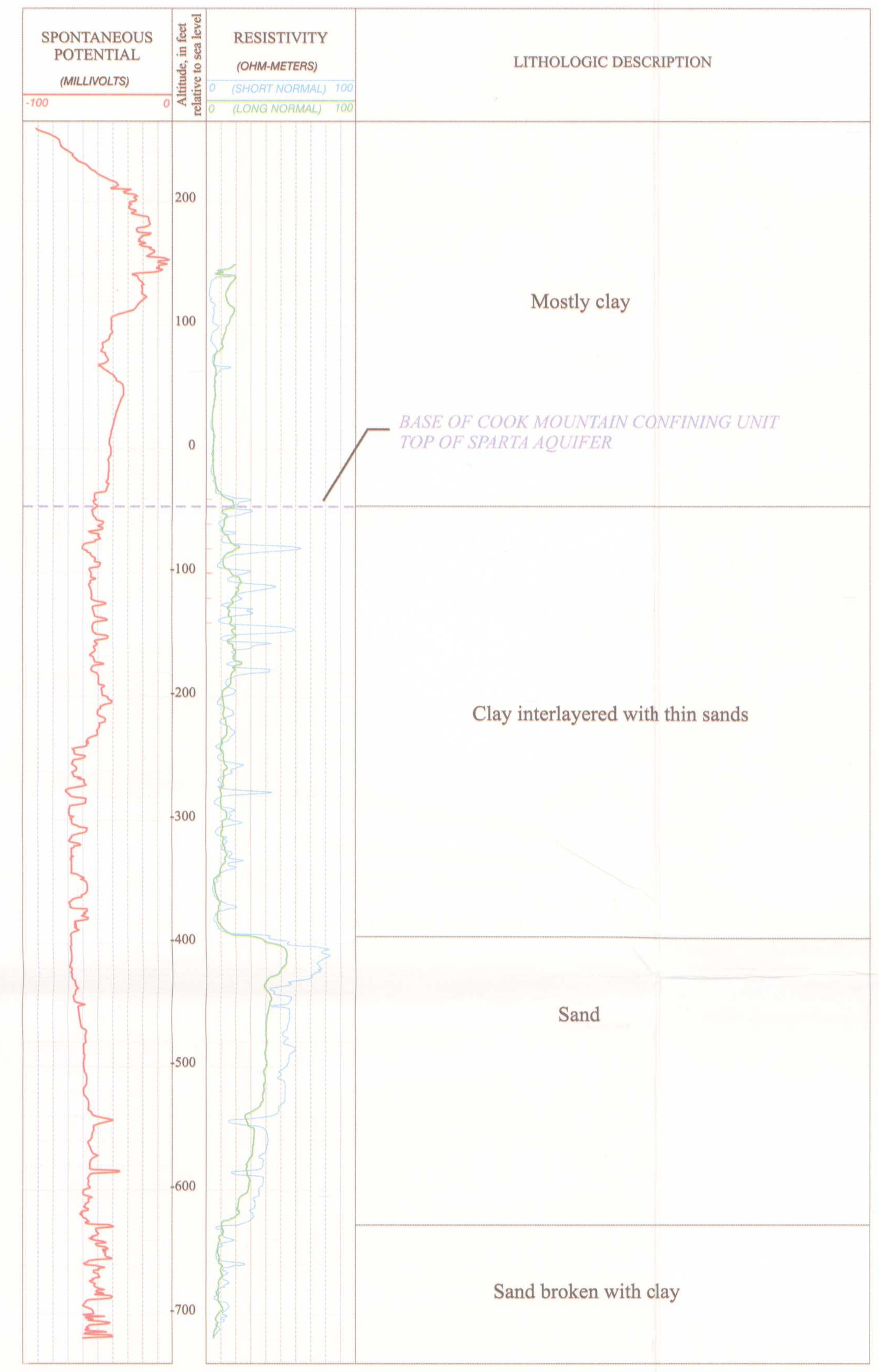

Figure 1. Geophysical log and lithologic description of well Ou-466, Ouachita Parish, Louisiana.

The altitude of the base of the Sparta aquifer ranges from approximately 150 ft above sea level in the outcrop area to approximately 1,000 ft or more 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 aquifer in southwestern Natchitoches Parish and southern Sabine Parish ranges from approximately 100 ft below sea level in the outcrop area to approximately 1,400 ft below sea level near the downdip limit of freshwater (fig. 3).

The concentric features shown in figure 3 (west of Homer, at Arcadia, and east of Minden) 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´, fig. 4; B-B´, fig. 5; C-C´, fig. 6; D-D´, fig. 7; and E-E´, fig. 8) illustrate that sand thickness varies within the Sparta aquifer. Section A-A´ extends from the outcrop area in northwestern Caddo Parish to north-central Morehouse Parish, approximately 138 mi (figs. 2 and 3). Along this section, the aquifer ranges in thickness from less than 100 ft in Caddo Parish to more than 600 ft in Union and Morehouse Parishes. Sand thickness of more than 300 ft is present in the lower part of the aquifer in both Claiborne and Morehouse Parishes (fig. 4). Near the Claiborne and Union Parish border, saltwater is present in well Un-82 at a depth of 534 ft below sea level. The altitude of the saltwater interface generally increases along the section eastward to the downdip limit of freshwater in Morehouse Parish.

Section B´B´ (fig. 5) extends from the outcrop area in northwestern Bienville Parish to the eastern boundary of Ouachita Parish near the downdip limit of freshwater (figs. 2 and 3). The section shows sand thickness in the Sparta aquifer varies. Near the Lincoln-Ouachita Parish line, the borehole geophysical logs from wells L-144, L-68, and Ou-441 show thick unbroken sand intervals approximately 300 ft thick. Along this section, the aquifer ranges in thickness from approximately 500 ft in Bienville Parish to approximately 625 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 northwestern Ouachita Parish. Saltwater is present in well Ou-443 at an altitude of 682 ft below sea level (fig. 5), and the altitude of the saltwater interface increases along the section in the downdip direction.

Section C-C´ (fig. 6) extends from the outcrop area in south-central Bienville Parish to the downdip limit of freshwater in southeast Ouachita Parish (figs. 2 and 3). The Sparta aquifer ranges in thickness along this section from approximately 200 ft in the outcrop area of Bienville Parish to approximately 725 ft near the downdip limit of freshwater in Caldwell Parish (fig. 6).

Section D-D´ (fig. 7) extends south from northwestern Claiborne Parish to the outcrop area in south-central Bienville Parish (figs. 2 and 3). Thickness of the Sparta aquifer along this section ranges from approximately 170 ft in the outcrop area of Bienville Parish to approximately 570 ft in Claiborne Parish (fig. 7). The aquifer contains no saltwater along this section.

Section E-E´ (fig. 8) extends from northeastern Union Parish southward through Ouachita and Jackson Parishes to southeastern Winn Parish near the downdip limit of freshwater (figs. 2 and 3). The Sparta aquifer ranges in thickness from approximately 625 ft in Union Parish to more than 700 ft near the downdip limit of freshwater in Winn Parish. Saltwater is present at varying depths along much of section E-E´. Saltwater is present in wells Un-74B, Un-78, Ou-466 and Ja-78880 at depths of 408, 591, 660, and 684 ft below sea level, respectively. The altitude of saltwater increases from 575 ft below sea level at well W-172 to 425 ft below sea level at well W-144B.

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNIT

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 unit: milligrams per liter (mg/L)

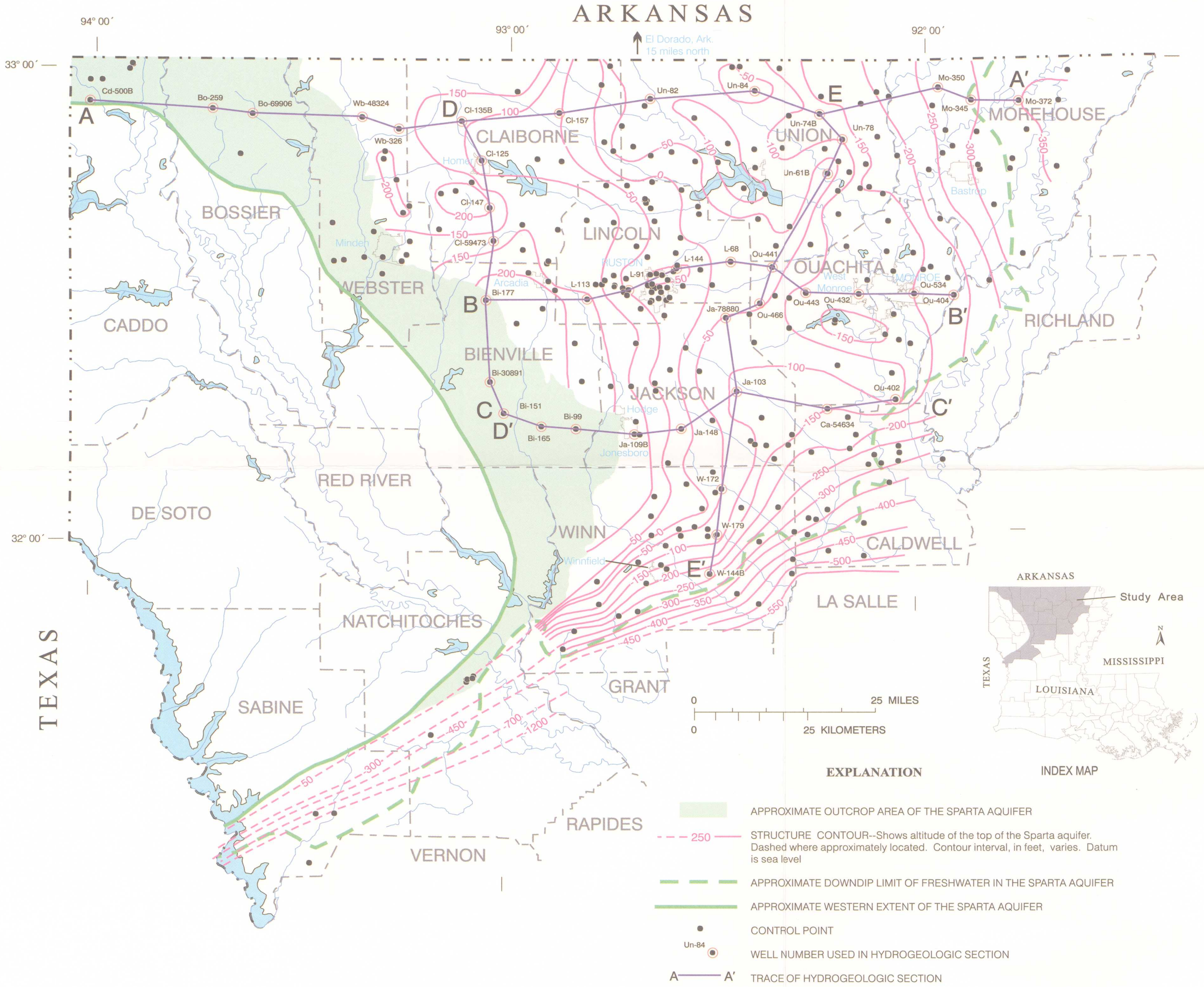

Figure 2. Altitude of the top of the Sparta aquifer in northern Louisiana.

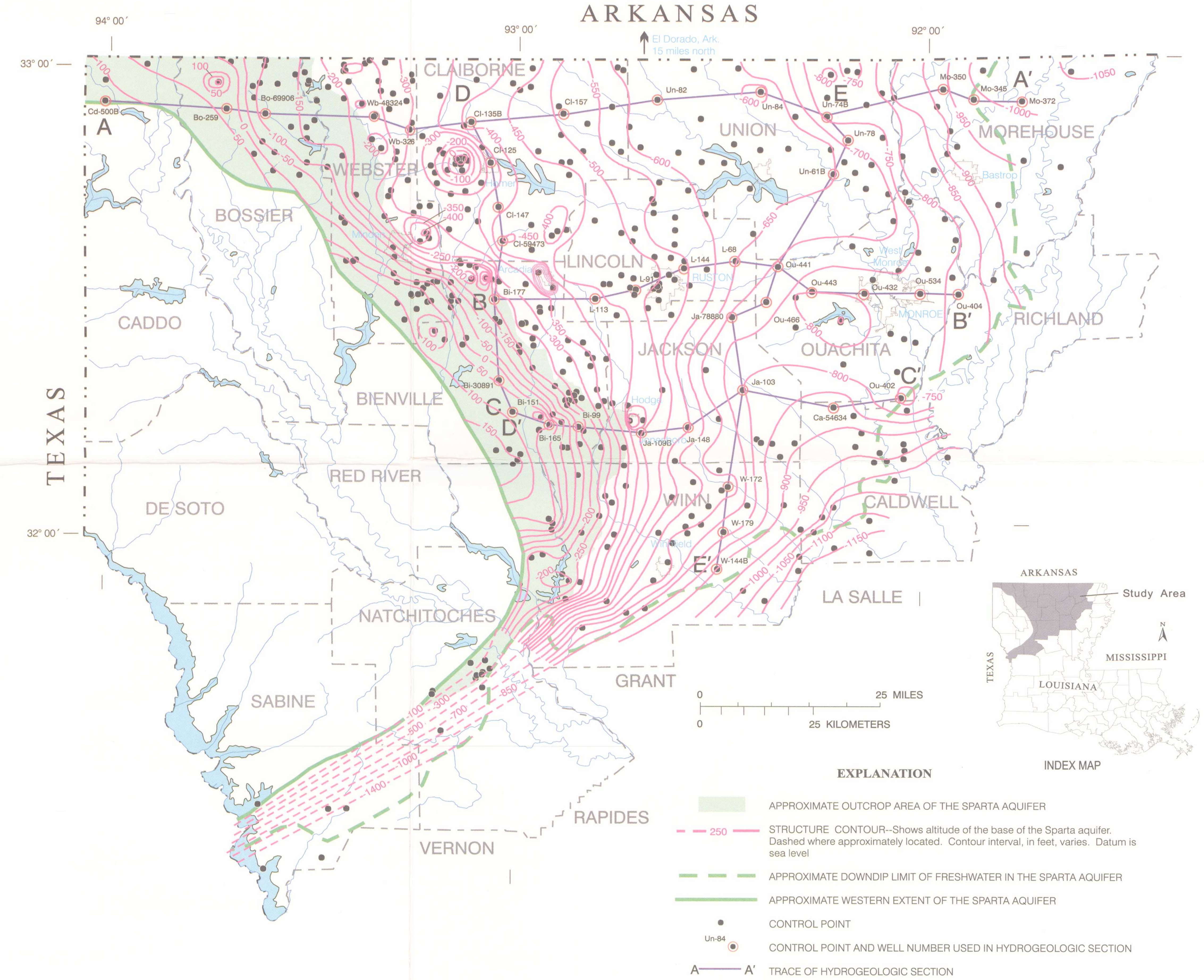

Figure 3. Altitude of the base of the Sparta aquifer in northern Louisiana.

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

Louisiana Ground-Water Map No. 13
Hydrogeology and Potentiometric Surface, October 1996, of the Sparta Aquifer in Northern Louisiana

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