INTRODUCTION

The Gulf Coast Regional Aquifer-System Analysis (Gulf Coast RASA) is a study of regional aquifers composed of sediments of mostly Cenozoic age that underlies about 230,000 mi^2 of the Gulf Coastal Plain in parts of Alabama, Arkansas, Florida, Illinois, Kentucky, Mississippi, Missouri, Tennessee, Texas, and all of Louisiana (fig. 1). The study also includes about 60,000 mi^2 of the Continental Shelf (Grubb, 1984). These regional aquifers, named the gulf coast aquifer systems, are part of three aquifer systems; the Mississippi embayment aquifer system, the Texas coastal uplands aquifer system, and the coastal lowlands aquifer system (fig. 2). The gulf coast aquifer systems have been divided into 10 water-yielding units based on geohydrologic and hydraulic factors (Weiss and Williamson, 1985; Pettijohn and others, 1988; Hosman and Weiss, 1991; Weiss, 1992).

The lower Wilcox aquifer is part of the Mississippi embayment aquifer system and its relation to overlying and underlying units is shown in figure 3. The lower Wilcox aquifer consists of a massive sand bed or a series of two or more thick sand beds separated by thin silt or clay beds. Sand content is greater than 80 percent throughout most of the northern part of the Mississippi embayment. Sand content generally decreases from northern Mississippi and adjacent Arkansas southward to less than 40 percent in parts of southeastern Louisiana, southern Mississippi, and southwestern Alabama (Hosman and Weiss, 1991). The aquifer averages about 300 ft thick and generally dips at about 6.5 ft/mi from the southern tip of Illinois along the Mississippi River to the Arkansas-Louisiana border. From the Arkansas-Louisiana border to the downdip limit of the aquifer the dip ranges from 42 to 50 ft/mi. Ground-water pumpage from the lower Wilcox aquifer was about 60 Mgal/d during 1985 (Mesko and others, 1990).

The Gulf Coast RASA is part of the U.S. Geological Survey's Regional Aquifer-System Analysis program. The program began in 1978 and is designed to provide an understanding and assessment of the Nation's ground-water resources on a regional basis (Bennett, 1979). A summary of progress in the RASA program through 1984 was given by Sun (1986), and progress on the Gulf Coast RASA was reported by Grubb (1987) and Williamson and others (1990).

Purpose and Scope

This report describes the water chemistry of the lower Wilcox aquifer. Maps in this report show the areal distribution of the concentration of dissolved solids, temperature, the primary water types, pH, and the concentrations of dissolved calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, and silica. Also included are five maps showing milliequivalent ratios of (1) magnesium to calcium, (2) magnesium plus calcium to bicarbonate, (3) magnesium plus calcium to sodium plus potassium, (4) bicarbonate to sulfate, and (5) bicarbonate to chloride. The maps of constituent ratios are included for comparing with the same constituent ratios commonly reported for seawater and for water used for specific purposes such as industry and public supply. The ratios also have been used to show trends that may indicate major controls on the chemistry of the ground water.

Compilation of Maps

The maps in this report are based primarily on data from the U.S. Geological Survey's National Water Data Storage and Retrieval System (WATSTORE) and data from the Texas Department of Water Resources (Pettijohn, 1988). The data were screened as explained by Pettijohn (1986) and values were posted on maps in each 100-square-mile area where data exist. The 100-square-mile areas are the same as those illustrated by Grubb (1987, p. 115) and used for simulation of ground-water flow by Williamson (1987) and Williamson and others (1990).

These maps show regional trends in chemical properties. The concentrations of dissolved solids and major ions, pH, and temperature vary with depth within the aquifer. Point values can be smaller or larger than the values shown on the map, depending on whether the point is at the top or bottom of the aquifer. Because there are clusters of sampling sites at some locations, the median value of a property or constituent in each 100-square-mile area was selected for constructing maps. The density of sampling sites in each 100-square-mile area is shown as an inset on each of the maps of the respective property or constituent. The number of sampling sites per interval is indicated on the bar graph included with each map. The number of 100-square-mile areas and a summary of median values for each constituent, property, and ratio are shown in table 1.

The maximum values in table 1 are usually larger than the maximum line of equal concentration shown on the corresponding maps. In some instances the maximum value in the table is much larger than the maximum line shown on the map because the value in the table is for only one 100-square-mile area and there are not enough data of equal magnitude to justify adding additional intervals.

The concentration of major ions and pH are based on median values of all samples within each 100-square-mile area. The dissolved-solids concentrations greater than 10,000 mg/L and temperature are based on depth-averaged values from geophysical well logs (Pettijohn and others, 1988). The water type was computed from the cation and anion that composed the largest percentage of milliequivalent per liter of the dissolved solids in a ground-water sample. Although water type was computed for each sampling site, only the most frequently observed water type (mode) in each 100-square-mile area is shown on the map. More detailed discussions of how the data were analyzed, processed, and mapped are given by Pettijohn (1986, 1988), Weiss (1987), and Pettijohn and others (1988).

Superimposed on selected maps are locations of geologic structures that are used as reference points in describing the chemistry of the ground water from east to west. Updip, middip, and downdip are used as references areas in describing the chemistry of the ground water from north to south. Updip areas include outcrop and subcrop areas; middip refers to areas about midway between the outcrop and the downdip limit of the data; and downdip refers to areas adjacent to the downdip limit of the data or the downdip limit of the aquifer. A map showing the location of salt domes and boundaries of salt dome basins (Beckman and Williamson, 1990) is included for the purpose of relating salt structures to constituent concentrations (fig. 4).

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

Multiply	By	To obtain
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.1894	meter per kilometer
mile (mi)	1.609	kilometer
million gallons per day (Mgal/d)	0.04381	cubic meters per second
square mile (mi^2)	2.590	square kilometer

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.

Chemical concentrations and water temperature are given in metric units. Chemical concentration is given in milligrams per liter (mg/L). Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F = 1.8\,(°C) + 32$$

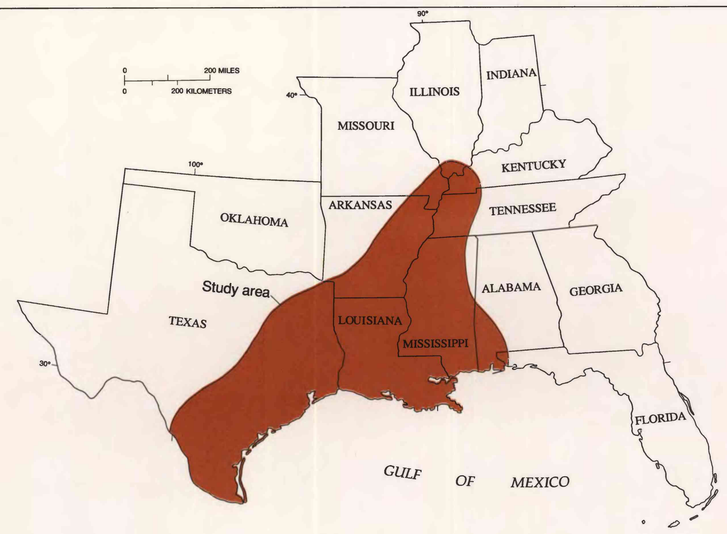

Figure 1.--Location of study area.

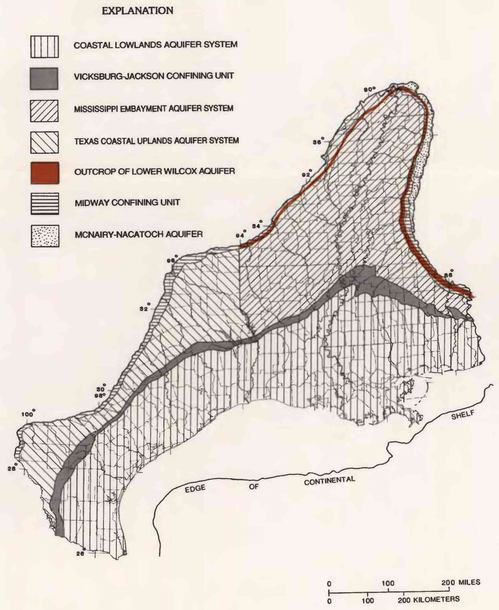

Figure 2.--Generalized outcrop of major aquifer systems and confining units in the Gulf Coast Regional Aquifer-System Analysis study area. Outcrop of the lower Wilcox aquifer superimposed.

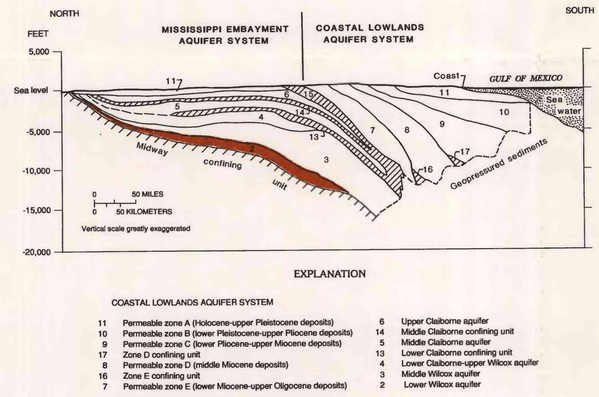

Figure 3.--Diagrammatic geohydrologic section through eastern part of study area.

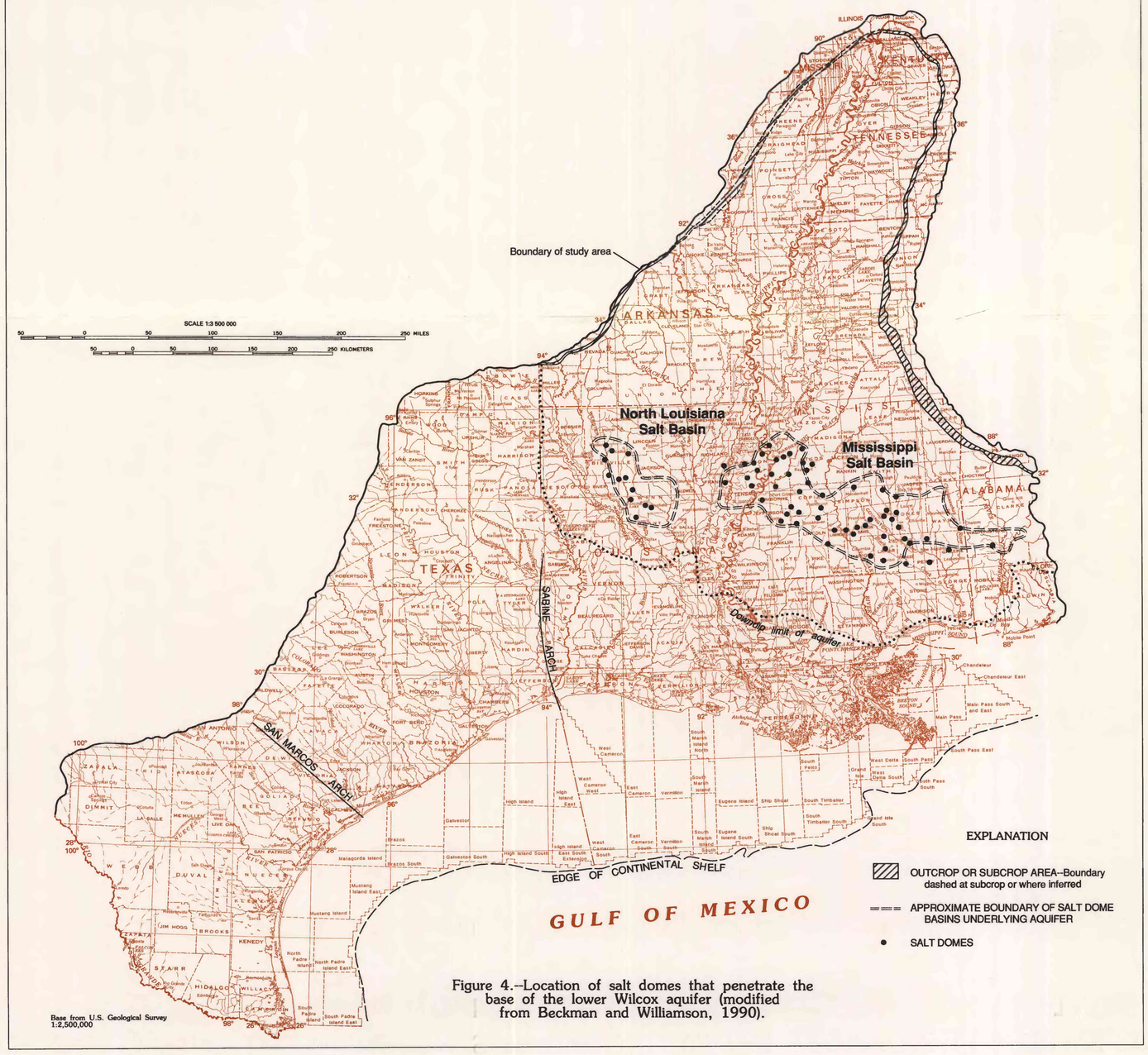

Figure 4.--Location of salt domes that penetrate the base of the lower Wilcox aquifer (modified from Beckman and Williamson, 1990).

SUMMARY AND CONCLUSIONS

The water chemistry of the lower Wilcox aquifer, which is part of the Mississippi embayment aquifer system, is presented by a series of maps. These maps show the areal distribution of (1) the concentration of dissolved solids and temperature, (2) the primary water types and pH, (3) the concentrations of major ions and silica, and (4) the milliequivalent ratios of selected ions. Dissolved constituents, pH, temperature, and ratios are based on the median values of all samples in each 100-square-mile area. Primary water type is based on the most frequently observed type (mode) in each 100-square-mile area.

The concentration of dissolved solids in water from the lower Wilcox aquifer, based on median values per each 100-square-mile area, ranges from 18 mg/L near the outcrop in western Tennessee to 122,000 mg/L in a downdip area in southern Mississippi. About one-third of the aquifer area has concentrations of dissolved solids that are less than 500 mg/L. The increase in concentration of dissolved solids in a downdip direction is attributed to mineral-water interaction such as dissolution of silicates in outcrop areas and the dissolution of evaporites comprising salt domes downdip in the deeper parts of the aquifer. The temperature, based on median values per each 100-square-mile area, ranges from 14 degrees Celsius in the outcrop area to 105 degrees Celsius in a downdip area of southern Louisiana. The primary water type is calcium bicarbonate in the outcrop area and sodium bicarbonate in all other areas of the aquifer within the limits of available data. The pH, based on median values per each 100-square-mile area, ranges from 4.5 in southwestern Arkansas to 9.3 in southwestern Alabama.

The concentrations of major ions in water from the lower Wilcox aquifer, based on median values of all samples in each 100-square-mile area, generally increase from the outcrop area to the downdip limit of the data in the southern part of the aquifer area east of the Mississippi River. The concentration of dissolved calcium ranges from 0.3 mg/L in eastern Arkansas to 1,500 mg/L in a downdip area in southern Mississippi. The concentration of dissolved magnesium ranges from 0.1 mg/L in central Mississippi to 620 mg/L in a downdip area near the southern border of Mississippi. The concentration of dissolved sodium ranges from about 2 mg/L in the outcrop area of western Tennessee and eastern Mississippi to 39,000 mg/L in a downdip near the southern border of Mississippi. The concentration of dissolved potassium ranges from 0.4 mg/L near the outcrop in western Kentucky and Tennessee to 360 mg/L in a downdip area in southern Mississippi. The concentration of dissolved bicarbonate ranges from 6 mg/L near the outcrop in western Tennessee to 714 mg/L near middip in northwestern Louisiana. The concentration of dissolved sulfate ranges from 0.1 mg/L in outcrop areas in western Tennessee and eastern Mississippi to 480 mg/L near the outcrop in southwestern Arkansas. The concentration of dissolved chloride ranges from 0.9 mg/L near the outcrop in northwestern Tennessee to 63,000 mg/L downdip in southern Mississippi. The concentration of silica in water of the lower Wilcox aquifer ranges from 1.6 mg/L in central Mississippi to 117 mg/L in southern Mississippi and the data exhibit no areal trend or pattern.

The milliequivalent ratio maps of selected ions in water from the lower Wilcox aquifer, constructed from the median milliequivalent ratio for each 100-square-mile area, indicate some areal trends. The milliequivalent ratio of magnesium to calcium ranges from 0.05 in central Mississippi to 5 in northwestern Tennessee and shows no areal trend. The milliequivalent ratio of magnesium plus calcium to bicarbonate ranges from less than 0.1 to 40.4 and decreases from outcrop to downdip limit of data in the southern part of the aquifer area east of the Mississippi River. The milliequivalent ratio of magnesium plus calcium to sodium plus potassium ranges from less than 0.01 to 7, decreases in a southerly direction in the northern part of the aquifer area and generally decreases from the outcrop to the downdip limit of the data in the southern part east of the Mississippi River. The milliequivalent ratio of bicarbonate to sulfate ranges from 0.20 to 1,740, increases in a southerly direction in the northern part of the aquifer area east of the Mississippi River, and increases from outcrop to downdip limit of the data in the southern part east of the Mississippi River. The milliequivalent ratio of bicarbonate to chloride ranges from less than 0.01 in southern Mississippi to 52.3 in northwestern Mississippi. This ratio increases from the outcrop toward the Mississippi River and from north to south in the northern part of the aquifer area east of the Mississippi River whereas the ratio increases from outcrop to middip and decreases from middip to downdip limit of the data in the southern part east of the Mississippi River.

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TABLE 1.--*Summary of median values in 100-square-mile areas for selected properties and chemical constituents in ground water from the lower Wilcox aquifer*

[All dissolved ion concentrations are in milligrams per liter. All dissolved ion concentrations used to calculate ratios, for example Ca:Mg, are in milliequivalents per liter. Temperatures are in degrees Celsius. pH is in standard units. Chemical symbols: Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; HCO_3, bicarbonate; SO_4, sulfate; Cl, chloride; <, less than]

Property or constituent	Statistics for median values of 100-square-mile areas: Median	Minimum	Maximum	Number of 100-square-mile areas
pH	7.7	4.5	9.3	128
Temperature	32.2	14.0	105	385
Dissolved-solids	13,600	18.0	122,000	247
Calcium	3.2	0.3	1,500	122
Magnesium	1.0	0.1	620	115
Sodium	53	2.0	39,000	120
Potassium	1.7	0.4	360	108
Bicarbonate	150	6.0	714	123
Sulfate	2.8	0.1	480	118
Chloride	9.0	0.9	63,000	137
Silica	13.0	1.6	117	108
Ratio Mg:Ca	0.43	0.05	5.0	115
Ratio Mg+Ca:HCO_3	0.13	<0.01	40.4	104
Ratio Mg+Ca:Na+K	0.10	<0.01	7.0	101
Ratio HCO_3:SO_4	28.1	0.20	1,740	106
Ratio HCO_3:Cl	6.3	<0.01	52.3	122

PROPERTIES AND CHEMICAL CONSTITUENTS IN GROUND WATER FROM THE LOWER WILCOX AQUIFER, MISSISSIPPI EMBAYMENT AQUIFER SYSTEM, SOUTH-CENTRAL UNITED STATES

by

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