

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 underlie about 230,000 mi² 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 mi² of the Continental Shelf (Grubb, 1986). 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 geologic and hydraulic factors (Weiss and Williamson, 1985; Pettijohn and others, 1988; Hosman and Weiss, 1991; Weiss, 1990).

The Mississippi River Valley alluvial aquifer, herein referred to as the alluvial aquifer, is part of the Mississippi embayment aquifer system and is composed mostly of Holocene age deposits. The deposits commonly grade downward from fine sand, silt, and clay at the top to coarse sand or gravel at the base (Hosman and Weiss, 1991). The alluvial aquifer has an average thickness of about 100 ft and a maximum thickness of about 140 ft (Ackerman, 1989). About 4,800 Mgal/d was withdrawn from this aquifer during 1985 (Meeko and others, 1990). Permeable zone A, a part of the coastal lowlands aquifer system and is composed mostly of Holocene and upper Pleistocene deposits. The deposits consist of interbedded clays, silts, and sands. Maximum sand percentages of greater than 60 to 80 percent occur at the updip limit of permeable zone A and extend downdip in a lobate pattern. Near the downdip limit of the permeable zone sand percentage generally decreases to less than 20 percent. Permeable zone A has an average thickness of about 700 ft and a maximum thickness of slightly more than 1,200 ft (Weiss, 1990). About 1,600 Mgal/d was withdrawn from permeable zone A during 1985 (Meeko and others, 1990). Both the alluvial aquifer and permeable zone A are at the top of the gulf coast aquifer system in their respective areas. The relation of permeable zone A to underlying units is shown in figure 3. The land-surface slope along the Mississippi River from southern Illinois to the Gulf of Mexico averages 0.54 ft/mi. The land-surface slope in the outcrop area of permeable zone A from its updip limit to the Gulf of Mexico, averages about 2.5 ft/mi in areas both east and west of the Mississippi River.

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 Mississippi River Valley alluvial aquifer and permeable zone A (Holocene-upper Pleistocene deposits). Maps in the 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 silice. Also included are five maps showing the milliequivalent ratio 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 sea water and for water used for specific purposes such as industry and public supply. The ratios have also 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 water-quality file of the WATSTORE system 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 area is 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, major ions, pH, and temperature vary with depth within the aquifer or permeable zone. 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 or permeable zone. Also there are clusters of sampling sites at some locations. Therefore 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 are shown on the bar graph attached to 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 value of equal concentration shown on the corresponding maps. In some instances the maximum value in the table is much larger than the maximum value shown on the map because the value in the table is for only one 100-square-mile area and there is not enough data of equal magnitude to justify adding additional intervals.

The major ions concentrations 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 the 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).

A map showing the location of salt domes (Beckman and Williamson, 1990) and boundary of salt dome basins (fig. 4) is included for the purpose of relating salt structures to constituent concentrations. Also 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. Whereas updip, mid-dip, and downdip are used as reference areas in describing the chemistry of the ground water from north to south. Updip areas include the areas adjacent to the updip limit of permeable zone A; mid-dip refers to areas about midway between the updip limit and the downdip limit of permeable zone A; and downdip refers to areas adjacent to the downdip limit of data or the downdip limit of permeable zone A.

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

Multiply	By	To obtain
Foot (ft)	0.3048	meter
Foot per mile (ft/mi)	0.1609	meter per kilometer
mile (mi)	1.609	kilometer
million gallons per day (MGD/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 level 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:

$$^{\circ}\text{F} = 1.8(^{\circ}\text{C}) + 32$$

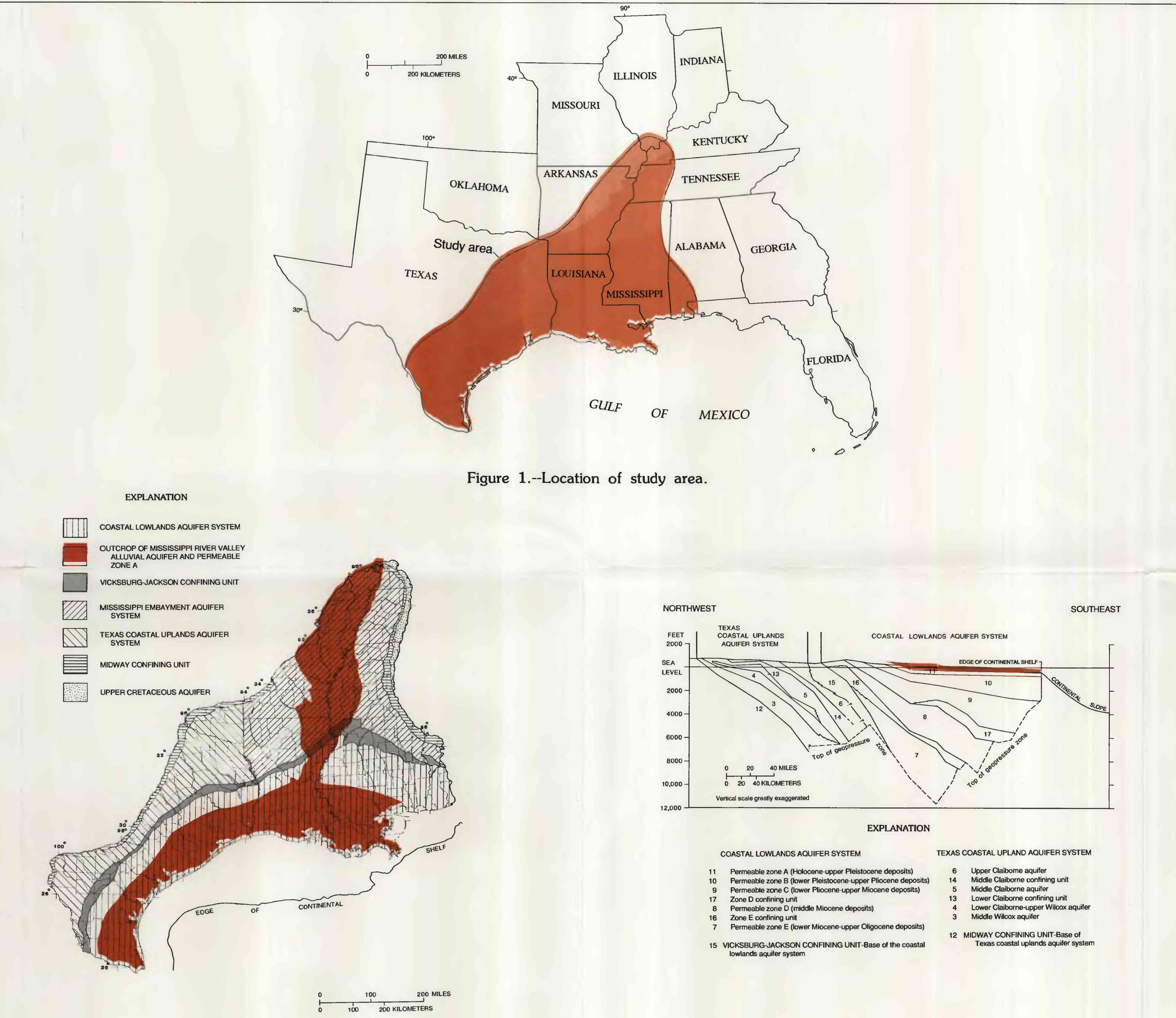


Figure 1.—Location of study area.

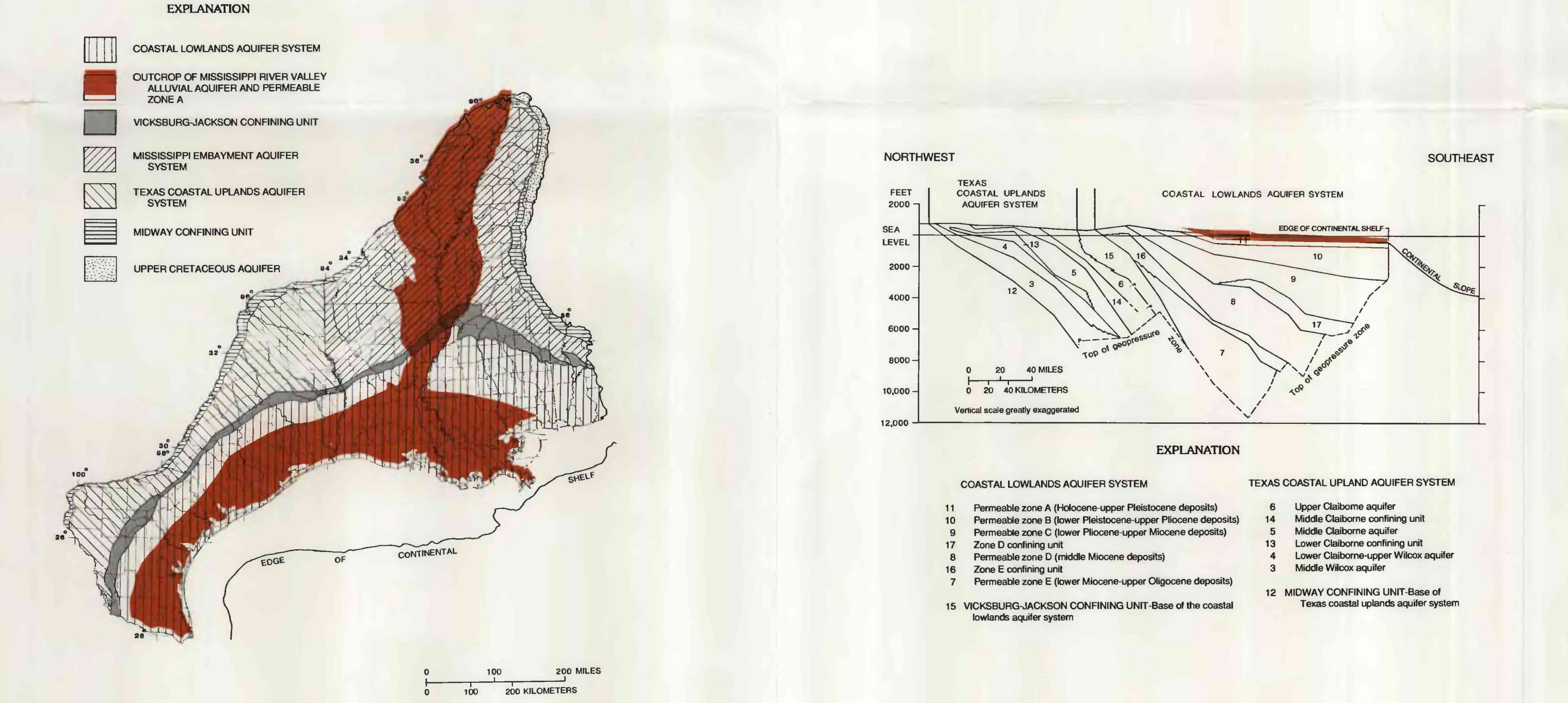


Figure 2.—Generalized outcrop of major aquifer systems and confining units in the Gulf Coast Regional Aquifer-Systems study area. Outcrop of the Mississippi River Valley alluvial aquifer and permeable zone A (Holocene-upper Pleistocene deposits) superimposed.

Figure 3.—Diagrammatic geohydrologic section through southwest part of study area.

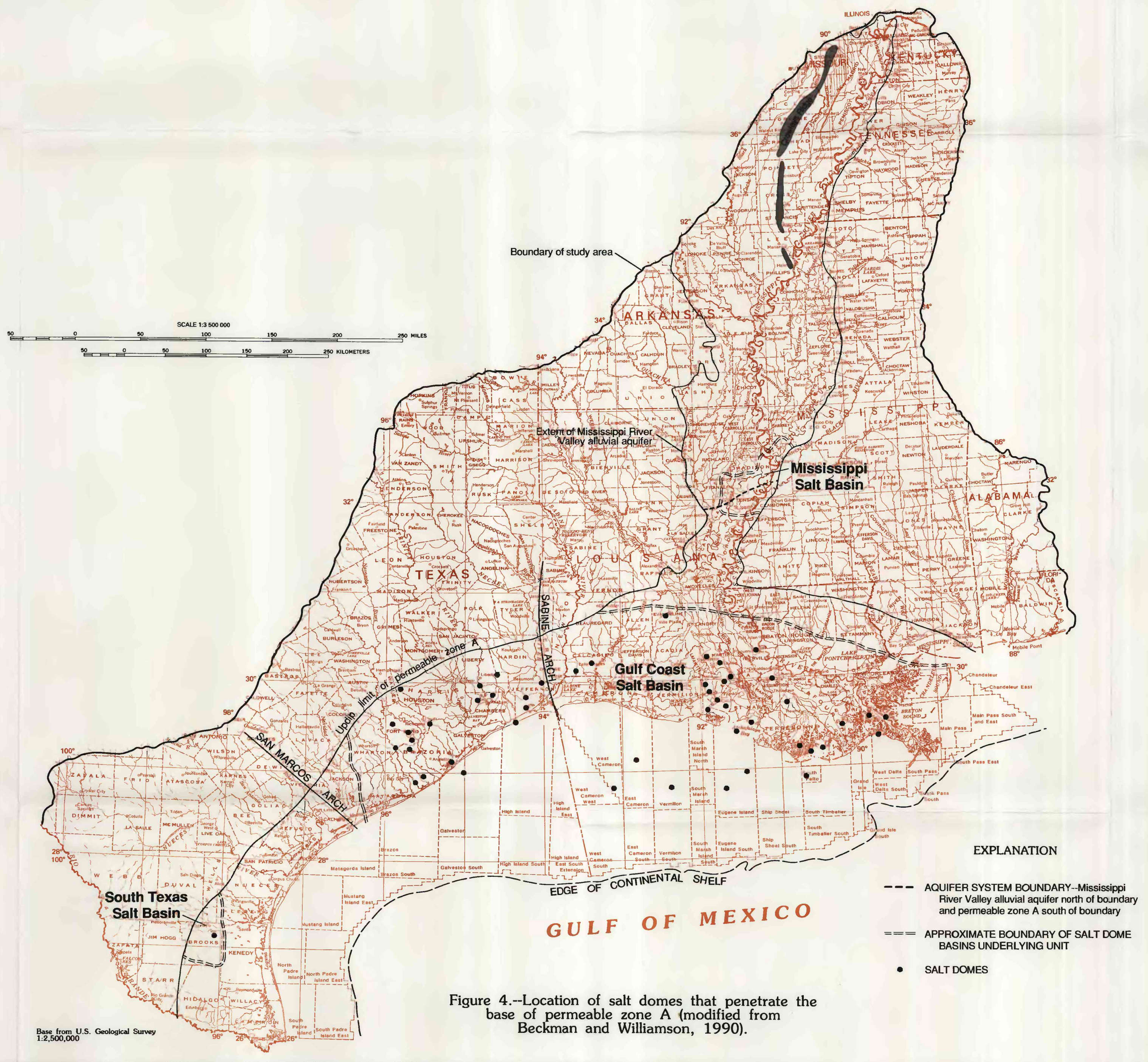


Figure 4.—Location of salt domes that penetrate the base of permeable zone A (modified from Beckman and Williamson, 1990).

SUMMARY AND CONCLUSIONS

The water chemistry of the Mississippi River Valley alluvial aquifer and permeable zone A (Holocene-upper Pleistocene deposits), which is part of both the Mississippi embayment aquifer system and the coastal lowlands aquifer system, is presented in 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.

The concentration of dissolved solids ranges from 203 to 3,000 mg/L in the alluvial aquifer, from less than 500 to 10,000 mg/L in permeable zone A from the updip limit to the coastline and 10,000 to 59,500 mg/L on the Continental Shelf. The increase in concentration of dissolved solids in the alluvial aquifer and in the updip area of permeable zone A is attributed to mineral-water interaction along flow paths. Whereas from mid-dip to the deeper part of permeable zone A the large increase in concentration is attributed to the presence of saline water from the dissolution of evaporites comprising salt domes. Temperature increases in a downdip direction from 11.2 degrees Celsius in the alluvial aquifer to 33.4 degrees Celsius in permeable zone A on the Continental Shelf.

The primary water type in the alluvial aquifer is calcium bicarbonate, in permeable zone A the primary water type is sodium bicarbonate in the area east of the San Marcos arch and sodium chloride in the area southwest of the San Marcos arch. The pH of water ranges from 5.1 to 7.0 along the boundary of the alluvial aquifer and the updip limit of permeable zone A and 8.0 to 9.0 in the central part of the alluvial aquifer and the downdip part of permeable zone A.

The concentration of each of the major ions is generally larger in water from permeable zone A than from the alluvial aquifer. The concentration of dissolved calcium ranges from about 10 to 200 mg/L in the alluvial aquifer and in permeable zone A east of the San Marcos arch. Southwest of the San Marcos arch the concentration of dissolved calcium ranges from about 50 to 900 mg/L. The concentration of dissolved magnesium generally ranges from 10 to 50 mg/L in the alluvial aquifer. In permeable zone A the concentration generally ranges from 10 to 100 mg/L in the area east of the San Marcos arch and 20 to 1,200 mg/L in the area southwest of the San Marcos arch. The concentration of dissolved sodium generally ranges from 10 to 100 mg/L in the alluvial aquifer and from 10 to 1,800 mg/L in permeable zone A. The concentration of dissolved potassium ranges from 1 to 20 mg/L in the alluvial aquifer and from 1 to more than 20 mg/L in permeable zone A. The concentration of dissolved bicarbonate generally ranges from 100 to 500 mg/L in the alluvial aquifer and from 20 to 800 mg/L in permeable zone A. The concentration of dissolved sulfate generally ranges from 5 to 100 mg/L in the alluvial aquifer and in permeable zone A east of the San Marcos arch. Southwest of the San Marcos arch the sulfate concentration ranges from 50 to 5,000 mg/L in permeable zone A. The concentration of dissolved chloride ranges from 10 to 500 mg/L in the alluvial aquifer and permeable zone A except in southeastern Louisiana and southwestern Texas where the concentration reaches 10,000 mg/L in permeable zone A. The concentration of silica generally ranges from 20 to 40 mg/L in the alluvial aquifer and from 20 to 50 mg/L in permeable zone A.

The milliequivalent ratio maps of constituents in water from the alluvial aquifer and permeable zone A show areal distributions and any trends in ratios from updip to the downdip limit of the data. The milliequivalent ratio of magnesium to calcium (Mg/Ca) ranges from 0.25 to 0.75 in the alluvial aquifer and has no trend. In permeable zone A the Mg/Ca ratio ranges from 0.50 to 2 and generally increases in a downdip direction between the Sabine arch and the San Marcos arch and decreases in a downdip direction between the San Marcos arch and the Rio Grande. The milliequivalent ratio of magnesium plus calcium to bicarbonate (Mg+Ca/HCO₃) is near 1 in the alluvial aquifer and shows no trend. In permeable zone A the Mg+Ca/HCO₃ ratio ranges from 0.10 to 1.00 and tends to decrease from updip to downdip between the Sabine arch and the San Marcos arch. Whereas between the San Marcos arch and the Rio Grande the ratio decreases from updip to mid-dip and increases from mid-dip to the downdip limit of the data. The milliequivalent ratio of magnesium plus calcium to sodium plus potassium (Mg+Ca/Na+K) generally ranges from 0.5 to 2.0 in the alluvial aquifer and decreases from north to south. The Mg+Ca/Na+K ratio in permeable zone A generally ranges from 0.10 to 2 and generally decreases from updip to the downdip limit of the data.

The milliequivalent ratio of bicarbonate to sulfate (HCO₃/SO₄) generally ranges from 10 to 1,000 in the alluvial aquifer with the largest ratios occurring along the eastern boundary of the aquifer. The HCO₃/SO₄ ratio in permeable zone A ranges from 0.10 to more than 1,000. The ratio appears to be larger east of the Sabine arch and near the downdip limit of the data. The milliequivalent ratio of bicarbonate to chloride (HCO₃/Cl) generally ranges from about 5 to 10 along the western boundary of the alluvial aquifer and 50 to 100 along the eastern boundary. East of the Sabine arch in permeable zone A the HCO₃/Cl ratio generally ranges from 0.10 to 10. The ratio generally increases from west to east and from updip to mid-dip and decreases from mid-dip to downdip. West of the Sabine arch the HCO₃/Cl ratio generally ranges from 0.1 to 5 and shows no trend or pattern.

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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 Mississippi River Valley alluvial aquifer and permeable zone A (Holocene-upper Pleistocene deposits)

[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; HCO₃, bicarbonate; SO₄, sulfate; Cl, chloride; <, less than]

Property or constituent	Statistics for median values of 100-square-mile areas			Number of 100-square-mile areas
	Median	Minimum	Maximum	
pH	7.4	5.1	9.0	645
Temperature	21.0	11.2	33.4	739
Dissolved-solids	414	20.3	59,500	665
Calcium	54	0.9	900	614
Magnesium	16.2	0.3	1,200	614
Sodium	36.0	2.0	4,200	618
Potassium	2.1	0.2	220	524
Bicarbonate	312	5.5	871	651
Sulfate	8.1	0.1	7,700	642
Chloride	33.5	0.5	18,600	699
Silica	29	4.9	82.0	548
Ratio Mg:Ca	0.54	0.02	5.2	614
Ratio Mg:Ca:HCO ₃	0.94	0.03	365	597
Ratio Mg:Ca:Na+K	2.2	0.02	76.4	517
Ratio HCO ₃ :SO ₄	21.5	<0.01	5,610	624
Ratio HCO ₃ :Cl	3.5	<0.01	299	649

PROPERTIES AND CHEMICAL CONSTITUENTS IN GROUND WATER FROM THE MISSISSIPPI RIVER VALLEY ALLUVIAL AQUIFER AND PERMEABLE ZONE A (HOLOCENE-UPPER PLEISTOCENE DEPOSITS), SOUTH-CENTRAL UNITED STATES.

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