DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Prepared in cooperation with the
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

WATER-RESOURCES INVESTIGATIONS
REPORT 83-4041

INTRODUCTION

The Floridan aquifer underlies all of the Southwest Florida Water Management District and is the principal source of freshwater in most of the District. The quality of water in the Floridan aquifer is variable. This report shows the distribution of some of the chemical constituents of water in the Floridan aquifer. The study is part of a continuing cooperative program with the Southwest Florida Water Management District to define and describe characteristics of the aquifer. Aquifer characteristics determined from the study will provide data necessary for regulatory agencies to more efficiently manage water supply and development. The study area includes 10 counties and parts of 6 other counties within the District.

Water-quality data used to construct the maps are from the files of the U.S. Geological Survey. The amount of available data varied with each selected chemical constituent and ranged from 150 analyses for sulfate to 236 analyses for hardness. Most water analyses were made between 1959 and 1980; one analysis used was made in 1949.

The Floridan aquifer consists of limestone and dolomite and includes the following formations (from oldest to youngest): Avon Park Limestone, Ocala Limestone, Suwannee Limestone, Tampa Limestone, and parts of the Hawthorne Formation. The age of these deposits ranges from middle Eocene to middle Miocene. The Floridan aquifer generally dips southwestward and becomes thicker from the northeast to the southwest (Wilson, 1982).

In the Southwest Florida Water Management District, ground-water flow in the Floridan aquifer is generally to the southwest and west (Wilson, 1982). Local variations to this pattern are caused by variable aquifer transmissivity and by areal distribution of several large and numerous small recharge areas from which rainwater percolates to the aquifer (Stewart, 1980).

There is considerable vertical and areal variation in the chemical character of ground water in the Floridan aquifer. Mineral content generally increases with depth in the aquifer, with distance from the recharge area, and with proximity to coastal margins. There are several causes for these variations: (1) water has been in contact with rock formations longer than upgradient or surficial-aquifer water, and the longer the water is in contact with soluble minerals in the aquifer, the more mineralized the water becomes; (2) saline or connate water (water that was trapped in rocks when they were formed) leaks upward into the aquifer; and (3) along the coast, saltwater mixes with fresh ground water (Causseaux and Fretwell, 1982). Also, downward leakage of water through locally phosphate-rich sediments may contribute to variation of mineral content of ground water.

The generalized maps show concentrations of dissolved solids, chlorides, sulfates, and hardness in water from wells open to the Floridan aquifer. Most analyses were from wells open to the highly permeable dolomite zone in the lower part of the Floridan aquifer described by Wolansky and others (1980). Analyses were selected in such a way that an average of the general chemical characteristics was obtained. However, due to variability in the quality of water in the aquifer, wells at different depths and short distances apart can produce water with quite different chemical characteristics. Most selected analyses represent a blend of water from different zones within the Floridan aquifer (Hickey, 1980). Selection of these constituents was based on availability of analytical data and usefulness of the data for comparison with established water-quality standards.

Areal distribution of concentrations of dissolved solids, chlorides, sulfates, and total hardness of the Floridan aquifer is shown on figures 1, 2, 3, and 4, respectively. Figure 1 also shows areal variation in concentrations of selected chemical constituents at selected wells by means of Stiff diagrams. The values shown represent the quality of water from the entire sequence of rocks that comprise the Floridan aquifer. The results, therefore, differ from those shown by Shampine (1975a; 1975b; 1975c; 1975d) for the upper part of the Floridan aquifer.

AREAL VARIATION OF IONIC CONCENTRATIONS

Water types can be shown graphically with Stiff diagrams (Hem, 1970). Concentrations (in milliequivalents per liter) of eight ions are used to make the Stiff diagrams. The shape of the diagram shows the changes in ionic concentration from one type of water to another.

Figure 1 presents Stiff diagrams for six water samples collected in a north to south direction in the Southwest Florida Water Management District. A change is evident from north to south from a predominantly calcium bicarbonate water type to a calcium magnesium sulfate type and then to a sodium chloride type.

The units, milliequivalents per liter, that are used in the Stiff diagrams are a measure of the amount of charge from ions dissolved in water. For example, when calcium sulfate is dissolved in pure water, the positive charge from calcium ions equals the negative charge from sulfate ions. Similarly, in natural waters, the sum of all positive charges (cations) equals the sum of all negative charges (anions). Concentration of an ion in milliequivalents per liter can be calculated by multiplying concentration of the ion in milligrams per liter by charge on the ion and dividing by atomic (or formula) weight.

Causseaux and Fretwell (1982) found that the 250-mg/L line of equal chloride concentration in the upper part of the Floridan aquifer is less than 3 miles inland from the coast in most of the District. The 250-mg/L line represents a point within the zone of transition. In southern Sarasota County, the 250-mg/L line turns inland and extends eastward through Charlotte and De Soto Counties.

DISSOLVED SOLIDS

Dissolved solids in water are mainly bicarbonate, sulfate, chloride, calcium, sodium, magnesium, and potassium ions. Iron, carbonate, fluoride, phosphate, nitrate, strontium, magnesium, and sulfide ions usually comprise less than 1 percent of dissolved solids, but occasionally may be found in greater amounts. Water containing less than 250 milligrams per liter (mg/L) dissolved solids occurs throughout much of the north-central part of the Southwest Florida Water Management District (fig. 1). In the southern part and along most of the coast, dissolved-solids concentrations in water exceed 1,000 mg/L and in some areas are as much as 38,000 mg/L. The recommended maximum dissolved-solids concentration for drinking water is 500 mg/L (U.S. Environmental Protection Agency, 1977, p. 17144).

Rainwater, which is initially low in dissolved solids, dissolves some material from the atmosphere and land surface (Shampine, 1975c). As it percolates through the ground to the aquifer, dissolved-solids concentrations increase. Processes that can alter areal distribution of dissolved-solids concentration in ground water are: (1) dissolution of limestone, which increases calcium and bicarbonate ions; (2) dissolution of gypsum, which increases calcium and sulfate ions; (3) exchange of sodium for calcium (natural water softening), which causes water to shift toward a sodium bicarbonate type; and (4) mixing with saline waters, which increases sodium and chloride (Shampine, 1975c).

CHLORIDE

In a map report that shows chloride concentrations in water from the upper part of the Floridan aquifer, Shampine (1975a) states "chloride occurs in almost all natural water. Some chloride is contained in rainwater and some is dissolved from surface materials. The amount of chloride contributed to the water from these sources will normally be small. After water enters the ground, however, chloride concentration is generally increased. This increase may result from solution of rocks and minerals through which the water percolates, mixing with connate water, *** encroachment of saltwater from the ocean, or by pollution."

Chloride concentrations in water in the Floridan aquifer vary widely in the District. Chloride concentrations of 10 to 25 mg/L occur in most inland areas. Water that is unmixed with saltwater (also called "background water") has chloride concentrations in this range. In coastal areas, the Floridan aquifer may contain water with chloride concentrations greater than 19,000 mg/L. The saltwater and background water are divided by a zone of transition (Wilson, 1982).

The recommended maximum chloride concentration for drinking water is 250 mg/L (U.S. Environmental Protection Agency, 1977, p. 17144). McKee and Wolf (1963, p. 161) suggest the following maximum concentrations of chloride, in parts per million (here converted to milligrams per liter), for the specified use:

Domestic water supply	250 mg/L
Industrial water supply	50 mg/L*
Irrigation	100 mg/L
Stock and wildlife	1,500 mg/L

*May vary with industry.

SULFATE

Sulfate concentrations in the Southwest Florida Water Management District range from zero in the northern and eastern parts to as much as 3,100 mg/L in the west-central part of Pinellas County (fig.3). In the northeastern part of the District, the Floridan aquifer contains water with sulfate concentrations of less than 5 mg/L. Sulfate concentration tends to be higher in deeper zones of the aquifer.

The source of sulfate in rainwater is principally: (1) decomposition of organic matter, (2) gases produced by burning the impurities in bituminous coal, (3) burning and refining of petroleum, and (4) pollution created by use of sulfate compounds by industries. In ground water, sulfate increases in concentration by leaching gypsum and other sulfate minerals and by mixing with saltwater. The recommended maximum sulfate concentration in drinking water is 250 mg/L (U.S. Environmental Protection Agency, 1977, p. 17144).

TOTAL HARDNESS

Total hardness is generally determined by the summation of calcium and magnesium concentrations, in milliequivalents per liter, expressed as calcium carbonate. Strontium and barium may also contribute to total hardness. There are two types of hardness: carbonate and noncarbonate (Sawyer and McCarty, 1978). Carbonate hardness is that portion of hardness equal to alkalinity (sum of carbonate and bicarbonate ions, in milliequivalents per liter). Hardness in excess of alkalinity is called noncarbonate hardness, It is more costly for water-treatment plants to reduce noncarbonate hardness than carbonate hardness. The most common problems associated with water hardness are excessive soap consumption and scale buildup in boilers.

In the Southwest Florida Water Management District, total hardness is mostly carbonate hardness. In most of the District, noncarbonate hardness is less than half the carbonate hardness except in the south.

In the northeastern part of the District, the Floridan aquifer contains water with total hardness concentrations of less than 120 mg/L. Dissolution of minerals in the water in the southern part of the District and upward seepage of saltwater toward the coast are the main reasons for water with a high total hardness in the part of the District that includes most of Hillsborough, Manatee, and Hardee Counties and all of Sarasota, De Soto, and Charlotte Counties (fig. 4). The U.S. Geological Survey uses the following classifications for total hardness (Shampine, 1975b):

Soft.—Water with total hardness of less than 60 mg/L; rarely requires treatment.

Moderately soft.—Water with total hardness ranging between 60 and 120 mg/L; may require some treatment by laundries and allied industries; treatment is not necessary for domestic use.

Hard.—Water with total hardness ranging between 120 and 180 mg/L; unsuitable for many industrial purposes and treatment is recommended for industrial and domestic use.

Very hard.—Water with total hardness of more than 180 mg/L; inadequate for most industrial use and unsuitable without treatment for domestic use.

SUMMARY

Ground-water flow in the Floridan aquifer within the Southwest Florida Water Management District is generally to the southwest and west. Mineralization of ground water increases in the same direction and with depth. Along the coast, mineralization of ground water is greater than in inland areas because of saltwater intrusion and solution of rocks and minerals. In the northwest and throughout the central part of the District, the concentration of dissolved solids in water is less than 250 mg/L. However, in the south and along the coast, the concentration of dissolved solids exceed 1,000 mg/L and in some areas is more than 38,000 mg/L.

In the Southwest Florida Water Management District, water in the Floridan aquifer contains increasingly high chloride concentrations (concentrations of more than 250 mg/L and sometimes as much as 19,000 mg/L) toward the southwest and along the coast. Chloride concentrations in the aquifer are 250 mg/L or less in the remainder of the District.

In the northeastern part of the District, the Floridan aquifer contains water with sulfate concentrations of less than 5 mg/L. However, in the southwest and along the coast, sulfate concentrations generally exceed 500 mg/L.

Similarly, in the northeastern part of the study area, the Floridan aquifer contains water with total hardness concentrations of less than 180 mg/L. Total hardness concentrations are greater toward the coast (because of mixing with saltwater) and in the southern part (because of dissolution of minerals in the aquifer).

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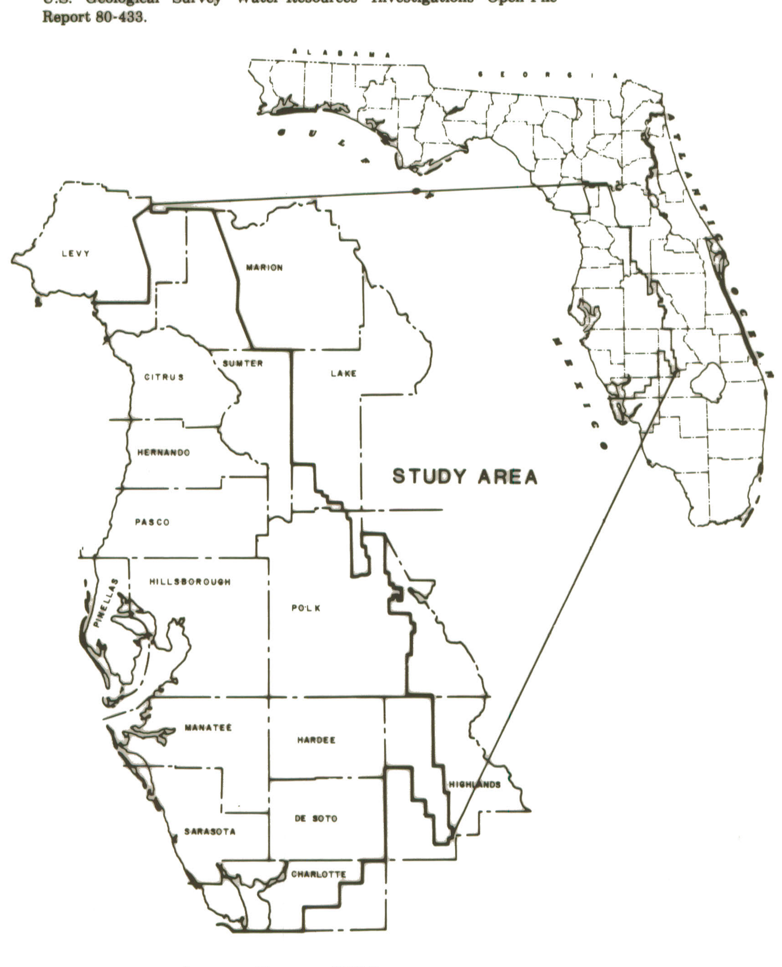

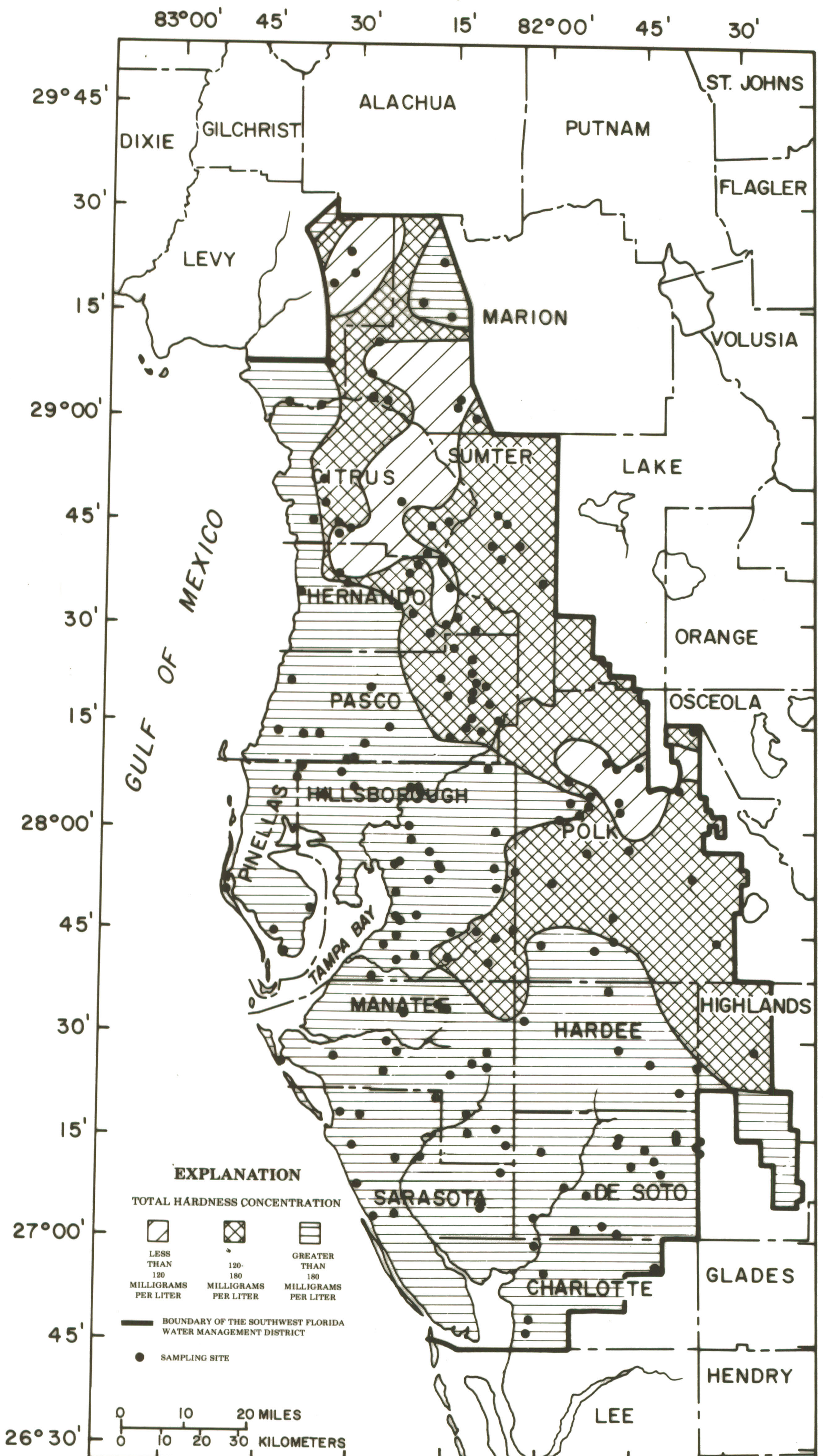

Figure 4.-- Total hardness concentrations.

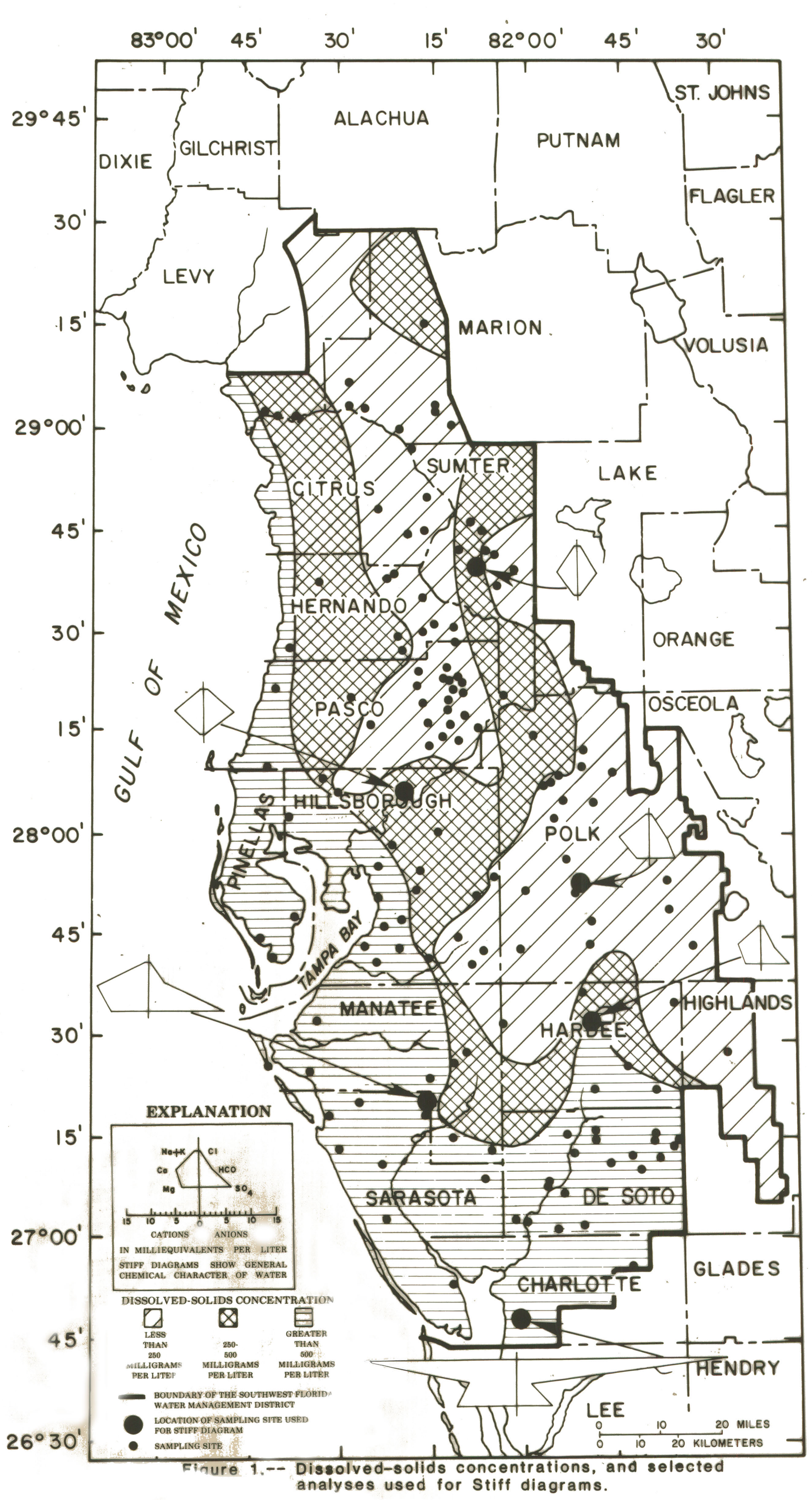

Figure 1.-- Dissolved-solids concentrations, and selected analyses used for Stiff diagrams.

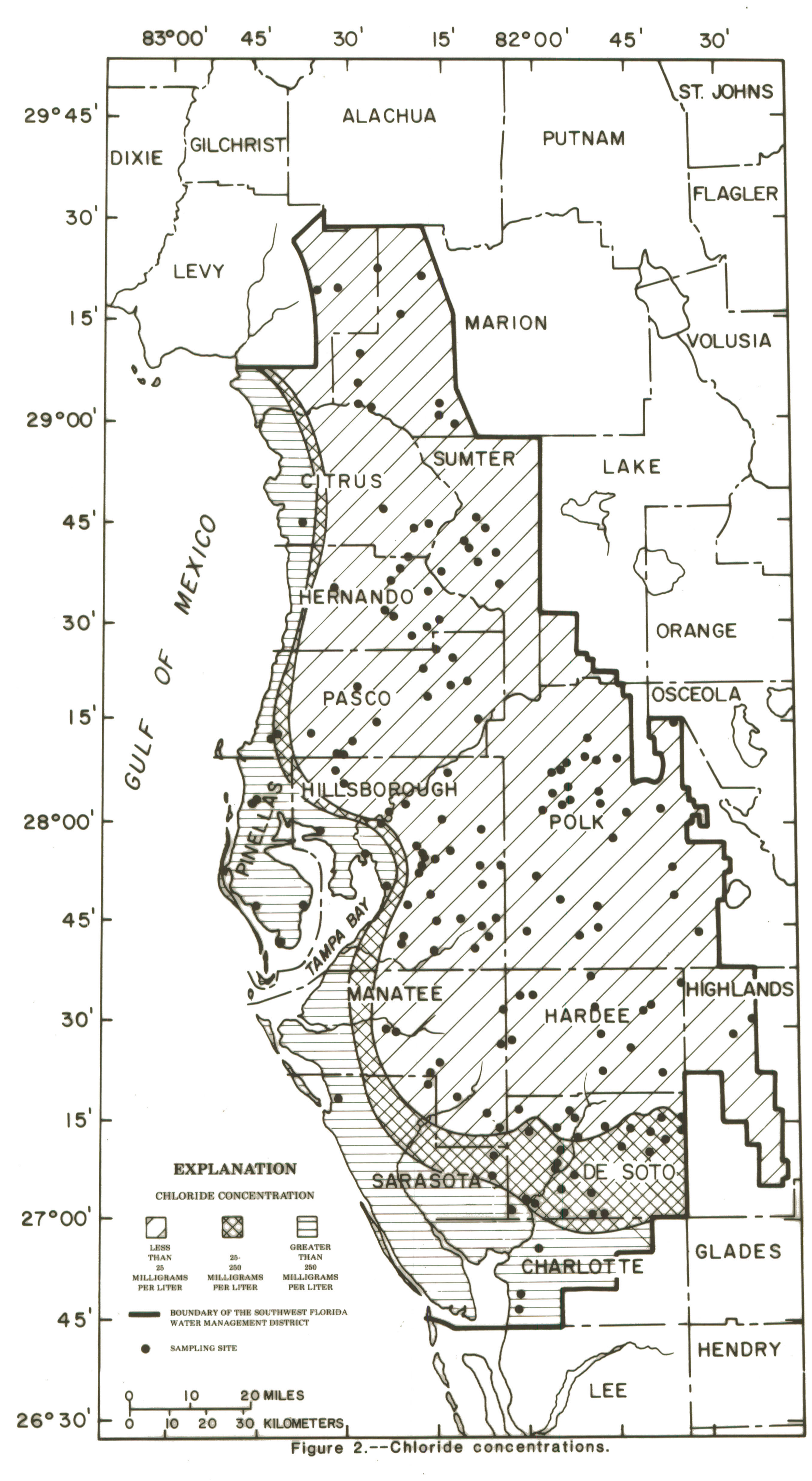

Figure 2.--Chloride concentrations.

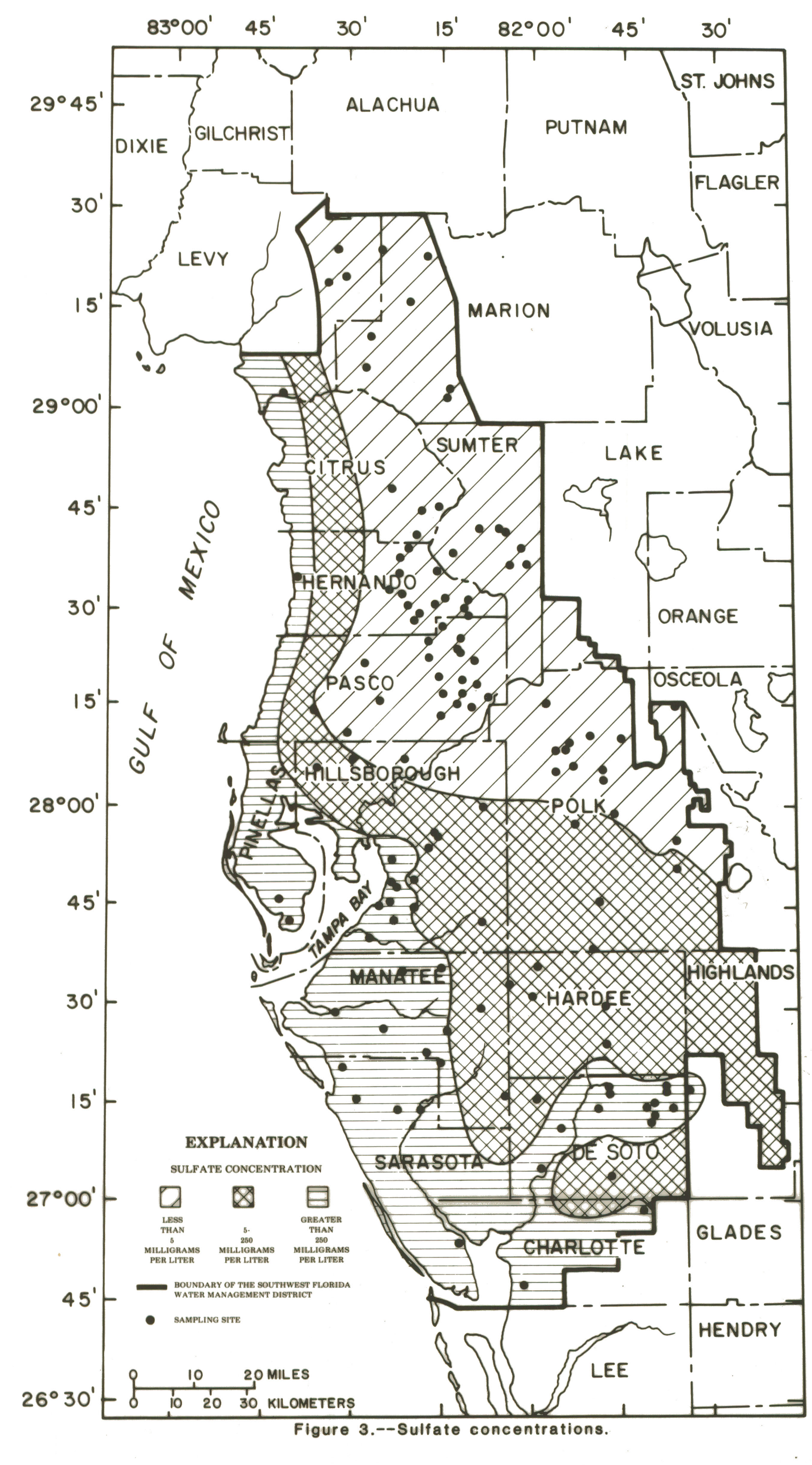

Figure 3.--Sulfate concentrations.

DISTRIBUTION OF SELECTED CHEMICAL CONSTITUENTS IN WATER FROM THE FLORIDAN AQUIFER, SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

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