

GROUND-WATER QUALITY

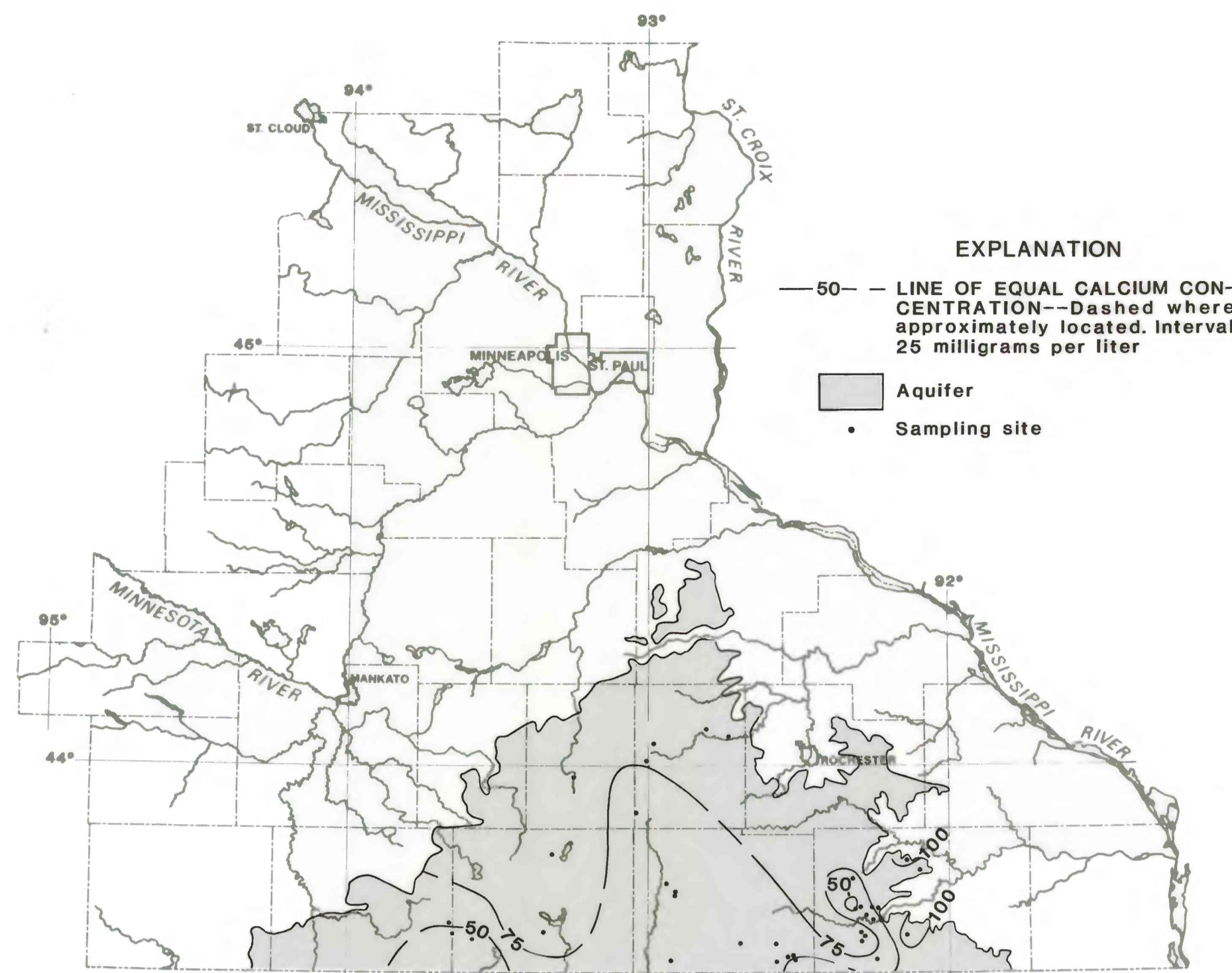


Figure 9.--Calcium concentration

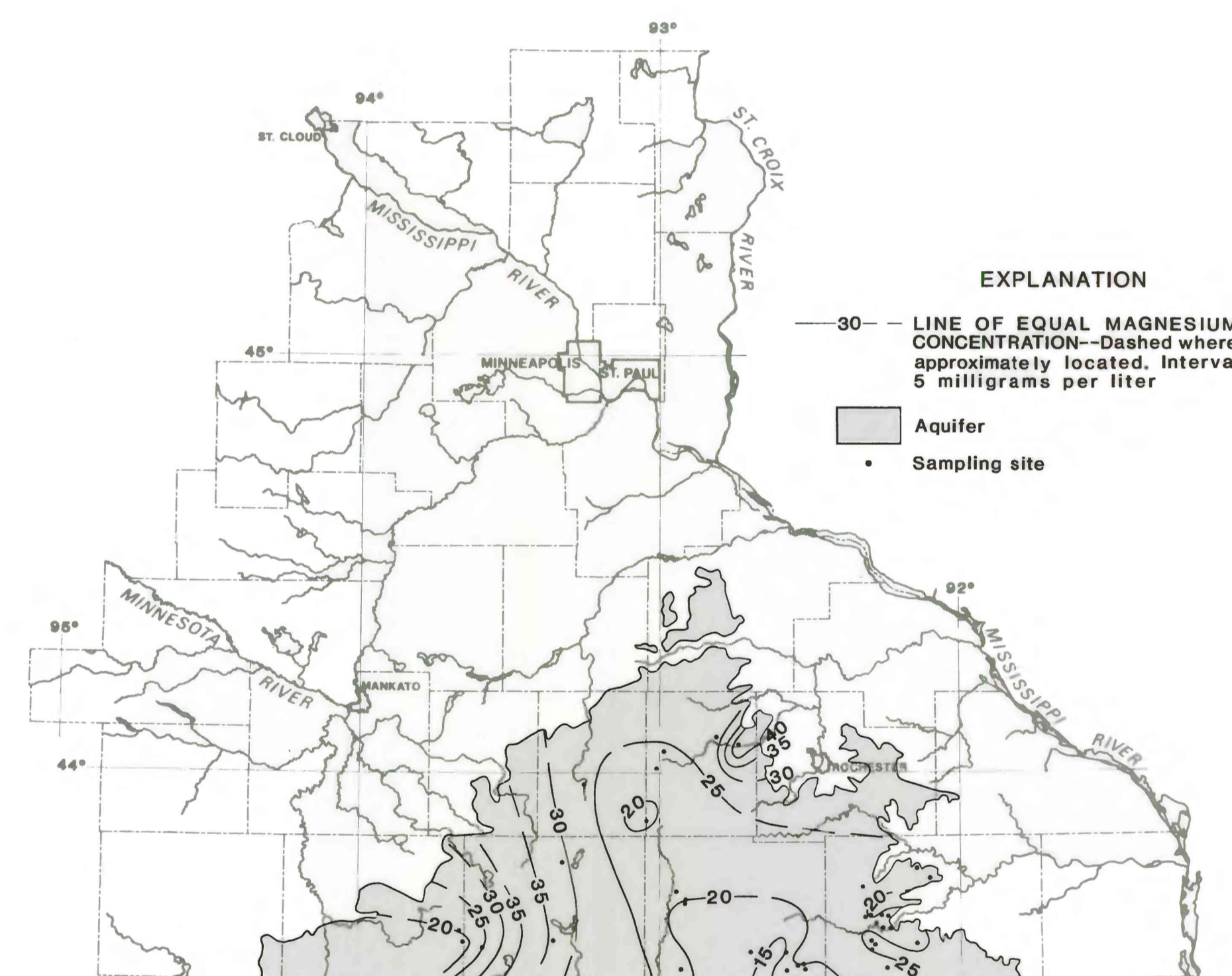


Figure 10.--Magnesium concentration

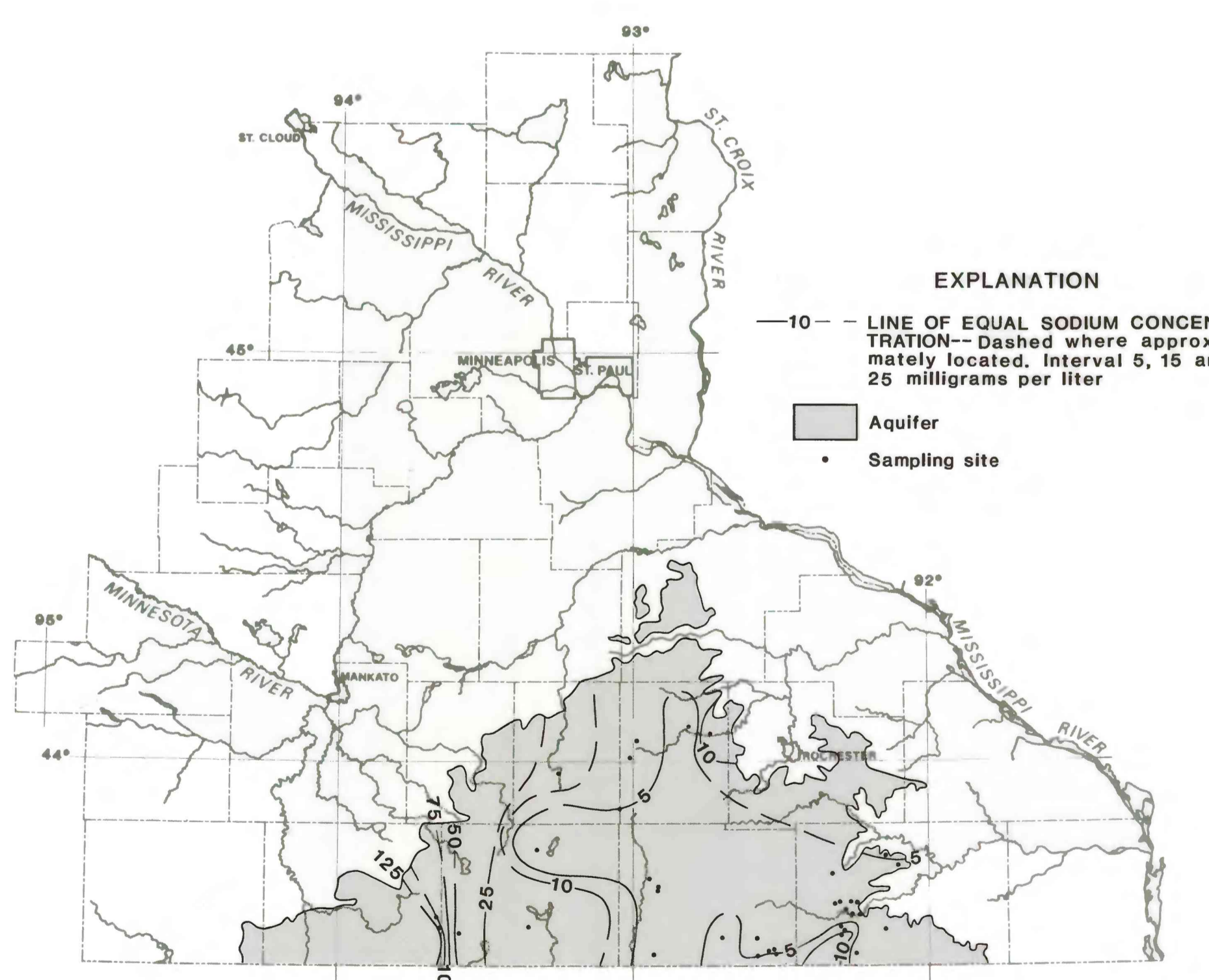


Figure 11.--Sodium concentration

WATER QUALITY

The quality of water in the Upper Carbonate aquifer is suitable for most uses; however, the water is potentially vulnerable to contamination in the eastern part of the study area where karst features are common. The mean, median, and range of selected chemical-constituent concentrations and properties of water from the aquifer are shown in table 2. Values used in the preparation of table 2 and the dissolved-solids and ion-concentration maps (figs. 8-14) are based on data from the U.S. Geological Survey Water Data Storage and Retrieval System (STORET) and from the U.S. Environmental Protection Agency Storage and Retrieval System (STORE). Most results of chemical analyses were obtained in the period 1960-80.

Table 2.--Summary of representative water-quality analyses of water from the aquifer

Recommended constituent or property	Number of analyses	Mean				Median				Maximum			
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Specific conductivity (µmhos/cm at 25°C)	45	509	566	295	1000	500	500	500	500	500	500	500	500
Temperature, water (°C)	5,228	9.9	7.8	7.0	8.3	9.2	9.3	6.4	11.9	10.0	10.0	10.0	10.0
Hardness as CaCO ₃ (mg/L)	41	9.2	9.3	6.4	11.9	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Calcium, dissolved (mg/L)	52	290	280	130	400	100	100	100	100	100	100	100	100
Magnesium, dissolved (mg/L)	50	35	14	27	110	10	10	10	10	10	10	10	10
Sulfate, dissolved (mg/L)	50	28	22	11	43	10	10	10	10	10	10	10	10
Sodium, dissolved (mg/L)	50	10	10	4.0	2.0	10	10	10	10	10	10	10	10
Potassium, dissolved (mg/L)	52	2	2	0	16	1	1	1	1	1	1	1	1
Chloride, dissolved (mg/L)	41	391	308	205	866	100	100	100	100	100	100	100	100
Dissolved solids (mg/L)	14	41	41	41	0	41	41	41	41	41	41	41	41
Total dissolved solids (mg/L)	250	50	24	20	41	70	70	70	70	70	70	70	70
Calcium, dissolved (mg/L)	250	50	24	2.3	2.8	37	37	37	37	37	37	37	37
Magnesium, dissolved (mg/L)	52	2	2	2	1.4	2	2	2	2	2	2	2	2
Sulfate, dissolved (mg/L)	48	19	18	5.1	4.8	18	18	18	18	18	18	18	18
Dissolved solids (mg/L)	500	41	353	336	190	560	560	560	560	560	560	560	560
Hardness as CaCO ₃ (mg/L)	10	11	2.8	4.3	2.0	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Boron, dissolved (mg/L)	46	180	60	110	190	190	190	190	190	190	190	190	190
Phosphate, dissolved (mg/L)	10	0.3	0.61	0.61	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Nitrate, dissolved (mg/L)	33	0.9	0.8	0.61	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Zinc, dissolved (mg/L)	300	25	1500	1000	20	5000	5000	5000	5000	5000	5000	5000	5000
Mercury, total (µg/L)	50	25	40	20	41	130	130	130	130	130	130	130	130

¹ U.S. Environmental Protection Agency, 1975, p. 5954-5957, p. 1743-1747.

Dissolved Solids

Dissolved-solids concentration, a measure of the dissolved substances in water, is a common indicator of the suitability of water for various uses. Water with less than 500 mg/L dissolved solids generally is satisfactory for domestic and industrial uses. The recommended maximum for dissolved solids proposed by the U.S. Environmental Protection Agency (1977) for drinking water is 500 mg/L.

Dissolved-solids concentrations generally are lower in the eastern part of the study area. Much of the recharge in this area is from precipitation with a low mineral content. This water infiltrates the aquifer through thin drift in predominantly karst terrain (fig. 8). The high values of about 500 mg/L are in the southwest and northeast. Leakage of mineralized water from thick drift and, possibly Cretaceous deposits, probably causes the high values in these areas.

Water Types and Major Ions

Ground water is commonly classified on the basis of relative concentrations in milliequivalents of major cations and anions. Water from the Upper Carbonate aquifer is predominantly of the calcium magnesium bicarbonate type, as shown by the water-type patterns in figure 8. This type of water is common in recharge areas and throughout the upper part of the ground-water system in Minnesota (Winter, 1974).

The concentrations of the major ions in the aquifer do not vary uniformly (figs. 10-14). Some of the ions, specifically sodium, bicarbonate, and sulfate, increase in concentration toward the southwestern part of the study area. Inflow of mineralized water from thick drift and possibly Cretaceous rocks probably causes the increases. Calcium concentration is higher to the north and east, and chloride concentrations are generally low throughout the aquifer, except for some locally high values in the eastern and southeastern parts of the study area.

Water-Quality Problems

The potential for contamination of the Upper Carbonate aquifer increases in the eastern part of the study area where the drift is less than 50 feet thick and karst features are common. The Minnesota Department of Health considers contamination of the aquifer in karst areas to be one of the major ground-water-quality problems in the State (Minnesota Department of Health, 1976). Sinkholes and disappearing streams in the karst areas provide direct passageways for entry of contaminants into the aquifer. Nitrates and pathogenic bacteria from livestock feedlots and septic tanks, and pesticides from agricultural areas are potential contaminants.

CONVERSION FACTORS

Multiply inch-pound unit by	To obtain SI metric unit
foot (ft)	0.3048 meter (m)
gallon (gal)	3.785 liter (l)
gallon per minute (gal/min)	0.06309 liter per second (l/s)
square mile (mi ²)	2.590 square kilometer (km ²)
microhm per centimeter (µhm/cm at 25°C)	1.000 micromhos per centimeter (µhm/cm at 25°C)

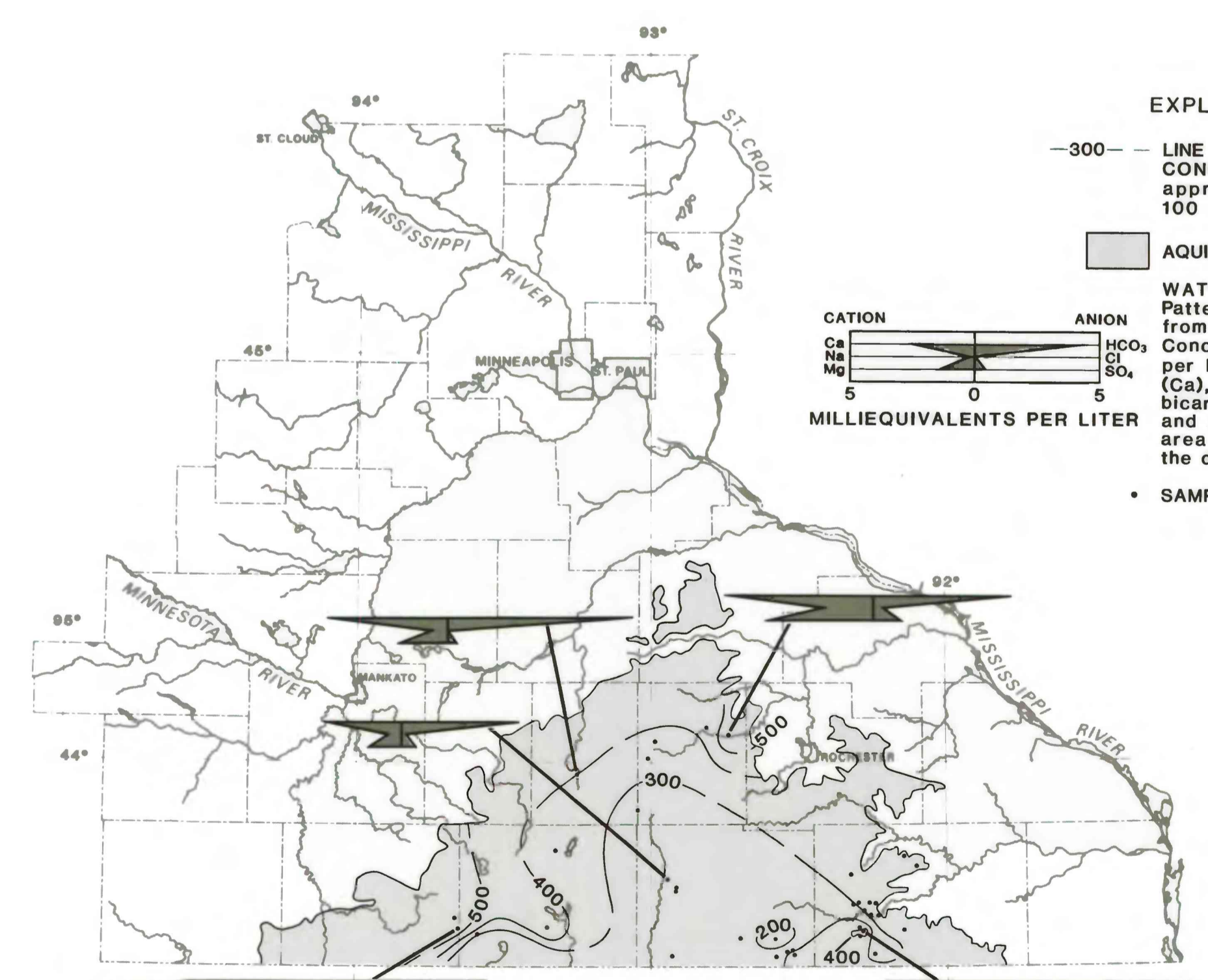


Figure 8.--Dissolved-solids concentration and water-type patterns

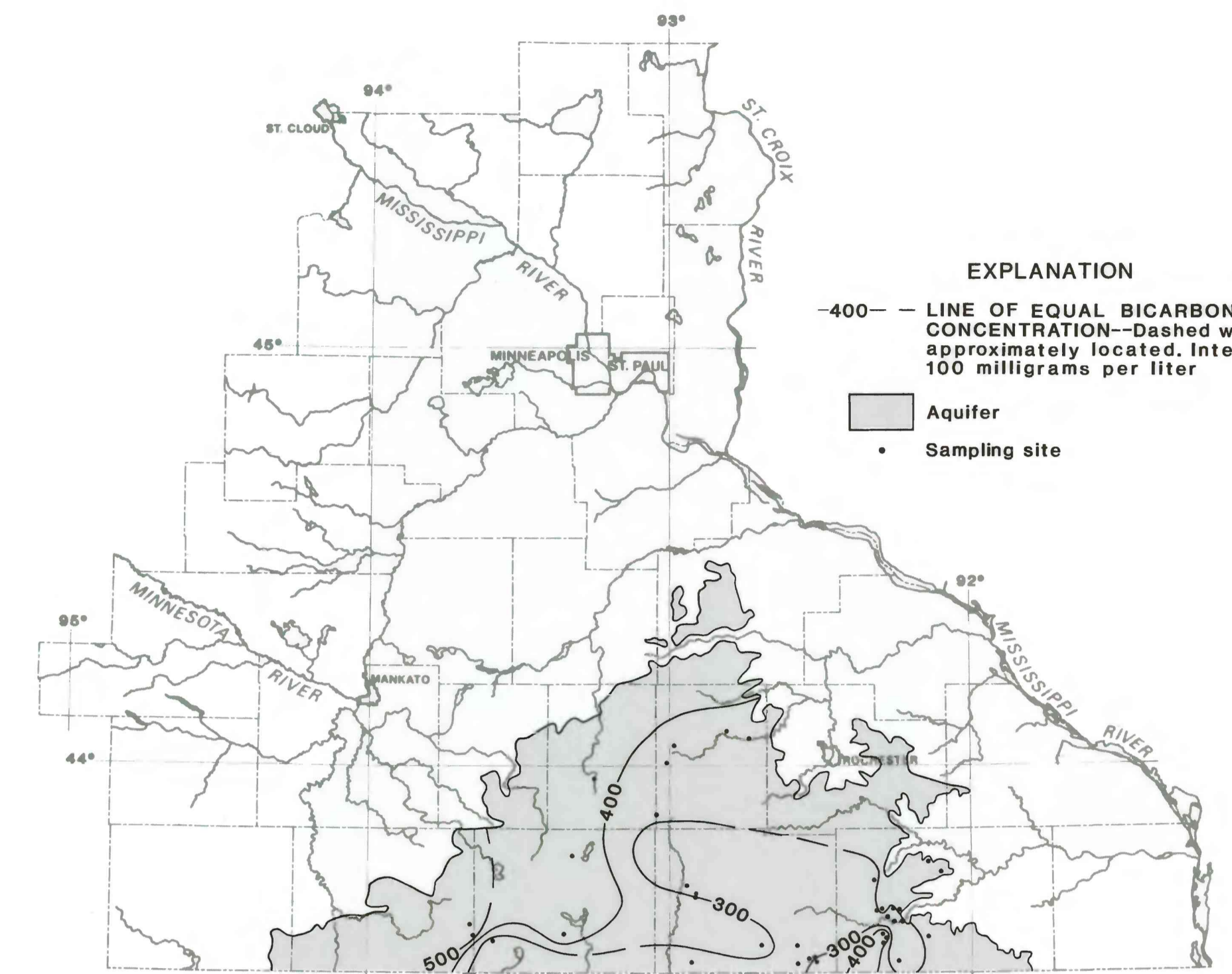


Figure 12.--Bicarbonate concentration

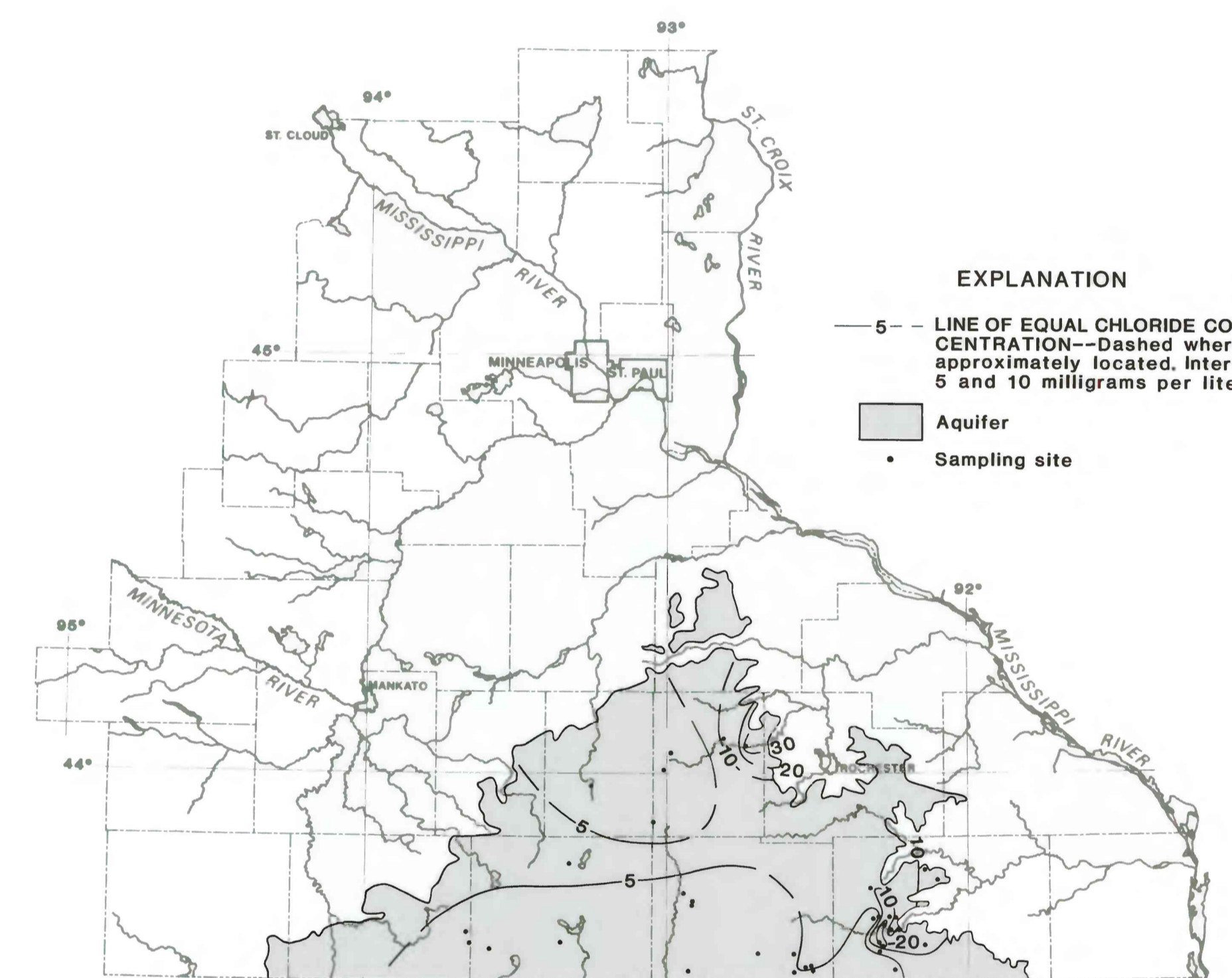


Figure 13.--Chloride concentration

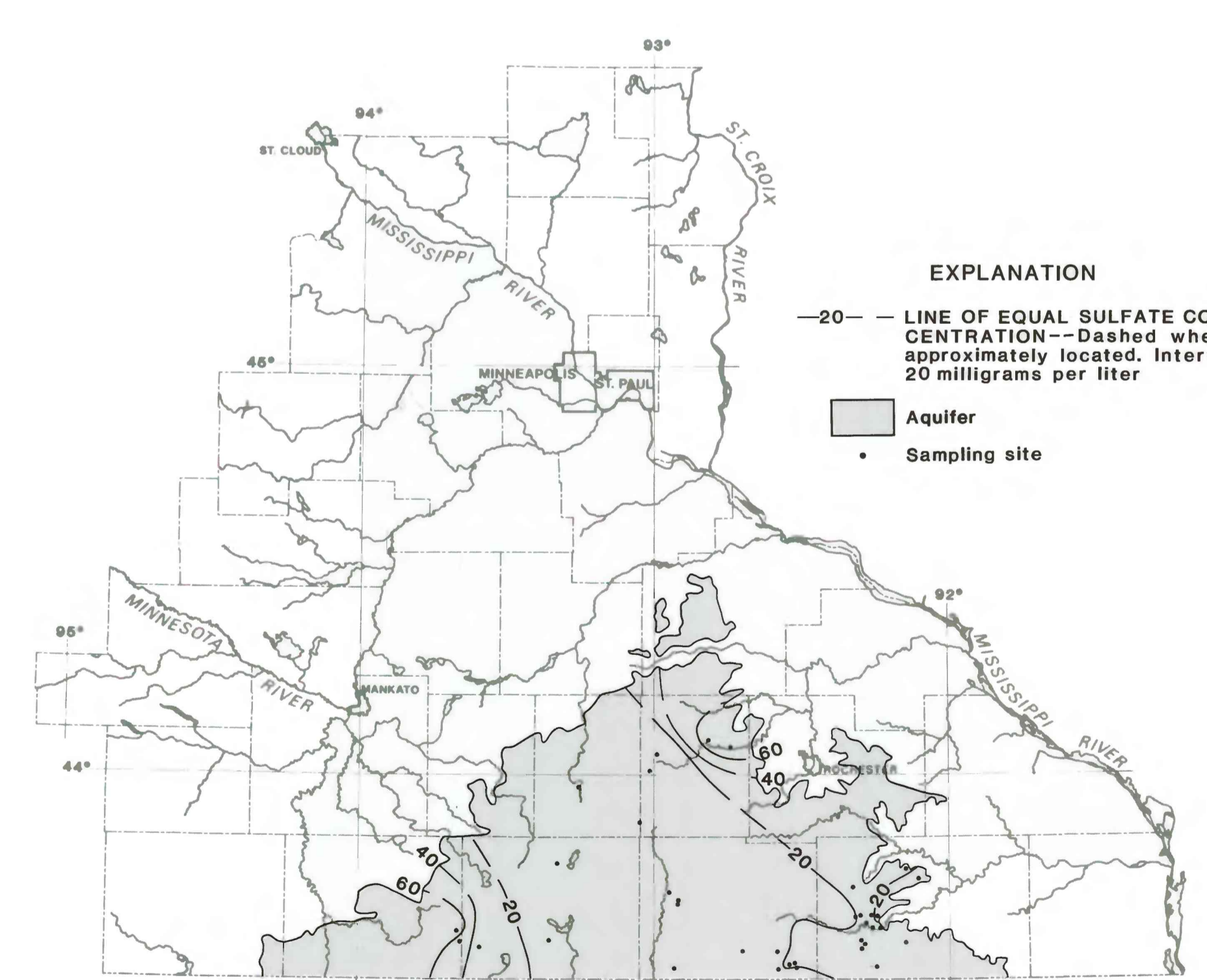


Figure 14.--Sulfate concentration

HYDROGEOLOGIC AND WATER-QUALITY CHARACTERISTICS OF THE UPPER CARBONATE AQUIFER IN MINNESOTA

BY
J. F. RUHL AND R. J. WOLF, 1984

Base from U.S. Geological Survey State base map, 1:1,000,000, 1965

For additional information write to:
District Chief
U.S. Geological Survey
702 New Orleans Building
St. Paul, Minnesota 55101
Telephone: (612) 725-7800

Copies of this report can be purchased from:
Open-File Service Section
Western Distribution Branch
U.S. Geological Survey
Box 25423, Federal Center
Denver, Colorado 80223
Telephone: (303) 536-7474