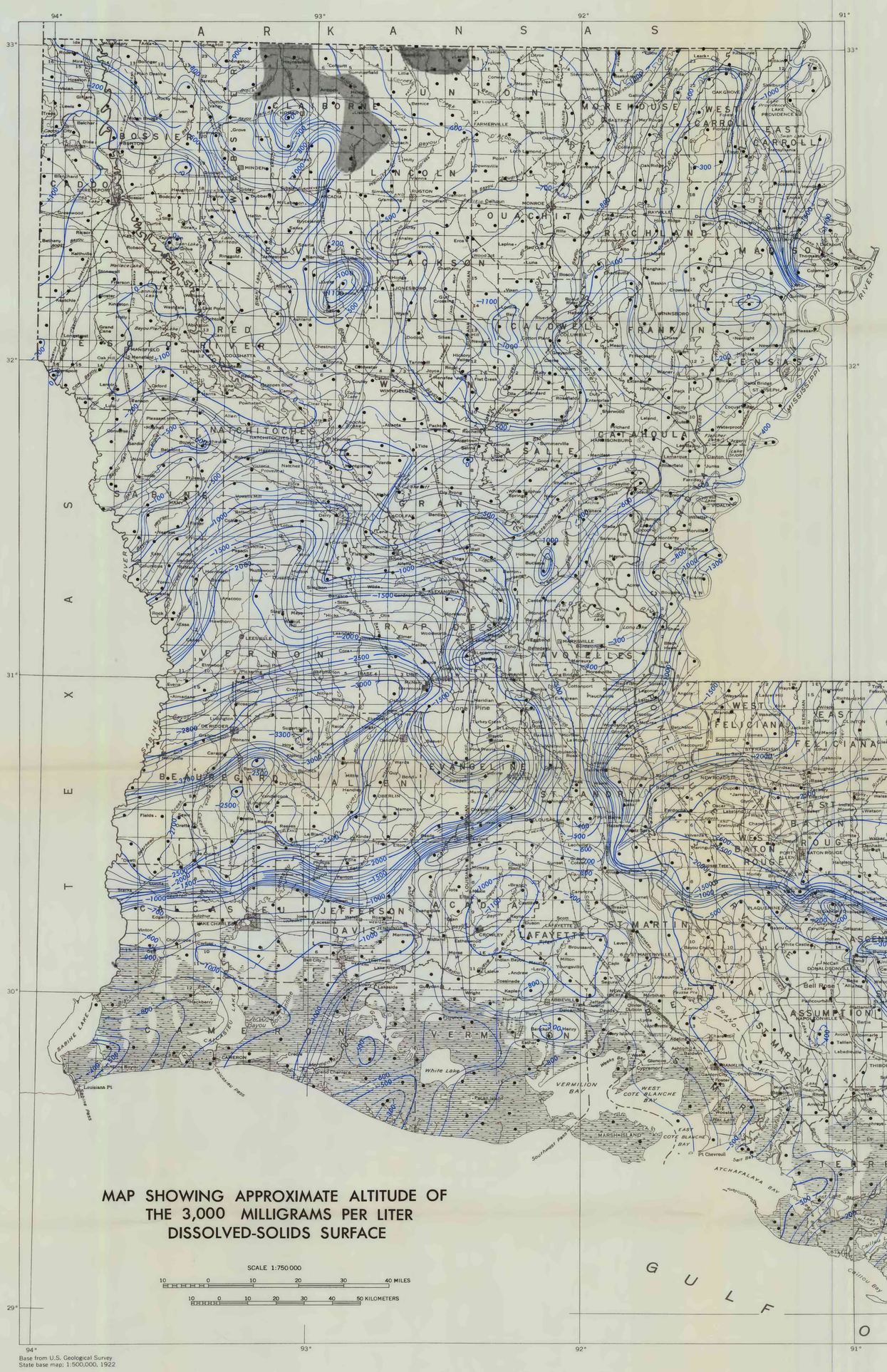
TABLE 1.—Chemical analyses and related physical measurements of slightly saline (1,000–3,000 mg/l dissolved solids) ground water.

Analyses in milligrams per liter, except as indicated

Parish	Location	Depth or producing interval (feet)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Barium (Ba)	Strontium (Sr)	Iodide (I)	Bromine (Br)	Manganese (Mn)	Phosphate (PO$_4$)	Hardness, as $CaCO_3$ Calcium, Magnesium	Hardness, as $CaCO_3$ Non-carbonate	Specific gravity	Specific conductance (micromhos at 25°C)	pH	Temperature (°C)	Remarks
Ascension	T. 10 S., R. 4 E., sec. 20	250	7-25-50	28	1.1	19	7.6	377*	—	217	5	1	504	—	1.2	—	1,050	—	—	—	—	—	—	78	—	—	1,830	8.4	21	
Do.	T. 8 S., R. 3 E., sec. 20	1,693	1-7-55	21	.10	4.8	1.2	420	1.3	387	0	.2	435	1.8	.2	0.35	1,080	—	—	—	—	0.01	0.80	17	0	—	1,920	8.1	28	
Do.	T. 10 S., R. 2 E., sec. 14	413	4-10-56	19	.56	122	46	463	—	248	0	0	919	—	—	—	1,690	—	—	—	—	—	—	498	—	—	—	6.9	—	Shilstone Testing Laboratory
Do.	T. 10 S., R. 2 E., sec. 33	196	3-8-57	22	3.2	53	19	961	4.8	290	0	11	1,470	.3	.5	.29	2,690	—	—	—	—	.08	.2	210	0	—	4,830	7.4	21	
Do.	T. 10 S., R. 14 E., sec. 24	341	4-3-64	32	.93	15	63	543	3.3	623	0	8.0	658	.2	.2	.11	1,640	—	—	—	—	.01	.05	298	0	—	2,850	7.8	21	
Assumption	T. 12 S., R. 13 E., sec. 42	306	5-4-61	—	—	—	—	—	—	—	—	—	868	—	—	—	1,880 est.	—	—	—	—	—	—	154	—	—	3,300	—	23	
Avoyelles	T. 1 S., R. 3 E., sec. 29	520-586	1-31-55	16	.05	4.0	1.2	473	1.9	790	0	.5	280	8.0	1.5	.14	1,180	—	—	—	—	.01	1.1	15	0	—	1,990	7.7	22	
Do.	T. 2 N., R. 5 E., sec. 36	357-372	3-17-66	30	3.4	1.6	1.5	405	2.0	726	0	.2	214	.6	0.0	—	1,010	—	—	—	—	—	—	10	—	—	1,710	7.1	18	
Do.	T. 2 N., R. 3 E., sec. 11	295-300	2-19-66	19	.58	24	5.4	661	2.0	374	0	0.0	890	1.5	0.0	—	1,790	—	—	—	—	—	—	82	0	—	3,210	7.9	—	
Bossier	T. 18 N., R. 13 W., sec. 28	65	5-20-41	20	28	248	136	153	7.7	862	0	544	171	.4	2.4	—	1,860	—	—	—	—	—	—	1,178	—	—	—	—	19	
Caddo	T. 20 N., R. 14 W., sec. 5	220	8-6-59	11	.17	13	5.3	426	5.5	567	0	.4	354	2.4	.1	1.4	1,160	—	—	—	—	.01	.5	54	0	—	1,870	8.0	21	
Do.	T. 22 N., R. 16 W., sec. 26	257-275	11-11-59	15	.05	35	4.6	356	3.2	448	0	1.4	370	.7	.9	.79	1,010	—	—	—	—	.01	.7	106	0	—	1,800	7.8	22	
Calcasieu	T. 10 S., R. 11 W., sec. 36	800-805	12-4-64	32	.18	29	22	391	4.0	316	0	0.0	533	.3	.1	.19	1,180	—	—	—	—	.04	.08	164	0	—	2,110	7.6	21	
Caldwell	T. 14 N., R. 4 E., sec. 25	594	11-12-64	8.3	.12	2.1	1.3	506	2.2	747	38	.2	293	3.0	.3	—	1,260	—	—	—	—	.00	1.6	8	0	—	2,070	8.4	—	
Do.	T. 14 N., R. 4 E., sec. 43	400±	8-25-65	10	.45	5.4	3.5	405	4.3	912	0	0.0	102	3.2	.6	—	1,020	—	—	—	—	0.00	.3	28	0	—	1,670	8.1	22	
Cameron	T. 15 S., R. 4 W., sec. 41	460	2-2-55	30	.04	48	19	408	4.5	416	0	2.1	547	.1	.2	.05	1,260	—	—	—	—	.01	.19	198	0	—	2,270	7.5	22	
Do.	T. 15 S., R. 11 W., sec. 41	836	9-20-51	33	1.5	32	14	769	2.8	340	0	3.3	1,080	.6	.5	.38	2,100	—	—	—	—	0.0	0.0	138	0	—	3,860	7.6	26	
Concordia	T. 7 N., R. 9 E., sec. 35	281-291	7-2-62	31	6.4	52	1.0	520	13	172	0	4.4	819	.1	.2	.51	1,530	—	—	—	—	.20	.08	134	0	—	2,890	6.8	21	
De Soto	T. 12 N., R. 14 W., sec. 2	398	4-28-55	16	.12	2.1	.3	474	2.2	828	19	.4	220	1.8	0.0	2.3	1,150	—	—	—	—	.02	3.7	6	0	—	1,930	8.4	—	
Do.	T. 13 N., R. 13 W., sec. 4	360-370	11-15-63	9.8	.45	1.1	1.5	561	1.6	714	11	0.0	460	3.2	.2	—	1,400	—	—	—	—	0.0	.89	9	0	—	2,450	8.4	21	
East Baton Rouge	T. 7 S., R. 1 W., sec. 54	2,671-2,675	6-22-65	19	.01	2.0	0.0	501	1.4	1,010	13	0.0	58	5.0	.3	—	1,200	—	—	—	—	0.0	1.3	5	0	—	2,050	8.3	—	
East Carroll	T. 19 N., R. 12 E., sec. 37	462	5-19-44	—	—	—	—	—	—	865	70	—	87.6	—	—	—	1,220	—	—	—	—	—	—	11	—	—	—	8.3	—	Louisiana State Board of Health
East Feliciana	T. 2 S., R. 2 E., sec. 83	2,240	12-12-58	30	.5	2.8	.6	332.3	—	402.6	6.0	.7	278	—	—	—	1,070	—	—	—	—	—	—	9.5	—	—	1,550	8.4	—	Curtis Laboratories
Iberville	T. 9 S., R. 1 E., sec. 24	473	12-6-57	38	.90	32	11	1,030	3.6	529	0	11	1,380	.6	.0	.47	2,770	—	—	—	—	.0	.80	125	0	—	4,880	7.7	22	
Jefferson	T. 13 S., R. 24 E., sec. 7	694-782	5-29-56	26	.22	42	21	910	—	434	0	.5	1,270	—	.1	—	2,490	—	—	—	—	.1	.60	191	—	—	—	7.7	—	
Do.	T. 14 S., R. 23 E., sec. 34	752	1-31-62	13	.22	18	6.1	647	14	682	0	.6	670	0.7	.0	1.2	1,710	—	—	—	—	0	1.1	70	0	—	2,940	8.1	23	
Lafourche	T. 19 S., R. 21 E., sec. 13	168-188	10-25-60	24	1.11	262	114	699	14	624	0	14	1,540	.9	0.0	.53	2,980	—	—	—	—	1.0	.1	1,120	609	—	5,370	7.1	—	
La Salle	T. 10 N., R. 2 E., sec. 9	108	5-14-64	—	—	164	—	—	—	272	0	—	255	—	—	—	1,280	—	—	—	—	—	—	262	—	—	2,280	7.1	—	
Morehouse	T. 21 N., R. 7 E., sec. 34	625	1-14-60	11	.10	2.0	.2	460	2.2	495	2	1.6	410	1.4	.3	.79	1,140	—	—	—	—	0.0	1.0	6	0	—	2,010	8.3	23	
Do.	T. 20 N., R. 6 E., sec. 29	964	1-14-60	13	—	2.1	.2	492	1.9	473	5	.4	476	1.2	.2	.91	1,230	—	—	—	—	0.0	1.1	6	0	—	2,160	8.3	25	
Natchitoches	T. 13 N., R. 7 W., sec. 4	395	5-14-56	15	—	2.0	1.8	655	3.6	809	0	17	548	3.0	2.9	2.8	1,700	—	—	—	—	0.0	1.2	12	0	—	2,090	7.8	24	
Orleans	T. 13 S., R. 11 E.	740	10-10-58	24	.29	16	3.4	465	4.7	482	0	1.4	474	1.0	.6	—	1,230	—	—	—	—	—	—	54	0	—	2,120	7.7	25	
Ouachita	T. 17 N., R. 4 E., sec. 30	760-780	8-17-65	14	.25	1.1	1.3	458	2.2	520	0	0.0	423	1.0	.7	—	1,160	—	—	—	—	0.0	0.0	8	0	—	2,070	7.8	—	
Plaquemines	T. 17 S., R. 25 E., sec. 10	360-400	9-19-50	27	.4	79	77	939	34	694	0	.6	1,450	.2	0.0	0.50	2,950	—	—	—	—	—	—	514	—	—	5,350	7.8	23	
Pointe Coupee	T. 6 S., R. 8 E., sec. 28	2,055-2,105	11-2-62	17	.31	0.0	1.5	469	1.4	1,220	0	0.0	24	9.0	.4	2.30	1,130	—	—	—	—	0.0	0.0	6	0	—	1,780	8.3	27	
Richland	T. 17 N., R. 9 E., sec. 15	335-370	4-7-61	12	.15	4.0	1.0	501	7.8	536	0	.4	478	.8	.3	.47	1,270	—	—	—	—	0.0	0.0	14	0	—	2,290	7.7	21	
Sabine	T. 6 N., R. 12 W., sec. 28	414-449	2-24-55	16	.16	1.2	.3	533	1.9	1,280	47	.1	23	3.6	.5	—	1,300	—	—	—	—	0.0	5.6	4	0	—	2,030	8.5	—	
Do.	T. 3 N., R. 12 W., sec. 12	759-769	5-12-64	18	.01	1.8	1.3	395	2.2	678	28	113	91	1.6	.2	—	1,020	—	—	—	—	0.0	2.5	10	0	—	1,570	8.5	—	
St. Bernard	T. 13 S., R. 12 E., sec. 13	800	5-20-42	26	.52	8.9	5.3	467	3.0	467	—	1.2	480	1.0	3.4	—	1,230	—	—	—	—	—	—	44	—	—	—	—	26	
St. Charles	T. 13 S., R. 8 E., sec. 4	484	1-14-55	38	.64	46	25	920	9.6	341	0	1.6	1,410	.5	0.0	.59	2,620	—	—	—	—	0.0	—	219	0	—	4,630	7.7	22	
Do.	T. 12 S., R. 8 E.	424	3-11-49	45	—	15	14	316*	—	409	41	7.0	332	—	0	—	1,020	—	—	—	—	—	—	95	—	—	1,760	8.9	23	
Do.	T. 13 S., R. 21 E., sec. 14	475	9-15-48	34	.10	90	50	733*	—	334	0	1.0	1,240	.2	.2	—	2,310	—	—	—	—	—	—	930	—	—	4,390	7.4	—	
St. James	T. 12 S., R. 17 E., sec. 41	300	9-30-60	25	.60	72	15	370	5.5	500	0	.4	435	.4	.2	.26	1,170	—	—	—	—	.02	.50	240	0	—	2,050	7.6	22	
St. John the Baptist	T. 11 S., R. 6 E., sec. 68	242	3-8-57	30	1.1	76	27	378	4.4	281	0	2.2	640	.2	1.2	.22	1,300	—	—	—	—	.10	.04	230	70	—	2,430	7.5	—	
Do.	T. 12 S., R. 18 E., sec. 18	416	8-9-62	21	.51	28	18	552	3.8	238	0	1.4	800	.3	.2	.21	1,540	—	—	—	—	.02	.01	142	0	—	2,880	7.8	22	
St. Landry	T. 6 S., R. 1 W., sec. 13	703-708	6-24-65	29	.04	10	3.4	584	2.9	709	0	0.0	523	1.6	.2	—	1,500	—	—	—	—	.00	.7	39	0	—	2,690	7.8	—	
St. Martin	T. 14 S., R. 11 E.	225-245	4-9-53	44	2	83	41	420	—	708	—	6	500	—	—	—	1,758	—	—	—	—	—	—	378	—	—	—	7.4	—	Humble Oil and Refining Co.
St. Mary	T. 14 S., R. 8 E., sec. 36	728-738	1-15-64	28	.59	93	89	856	4.7	419	0	11	1,520	.1	—	—	2,800	—	—	—	—	.14	.09	599	255	—	4,950	7.7	24	
Do.	T. 16 S., R. 9 E.	509-530	7-1-52	49	1.0	58	21	328	—	653	0	0	290	—	—	—	1,350	—	—	—	—	—	—	231	—	—	—	7.9	—	Humble Oil and Refining Co.
Terrebonne	T. 17 S., R. 16 E., sec. 47	220	2-2-62	21	1.7	151	59	196	18	525	0	0.6	459	0.1	0.1	0.14	1,170	—	—	—	—	0.40	0.5	620	190	—	2,070	7.0	21	
Vermilion	T. 13 S., R. 3 E., sec. 15	398-404	1-27-64	33	—	203	65	773	4.9	360	0	4.4	1,540	.0	—	—	2,800	—	—	—	—	.36	.08	775	480	—	4,820	7.5	22	
West Baton Rouge	T. 8 S., R. 12 E., sec. 10	2,065-2,098	12-30-54	28	10	33	7.8	556	2.2	265	0	5.1	778	.4	2.5	.33	1,540	—	—	—	—	.04	.6	114	0	—	2,850	7.6	28	

*Sodium and potassium



MAP SHOWING APPROXIMATE ALTITUDE OF THE 3,000 MILLIGRAMS PER LITER DISSOLVED-SOLIDS SURFACE

SCALE 1:750 000

10 0 10 20 30 40 MILES

10 0 10 20 30 40 50 KILOMETERS

EXPLANATION

Control point

—100— Water-zone contour

Shows the approximate altitude of the 3,000 milligrams per liter dissolved-solids surface which defines the base of the slightly-saline-water zone and the top of the moderately-saline-water zone. Contour interval, in feet, is variable. Datum is mean sea level

Area where slightly-saline water is not present in aquifers

Base from U.S. Geological Survey
State base map; 1:500,000, 1922

INTRODUCTION

In most places, the occurrence of saline ground water has been the source of hydrologic problems. However, in many parts of the country, including some of the humid coastal areas where fresh-water resources are inadequate, vast amounts of saline ground water are available and can be made usable for public and industrial supplies. These occurrences are becoming recognized as a natural resource of great economic importance.

Some of the saline water can be used without treatment for such purposes as industrial cooling, fish processing, fire protection, oilfield repressuring, and sanitation systems. Desalination processes can make much of the saline water suitable for public supplies and also provide such economic by-products as salt, iodine, bromine, magnesium, barium, and strontium.

PURPOSE AND SCOPE OF THIS REPORT

This atlas presents data on the occurrence and distribution of saline ground water in Louisiana. The purpose of the report is to show the areal and vertical extent of subsurface zones containing water of different salinities and to give chemical analyses of water samples from the different zones.

The approximate altitudes, estimated potential yields, and aggregate sand thicknesses of the saline-water zones are shown by maps. The chemical analyses and related physical measurements are given in tables.

DEFINITION OF SALINE WATER

Definitions of the term "saline water" vary according to the type of water that is available or being used in various parts of the country. In most of the reports of the U.S. Geological Survey in Louisiana, "fresh water" is defined as water having less than 250 mg/l (milligrams per liter) chloride; water having more than 250 mg/l chloride is classified as saline. In this report and in the terminology adopted by the Office of Saline Water, U.S. Department of the Interior, "saline water" is defined as any water having more than 1,000 mg/l dissolved solids.

It is desirable, however, to refer to water having different degrees of salinity; therefore, the following arbitrary classification, based on the dissolved-solids content, is used in this report.

Classification	Dissolved-solids content (mg/l)
Slightly saline	1,000–3,000
Moderately saline	3,000–10,000
Very saline	10,000–35,000
Brine	More than 35,000

SOURCES OF DATA AND ACKNOWLEDGEMENTS

Chemical analyses of saline water were obtained from the files of the U.S. Geological Survey, Baton Rouge, La., from reports of the U.S. Bureau of Mines, from the Louisiana Geological Survey, from various oil companies, and from companies related to the oil industry. Several hundred analyses were furnished by the Humble Oil and Refining Company, through its affiliate, the Esso Production Research Laboratory in Houston, Tex. Analyses were also furnished by the Atlantic Richfield Company, Dallas, Tex., the Dowell Division of the Dow Chemical Company, Shreveport, La., and the Halliburton Company, Shreveport, La.

The electrical logs of oil tests, used for construction of the maps, were provided by the Louisiana Geological Survey. Calculations of the availability of water were made from data in the files of the U.S. Geological Survey, Baton Rouge, La.

METHODS OF STUDY

The electrical logs were interpreted to delineate, according to the preceding classification, three saline-water zones—slightly saline, moderately saline, and very saline. The method of interpretation (Turcan, 1962, p. C135–136; and Turcan, 1966) is based on the relation between the electrical resistivity and the dissolved-solids content of the water. The resistivity of the water was determined from the long normal or lateral curves of the logs, adjusted to 25°C; and from field formation resistivity factors of the various hydrologic units. About 1,000 logs were used in making the determinations. The results are approximate and more detailed studies are needed to map more exactly the relations of hydrology, geopressure, and temperature to the salinity of water.

Maps showing the altitude of the base of each of the three salinity zones were checked by comparison with chemical analyses of water from wells completed at various depths. Agreement was satisfactory in the range 1,000–10,000 mg/l dissolved solids, slightly and moderately saline zones (sheets 1 and 2), but the position of the base of the very saline zone (10,000–35,000 mg/l dissolved solids), as determined from the electrical logs, was considered to be unreliable.

The approximate altitude of the top of 1,000 mg/l dissolved-solids surface corresponds in general to the base of fresh ground water. The map shown in this report is generalized from various reports on the ground-water resources of Louisiana, a report by Rollo (1960, pl. 3), a map of the base of fresh water in southwestern Louisiana by Harder and others (1967), and data obtained from interpretation of the electrical logs. Contours drawn by Rollo (1960, pl. 3) and Harder and others (1967, pl. 6) may differ as the criteria used for fresh water is 250 mg/l of chloride instead of 1,000 mg/l of dissolved solids.

DISTRIBUTION AND AVAILABILITY OF SALINE GROUND WATER

The entire state of Louisiana is underlain by water-bearing units that contain saline water of varying degrees of salinity and availability. Fresh water is abundant throughout most of Louisiana, but there are areas along the coast and in the extreme northwestern part of the state where fresh-water supplies are meager. Therefore, it may be desirable at some time in the future to consider desalination of the saline-water resources in these areas.

In general, salinity increases with depth, to a concentration of about 50,000 mg/l dissolved solids; in some parts of the state, sands with water of low salinity underlie water of higher salinity, even at depths of several thousand feet. In some places, sands containing saline water are interbedded with sands containing fresh water (Rollo, 1960, pl. 3). These anomalous occurrences are not considered in this report. The map of the top of the slightly saline zone or the approximate altitude of 1,000 mg/l dissolved solids surface, in general, is the deepest occurrence of fresh water.

Sheets 3 and 4 show the thicknesses of sand in the slightly and moderately saline zones and the estimated potential yields of wells tapping these zones. The sand thicknesses were determined from the electrical logs, and the hydraulic properties are assumed to be approximately the same as in the fresh-water parts of the zones.

The potential yield of an individual well is based on a drawdown of 100 feet after one day of pumping. It is also assumed that not more than 200 feet of sand is screened in the well. If the sand thickness is less than 200 feet, then the full thickness is assumed to be screened. The diameter of the well screen is assumed to be 12 inches, and the screened section is assumed to be 100 percent efficient. The yields shown are for individual wells, and the estimates do not consider the interference effects of pumping from other wells.

CHEMICAL QUALITY OF SALINE GROUND WATER

The chemical analyses and related physical properties of saline ground water in Louisiana are given in the tables. The analyses are representative of several hundred that were collected from various sources. The analyses from sources other than the U.S. Geological Survey are indicated in the remarks columns of the tables.

The analyses show that most of the saline ground water in Louisiana is of the sodium-chloride type, in which sodium is the predominant cation and chloride is the predominant anion. There are exceptions to this generality, particularly in the slightly saline range, in which many of the analyses show that the waters are of the sodium bicarbonate type or that the concentrations of chloride and bicarbonate are nearly equal. Sodium, however, is nearly always the predominant cation; high percentages of sulfate are not common.

The analyses indicate that at particular depths in certain areas exceptionally large quantities of certain elements are present. These elements, bromine, iodine, magnesium, and barium, are frequently extracted from brines for commercial use. The data are too limited to determine the economic availability, but further exploration of the highly concentrated brines in these areas is probably warranted.

The brine analyses in table 4 are not typical of oil-field brines in Louisiana. Only representative analyses of the more diluted brines are included. Most of the oil-field brines are far more concentrated than those for which the analyses are given.

The temperature of the saline ground water generally increases with depth. The temperature gradients in Louisiana probably range from about 1°C per 90 feet (1°F per 50 feet) of depth to about 1°C per 180 feet (1°F per 100 feet). Examples of temperatures of water samples collected at various depths are given in the tables.

REFERENCES CITED

Harder, A. H., Kilburn, Chabot, Whitman, H. M., and Rogers, S. M., 1967, Effects of ground-water withdrawals on water levels and salt-water encroachment in southwestern Louisiana: Dept. Conserv., Louisiana Geol. Survey and Louisiana Dept. Public Works Water Resources Bull. 10.

Rollo, J. R., 1960, Ground water in Louisiana: Dept. Conserv., Louisiana Geol. Survey and Louisiana Dept. Public Works Water Resources Bull. 1.

Turcan, A. N., Jr., 1962, Estimating water quality from electrical logs: U.S. Geol. Survey Prof. Paper 450-C, p. C135–136.

———, 1966, Calculation of water quality from electrical logs, theory and practice: Dept. Conserv., Louisiana Geol. Survey and Louisiana Dept. Public Works Water Resources Pamphlet 19.

MAP SHOWING APPROXIMATE ALTITUDE OF THE 1,000 MILLIGRAMS PER LITER DISSOLVED-SOLIDS SURFACE

50 0 50 100 MILES

50 0 50 100 KILOMETERS

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1968—W68200

SALINE GROUND WATER IN LOUISIANA

By

A. G. Winslow, D. E. Hillier, and A. N. Turcan, Jr.

1968

For sale by U.S. Geological Survey, price $1.75 per set