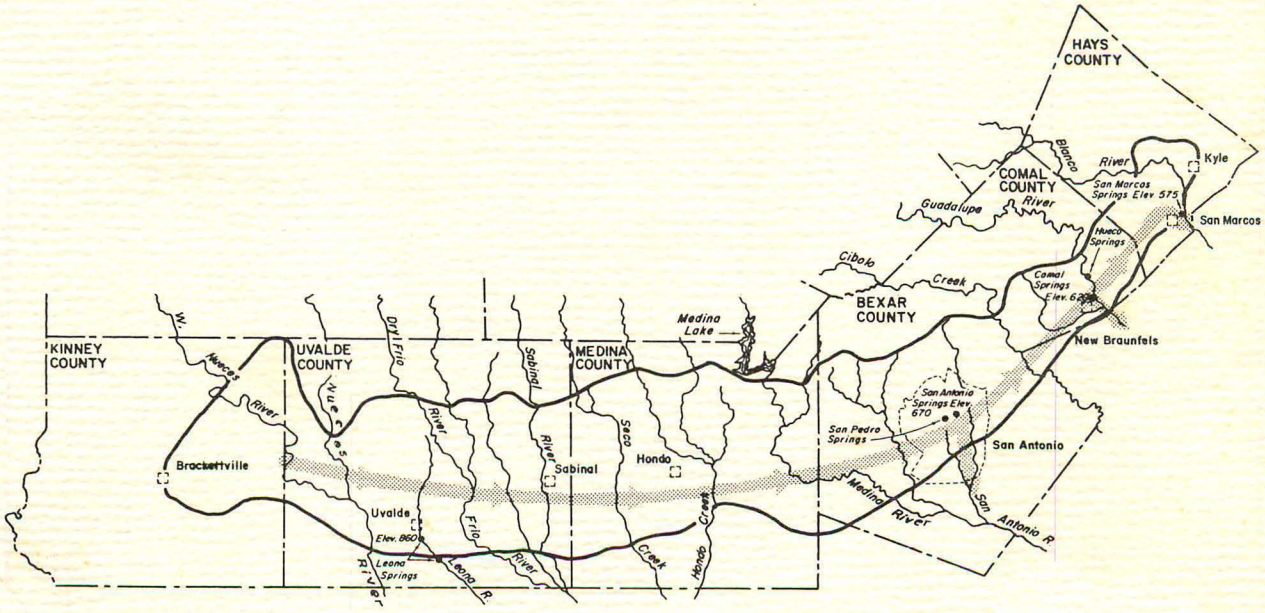
Geology and Water Quality at Selected Locations in the San Antonio Area Texas, Progress Report, 1969

Edwards Underground Water District
San Antonio, Texas



Prepared in cooperation with the U.S. Geological Survey and the Texas Water Development Board

EDWARDS UNDERGROUND WATER DISTRICT

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GEOLOGY AND WATER QUALITY AT SELECTED LOCATIONS IN THE SAN ANTONIO AREA, TEXAS

PROGRESS REPORT, 1969

By

R. D. Reeves and J. F. Blakey
United States Geological Survey

Prepared by the U.S. Geological Survey
in cooperation with the
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ABSTRACT

The Edwards aquifer is the principal source of water supply for the San Antonio area. Increasing urban development on or adjacent to the recharge area of the aquifer is causing great concern because of possible pollution of the ground water. A detailed map of the surface geology has been prepared for areas where the greatest threat of pollution exists. Water-quality data are being collected throughout the San Antonio area to provide background reference information and to detect any current pollution of the ground water in the Edwards and associated limestones.

Mapping of the surface geology will continue in areas where waste waters may be recharging the aquifer. Water-quality data will be collected at additional sites, and some sites will be resampled where pollution may be occurring or where more background data are needed.

INTRODUCTION

Geologic and hydrologic investigations of the Edwards and associated limestones (aquifer) in the San Antonio area have been carried on for many years by the U.S. Geological Survey in cooperation with the Texas Water Development Board and local agencies. In recent years, the studies in cooperation with the Edwards Underground Water District have been chiefly hydrologic. However, since 1968, local water users have become greatly concerned about the possible pollution of ground water in the Edwards aquifer resulting from urban development on or adjacent to the recharge area.

The Edwards aquifer is the principal source of water for municipal supply, defense establishments, industrial use, and agricultural use. One of the main sources of potential pollution is the infiltration of effluent from septic tanks and from sewage-treatment plants that are in the recharge area or that discharge their effluent into dry stream beds that cross the recharge area. Other possible sources of pollution are sanitary landfills, industrial wastes, surface runoff from residential subdivisions, and leakage from sewage collection systems.

During 1968-69, field work consisted of detailed mapping of the surface geology, with special emphasis on those areas in north-central Bexar County where sewage-treatment plants are either operational or planned, and the collection of water-quality data for selected wells and streams in the San Antonio area (fig. 1). Water samples were collected below sewage plants at the request of local agencies. Quality data for the waste waters are an important part of the study, particularly the determination of minor-element concentrations. Minor elements identified in the waste water may serve as tracers for determining movement of the waste water in the aquifer. Chemical and biological analyses of the water samples collected during the investigation will be used as historical reference data to determine changes in water quality and to detect any current pollution of the ground water in the Edwards and associated limestones.

GEOLOGY

The geologic units exposed in the vicinity of the sewage plants are, from oldest to youngest: The Edwards and associated limestones, Grayson Shale, Buda Limestone, Austin Chalk, Anacacho Limestone, and Quaternary alluvium (fig. 1). Except for the alluvium, the formations dip generally toward the southeast at an angle steeper than the slope of the land surface; thus, the older formations crop out in the northwest part of the area. In some places the continuity of the formations is disrupted by faulting.

In part of the area, the Edwards and associated limestones are overlain by formations, such as the Grayson Shale and the Anacacho Limestone, that for all practical purposes are impervious to the infiltration of pollutants. It seems probable, therefore, that the effluent from the airport sewage plant or the proposed sewage plant near Wetmore would not percolate downward to the aquifer.

Seepage investigations during periods of flood show that in the vicinity of the San Pedro Hills sewage plant, some of the flow is lost to the Austin Chalk. Because the Austin Chalk is in contact with the Edwards and associated limestones as a result of faulting, it seems highly likely that the effluent from the plant will eventually make its way into the Edwards aquifer.

The greatest threat of pollution exists where pollutants are deposited on or flow into the fractured and cavernous outcrop of the Edwards and associated limestones. In general, the greatest concentrations of solution-enlarged fractures are found in the streambeds (fig. 1), which are dry except during periods of high rainfall and flood runoff.

WATER QUALITY

During this study, waters of the San Antonio area have been analyzed for a number of properties and characteristics--including inorganic parameters, organic and biological parameters (nutrients, bacteria, and biochemical-oxygen demand), selected pesticides, and minor elements. Although sampling has been concentrated in the areas north and northwest of San Antonio, samples have been collected elsewhere in the San Antonio area, including one or more sites in seven counties (fig. 1).

All water-quality data collected through August 1969, except pesticide data, are shown in tables 1 and 2. Waters from the following sites (fig. 1) were analyzed for pesticides (9 insecticides and 3 herbicides) during the study, and all concentrations were less than 0.005 µg/l (micrograms per liter):

AY-68-28-903	AY-68-36-410
AY-68-29-204	JJ-55-63-701
AY-68-29-403	JJ-55-63-703
AY-68-29-810	Site 6 - Frio River at Concan.

A water sample collected downstream from the airport sewage plant (site C) in September 1968 contained 0.15 µg/l DDD [1, 1-dichloro-2, 2-bis (p-chlorophenyl) ethane]; 0.10 µg/l DDE [1, 1-dichloro-2, 2-bis (p-chlorophenyl) ethylene]; 0.06 µg/l DDT [1, 1, 1-trichloro-2, 2-bis (p-chlorophenyl) ethane]; and 0.02 µg/l Dieldrin. Other insecticides and herbicides were less than 0.005 µg/l. Concentrations of pesticides permissible in public water supplies are given in the following table:

(Adapted from Water Quality Criteria--Report of the National Technical Advisory Committee to the Secretary of the Interior: Federal Water Pollution Control Administration, 1968)

Insecticide (micrograms/liter)		Herbicide (micrograms/liter)	
Aldrin	17	2, 4-D plus	100
DDT	42	2, 4, 5-T plus	
Dieldrin	17	Silvex	
Endrin	1		
Heptachlor	18		
Heptachlor epoxide	18		
Lindane	56		

Analyses of water for inorganic parameters and minor elements, in addition to portraying existing conditions, provide background data for determining movement and volume of future recharge that may have significant quantities of one or more of these minerals--a possible source of pollution may provide its own tracer.

Nutrients (nitrogen and phosphorus compounds) and BOD (biochemical oxygen demand) are indicators of pollution. However, the sanitary condition of water supplies is routinely based on an evaluation of the concentrations of coliform bacteria. The use of coliform organism as an indicator of pollution is discussed by the U.S. Public Health Service (1962, p. 14). In summary, the report states that the presence of any type of coliform organism is undesirable in drinking water. The presence of fecal coliform organisms indicates recent pollution, whereas the presence of organisms determined as total coliforms includes bacteria with longer survival times in water and may indicate less recent pollution.

Fecal streptococci are also indicators of fecal pollution, and together with fecal coliforms, they can provide information on the source of pollution. For example, Geldreich (1966, p. 102) reported an average ratio of fecal coliforms to fecal streptococci of 4.4 in man, 0.04 in pigs, and less than 0.1 in other domestic animals.

The short survival time and the possible increase in population of bacteria in water make it imperative that analysis for these organisms be started as soon as possible after a sample is collected. Portable equipment is being used in this study and determinations are begun at the sampling site. Such equipment for determining fecal coliforms and fecal streptococci was not available until 1969.

CONTINUING STUDIES

Mapping of surface geology will continue, with special emphasis on those areas where waste waters may be recharging the aquifer. Water-quality data will be collected at additional sites, and some sites will be resampled for determination of selected parameters. Additional pesticide data will be collected in areas of possible pollution and from selected wells to provide background data for the study area. Bacteria counts and nutrient concentration will be determined at all new and resampled sites.

REFERENCES CITED

Geldreich, E. E., 1966, Sanitary significance of fecal coliforms in the environment: Federal Water Pollution Control Adm. Pub. WP-20-3, p. 122.

National Technical Advisory Committee to the Secretary of the Interior, 1968, Water Quality Criteria: Federal Water Pollution Control Adm., p. 20-83.

U.S. Public Health Service, 1962, Public Health Service drinking water standards: U.S. Public Health Service Pub. 956, 61 p., 1 fig.

Table 1.--Quality-of-water data from wells and springs in the San Antonio area

(Results in milligrams per liter except as indicated)

Well Number	AY-68-27-502	AY-68-27-503	AY-68-27-504	AY-68-27-506	AY-68-27-507	AY-68-28-502	AY-68-28-903	AY-68-29-203	AY-68-29-204	AY-68-29-401	AY-68-29-403
Date of Collection	July 18,1969	July 18,1969	July 18,1969	July 18,1969	July 18,1969	Sept.11,1968	Oct. 30,1968	Sept.11,1968	Sept.11,1968	Sept.11,1968	Sept.11,1968
Depth of well (ft)	400	435	508	400	385	506	762	239	280	517	340
Silica (SiO_2).....	10	10	10	10	10	11	13	12	11	12	12
Ammonia (NH_4).....	.00	.00	.00	.00	.00	.00	--	.00	.00	.00	.00
Calcium (Ca).....	308	83	93	80	72	81	91	80	92	85	110
Magnesium (Mg).....	50	15	14	16	16	12	14	19	14	15	8.8
Sodium (Na).....	11	6.1	8.3	6.6	6.1	5.4	5.4	4.2	4.4	5.7	5.8
Potassium (K).....	3.3	.8	1.1	.9	.6	1.0	1.2	.7	.9	.6	1.0
Bicarbonate (HCO_3).....	288	292	318	292	272	284	314	322	332	326	368
Carbonate (CO_3).....	0	0	0	0	0	0	0	0	0	0	0
Sulfate (SO_4).....	700	17	23	16	16	16	16	9.8	9.6	8.0	15
Chloride (Cl).....	20	13	14	13	12	9.8	16	6.6	7.0	9.6	7.8
Fluoride (F).....	1.8	.2	.2	.2	.2	.2	.2	.1	.1	.2	.2
Nitrate (NO_3).....	4.9	6.8	6.1	7.1	5.9	4.2	5.3	5.4	8.1	3.5	1.6
Nitrite (NO_2).....	.44	.00	.00	.00	.00	.00	--	.00	.00	.00	.00
Phosphate (PO_4).....	.00	.02	.05	.08	.02	.03	--	.05	.07	.06	.05
Boron (B).....	.10	.05	.06	.05	.03	.04	.08	.03	.03	.02	.00
Dissolved solids.....	1250	296	326	294	273	281	316	296	310	300	343
Hardness as $CaCO_3$.....	974	268	290	266	246	252	284	278	287	274	310
Noncarbonate hardness...	738	29	29	26	22	19	28	14	15	6	9
Sodium adsorption ratio (SAR).....	.2	.2	.2	.2	.2	.1	.1	.1	.1	.1	.1
Residual sodium carbonate (RSC) (milli-equivalents per liter)	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Specific conductance (micromhos at 25°C)...	1550	510	564	509	472	486	563	514	535	525	583
pH.....	7.0	7.2	7.0	7.1	7.5	7.6	7.5	7.4	7.3	7.3	7.6
Temperature (°C).....	22	--	22	24	22	26	22	23	24	24	22
Total coliform (per 100 ml)	0	0	0	6	0	0	--	680	2	0	a2
Biochemical oxygen demand (BOD).....	.0	.2	.1	.5	.4	.8	--	1.1	1.1	1.0	1.1
Detergents (MBAS).....	--	--	--	--	--	--	--	.02	.02	.01	.01
Dissolved oxygen (DO)...	--	--	--	--	--	--	--	--	--	--	--
Aluminum (Al).....	.2	.0	.1	.0	.0	.1	--	.1	.0	.0	.0
Iron (Fe).....	.23	.00	.00	.00	.00	.00	--	.00	.00	.00	.00
Manganese (Mn).....	.01	.00	.00	.00	.00	.00	--	.00	.00	.00	.00
Copper (Cu).....	.00	.00	.01	.00	.01	.03	--	.02	.00	.01	.01
Zinc (Zn).....	1.7	.03	.04	.29	.24	.03	--	.14	.58	.03	.56
Lithium (Li).....	--	--	--	--	--	.00	--	.00	.00	.00	.00
Strontium (Sr).....	--	--	--	--	--	.50	--	.17	.10	.28	.14
Nickel (Ni).....	--	--	--	--	--	.00	--	.00	.00	.00	.00
Lead Pb).....	--	--	--	--	--	--	--	.00	.00	.00	.00
Iodide (I).....	--	--	--	--	--	.01	--	.01	.01	.01	.01

See footnotes at end of table.

Table 1.---Quality-of-water data from wells and springs in the San Antonio area--continued

(Results in milligrams per liter except as indicated)

Well Number	AY-68-29-405	AY-68-29-407	AY-68-29-408	AY-68-29-409	AY-68-29-501	AY-68-29-502	AY-68-29-503	AY-68-29-809	AY-68-29-809	AY-68-29-810	AY-68-35-307
Date of Collection	Sept.11,1968	Sept.11,1968	Sept.11,1968	Apr. 2,1969	Jan. 11,1969	Sept.11,1968	Sept.11,1968	Oct. 31,1968	Apr. 2, 1969	Apr. 2, 1969	July 18,1969
Depth of well (ft)	395	349	390	460	350±	284	349	364	364	500	291
Silica (SiO_2).....	12	12	12	13	14	12	11	9.3	13	12	14
Ammonia (NH_4).....	.00	.00	.00	--	.00	.00	.00	.00	--	--	.00
Calcium (Ca).....	90	99	100	98	108	98	90	74	77	86	81
Magnesium (Mg).....	11	8.4	11	12	11	12	11	15	15	15	31
Sodium (Na).....	8.6	10	5.6	2.5	6.2	5.4	4.4	13	9.7	6.9	16
Potassium (K).....	1.2	.6	--	--	--	1.0	.7	--	--	--	5.0
Bicarbonate (HCO_3).....	308	324	344	344	372	350	320	284	276	300	348
Carbonate (CO_3).....	0	0	0	0	0	0	0	0	0	0	0
Sulfate (SO_4).....	13	17	7.2	6.8	6.8	7.2	4.8	15	23	23	33
Chloride (Cl).....	12	14	8.0	6.5	7.8	8.6	6.6	18	16	11	32
Fluoride (F).....	.1	1.3	.1	.1	.1	.1	.1	.3	.2	.2	1.0
Nitrate (NO_3).....	5.6	2.9	3.6	1.4	5.8	3.8	3.5	.0	1.8	6.0	.0
Nitrite (NO_2).....	.00	.00	.00	.01	.00	.00	.00	.00	.09	.01	.00
Phosphate (PO_4).....	.09	.05	.05	.04	.05	.03	.03	.03	.03	.04	.02
Boron (B).....	.03	.04	.04	.03	.22	.03	.02	.04	.05	.04	.00
Dissolved solids.....	304	324	318	309	343	320	289	285	292	308	384
Hardness as $CaCO_3$.....	270	282	294	294	314	294	270	246	254	276	330
Noncarbonate hardness...	17	16	12	12	10	7	8	14	28	30	44
Sodium adsorption ratio (SAR).....	.2	.3	.1	.1	.1	.1	.1	.4	.3	.2	.4
Residual sodium carbonate (RSC) (milli-equivalents per liter)	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Specific conductance (micromhos at 25°C)...	572	548	546	547	593	559	531	517	511	529	659
pH.....	7.6	7.5	7.9	7.2	6.9	7.7	7.6	7.0	7.4	7.3	7.2
Temperature (°C).....	24	22	23	22	22	22	24	--	23	23	26
Total coliform (per 100 ml).....	0	420	4	71	32	0	b460	0	--	0	0
Biochemical oxygen demand (BOD).....	1.5	1.1	1.3	.3	.3	1.1	1.5	3.0	.6	.3	.3
Detergents (MBAS).....	.02	.03	.02	.10	--	.04	.00	.04	.16	.03	--
Dissolved oxygen (DO)...	--	--	--	--	--	--	--	--	--	--	--
Aluminum (Al).....	.0	.1	.0	--	.0	.0	.0	.0	--	--	.1
Iron (Fe).....	.00	.00	.00	.01	.01	.03	.00	2.9	.46	.00	1.0
Manganese (Mn).....	.00	.00	.00	.00	.01	.00	.00	.08	.00	.00	.10
Copper (Cu).....	.01	.02	.00	--	.40	.01	.01	.01	--	--	.00
Zinc (Zn).....	.07	.08	.23	--	.00	.68	.12	.06	--	--	.06
Lithium (Li).....	.01	.01	.00	--	.00	.00	.00	.00	--	--	--
Strontium (Sr).....	.21	.20	.12	--	.14	.14	.10	.43	--	--	--
Nickel (Ni).....	.00	.00	.00	--	.00	.00	.00	.01	--	--	--
Lead (Pb).....	.00	.00	.00	--	.00	.00	.00	.00	--	--	--
Iodide (I).....	.01	.01	.01	--	.01	.01	.01	.04	--	--	--

See footnotes at end of table.

Table 1.--Quality-of-water data from wells and springs in the San Antonio area--continued

(Results in milligrams per liter except as indicated)

Well Number	AY-68-36-410	DX-68-15-901	DX-68-16-802	DX-68-23-201	JJ-55-63-701	JJ-55-63-703	LR-67-01-701	LR-67-01-801	LR-67-09-101
Date of Collection	Jan. 11,1969	Oct. 31,1968	Jan. 11,1969	Jan. 11,1969	Nov. 7, 1968	Nov. 7, 1968	Oct. 31,1968	Oct. 31,1968	Oct. 31,1968
Depth of well (ft)	604	--	190	367	563	146	--	--	229
Silica (SiO_2)	13	11	12	12	12	14	11	11	12
Ammonia (NH_4)	.00	.00	.00	.00	--	--	.00	.00	.00
Calcium (Ca)	68	98	82	91	46	72	92	82	100
Magnesium (Mg)	15	15	16	7.6	16	4.8	12	19	16
Sodium (Na)	9.2	7.4	12	11	12	15	14	7.4	23
Potassium (K)	--	--	--	--	--	--	--	--	--
Bicarbonate (HCO_3)	252	340	304	288	212	220	308	300	342
Carbonate (CO_3)	0	0	0	0	0	0	0	0	0
Sulfate (SO_4)	23	15	20	11	7.0	11	9.2	23	36
Chloride (Cl)	11	14	14	16	16	22	13	19	23
Fluoride (F)	.1	.3	.1	.1	.4	.2	.2	.3	.3
Nitrate (NO_3)	5.6	9.2	8.1	15	3.1	11	1.1	.6	11
Nitrite (NO_2)	.00	.04	.00	.00	.00	.00	.00	.00	.07
Phosphate (PO_4)	.02	.05	.03	.03	--	--	.07	.04	.05
Boron (B)	.05	.04	.07	.00	.04	.07	.01	.01	.05
Dissolved solids	269	337	313	306	217	258	291	310	393
Hardness as $CaCO_3$	231	306	270	258	181	199	279	282	316
Noncarbonate hardness	24	28	22	22	7	19	26	36	35
Sodium adsorption ratio (SAR)	.3	.2	.3	.3	.4	.5	.0	.2	.6
Residual sodium carbonate (RSC) (milli-equivalents per liter)	.00	.00	.00	.00	.00	.00	.00	.00	.00
Specific conductance (micromhos at 25°C)	466	596	540	514	393	455	554	574	658
pH	7.4	6.9	7.3	7.1	7.7	7.5	6.9	7.0	6.9
Temperature (°C)	24	--	23	23	23	18	--	--	--
Total coliform (per 100 ml)	12	24	0	0	0	3100	0	8	0
Biochemical oxygen demand (BOD)	.1	.2	.1	.1	.1	.1	.3	.4	.3
Detergents (MBAS)	--	.00	--	--	--	--	.01	.01	.00
Dissolved oxygen (DO)	--	--	--	--	--	--	--	--	--
Aluminum (Al)	.0	.0	.0	.0	.1	.0	.0	.0	.1
Iron (Fe)	.00	.03	.00	.00	.03	.03	.03	.00	.01
Manganese (Mn)	.00	.00	.00	.00	.00	.00	.02	.00	.00
Copper (Cu)	.00	.00	.00	.01	.00	.04	.02	.00	.00
Zinc (Zn)	.09	.02	.28	1.0	.01	.01	.05	.02	.10
Lithium (Li)	.00	.00	.00	.00	.00	.00	.00	.00	.00
Strontium (Sr)	.40	.37	.57	.18	.42	.13	.17	.57	.59
Nickel (Ni)	.00	.01	.00	.00	.00	.00	.00	.00	.00
Lead (Pb)	.00	.00	.00	.01	.00	.00	.00	.00	.00
Iodide (I)	.01	.01	.01	.01	.02	.02	.01	.01	.01

a Resample of Sept. 15, 1969 contained 67 colonies/100 ml total coliform, 3 colonies/100 ml fecal coliform, and 1 colony/100 ml fecal streptococci.
b Resample of Sept. 15, 1969 contained 1500 colonies/100 ml total coliform, 0 colonies/100 ml fecal coliform, and 3 colonies/100 ml fecal streptococci.

Table 2.--Quality-of-water data from sites other than wells and springs in the San Antonio area

(Results in milligrams per liter except as indicated)

	Site 2	Site 2	Site 3	Site 3	Site 4	Site 4	Site 5	Site 5	Site 6	Site 6
	East Frio R. 1 mile above mouth at Leaky.	East Frio R. 1 mile above mouth at Leaky.	Frio R. at Hwy. 1120 1 mile below Leaky.	Frio R. at Hwy. 1120 1 mile below Leaky.	Frio R. at Hwy. 1050 above Garner Park.	Frio R. at Hwy. 1050 above Garner Park.	Frio R. at Mager's crossing below Garner Park.	Frio R. at Mager's crossing below Garner Park.	Frio R. at Con Can.	Frio R. at Con Can.
Date of collection	Aug. 28,1968	July 29,1969	Aug. 28,1968	July 29,1969	Aug. 28,1968	July 29,1969	Aug. 28,1968	July 29,1969	Aug. 28,1968	July 29,1969
Discharge (cfs)	18.2	5.78	48.2	a42	64.8	a23	60.5	21.1	72.5	17.6
Silica (SiO_2)	--	--	--	--	--	--	--	--	--	--
Ammonia (NH_4)	.00	.00	.00	--	.00	--	.00	.00	.00	.00
Calcium (Ca)	--	--	--	--	--	--	--	--	--	--
Magnesium (Mg)	--	--	--	--	--	--	--	--	--	--
Sodium (Na)	--	--	--	--	--	--	--	--	--	--
Potassium (K)	--	--	--	--	--	--	--	--	--	--
Bicarbonate (HCO_3)	226	--	258	--	250	--	231	--	216	204
Carbonate (CO_3)	0	--	0	--	0	--	0	--	0	0
Sulfate (SO_4)	7.4	--	7.6	--	7.6	--	12	--	13	16
Chloride (Cl)	12	--	12	--	14	--	14	--	15	16
Fluoride (F)	--	--	--	--	--	--	--	--	--	--
Nitrate (NO_3)	3.8	.9	4.3	--	5.7	--	4.6	2.8	5.0	.8
Nitrite (NO_2)	.00	.00	.00	--	.00	--	--	--	.00	.00
Phosphate (PO_4)	.02	.03	.04	--	.01	--	.02	.05	.02	.02
Boron (B)	--	--	--	--	--	--	--	--	--	--
Dissolved solids	--	--	--	--	--	--	--	--	--	--
Hardness as $CaCO_3$	201	--	243	--	231	--	216	--	206	148
Noncarbonate hardness	16	--	32	--	26	--	27	--	29	0
Sodium adsorption ratio (SAR)	--	--	--	--	--	--	--	--	--	--
Residual sodium carbonate (RSC) (milliequavalents per liter)	--	--	--	--	--	--	--	--	--	--
Specific conductance (micromhos at 25°C)	395	--	447	444	452	444	427	403	414	362
pH	7.6	b7.6	7.6	b7.5	7.7	b7.5	7.8	b7.7	7.7	7.9
Temperature (°C)	25	26	24	26	25	29	27	29	28	30
Total coliform (per 100 ml)	9700	2200	9200	5000	5600	0	1700	12000	6600	8200
Fecal coliform (per 100 ml)	--	--	--	--	--	--	--	--	--	--
Fecal streptococci (per 100 ml)	--	--	--	--	--	--	--	--	--	--
Biochemical oxygen demand (BOD)	.5	.7	.4	--	.6	--	.8	1.1	.5	.7
Detergents (MBAS)	--	--	--	--	--	--	--	--	--	--
Dissolved oxygen (DO)	7.3	9.2	7.9	8.8	9.0	11	9.4	8.9	8.9	8.7
Aluminum (Al)	--	--	--	--	--	--	--	--	--	--
Iron (Fe)	--	--	--	--	--	--	--	--	--	--
Manganese (Mn)	--	--	--	--	--	--	--	--	--	--
Copper (Cu)	--	--	--	--	--	--	--	--	--	--
Zinc (Zn)	--	--	--	--	--	--	--	--	--	--
Lithium (Li)	--	--	--	--	--	--	--	--	--	--
Strontium (Sr)	--	--	--	--	--	--	--	--	--	--
Nickel (Ni)	--	--	--	--	--	--	--	--	--	--
Lead (Pb)	--	--	--	--	--	--	--	--	--	--
Bromide (Br)	--	--	--	--	--	--	--	--	--	--
Iodide (I)	--	--	--	--	--	--	--	--	--	--

NOTE: No flow at site 1 during both investigations.

Table 2.--Quality-of-water data from sites other than wells and springs in the San Antonio area--continued

(Results in milligrams per liter except as indicated)

Site	Site A	Site B	Site C	Site C	Site D	Site E	Site F	Site G	Site H	Site I
	Salado Creek at old Bitters Road	Sanitary (trash pit) land fill effluent near airport	Airport sewage plant	Airport sewage plant	Mud Creek	Salado Creek at Nacogdoches Road	Capitol Cement Co.pit (bottom of pit)	Capitol Cement Co.pit (seepage from west side)	Thunderbird and Oak Hills sewage plants	Medina Canal near Rio Medina
Date of collection	May 17, 1969	Apr. 11, 1969	Sept. 11,1968	Oct. 31,1968	Aug. 27,1969	May 17,1969	Apr. 2, 1969	May 22,1969	July 18,1969	Aug. 15,1969
Discharge (cfs)	--	--	--	--	--	--	--	--	--	a41
Silica (SiO_2)	12	14	17	13	12	11	17	17	19	--
Ammonia (NH_4)	--	--	19	.96	--	--	--	--	20	--
Calcium (Ca)	42	136	115	72	28	40	104	116	83	--
Magnesium (Mg)	1.0	15	18	18	1.3	1.7	15	4.4	14	--
Sodium (Na)	1.6	65	48	28	.0	1.7	52	18	112	--
Potassium (K)	4.7	--	15	--	--	4.3	--	--	7.4	--
Bicarbonate (HCO_3)	132	460	448	90	86	123	304	280	410	--
Carbonate (CO_3)	0	0	0	0	0	0	0	0	0	--
Sulfate (SO_4)	5.2	39	43	54	.0	4.8	101	90	58	--
Chloride (Cl)	1.8	88	79	70	1.8	2.4	54	16	134	--
Fluoride (F)	.1	.2	2.0	2.7	.1	.1	.8	.2	.2	--
Nitrate (NO_3)	2.6	.3	42	101	1.6	1.8	2.0	.2	7.2	--
Nitrite (NO_2)	--	--	11	.56	--	--	.11	.00	.10	--
Phosphate (PO_4)	--	--	12	17	--	--	.04	--	19	--
Boron (B)	.05	--	1.6	3.2	.08	.06	.32	--	.41	--
Dissolved solids	137	584	629	408	87	128	495	400	657	--
Hardness as $CaCO_3$	113	401	361	254	75	107	321	308	264	--
Noncarbonate hardness	4	24	0	180	5	6	72	78	0	--
Sodium adsorption ratio (SAR)	.1	1.4	1.1	.8	.0	.1	1.3	.4	3.0	--
Residual sodium carbonate (RSC) (milliequivalents per liter)	.00	.00	.12	.00	.00	.00	.00	.00	1.43	--
Specific conductance (micromhos at 25°C)	224	1030	1030	898	150	213	809	655	1150	--
pH	7.8	7.1	7.2	6.6	7.2	7.4	7.5	6.9	7.1	--
Temperature (°C)	19	22	26	--	26	19	20	22	--	--
Total coliform (per 100 ml)	--	--	--	360,000	--	--	8000	--	c0	1600
Fecal coliform (per 100 ml)	--	--	--	--	--	--	--	--	--	0
Fecal streptococci (per 100 ml)	--	--	--	--	--	--	--	--	--	10
Biochemical oxygen demand (BOD)	--	--	22	11	--	--	2.5	--	3.7	--
Detergents (MBAS)	--	--	.28	.10	--	--	.06	--	--	--
Dissolved oxygen (DO)	--	--	.7	--	--	--	--	--	--	--
Aluminum (Al)	--	--	.3	--	.8	--	--	--	.1	--
Iron (Fe)	--	--	.15	--	.28	--	.03	--	.02	--
Manganese (Mn)	--	--	.81	--	.00	--	.00	--	.00	--
Copper (Cu)	--	--	.01	--	.00	--	--	--	.02	--
Zinc (Zn)	--	--	.26	--	.00	--	--	--	.05	--
Lithium (Li)	--	--	.01	--	--	--	--	--	--	--
Strontium (Sr)	--	--	.52	--	--	--	--	--	--	--
Nickel (Ni)	--	--	.02	--	--	--	--	--	--	--
Lead (Pb)	--	--	.01	--	--	--	--	--	--	--
Bromide (Br)	--	--	.4	--	--	--	--	--	--	--
Iodide (I)	--	--	.16	--	--	--	--	--	--	--

a Estimated.
b Field pH.
c Resample of Aug. 15, 1969 contained 7 colonies/100 ml total coliform, 0 colonies/100 ml fecal coliform, and 1400 colonies/100 ml fecal streptococci.

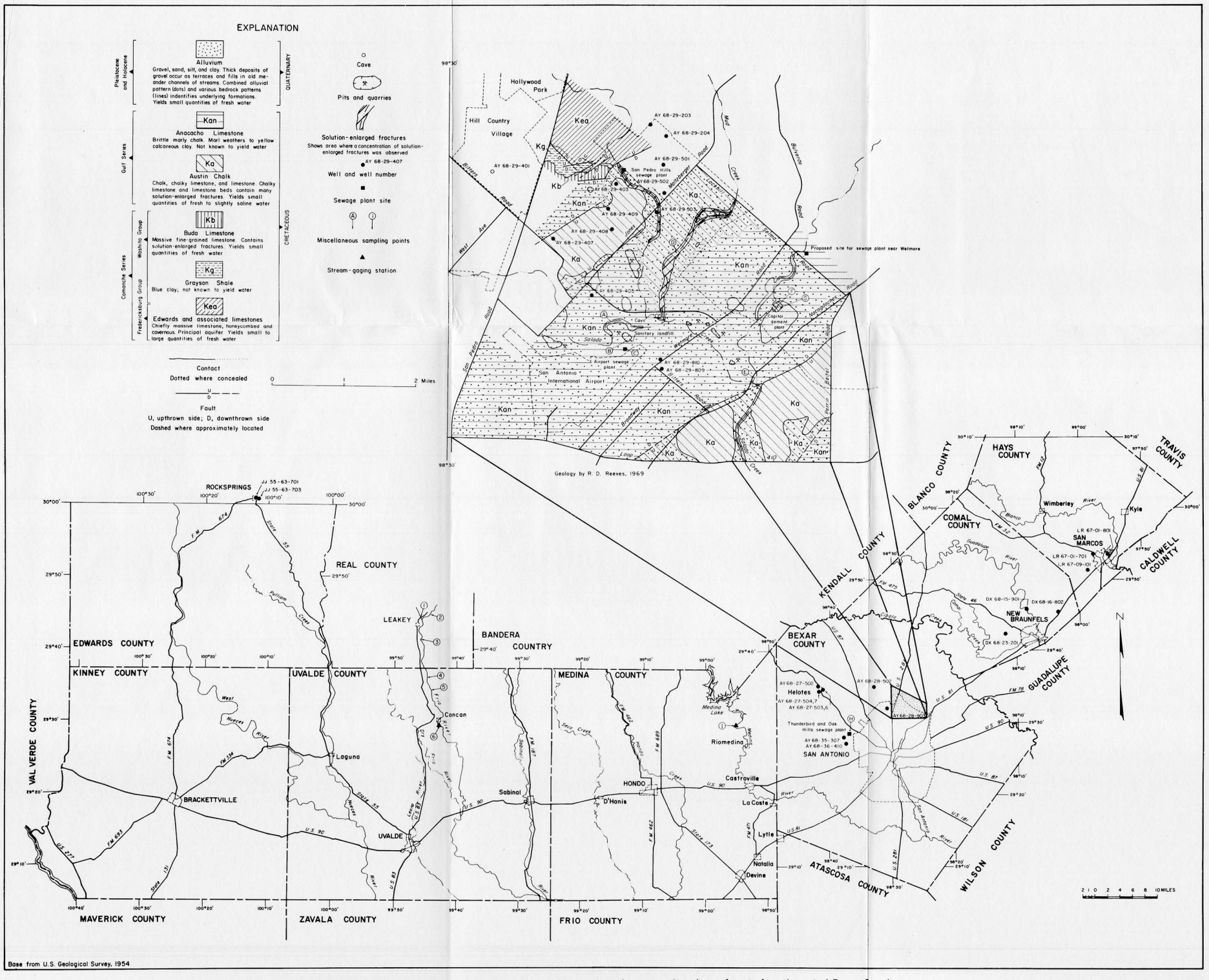

FIGURE 1.-Water-quality data-collection sites in the San Antonio area and geology of part of north-central Bexar County

Note: Large-format version of the original plate is on the following page.

EXPLANATION

Alluvium
Gravel, sand, silt, and clay. Thick deposits of gravel occur as terraces and fills in old meander channels of streams. Combined alluvial pattern (dots) and various bedrock patterns (lines) indentifies underlying formations. Yields small quantities of fresh water

Pleistocene and Holocene — QUATERNARY

Kan — Anacacho Limestone
Brittle marly chalk. Marl weathers to yellow calcareous clay. Not known to yield water

Ka — Austin Chalk
Chalk, chalky limestone, and limestone. Chalky limestone and limestone beds contain many solution-enlarged fractures. Yields small quantities of fresh to slightly saline water

Gulf Series — CRETACEOUS

Kb — Buda Limestone
Massive fine-grained limestone. Contains solution-enlarged fractures. Yields small quantities of fresh water

Kg — Grayson Shale
Blue clay; not known to yield water

Kea — Edwards and associated limestones
Chiefly massive limestone, honeycombed and cavernous. Principal aquifer. Yields small to large quantities of fresh water

Comanche Series — Washita Group; Fredericksburg Group

Cave

Pits and quarries

Solution-enlarged fractures
Shows area where a concentration of solution-enlarged fractures was observed

AY 68-29-407 — Well and well number

Sewage plant site

Miscellaneous sampling points

Stream-gaging station

Contact
Dotted where concealed

Fault
U, upthrown side; D, downthrown side
Dashed where approximately located

0 1 2 Miles

Geology by R. D. Reeves, 1969

Proposed site for sewage plant near Wetmore

Base from U.S. Geological Survey, 1954

FIGURE 1.- Water-quality data-collection sites in the San Antonio area and geology of part of north-central Bexar County