TOTAL PESTICIDES

Pesticides are manmade organic chemicals used to control populations of pests and are called insecticides if intended for insects or herbicides if intended for plants. At sufficiently large concentrations, pesticides are toxic to animals and man; additionally, long-term exposure to small concentrations of some pesticides can have carcinogenic or mutagenic effects. Long-lasting pesticides, such as DDT and dieldrin, are especially dangerous because they are concentrated in the food chain, and these environmentally persistent pesticides are no longer available for use in the United States.

Although the number of analyses for each pesticide was different, analyses for DDT were the most numerous. Of the 380 samples collected for DDT analysis, 126 were taken from wells, 6 from Comal Springs, 8 from San Marcos Springs, 2 from Woodard Cave, and 238 from 13 surface-water sites. A summary of pesticide data for wells, springs, and surface-water sampling sites is given by hydrologic subarea in table 5.

DISTRIBUTION OF PESTICIDES

Pesticides were detected in only 12 of 211 water samples taken from wells and springs. All ground-water samples with detected concentrations of pesticides were collected from sites in or near the recharge area of the aquifer. Isolated and localized instances of pesticide detection suggest that these wells may have been sampled soon after pesticides were applied at the surface and the pesticides then seeped or were washed into the aquifer.

Pesticides were detected in only 8 of 174 samples collected at surface-water sites in the rural subarea and were detected in 55 of 64 samples collected at surface-water sites in the urban subarea. Maximum detected concentrations generally were larger in samples from the urban subarea. Larger pesticide concentrations in samples from the urban subarea are partly the result of sampling during storms when the relatively insoluble pesticides are adsorbed by suspended particles.

Six insecticides (DDE, DDT, dieldrin, endosulfan, malathion, and diazinon) and two herbicides (2,4-D and 2,4,5-T) were detected in the samples (fig. 6, table 5). DDE and DDT were detected in three samples from a well in Uvalde County, and DDE was detected in a sample from Woodard Cave. Dieldrin was detected in one sample from a well in Uvalde County. None of these three environmentally persistent pesticides have been detected in water from the aquifer since their ban from use in the United States. Malathion was not detected in any ground-water samples. Endosulfan was detected only once, in a sample from a well in northern Bexar County. Diazinon, a relatively less harmful insecticide, was detected in a sample from a well in northern Bexar County and in a sample from a northern Hays County well. The herbicide 2,4-D was detected once in a Uvalde well, once in two wells in Bexar County, and in one sample from Comal Springs. The herbicide 2,4,5-T was not detected in any ground-water samples.

The insecticides and herbicides were found more frequently in surface-water samples collected from sites in the urban subarea than in either ground water or water from rural surface-water sites. DDE and DDT were each detected five times in surface-water samples collected in the urban subarea. Dieldrin was detected in 13 samples and malathion was detected in 5 samples collected at 2 sites in the urban subarea. Diazinon was detected very frequently, in 35 samples collected at the four urban subarea sites, and in two samples collected at one rural site. The chlorophenoxy-acid herbicides (2,4-D and 2,4,5-T) are more soluble in water and were detected most frequently. The herbicide 2,4-D was detected in water collected at 3 rural sites and in 22 samples from 3 sites in the urban area. The herbicide 2,4,5-T also was detected in samples from 3 rural sites, but was detected in 31 urban subarea samples and at all of the 4 urban sites.

CONVERSION FACTORS

Some values in this report are given in inch-pound units. Conversion factors for metric (International System) units are listed below:

Multiply inch-pound units	By	To obtain metric units
acre-foot (acre-ft)	0.001233	cubic hectometer
foot (ft)	0.3048	meter
inch per year (in/yr)	25.4	millimeter per year
mile (mi)	1.609	kilometer
square foot per day (ft^2/d)	0.09290	square meter per day
square mile (mi^2)	2.590	square kilometer

EXPLANATION

Approximate recharge area (adapted from Burchett, Rettman, and Boning, 1986)

"Bad-water" line

Type of site

2 Well in pesticide sampling network

16 Stream gage in urban area

14 Stream gage in rural area

9 Spring

10 Cave

4 Number is site location. See table showing maximum detected pesticide concentration

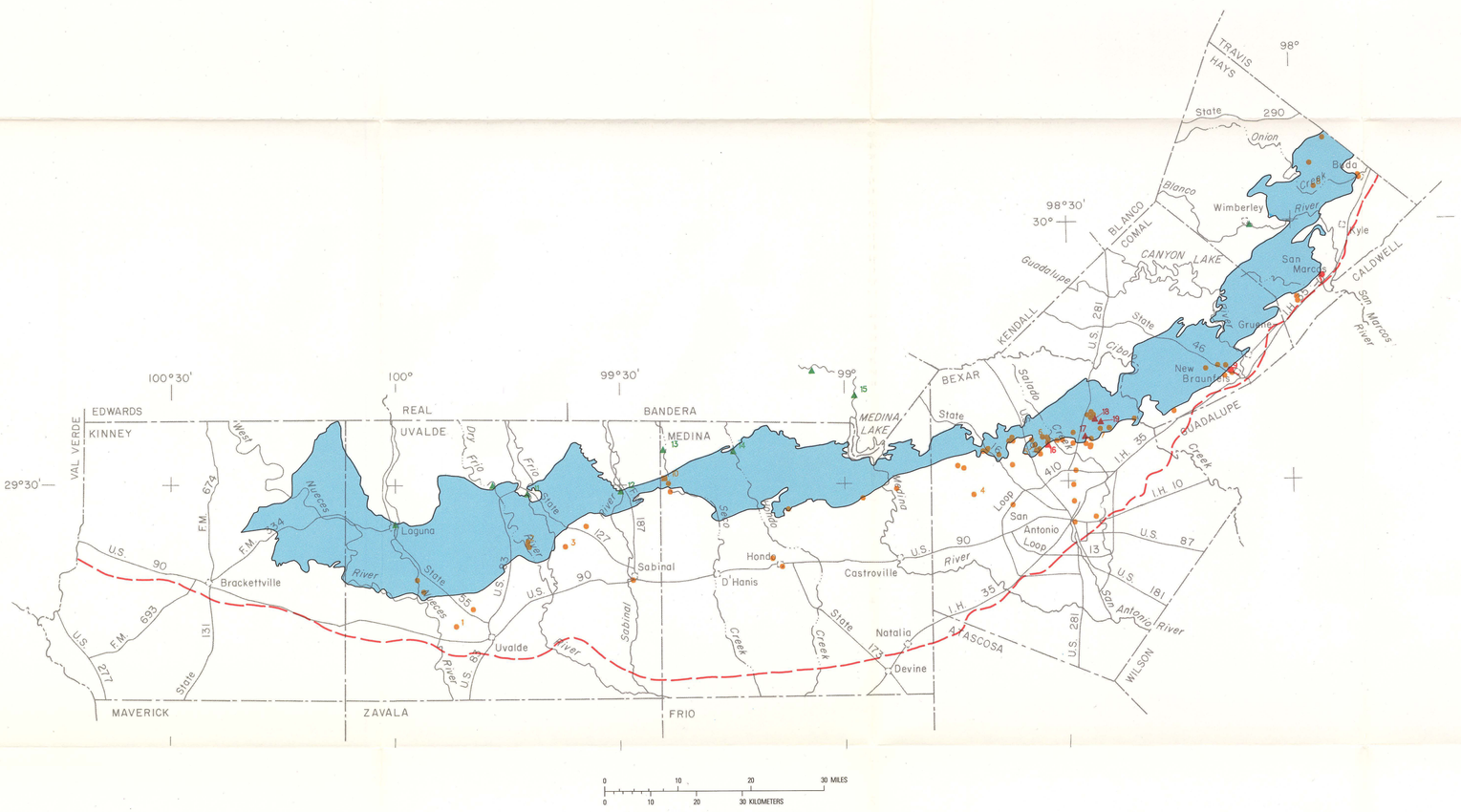

Figure 6. Areal distribution of pesticide concentrations.

Table 5. *Results of analyses for total pesticides by hydrologic subarea*

[µg/L, micrograms per liter; <, less than]

DDE

Hydrologic subarea	Number of sites	Percent of sites with detected concentrations	Number of samples	Concentration (µg/L) Minimum	Concentration (µg/L) Maximum
Urban	4	75	64	<0.01	0.02
Rural	9	0	174	<.01	<.01
Medina-Bexar	13	0	17	<.01	<.01
Uvalde	10	10	14	<.01	.04
North Bexar	35	0	75	<.01	<.01
Comal-Hays	10	0	26	<.01	<.01
North Hays	5	0	8	<.01	<.01

DDT

Hydrologic subarea	Number of sites	Percent of sites with detected concentrations	Number of samples	Concentration (µg/L) Minimum	Concentration (µg/L) Maximum
Urban	4	50	64	<0.01	0.02
Rural	9	0	174	<.01	<.01
Medina-Bexar	13	0	17	<.01	<.01
Uvalde	10	10	14	<.01	1.00
North Bexar	35	0	75	<.01	<.01
Comal-Hays	10	0	26	<.01	<.01
North Hays	5	0	8	<.01	<.01

Dieldrin

Hydrologic subarea	Number of sites	Percent of sites with detected concentrations	Number of samples	Concentration (µg/L) Minimum	Concentration (µg/L) Maximum
Urban	4	50	64	<0.01	0.02
Rural	9	0	174	<.01	<.01
Medina-Bexar	13	0	17	<.01	<.01
Uvalde	10	10	14	<.01	.08
North Bexar	35	0	75	<.01	<.01
Comal-Hays	10	0	26	<.01	<.01
North Hays	5	0	8	<.01	<.01

Endosulfan

Hydrologic subarea	Number of sites	Percent of sites with detected concentrations	Number of samples	Concentration (µg/L) Minimum	Concentration (µg/L) Maximum
Urban	4	0	40	<0.01	<0.01
Rural	9	0	95	<.01	<.01
Medina-Bexar	8	0	11	<.01	<.01
Uvalde	5	0	5	<.01	<.01
North Bexar	21	5	51	<.01	.03
Comal-Hays	9	0	23	<.01	<.01
North Hays	5	0	8	<.01	<.01

Malathion

Hydrologic subarea	Number of sites	Percent of sites with detected concentrations	Number of samples	Concentration (µg/L) Minimum	Concentration (µg/L) Maximum
Urban	4	50	60	<0.01	0.61
Rural	9	0	173	<.01	<.01
Medina-Bexar	9	0	12	<.01	<.01
Uvalde	5	0	5	<.01	<.01
North Bexar	33	0	72	<.01	<.01
Comal-Hays	10	0	24	<.01	<.01
North Hays	5	0	8	<.01	<.01

Diazinon

Hydrologic subarea	Number of sites	Percent of sites with detected concentrations	Number of samples	Concentration (µg/L) Minimum	Concentration (µg/L) Maximum
Urban	4	100	62	<0.01	1.30
Rural	9	11	173	<.01	.16
Medina-Bexar	9	0	12	<.01	<.01
Uvalde	5	0	5	<.01	<.01
North Bexar	33	3	72	<.01	.05
Comal-Hays	10	0	24	<.01	<.01
North Hays	5	20	8	<.01	.01

2,4-D

Hydrologic subarea	Number of sites	Percent of sites with detected concentrations	Number of samples	Concentration (µg/L) Minimum	Concentration (µg/L) Maximum
Urban	4	75	61	<0.01	0.13
Rural	9	33	174	<.01	.03
Medina-Bexar	13	8	17	<.01	.11
Uvalde	8	13	10	<.01	.01
North Bexar	35	3	73	<.01	.01
Comal-Hays	10	10	25	<.01	.16
North Hays	5	0	8	<.01	<.01

2,4,5-T

Hydrologic subarea	Number of sites	Percent of sites with detected concentrations	Number of samples	Concentration (µg/L) Minimum	Concentration (µg/L) Maximum
Urban	4	100	61	<0.01	1.10
Rural	9	33	174	<.01	.05
Medina-Bexar	13	0	17	<.01	<.01
Uvalde	8	0	10	<.01	<.01
North Bexar	35	0	73	<.01	<.01
Comal-Hays	10	0	25	<.01	<.01
North Hays	5	0	8	<.01	<.01

Maximum detected pesticide concentration

[ND, not detected; NA, not analyzed]

Site	DDE	DDT	Dieldrin	Endosulfan	Malathion	Diazinon	2,4-D	2,4,5-T
	Concentration (micrograms per liter) and year of sample collection							
	Wells							
1	ND	ND	0.08 1969	NA	NA	NA	ND	ND
2	0.04 1968	1.00 1968	ND	NA	NA	NA	ND	ND
3	ND	ND	ND	ND	ND	ND	0.01 1981	ND
4	ND	ND	ND	ND	ND	ND	.11 1978	ND
5	ND	ND	ND	0.03 1979	ND	ND	ND	ND
6	ND	ND	ND	ND	ND	ND	.01 1975	ND
7	ND	ND	ND	ND	ND	0.05 1977	ND	ND
8	ND	ND	ND	ND	ND	.01 1978	ND	ND
	Spring							
9	ND	ND	ND	ND	ND	ND	.16 1981	ND
	Cave							
10	.01 1977	ND	ND	ND	ND	ND	NA	NA
	Stream gages in rural area							
11	ND	ND	ND	ND	ND	ND	ND	0.05 1980
12	ND	ND	ND	ND	ND	ND	ND	.02 1977
13	ND	ND	ND	ND	ND	ND	.01 1975	ND
14	ND	ND	ND	ND	ND	ND	.03 1971	ND
15	ND	ND	ND	ND	ND	.16 1983	.03 1977	.01 1983
	Stream gages in urban area							
16	.01 1974	.01 1975	.02 1972	ND	0.61 1979	.49 1981	.02 1981	1.10 1973
17	.01 1983	ND	.01 1983	ND	.01 1983	.25 1983	.04 1983	.03 1983
18	.02 1979	.02 1979	ND	ND	ND	1.30 1980	.13 1983	.01 1979
19	ND	ND	ND	ND	ND	.02 1979	ND	.02 1979

INDICATOR BACTERIA

Fecal coliform and fecal streptocococcus are two species of bacteria that are present in the intestines of warm-blooded animals. Although these bacteria are not pathogenic, or disease-causing, the presence of these bacteria in water is indicative of fecal pollution. Consequently, the larger the densities of these bacteria, the greater the chance that pathogenic bacteria are present.

Relative densities of fecal coliform and fecal streptococcus are indicative of the source of fecal pollution. Fecal coliforms predominate in the intestines of man, whereas fecal streptococci predominate in the intestines of livestock and other animals. A coliform to streptococcus ratio of 4:1 or greater is an indication of human pollution; a ratio of less than 1:1 is an indication of animal pollution.

Bacteria densities are reported by the Geological Survey as the number of colonies per 100 milliliters of sample (cols./100 mL). If no colonies are detected in a 100-mL sample, the results are reported as less than 1 col./100 mL, which is the EPA maximum contaminant level for drinking water. There were 1,382 samples analyzed for fecal coliforms, and 1,392 for fecal streptococci. Of the total number of samples analyzed for fecal streptococci, 916 were collected from 188 wells, 14 from Comal Springs, 12 from San Marcos Springs, 2 from Woodard Cave, and 448 from 13 surface-water sites. About one-third of the wells were sampled once, about another one-third were sampled twice, and about 10 percent were sampled more than 11 times. A summary of the indicator bacteria for wells, springs, and surface-water sampling sites is given by hydrologic subarea in table 6.

DISTRIBUTION OF FECAL COLIFORMS AND FECAL STREPTOCOCCI

Densities of fecal coliforms and fecal streptococci usually were less than the detection limit of 1 col./100 mL in water from wells and springs (fig. 7). Within the aquifer, greatest time-nested log-mean densities of bacteria were detected in water from wells in or near the recharge area, or in the shallow parts of the aquifer in Uvalde and Hays Counties (table 6). The rare instances in which bacteria were detected in samples from artesian wells were likely due to sample contamination or to leaking well seals. Bacteria densities in water samples collected at surface-water sites in the rural subarea were greater than those collected from wells, but were within limits for water-contact sports and smaller than densities at typical stream sites in south-central Texas (U.S. Geological Survey, 1968–84). Densities from water samples collected at surface-water sites in the urban subarea were extremely large, but this is typical for samples collected during stormflow.

SUMMARY

The Edwards aquifer in the San Antonio region of Texas is a productive, important aquifer that is vulnerable to anthropogenic pollution because of the relatively fast infiltration of surface water through the faulted limestone in the recharge area. Nonetheless, water quality of the aquifer and of the major surface waters recharging the aquifer generally remains acceptable for most uses.

The quality of ground and surface waters in the study area was evaluated by examining frequency distributions of time-nested-average concentrations of various constituents and compounds in the water for aquifer and surface subareas. Time-nested-average concentrations of individual constituents in water from sampled sites were calculated by successively averaging measured concentrations by day, by month, by year, and by period of record.

Dissolved-solids concentrations in most of the aquifer and in major surface waters recharging the aquifer ranged from 200 to 400 mg/L, which is acceptable on the basis of the EPA drinking-water secondary maximum contaminant level. Concentrations of nutrients indicated minimal anthropogenic impacts. Median time-nested-average concentrations of total nitrogen were less than 3 mg/L in nearly the entire aquifer and about 1 mg/L for the major surface waters. Total phosphorus concentration in the aquifer and in major surface waters usually was 0.01 mg/L or less. Fecal-coliform and fecal-streptococcus densities usually were less than the detection limit of 1 col./100 mL in the aquifer and normally less than 75 cols./100 mL in major surface waters. Dissolved-metals concentrations did not significantly exceed the laboratory detection limits. Median time-nested-average concentrations typically were less than 1 µg/L for arsenic, less than 60 µg/L for boron, less than 15 µg/L for iron, less than 3 µg/L for lead, less than 0.3 µg/L for mercury, less than 1 µg/L for selenium, and less than 20 µg/L for zinc. Pesticides were detected in only 12 of 211 ground-water samples and in only 8 of 174 samples in the major surface waters in the rural subarea.

Anthropogenic impacts were indicated in parts of the aquifer in or near urban areas or the recharge area. Maximum ground-water concentrations of nearly all constituents were measured in these areas. Some constituent concentrations almost equaled or exceeded EPA drinking-water maximum contaminant levels, but only one, nitrite plus nitrate concentration (11 mg/L) for one sample, exceeded the EPA limit (10 mg/L). The water quality of the urban creeks was significantly degraded by anthropogenic impacts, and often, EPA maximum contaminant levels for drinking water were exceeded.

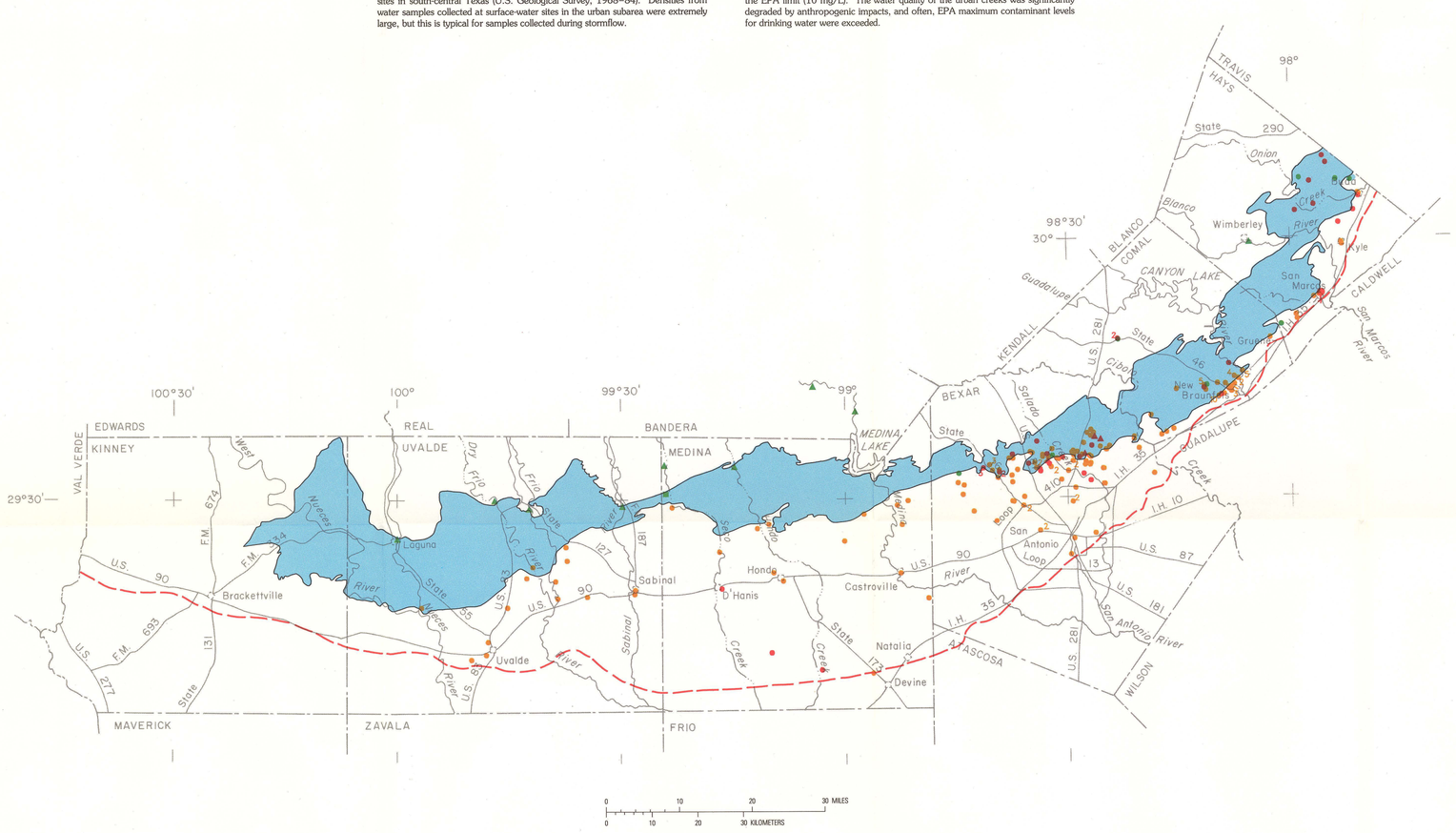

Figure 7. Areal distribution of fecal coliform and/or fecal streptococcal bacteria.

EXPLANATION

Approximate recharge area (adapted from Burchett, Rettman, and Boning, 1986)

"Bad-water" line

FECAL COLIFORM AND/OR FECAL STREPTOCOCCUS

Map symbol	Range of nested-log mean density, in colonies per 100 milliliters	Number and type of site in range
	Less than 1	147 wells
	Less than 1	1 spring
	1–10	33 wells
	1–10	1 spring
	11–1,000	9 stream gages in rural area
	11–1,000	8 wells
	11–1,000	1 cave
	More than 1,000	4 stream gages in urban area

3 Number indicates the number of wells at location

Table 6. *Results of analyses for bacteria by hydrologic subarea*

[cols./100 mL, colonies per 100 milliliters; <, less than; maximum detection level is 1 col./100 mL, but value reported can differ depending on volume of sample analyzed]

Fecal coliforms

Hydrologic subarea	Number of sites	Percent of sites with detected concentrations	Number of samples	Density (cols./100 mL) Minimum	Density (cols./100 mL) Maximum	Density (cols./100 mL) Percentile, based on time-nested log means[1] 50th	Density (cols./100 mL) Percentile, based on time-nested log means[1] 90th
Urban	4	100	81	1,000	130,000	32,000	33,000
Rural	9	100	363	<1	12,000	28	514
Medina-Bexar	34	7	80	<1	1	<1	<1
Uvalde	13	20	28	<1	1,000	<1	3
North Bexar	72	27	591	<1	500	<1	2
Comal-Hays	51	14	155	<1	3,100	<1	1
North Hays	15	40	71	<1	330	<1	3
Transition	2	0	3	<1	<1	<1	<1
Glen Rose	3	100	8	<1	88	<5	32

Fecal streptococci

Hydrologic subarea	Number of sites	Percent of sites with detected concentrations	Number of samples	Density (cols./100 mL) Minimum	Density (cols./100 mL) Maximum	Density (cols./100 mL) Percentile, based on time-nested log means[1] 50th	Density (cols./100 mL) Percentile, based on time-nested log means[1] 90th
Urban	4	100	82	200	390,000	64,000	95,000
Rural	9	100	366	<1	22,000	70	566
Medina-Bexar	34	24	82	<1	44	<1	1
Uvalde	13	0	31	<1	<1	<1	<1
North Bexar	72	51	588	<1	6,400	1	3
Comal-Hays	51	23	157	<1	16,000	<1	2
North Hays	15	73	73	<1	860	4	50
Transition	2	0	3	<1	<1	<1	<1
Glen Rose	3	100	8	<1	180	<7	91

[1] A time-nested log mean was computed for each site by taking the log of each density and then successively averaging the log numbers by day, month, year, and period of record. The antilog of the resulting average is the density for that station. Thus for fecal streptococci, 90 percent of the wells in the Medina-Bexar subarea had time-nested log means of 1 col./100 mL or less.

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INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1992

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

WATER QUALITY OF THE EDWARDS AQUIFER AND STREAMS RECHARGING THE AQUIFER IN THE SAN ANTONIO REGION, TEXAS

By
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