QUALITY-OF-WATER DATA AND STATISTICAL SUMMARY FOR SELECTED COAL-MINED STRIP PITS IN CRAWFORD AND CHEROKEE COUNTIES, SOUTHEASTERN KANSAS

By Larry M. Pope and Arthur M. Diaz

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CONVERSION FACTORS

Inch-pound units of measurements and abbreviations used in this report are listed below with the factors for conversion to the International System (SI) of Units.

Multiply inch-pound unit	By	To obtain SI unit
inch	[1] 25.4	millimeter
foot	0.3048	meter
mile	1.609	kilometer
acre	0.4047	hectare
square mile (mi^2)	2.590	square kilometer
ton per acre foot (tons/acre-ft)	0.7354	kilograms per cubic meter
micromhos per centimeter (µmhos/cm)	1.000	microsiemens per centimeter
degree Fahrenheit (°F)	(2)	degree Celcius (°C)

[1] Exact conversion factor.
[2] °F = 1.8 °C + 32.

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ABSTRACT

Quality-of-water data, collected October 21-23, 1980, and a statistical summary are presented for 42 coal-mined strip pits in Crawford and Cherokee Counties, southeastern Kansas. The statistical summary includes minimum and maximum observed values, mean, and standard deviation. Simple linear-regression equations relating specific conductance, dissolved solids, and acidity to concentrations of dissolved solids, sulfate, calcium, magnesium, potassium, aluminum, and iron are also presented.

INTRODUCTION

The quality-of-water data presented in this report are for water samples obtained in a survey of 42 selected strip pits in the coal-mined areas of Crawford and Cherokee Counties, southeastern Kansas, October 21-23, 1980.

This survey was conducted by the U.S. Geological Survey in cooperation with the U.S. Office of Surface Mining, Region IV, Kansas City, Missouri. The selection of the strip pits and the timing of the sampling were closely coordinated with remote-sensing activities of the Center for Public Affairs and the Space Technology Center, University of Kansas, Lawrence, Kansas. These research centers are conducting a prototype study of abandoned-mined lands to define problems and issues common to Region IV, U.S. Office of Surface Mining.

The purpose of this report is to (1) provide a hydrologic data base for the physical and chemical quality of water in the strip pits within the coal-mined areas, and (2) to present descriptive statistics and simple linear-regression equations relating concentrations of selected chemical constituents to specific conductance, dissolved solids, and acidity. This information could be useful for determining the pollution potential of mine spoils to the quality of ground and surface waters in mined areas.

STUDY AREA

The study area, shown in figure 1, is located in Crawford and Cherokee Counties, southeastern Kansas. During the active coal-mining period, from the late 1800's to about 1969, large portions of the two-county region were strip mined for the underlying coal beds. This activity produced nearly 41,000 acres (64 mi^2) of abandoned-mine area, of which approximately 7 percent is surface water (Camin and Hardy, 1970, p. 5). Water on these mined lands accumulates in areas between spoil-bank ridges and in the terminal pits of strip-mined areas by overland runoff, ground-water seepage, or infiltration through the irregular piles of broken limestone and shale and overturned alluvium and terrace deposits. The general location of the strip pits in Crawford and Cherokee Counties and specific locations of sampling sites used in this study are shown in figures 2-4. Location descriptions and corresponding map-index numbers are listed in table 1.

SAMPLE COLLECTION AND ANALYSIS

The survey and collection of samples were scheduled in the fall of 1980, following a period of minimal rainfall during which the quality of water in the strip pits was not subjected to changes associated with large volumes of overland runoff or fluctuation in ground-water seepage. Most of the strip pits listed in table 1 were sampled only once; however, pits, 18, 19, 22 (relatively deep pits) were each sampled twice in the vertical profile, once near the surface and once near the bottom. These double samples were taken to document any change in water quality that might occur with depth. Pits 4 and 35 also were sampled twice, but at near-surface locations horizontally spaced within the pit. Surface samples, samples taken not deeper than 3 feet, were collected by submerging a sample container. Samples from greater depths were collected in a trip-activated Kemmerer-type bottle. Adjacent strip pits 34 and 35, and 41 and 42, although appearing to be single pits in figure 4, were considered at the time of sampling, to be individual pits due to spoil-bank separation not evident in the detail of the figure. It is possible, however, that based upon onsite observations, the adjacent pits become a common pit during rainfall-runoff periods.

Onsite measurements of water depth, transparency (Secchi disk), water temperature, dissolved oxygen, specific conductance, pH, alkalinity, and acidity were made at the time of sample collection. Chemical analyses of water samples were made by the Central Laboratories, U. S. Geological Survey, Arvada, Colorado, in accordance with procedures outlined in Skougstad and others (1979). Quality-of-water measurements and chemical constituents determined from samples collected for this study are listed in table 2. Values reported for concentrations of dissolved chemical constituents were determined from water samples that were filtered through 0.45-micron filters immediately following collection. Values reported for chemical oxygen demand, acidity, alkalinity, and for total recoverable concentrations of trace metals were determined from unfiltered whole-water samples.

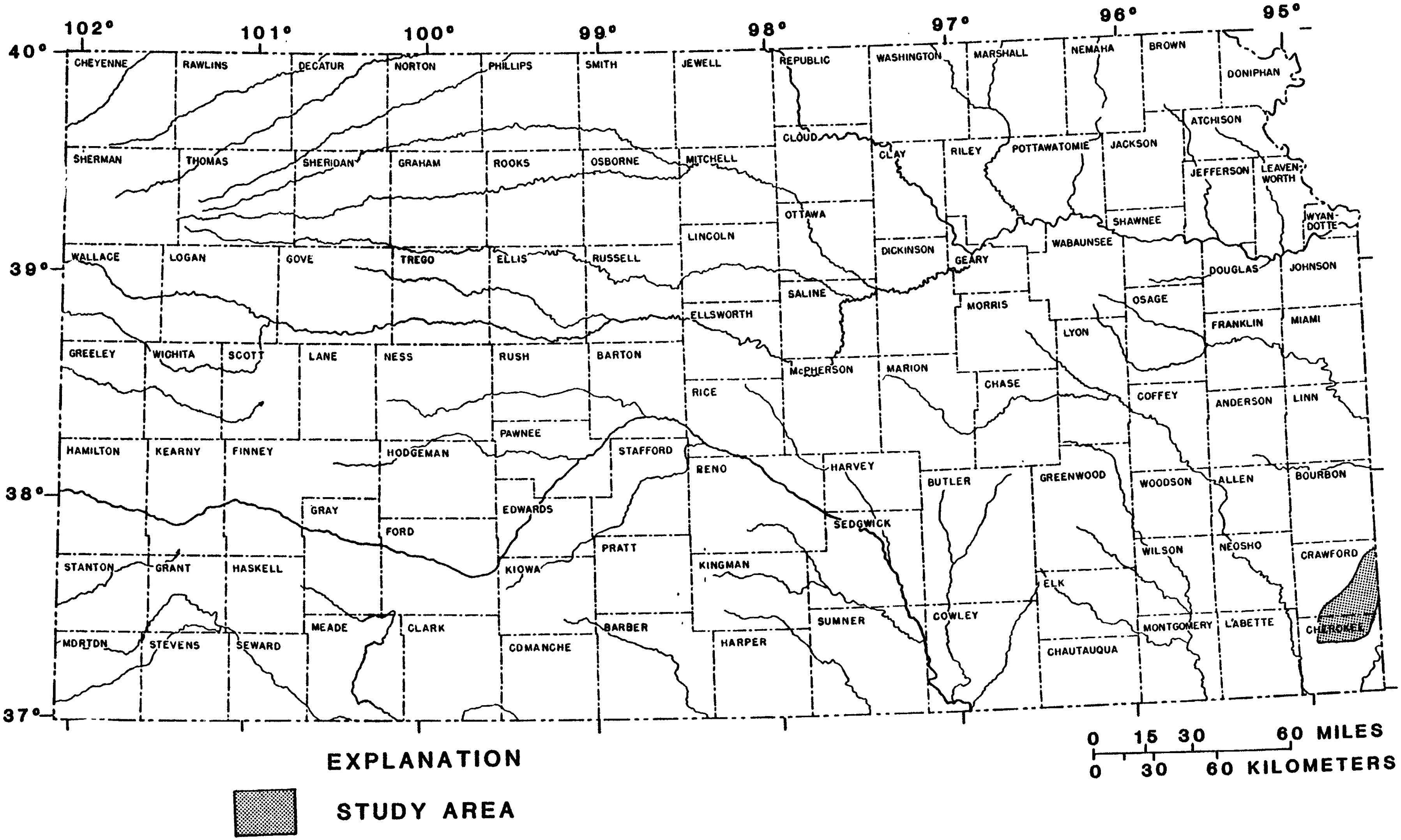


Figure 1.--Location of study area.

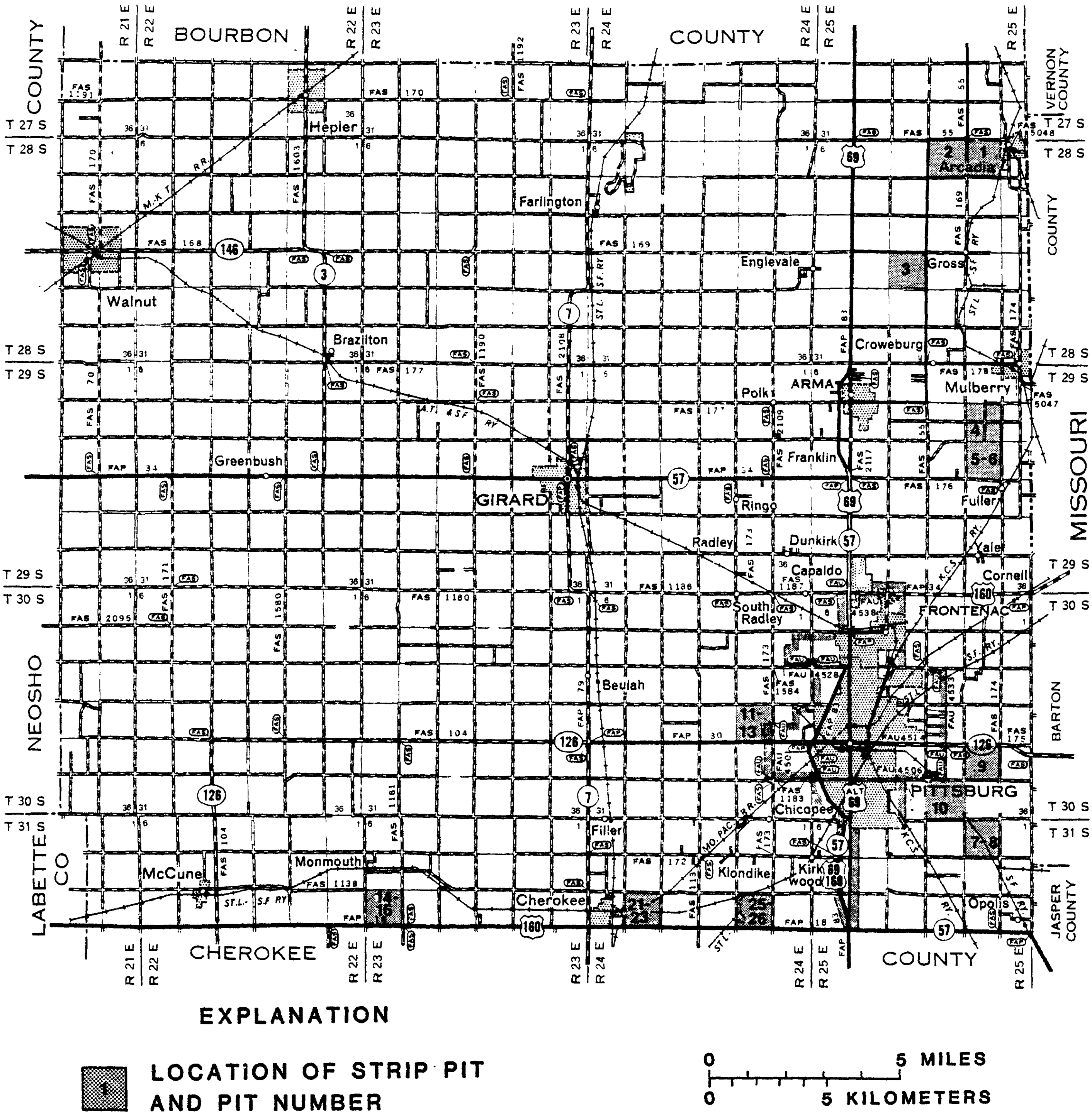


Figure 2.--General locations of strip pits sampled in Crawford County.

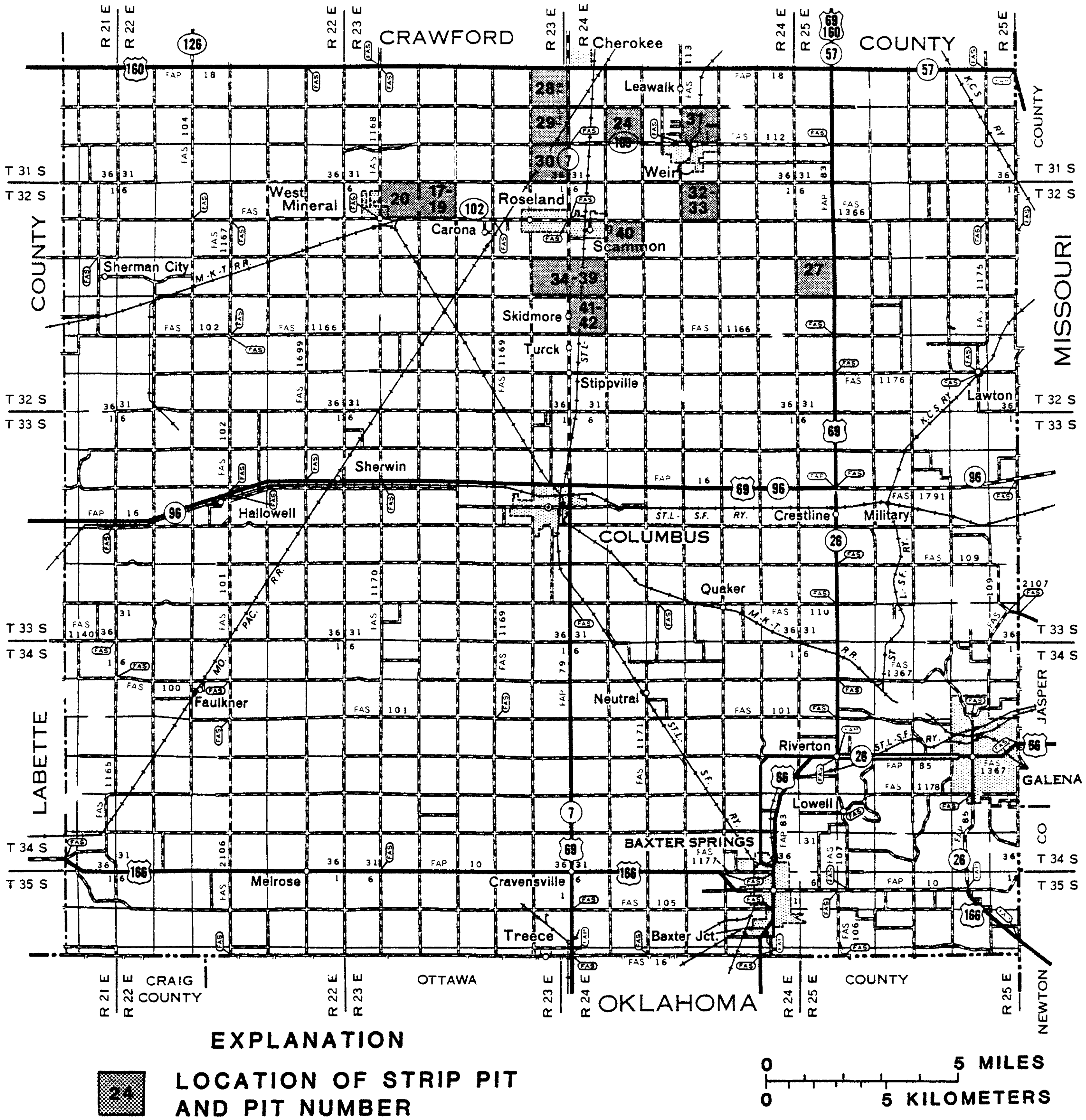
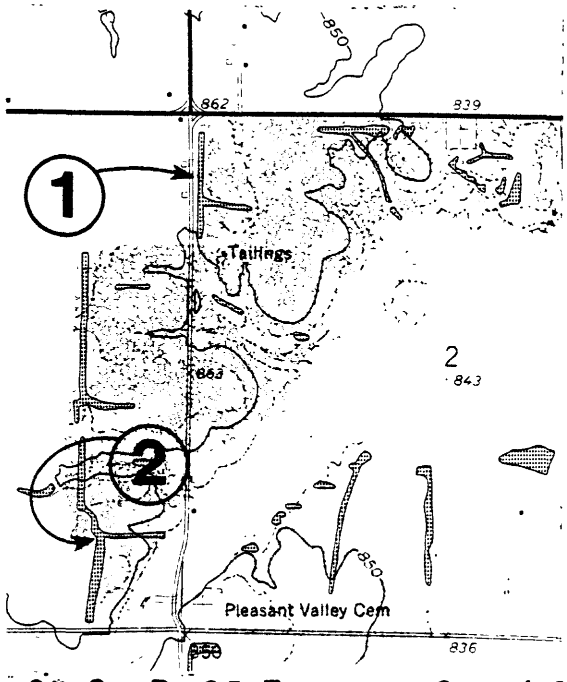
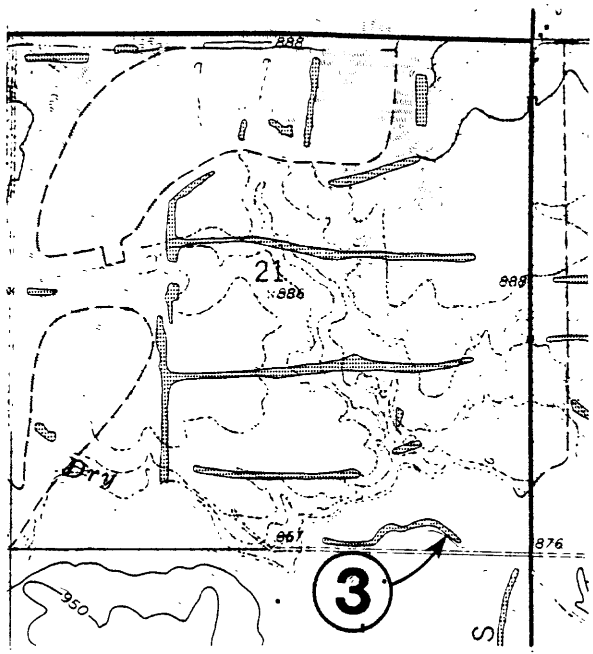


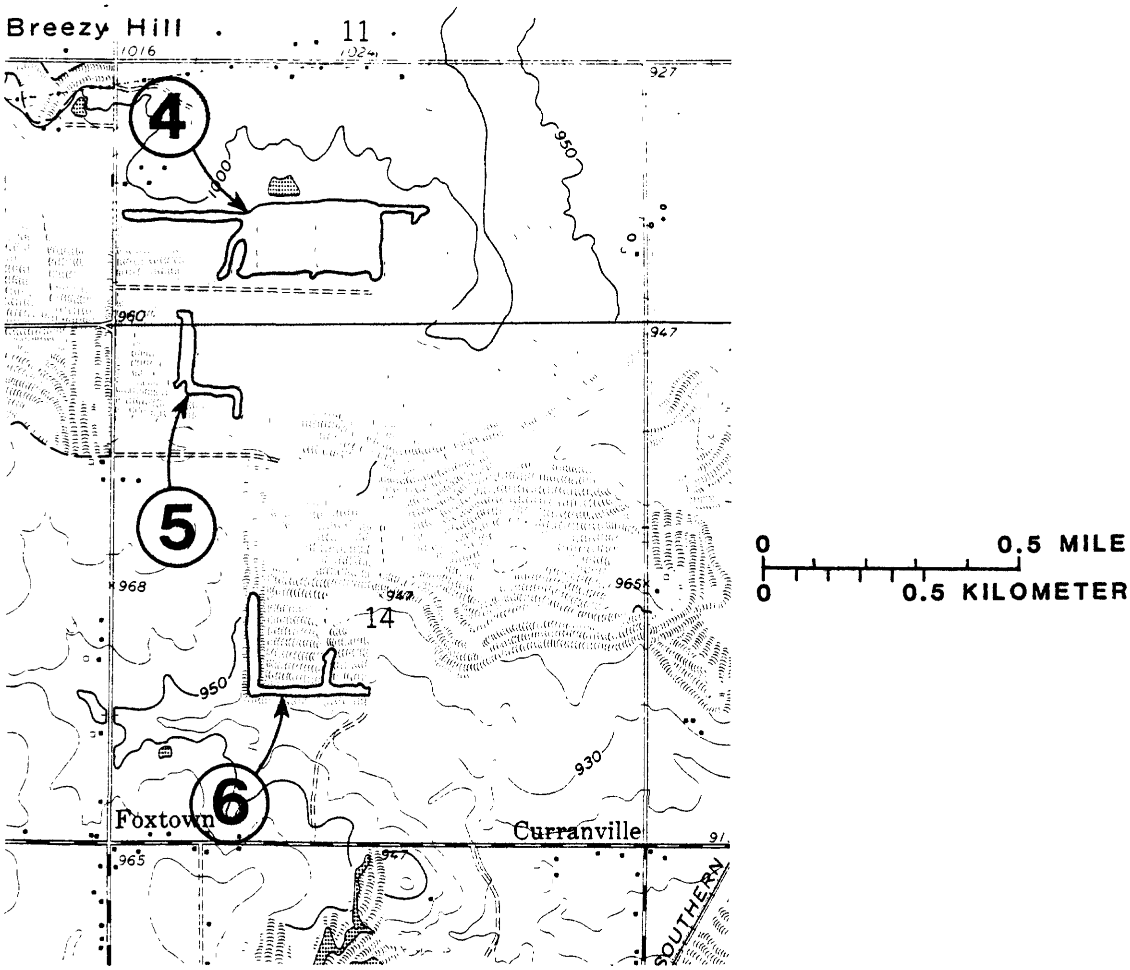
Figure 3.--General locations of strip pits sampled in Cherokee County.



T. 28 S., R. 25 E., secs. 2 and 3

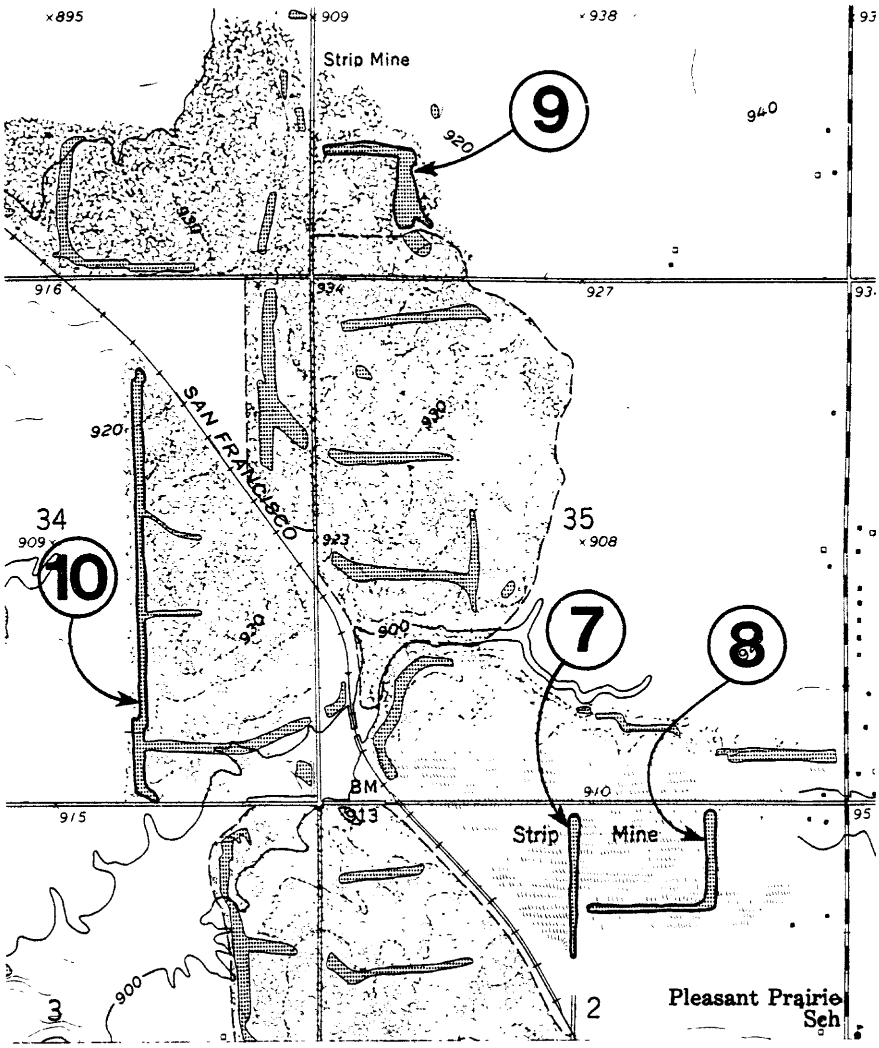


T. 28 S., R. 25 E., sec. 21



T. 29 S., R. 25 E., secs. 11 and 14

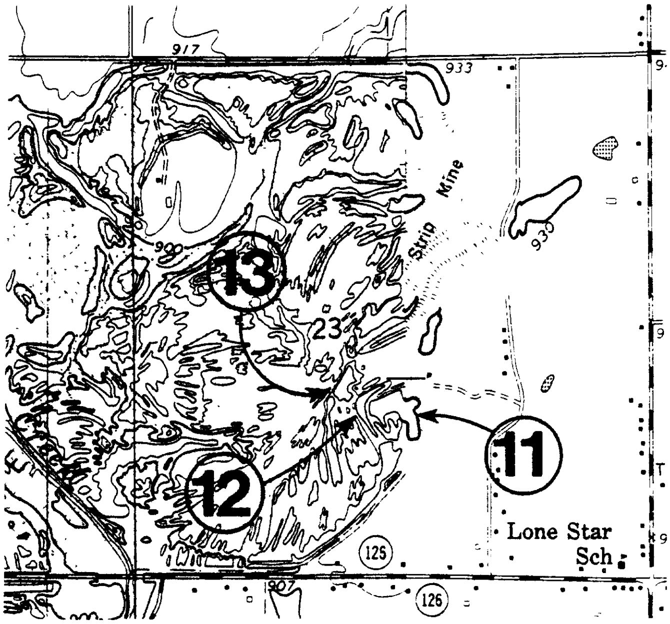
Figure 4.--Specific locations of sampling sites in study area.



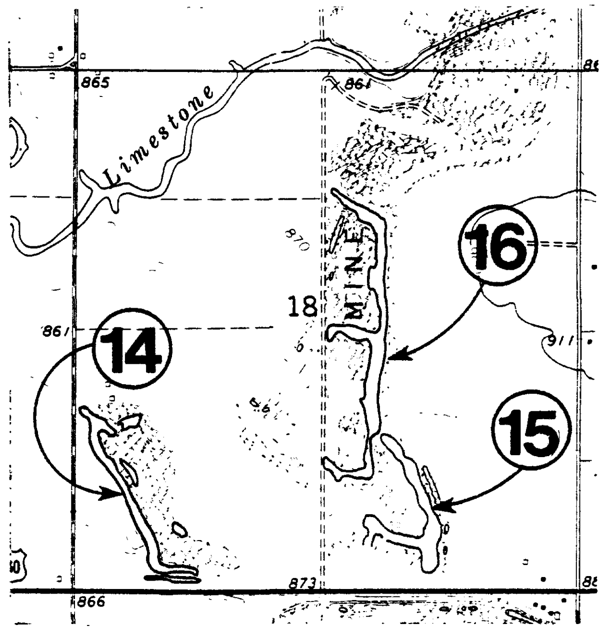
T. 30 S., R. 25 E., secs. 26 and 34

T. 31 S., R.25 E., sec. 2

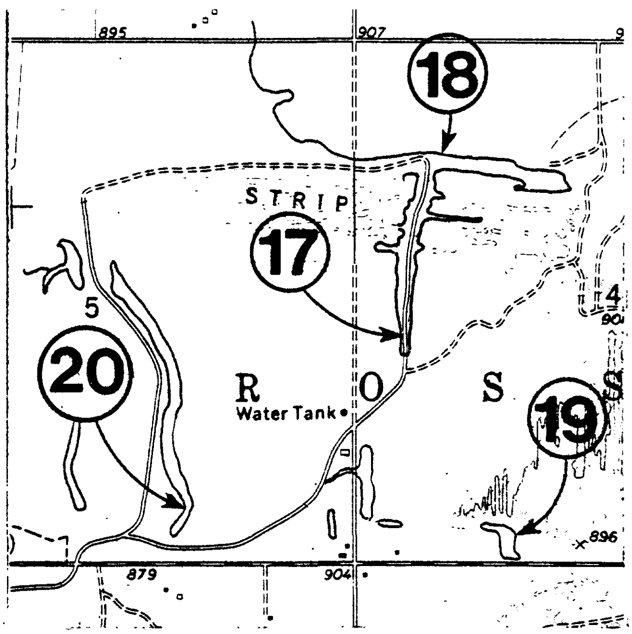
Figure 4.--Specific locations of sampling sites in study area--Continued.



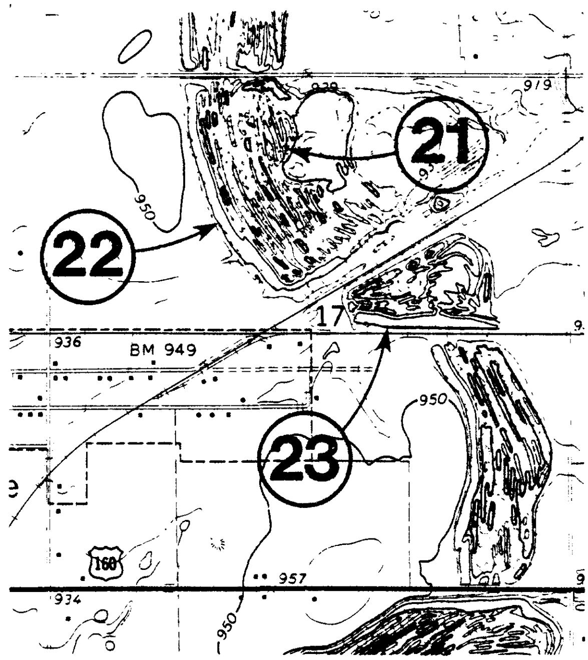
T. 30 S., R. 24 E., sec. 23



T. 31 S., R. 23 E., sec. 18

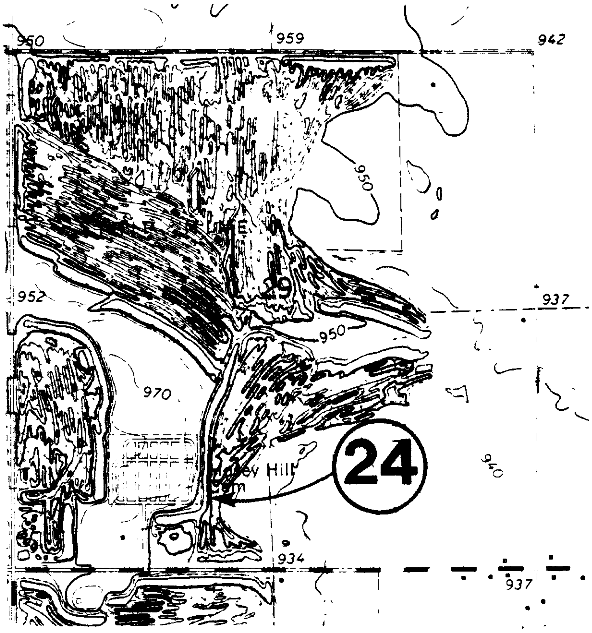


T. 32 S. , R. 23 E., secs. 4 and 5

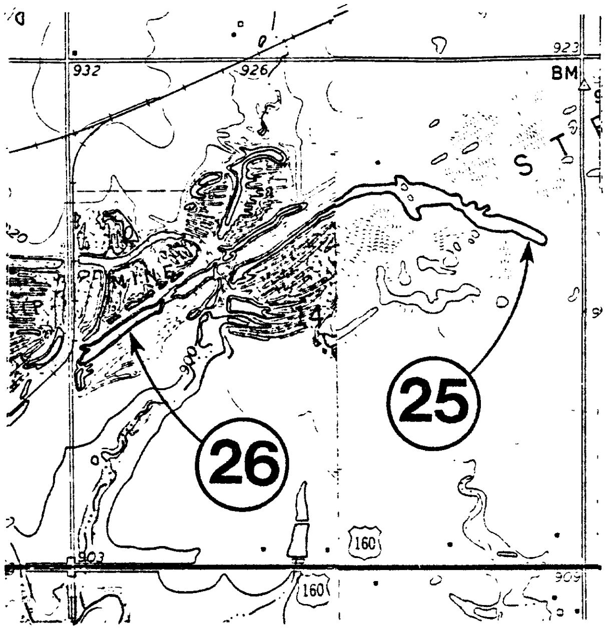


T. 31 S., R. 24 E., sec. 17

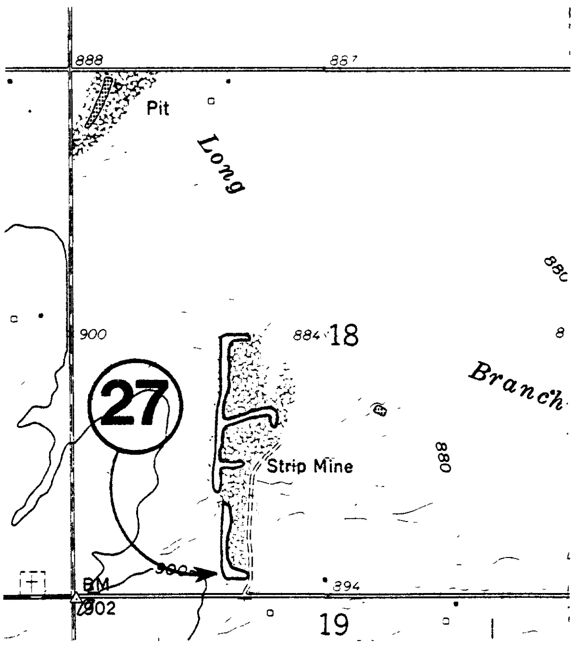
Figure 4.--Specific locations of sampling sites in study area--Continued.



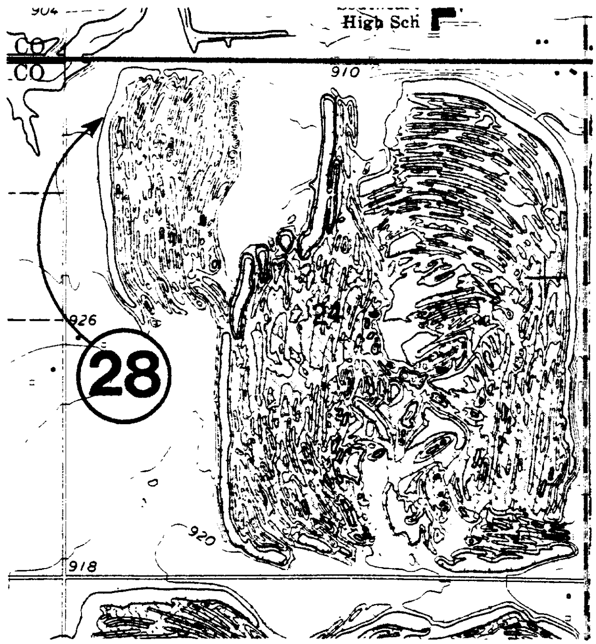
T. 31 S., R. 24 E., sec. 29



T. 32 S., R. 24 E., sec. 14

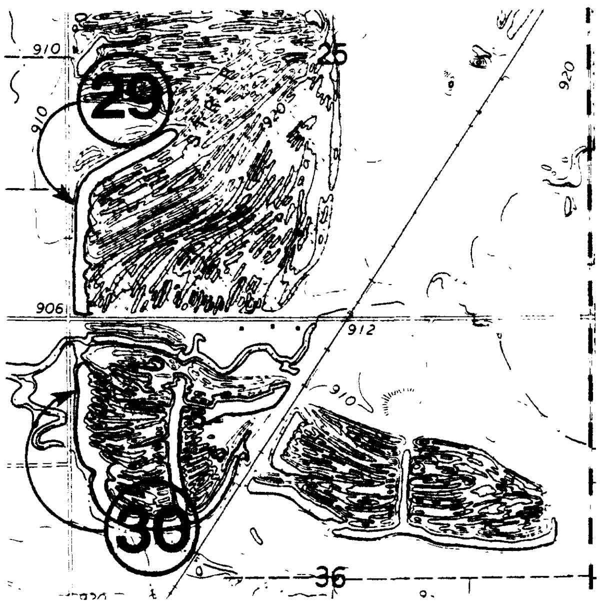


T. 32 S., R. 25 E., sec. 18

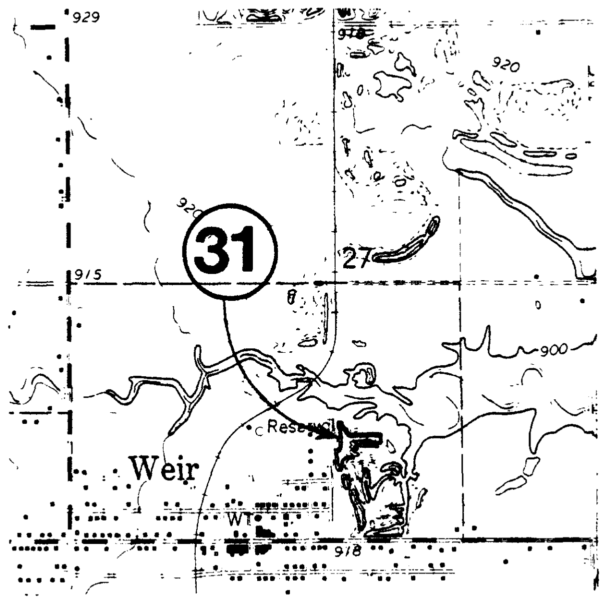


T. 31 S., R. 23 E., sec. 24

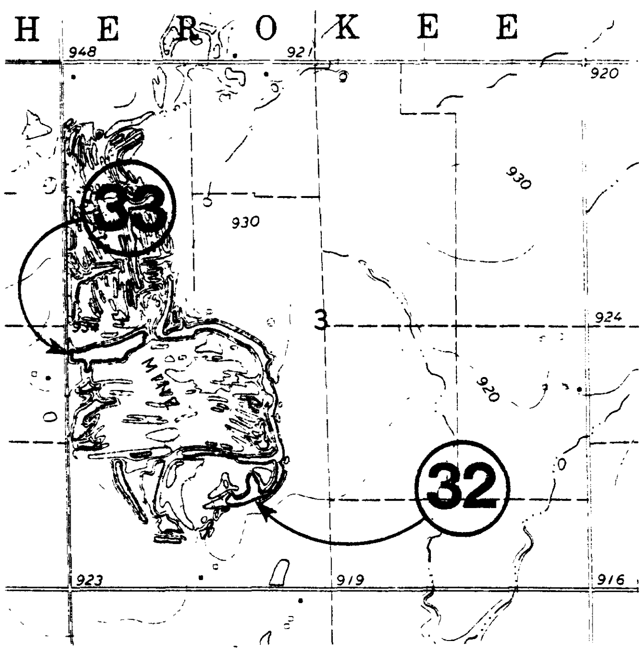
Figure 4.--Specific locations of sampling sites in study area--Continued.



T. 31 S., R. 23 E., secs. 25 and 36

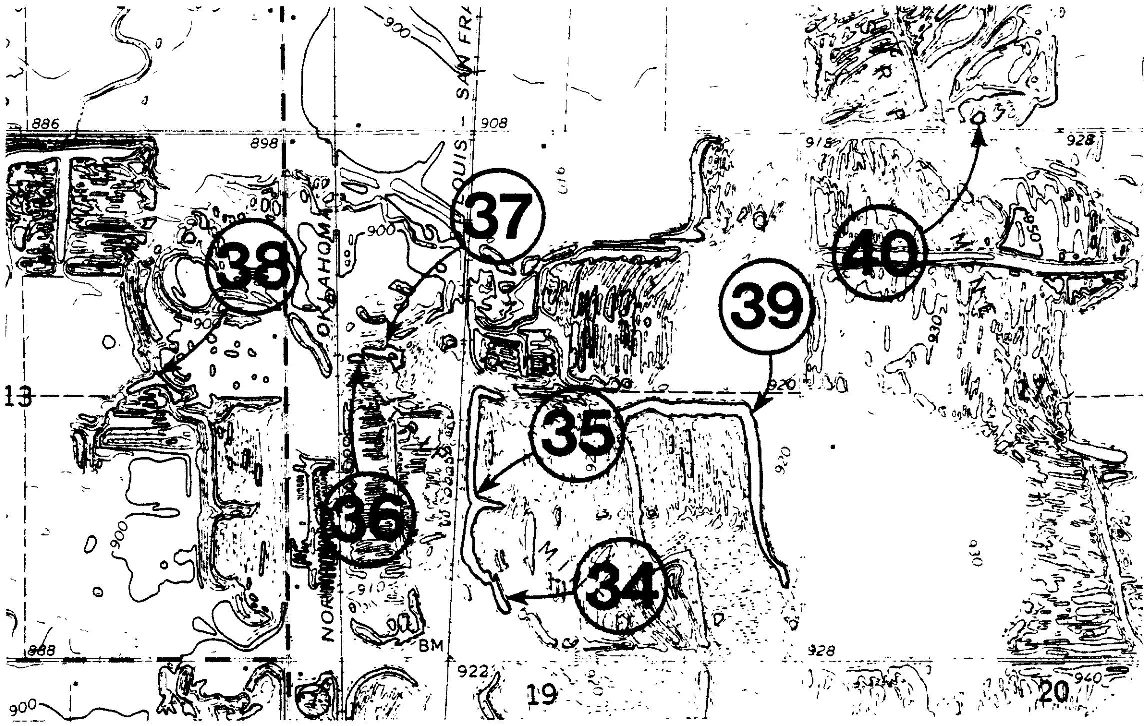


T. 31 S., R.24 E., sec. 27



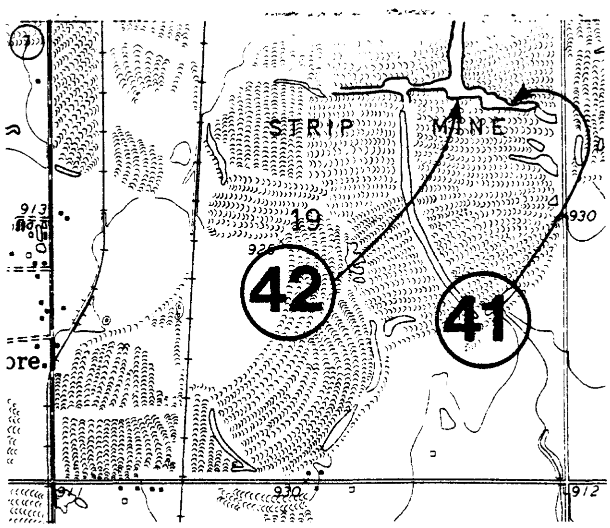
T. 32 S., R. 24 E., sec. 3

Figure 4.--Specific locations of sampling sites in study area--Continued .



T. 32 S., R. 23 E., sec. 13

T. 32 S., R. 24 E., secs. 8 and 18



T. 32 S., R. 24 E., sec. 19

Figure 4.--Specific locations of sampling sites in study area--Continued.

Table 1.--Location descriptions and map-index numbers of strip pits sampled in the study area

Map index number	Latitude	Longitude	Land-line description	County
1	37°38'33"	94°38'54"	NW 1/4 NW 1/4 sec. 2, T. 28 S., R. 25 E.	Crawford
2	37°37'54"	94°39'10"	SE 1/4 SE 1/4 sec. 3, T. 28 S., R. 25 E.	Crawford
3	37°35'16"	94°40'31"	SW 1/4 SE 1/4 sec. 21, T. 28 S., R. 25 E.	Crawford
4	37°35'16"	94°40'31"	SE 1/4 SW 1/4 sec. 11, T. 29 S., R. 25 E.	Crawford
5	37°31'33"	94°38'53"	NW 1/4 NW 1/4 sec. 14, T. 29 S., R. 25 E.	Crawford
6	37°31'06"	94°38'37"	NE 1/4 SW 1/4 sec. 14, T. 29 S., R. 25 E.	Crawford
7	37°22'48"	94°38'38"	NE 1/4 NW 1/4 sec. 2, T. 31 S., R. 25 E.	Crawford
8	37°22'48"	94°38'21"	NW 1/4 NE 1/4 sec. 2, T. 31 S., R. 25 E.	Crawford
9	37°23'53"	94°38'53"	SW 1/4 SW 1/4 sec. 26, T. 30 S., R. 25 E.	Crawford
10	37°23'01"	94°39'09"	SE 1/4 SE 1/4 sec. 34, T. 30 S., R. 25 E.	Crawford
11	37°24'59"	94°44'54"	NW 1/4 SE 1/4 sec. 23, T. 30 S., R. 24 E.	Crawford
12	37°24'56"	94°45'07"	NE 1/4 SW 1/4 sec. 23, T. 30 S., R. 24 E.	Crawford
13	37°24'59"	94°45'27"	NW 1/4 SW 1/4 sec. 23, T. 30 S., R. 24 E.	Crawford
14	37°20'27"	94°56'16"	SW 1/4 SW 1/4 sec. 18, T. 31 S., R. 23 E.	Crawford
15	37°20'27"	94°55'43"	SW 1/4 SE 1/4 sec. 18, T. 31 S., R. 23 E.	Crawford
16	37°20'40"	94°55'43"	NW 1/4 SE 1/4 sec. 18, T. 31 S., R. 23 E.	Crawford
17	37°17'10"	94°54'03"	NW 1/4 SW 1/4 sec. 4, T. 32 S., R. 23 E.	Cherokee
18	37°17'23"	94°54'04"	SW 1/4 NW 1/4 sec. 4, T. 32 S., R. 23 E.	Cherokee
19	37°16'53"	94°53'51"	SE 1/4 SW 1/4 sec. 4, T. 32 S., R. 23 E.	Cherokee
20	37°16'57"	94°54'36"	SW 1/4 SE 1/4 sec. 5, T. 32 S., R. 23 E.	Cherokee
21	37°21'05"	94°48'08"	NW 1/4 NE 1/4 sec. 17, T. 31 S., R. 24 E.	Crawford
22	37°21'05"	94°48'24"	NE 1/4 NW 1/4 sec. 17, T. 31 S., R. 24 E.	Crawford
23	37°21'02"	94°48'28"	SW 1/4 NE 1/4 sec. 17, T. 31 S., R. 24 E.	Crawford
24	37°18'41"	94°48'24"	SE 1/4 SW 1/4 sec. 29, T. 31 S., R. 24 E.	Cherokee
25	37°15'36"	94°44'40"	SE 1/4 NE 1/4 sec. 14, T. 32 S., R. 24 E.	Crawford
26	37°15'23"	94°45'28"	NW 1/4 SW 1/4 sec. 14, T. 32 S., R. 24 E.	Crawford
27	37°15'09"	94°43'04"	SE 1/4 SW 1/4 sec. 18, T. 32 S., R. 25 E.	Cherokee
28	37°20'13"	94°50'50"	NW 1/4 NW 1/4 sec. 24, T. 31 S., R. 23 E.	Cherokee
29	37°18'41"	94°50'49"	SW 1/4 SW 1/4 sec. 25, T. 31 S., R. 23 E.	Cherokee
30	37°18'28"	94°50'49"	NW 1/4 NW 1/4 sec. 36, T. 31 S., R. 23 E.	Cherokee
31	37°18'40"	94°45'59"	SW 1/4 SE 1/4 sec. 27, T. 31 S., R. 24 E.	Cherokee
32	37°16'55"	94°46'31"	SW 1/4 SW 1/4 sec. 3, T. 32 S., R. 24 E.	Cherokee
33	37°17'08"	94°46'31"	NW 1/4 SW 1/4 sec. 3, T. 32 S., R. 24 E.	Cherokee
34	37°15'11"	94°49'27"	SE 1/4 SW 1/4 sec. 18, T. 32 S., R. 24 E.	Cherokee
35	37°15'24"	94°49'27"	NE 1/4 SW 1/4 sec. 18, T. 32 S., R. 24 E.	Cherokee
36	37°15'37"	94°49'43"	SW 1/4 NW 1/4 sec. 18, T. 32 S., R. 24 E.	Cherokee
37	37°15'37"	94°49'27"	SE 1/4 NW 1/4 sec. 18, T. 32 S., R. 24 E.	Cherokee
38	37°15'37"	94°49'59"	SE 1/4 NE 1/4 sec. 13, T. 32 S., R. 23 E.	Cherokee
39	37°15'24"	94°48'55"	NE 1/4 SE 1/4 sec. 18, T. 32 S., R. 24 E.	Cherokee
40	37°16'03"	94°48'23"	SE 1/4 SW 1/4 Sec. 8, T. 32 S., R. 24 E.	Cherokee
41	37°14'58"	94°48'55"	NE 1/4 NE 1/4 sec. 19, T. 32 S., R. 24 E.	Cherokee
42	37°14'58"	94°49'11"	NW 1/4 NE 1/4 sec. 19, T. 32 S., R. 24 E.	Cherokee

Table 2.--Quality-of-water measurements and chemical constituents presented in this report

Measurement or constituent	Unit of measurement	Symbols used in regression equations
Specific conductance	μmhos/cm at 25°C (micromhos per centimeter at 25°C)	Sp. cond.
pH	pH units	
Temperature	°C (degrees Celsius)	
Turbidity	NTU (Nephelometric turbidity units)	
Transparency, Secchi disk	inches	
Oxygen, dissolved	mg/L (milligrams per per liter)	
Oxygen, demand, chemical (high level)	mg/L	
Acidity (as $CaCO_3$)	mg/L	A
Alkalinity, field (as $CaCO_3$)	mg/L	
Hardness (as $CaCO_3$)	mg/L	
Calcium, dissolved (Ca)	mg/L	Ca
Magnesium, dissolved (Mg)	mg/L	Mg
Sodium, dissolved (Na)	mg/L	
Potassium, dissolved (K)	mg/L	K
Sulfate, dissolved (SO_4)	mg/L	SO_4
Chloride, dissolved (Cl)	mg/L	
Fluoride, dissolved (F)	mg/L	
Silica, dissolved, (as SiO_2)	mg/L	
Solids, residue at 180°C, dissolved	mg/L	DS
Solids, dissolved	tons/acre-ft (tons per acre-foot)	T/A-ft
Nitrogen, nitrite + nitrate, dissolved (as N)	mg/L	
Nitrogen, ammonia + organic, total (as N)	mg/L	
Phosphorus, total (as P)	mg/L	
Phosphorus, total (as PO_4)	mg/L	
Aluminum, total recoverable (Al)	μg/L (micrograms per liter)	Al
Boron, total recoverable (B)	μg/L	
Iron, total recoverable (Fe)	μg/L	Fe
Lead, total recoverable (Pb)	μg/L	
Manganese, total recoverable (Mn)	μg/L	
Nickel, total recoverable (Ni)	μg/L	
Zinc, total recoverable (Zn)	μg/L	

ANALYTICAL RESULTS AND DESCRIPTIVE STATISTICS

Results of onsite measurements and chemical analysis of water for strip pits sampled in this survey are listed in table 3.

Descriptive statistics for 30 selected quality-of-water characteristics are presented in table 4. Data from all selected strip pits, except pit 21, were used to compute the listed statistics. Strip pit 21 received overland runoff and ground-water seepage from an adjacent waste pile, which contained the remnants of a coal-washing operation. Including the high concentrations of such constituents as acidity, sulfate, dissolved solids, and total iron and manganese found in pit 21 would have biased the statistics and distorted the mean and standard deviation for the remainder of the pits. Furthermore, since there was no significant difference in the results of chemical analysis for those strip pits that were sampled twice, only one analysis from each pit was selected for inclusion in the descriptive statistics computations (table 4). Where two samples were collected in the vertical profile (pits 18, 19, and 22), the analysis of the first listed sample (see table 3) was used in the computations because it was collected at approximately the same depth as the samples from the pits that were sampled only once. Where the double samples were spaced horizontally in the pit (pits 34 and 35, and 41 and 42),the analysis of the sample taken from that portion of the pit with the greater water depth was used.

The descriptive statistics presented in table 4 were tabulated by the "Means" procedure of the SAS System (Goodnight and others, 1979, p. 303). The descriptive statistics include:

(1) N - the number of data values available for computing the descriptive statistics.

(2) Mean - the arithmetic mean of the data values.

(3) Minimum value - the minimum value of the data values.

(4) Maximum value - the maximum value of the data values.

(5) Standard deviation - a measure of the dispersion of the data values about their mean. The greater the dispersion about the mean, the larger the standard deviation. Extreme deviations from the mean have by far the greater weight in determining the standard deviation. If a few of the data values are very extreme, the standard deviation could be misleading in that it may be unusually large (Blalock, 1972, p. 80).

Table 3.--Results of onsite measurements and chemical analysis of water from selected strip pits in Crawford and Cherokee Counties, Kansas

LOCAL IDENT-I-FIER	DATE OF SAMPLE (YY MM DD)	TIME	DEPTH OF PIT (FEET)	SAMP-LING DEPTH (FEET)	SPE-CIFIC CON-DUCT-ANCE (UMHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)
PIT 1	80-10-23	1100	16	5.0	3700	7.4	16.5
PIT 2	80-10-23	1030	17	8.0	1420	7.4	15.5
PIT 3	80-10-23	1000	6	1.0	2140	2.9	15.5
PIT 4	80-10-23	0900	12	2.0	2190	7.1	16.0
PIT 4	80-10-23	0915	20	2.0	2170	7.4	16.0
PIT 5	80-10-23	0900	7	3.0	2220	7.5	16.0
PIT 6	80-10-23	0950	3	2.0	5170	2.5	15.5
PIT 7	80-10-22	1515	12	2.0	1770	2.8	17.5
PIT 8	80-10-22	1450	10	2.0	1600	2.9	17.5
PIT 9	80-10-22	1435	7	5.0	1160	3.3	17.0
PIT 10	80-10-22	1530	15	2.0	2590	7.3	17.0
PIT 11	80-10-22	1530	--	1.0	2450	2.6	19.5
PIT 12	80-10-22	1500	18	1.0	2440	2.6	19.0
PIT 13	80-10-22	1450	12	2.0	1610	7.5	19.5
PIT 14	80-10-22	1015	3	2.0	1990	8.2	16.0
PIT 15	80-10-22	1140	16	2.0	877	7.9	17.5
PIT 16	80-10-22	1100	20	2.0	328	7.7	17.0
PIT 17	80-10-21	1615	9	2.0	1720	6.1	17.5
PIT 18	80-10-21	1530	45	2.0	1700	6.1	18.0
PIT 18	80-10-21	1535	45	40	1570	6.2	13.0
PIT 19	80-10-21	1700	29	2.0	3620	2.0	18.5
PIT 19	80-10-21	1705	29	27	3390	2.8	17.0
PIT 20	80-10-21	1640	23	2.0	2840	7.9	17.5
PIT 21	80-10-22	1415	5	1.0	15600	2.2	22.0
PIT 22	80-10-22	1330	22	5.0	1830	6.8	18.5
PIT 22	80-10-22	1335	22	15	1830	7.1	17.5
PIT 23	80-10-22	1330	20	2.0	1120	7.7	18.5
PIT 24	80-10-22	0845	7	5.0	2380	7.2	16.0
PIT 25	80-10-22	1100	9	5.0	1730	2.8	16.5
PIT 26	80-10-22	1030	6	3.0	1500	4.9	16.0
PIT 27	80-10-21	1645	10	5.0	2140	2.2	16.0
PIT 28	80-10-22	0850	15	5.0	2670	7.3	16.0
PIT 29	80-10-22	0915	25	2.0	3080	7.7	17.5
PIT 30	80-10-22	0930	17	2.0	1250	7.7	16.5
PIT 31	80-10-22	0930	8	5.0	2280	2.4	16.0
PIT 32	80-10-21	1600	5	2.0	402	8.5	18.0
PIT 33	80-10-21	1525	11	5.0	293	7.6	17.0
PIT 34	80-10-21	1230	10	5.0	351	6.8	16.5
PIT 35	80-10-21	1225	5	2.0	370	7.5	17.0
PIT 35	80-10-21	1240	7	2.0	371	7.5	17.0
PIT 36	80-10-21	1320	5	2.0	73	7.9	18.0
PIT 37	80-10-21	1335	6	2.0	212	7.5	16.0
PIT 38	80-10-21	1415	4	2.0	732	3.1	17.0
PIT 39	80-10-21	1325	15	5.0	1610	7.0	18.0
PIT 40	80-10-21	1450	3	2.0	156	6.2	17.0
PIT 41	80-10-21	1430	1	0.5	1520	3.0	20.0
PIT 42	80-10-21	1435	1	0.5	1440	3.6	19.0

Table 3.--Results of onsite measurements and chemical analysis of water from selected strip pits in Crawford and Cherokee Counties, Kansas--Continued

LOCAL IDENT-I-FIER	TUR-BID-ITY (NTU)	TRANS-PAR-ENCY (SECCHI DISK, INCHES)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN DEMAND, CHEM-ICAL (HIGH LEVEL MG/L)	ACIDITY (MG/L AS CACO3)	ALKA-LINITY FIELD (MG/L AS CACO3)	HARD-NESS (MG/L AS CACO3)
PIT 1	4.0	84.0	8.1	8	12	280	2100
PIT 2	10	72.0	8.7	9	4.0	170	600
PIT 3	1.0	72.0	8.8	28	360	0	1000
PIT 4	2.0	58.0	7.1	19	15	130	1400
PIT 4	2.0	66.0	6.9	19	15	180	1400
PIT 5	4.0	84.0	9.4	18	5.0	96	1300
PIT 6	10	36.0	10.3	31	450	0	3000
PIT 7	1.0	144	9.1	130	170	0	660
PIT 8	2.0	120	9.0	130	110	0	610
PIT 9	33	72.0	8.9	65	40	0	540
PIT 10	4.0	61.0	9.3	14	5.0	94	1800
PIT 11	16	72.0	8.6	31	560	0	760
PIT 12	20	72.0	8.5	29	530	0	720
PIT 13	2.0	72.0	10.2	17	5.0	86	730
PIT 14	10	17.0	7.6	23	0	180	1100
PIT 15	3.0	61.0	7.3	13	0	92	300
PIT 16	8.0	29.0	7.4	21	5.0	110	140
PIT 17	2.0	62.0	8.0	8	5.0	10	970
PIT 18	1.0	70.0	7.5	12	5.0	10	970
PIT 18	2.0	70.0	1.9	10	10	36	900
PIT 19	6.0	101	14.6	14	74	0	2000
PIT 19	20	101	9.1	16	80	0	2000
PIT 20	2.0	60.0	7.8	10	5.0	190	1400
PIT 21	6400	--	.1	--	9400	0	2300
PIT 22	2.0	84.0	7.6	19	5.0	84	950
PIT 22	2.0	84.0	7.3	13	5.0	100	860
PIT 23	2.0	86.0	8.1	6	5.0	110	570
PIT 24	2.0	72.0	7.9	3	5.0	98	1400
PIT 25	6.0	108	8.0	72	130	0	550
PIT 26	77	60.0	8.5	64	10	4	720
PIT 27	10	24.0	9.2	46	340	0	540
PIT 28	4.0	101	9.3	8	5.0	54	1900
PIT 29	1.0	94.0	8.3	8	20	270	2200
PIT 30	2.0	--	7.2	10	5.0	150	710
PIT 31	2.0	72.0	8.8	39	950	0	270
PIT 32	4.0	60.0	12.2	13	0	68	130
PIT 33	60	36.0	9.5	18	5.0	48	83
PIT 34	95	120	9.4	37	5.0	34	110
PIT 35	5.0	50.0	7.7	8	5.0	44	130
PIT 35	4.0	65.0	7.8	9	5.0	44	130
PIT 36	9.0	47.0	7.8	26	5.0	24	27
PIT 37	4.0	59.0	6.9	32	5.0	70	51
PIT 38	1.0	48.0	9.8	7	65	0	350
PIT 39	2.0	120	9.5	8	5.0	28	880
PIT 40	15	24.0	8.3	8	5.0	44	46
PIT 41	2.0	12.0	7.7	18	120	0	510
PIT 42	2.0	18.0	8.8	4	35	0	580

Table 3.--Results of onsite measurements and chemical analysis of water from selected strip pits in Crawford and Cherokee Counties, Kansas--Continued

LOCAL IDENT-I-FIER	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA DIS-SOLVED (MG/L AS SIO2)
PIT 1	360	280	230	18	2100	6.8	.3	12
PIT 2	120	74	82	7.9	680	4.1	.5	3.0
PIT 3	210	120	13	10	1400	3.4	.2	15
PIT 4	280	180	31	6.0	1300	5.6	.6	7.1
PIT 4	280	180	30	6.0	1200	5.5	.6	7.2
PIT 5	270	140	52	6.4	1300	5.6	.8	2.9
PIT 6	470	450	110	17	3700	13	1.6	31
PIT 7	160	64	40	5.8	1000	2.4	1.9	24
PIT 8	150	57	34	5.5	910	2.5	1.2	17
PIT 9	110	64	37	18	630	33	.8	2.9
PIT 10	340	230	70	10	1800	3.5	.5	3.8
PIT 11	230	46	30	8.7	1400	2.6	.5	52
PIT 12	230	35	26	8.6	1400	2.6	.5	51
PIT 13	220	44	35	7.0	940	3.8	.4	22
PIT 14	190	150	100	5.4	1200	12	.7	5.3
PIT 15	66	32	78	1.7	430	7.9	.6	2.4
PIT 16	45	7.7	15	2.9	71	3.9	.5	3.3
PIT 17	250	85	43	7.6	1100	4.4	.4	.5
PIT 18	240	91	53	7.7	1100	4.4	.4	.5
PIT 18	230	79	50	6.6	980	3.9	.3	.5
PIT 19	530	160	68	8.9	2200	12	.3	8.4
PIT 19	520	160	68	8.7	2200	12	.4	8.5
PIT 20	280	180	190	10	1700	16	.5	3.3
PIT 21	430	290	8.3	.9	12000	48	.0	10
PIT 22	200	110	59	6.0	1100	6.4	.4	3.4
PIT 22	180	100	51	5.5	1000	6.3	.4	3.1
PIT 23	130	59	23	4.8	600	5.1	.4	5.1
PIT 24	250	200	50	8.2	1400	4.6	.4	4.8
PIT 25	130	54	26	4.6	910	4.5	1.8	22
PIT 26	220	42	22	4.3	890	5.4	.6	5.3
PIT 27	120	58	46	3.4	2000	3.3	.6	31
PIT 28	380	240	41	11	1900	6.0	1.1	.9
PIT 29	380	310	140	9.2	2200	5.8	.2	14
PIT 30	120	100	48	4.6	630	2.7	.4	6.0
PIT 31	70	23	10	7.9	1200	3.2	1.3	29
PIT 32	28	14	31	3.2	130	6.6	.7	.2
PIT 33	20	8.1	24	1.9	93	2.8	.6	2.5
PIT 34	30	8.0	26	1.3	130	1.8	.4	12
PIT 35	36	9.1	28	1.3	160	1.8	.5	5.0
PIT 35	37	9.2	29	1.4	150	1.7	.4	5.4
PIT 36	5.8	3.0	6.8	1.7	18	.8	.4	3.4
PIT 37	10	6.4	24	.4	41	1.6	.5	1.8
PIT 38	82	36	57	3.6	430	5.4	.5	37
PIT 39	210	87	120	4.6	1200	4.8	.8	16
PIT 40	14	2.6	1.9	2.2	17	.8	.4	4.2
PIT 41	130	45	75	4.6	830	3.5	1.3	35
PIT 42	140	56	97	3.6	830	3.6	1.2	22

Table 3.--Results of onsite measurements and chemical analysis of water from selected strip pits in Crawford and Cherokee Counties, Kansas--Continued

LOCAL IDENT-I-FIER	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	SOLIDS, DIS-SOLVED (TONS/ACRE-FT)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	PHOS-PHORUS TOTAL (MG/L AS PO4)
PIT 1	3230	4.3	.02	.63	.020	.06
PIT 2	1020	1.3	.00	.73	.010	.03
PIT 3	1980	2.6	.06	1.30	.030	.09
PIT 4	2180	2.9	.00	.77	.030	.09
PIT 4	2190	2.9	.00	1.20	.030	.09
PIT 5	1890	2.5	.00	.68	.030	.09
PIT 6	5390	7.3	.00	6.70	.120	.37
PIT 7	1440	1.9	.14	1.20	.010	.03
PIT 8	1300	1.7	.11	2.10	.010	.03
PIT 9	898	1.2	.00	1.10	.020	.06
PIT 10	2740	3.7	.00	.65	.020	.06
PIT 11	1740	2.3	.00	1.60	.020	.06
PIT 12	1720	2.3	.00	1.60	.030	.09
PIT 13	1380	1.8	.00	.64	.020	.06
PIT 14	1920	2.6	.00	1.00	.090	.28
PIT 15	658	.89	.00	.78	.020	.06
PIT 16	228	.31	.02	1.00	.040	.12
PIT 17	1570	2.1	.04	1.30	.010	.03
PIT 18	1590	2.1	.00	.94	.010	.03
PIT 18	1430	1.9	.14	.45	.010	.03
PIT 19	3290	4.4	.00	.51	.010	.03
PIT 19	3290	4.4	.00	.77	.020	.06
PIT 20	2730	3.7	.00	1.00	.010	.03
PIT 21	20700	28.2	--	--	--	--
PIT 22	1600	2.1	.00	.60	.010	.03
PIT 22	1540	2.0	.00	.85	.010	.03
PIT 23	957	1.3	.00	.77	.010	.03
PIT 24	2200	2.9	.00	.72	.020	.06
PIT 25	1260	1.7	.00	1.00	.010	.03
PIT 26	1270	1.7	.00	.94	.040	.12
PIT 27	2490	3.3	.00	1.00	.040	.12
PIT 28	2770	3.7	.70	.39	.030	.09
PIT 29	3440	4.6	.00	.47	.010	.03
PIT 30	983	1.3	.17	.83	.020	.06
PIT 31	1540	2.0	.00	.74	.020	.06
PIT 32	267	.36	.00	.97	.030	.09
PIT 33	178	.24	.00	.74	.070	.21
PIT 34	239	.33	.00	.74	.100	.31
PIT 35	256	.35	.00	1.20	.020	.06
PIT 35	253	.34	.00	.53	.010	.03
PIT 36	66	.09	.00	1.00	.020	.06
PIT 37	139	.19	.02	1.20	.030	.09
PIT 38	586	.80	.04	.34	.010	.03
PIT 39	1800	2.4	.00	.47	.010	.03
PIT 40	77	.10	.08	1.20	.040	.12
PIT 41	1190	1.6	.00	1.40	.010	.03
PIT 42	1240	1.6	.00	.83	.010	.03

Table 3.--Results of onsite measurements and chemical analysis of water from selected strip pits in Crawford and Cherokee Counties, Kansas--Continued

LOCAL IDENT-I-FIER	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	BORON, TOTAL RECOV-ERABLE (UG/L AS B)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI)	ZINC TOTAL RECOV-ERABLE (UG/L AS ZN)
PIT 1	50	400	250	2	180	14	30
PIT 2	130	220	290	5	770	18	30
PIT 3	19000	100	3700	3	16000	940	1600
PIT 4	20	170	130	3	270	6	20
PIT 4	70	160	120	3	250	7	20
PIT 5	90	160	280	4	110	19	20
PIT 6	24000	210	23000	11	24000	510	690
PIT 7	10000	50	3100	15	74000	930	740
PIT 8	780	50	2000	16	61000	720	460
PIT 9	1000	150	1700	20	30000	300	260
PIT 10	70	100	210	3	440	15	30
PIT 11	17000	70	25000	120	9400	180	830
PIT 12	24000	60	23000	96	8800	200	840
PIT 13	50	70	440	4	170	5	30
PIT 14	150	220	450	4	270	7	40
PIT 15	50	90	150	5	60	4	10
PIT 16	170	30	350	3	190	6	10
PIT 17	30	80	290	3	350	17	330
PIT 18	90	80	230	6	340	18	330
PIT 18	50	80	390	2	1500	18	440
PIT 19	960	70	3600	24	4100	52	2000
PIT 19	3300	80	4500	28	4200	53	2000
PIT 20	0	260	170	59	340	10	40
PIT 21	20	590	410000	10	58000	69	5700
PIT 22	20	70	580	9	410	16	50
PIT 22	20	110	170	10	400	13	40
PIT 23	40	80	140	15	640	4	30
PIT 24	20	130	170	11	60	44	50
PIT 25	790	80	2200	28	40000	450	330
PIT 26	400	80	4100	13	18000	140	290
PIT 27	17000	90	16000	36	28000	2000	8000
PIT 28	80	170	190	3	160	12	40
PIT 29	60	380	100	1	350	10	20
PIT 30	40	170	200	3	250	6	60
PIT 31	30000	80	42000	21	15000	1400	1800
PIT 32	70	130	90	1	40	7	20
PIT 33	360	120	2900	9	280	12	30
PIT 34	150	50	9100	17	450	25	90
PIT 35	130	50	250	3	40	6	20
PIT 35	70	40	210	2	30	4	20
PIT 36	130	50	660	3	130	6	30
PIT 37	20	40	160	0	70	4	40
PIT 38	50	60	560	26	5800	100	190
PIT 39	10	90	460	51	330	23	60
PIT 40	200	40	680	10	130	11	30
PIT 41	490	70	2000	18	14000	300	760
PIT 42	200	70	300	10	6300	100	320

Table 4.--Descriptive statistics of quality-of-water measurements and chemical constituents for water samples collected from selected strip pits

[Data from pit 21 were not used in the computation of these statistics]

Measurement or constituent	N	Mean	Minimum	Maximum	Standard deviation
Specific conductance (μmhos/cm at 25°C)	41	1720	73	5,170	1,080
pH (units)	41	5.7	2.0	8.5	2.3
Temperature (°C)	41	17.2	15.5	20.0	1.2
Turbidity (NTU)	41	11	1.0	95	20
Oxygen, dissolved (mg/L)	41	8.7	6.9	14.6	1.4
Oxygen demand, chemical (high level) (mg/L)	41	28	3	130	30
Acidity (mg/L as $CaCO_3$)	41	100	0	950	200
Alkalinity, field (mg/L as $CaCO_3$)	41	64	0	280	76
Hardness (mg/L as $CaCO_3$)	41	850	27	3,000	690
Calcium, dissolved (mg/L)	41	180	5.8	530	130
Magnesium, dissolved (mg/L)	41	97	2.6	450	97
Sodium, dissolved (mg/L)	41	56	1.9	230	48
Potassium, dissolved (mg/L)	41	6	.4	18	4
Sulfate, dissolved (mg/L)	41	1,000	17	3,700	760
Chloride, dissolved (mg/L)	41	5.6	.8	33	5.5
Fluoride, dissolved (mg/L)	41	.7	.2	1.9	.4
Silica, dissolved (mg/L as SiO_2)	41	13	.2	52	14
Solids, residue at 180°C, dissolved (mg/L)	41	1,550	66	5,390	1,110
Solids, dissolved (tons/acre-ft)	41	2.10	0.09	7.33	1.51
Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	41	.03	.00	.70	.11
Nitrogen, ammonia + organic total (mg/L as N)	41	1.1	.34	6.7	.97
Phosphorus, total (mg/L as P)	41	.03	.01	.12	.03
Phosphorus, total (mg/L as PO_4)	41	.08	.03	.37	.08
Aluminum, total recoverable (μg/L)	41	3,600	[1] 0	30,000	8,000
Boron, total recoverable (μg/L)	41	120	30	400	80
Iron, total recoverable (μg/L)	41	4,200	90	42,000	8,900
Lead, total recoverable (μg/L)	41	20	[2] 0	120	20
Manganese, total recoverable (μg/L)	41	8,800	30	74,000	17,000
Nickel, total recoverable (μg/L)	41	210	4	2,000	420
Zinc, total recoverable (μg/L)	41	500	10	8,000	1,300

[1] Value is less than detection limit of 10 μg/L.
[2] Value is less than detection limit of 1 μg/L.

REGRESSION ANALYSIS

The regression equations presented in tables 5 and 6 were computed by the Graphplot procedure presented in the "Watstore User's Guide" (Morgan, 1982, volume 3, chapter IV). Results of regression analysis presented in table 5 relate selected chemical constituents to specific conductance and concentration of dissolved solids for all sampled pits except pit 21. Table 6 contains the results of regression analysis relating chemical constituents common to pits with highly acidic water (less than 4.5 pH) to specific conductance, concentration of dissolved solids, and acidity as $CaCO_3$. The regression equations were computed by an arithmetic linear least-squares regression procedure and are expressed by the formula:

$$y = mx + b, \qquad (1)$$

where

y is the dependent variable;
m is the slope of the regression line;
x is the independent variable; and
b is the y-intercept value.

A word of caution, the extrapolation of a regression equation beyond the range of x used in estimating m and b, predicting y, is discouraged for two reasons. First, the confidence intervals on the regression line become very wide as the distance from mean x is increased. Second, the relation between y and x may be nonlinear over the entire range of x and only linear, or approximately linear, for the range of x investigated (Haan, 1977, p. 192). See table 4 for range of specific conductance, dissolved solids, and acidity used in the development of the equations presented in tables 5 and 6.

The statistical parameters presented with the regression equations include:

(1) N - the number of data pairs used to compute the regression equation.

(2) Correlation coefficient - a measure of degree of linear relationship between two variables. The correlation-coefficient value, r, has limits of + 1.0 and -1.0. If all points fall on the straight line and the relation is direct, the value of r will be 1.0. If the relation is inverse and all points fall on the regression line, r will be -1.0. If the points are randomly scattered, r will be zero (Blalock, 1972, p. 376).

(3) F test - an analysis-of-variance test for significance of the correlation coefficient, r. If the computed F value is less than the table F value, no linear relationship exists. In other words, the indicated correlation coefficient could occur fairly frequently by chance even if there were absolutely no association between the two regression parameters (Blalock, 1972, p. 399-400).

(4) Standard error of estimate - this term is equivalent to the standard deviation of the observed data values about a regression line. It is an estimate of the error likely to be committed in making predictions from the regression equation (Kendall and Buckland, 1960, p. 277).

Table 5.--Results of regression analysis relating selected chemical constituents, in milligrams per liter, to specific conductance (Sp. Cond.), in micromhos, and concentration of dissolved solids (DS), in milligrams per liter, for selected strip pits

[Data from pit 21 were not used in the regression-analysis computations]

Regression equation; presented only if significant at the 0.05 level of significance	N	Correlation coefficient, r	F test: F, computed	F test: F, table[1]	Standard error of estimate, in milligrams per liter, except as noted
DS = 1.0038 x Sp. Cond. - 182	41	0.98	936	4.09	249
[2] T/A-ft = 0.0014 x Sp. Cond. -0.25	41	.98	936	4.09	0.34 (tons/acre-ft)
SO_4 = 0.0689 x Sp. Cond. - 140	41	.98	936	4.09	160
Ca = 0.1074 x Sp. Cond. - 3.2	41	.91	190	4.09	54
Mg = 0.0771 x Sp. Cond. - 36	41	.85	100	4.09	51
K = 0.0030 x Sp. Cond. + 1	41	.77	56.0	4.09	3
SO_4 = 0.6791 x DS - 4.2	41	.99	1,190	4.09	100
Ca = 0.1049 x DS + 20	41	.91	190	4.09	53
Mg = 0.0799 x DS - 27	41	.91	190	4.09	40
K = 0.0028 x DS + 2	41	.73	44.0	4.09	3

[1] Indicated value at 0.05 level of significance (taken from Fisher and Yates, 1963).

[2] Dissolved solids, in tons per acre-foot.

Table 6.--Results of regression analysis relating selected chemical constituents, in milligrams per liter, to specific conductance (Sp. Cond.), in micromhos, concentration of dissolved solids (DS), in milligrams per liter, and acidity as $CaCO_3$ (A), in milligrams per liter, for selected strip pits with pH less than 4.5

[Data from pit 21 were not used in the regression-analysis computations]

Regression equation; presented only if significant at the 0.05 level of significance	N	Correlation coefficient	F test: F, computed	F test: F, table[1]	Standard error of estimate, in milligrams per liter, except as noted
DS = 1.0620 x Sp. Cond. - 428	14	0.97	188	4.75	323
[2] T/A-ft = 0.0014 x Sp. Cond. -0.58	14	.97	188	4.75	0.44 (tons/acre ft)
SO_4 = 0.7271 x Sp. Cond. - 220	14	.96	138	4.75	240
Ca = 0.1074 x Sp. Cond. - 34	14	.87	38.0	4.75	72
Mg = 0.0845 x Sp. Cond. - 92	14	.86	34.0	4.75	59
K versus Sp. Cond.	14	.51	4.22	4.75	4
SO_4 = 0.6821 x DS + 76	14	.99	588	4.75	110
Ca = 0.0942 x DS + 22	14	.83	26.7	4.75	79
Mg = 0.0822 x DS - 62	14	.91	58.6	4.75	46
K versus DS	14	.48	3.58	4.75	4
SO_4 versus A	14	.33	1.47	4.75	820
Al = 38.3172 x A - 400	14	.92	68.0	4.75	4,400 (micrograms per liter)
Fe = 46.7859 x A - 2,600	14	.96	138	4.75	3,700 (micrograms per liter)

[1] Indicated value at 0.05 level of significance (taken from Fisher and Yates, 1963).

[2] Dissolved solids, in tons per acre-foot.

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