NITRATE-NITROGEN CONCENTRATIONS IN GROUND WATER FROM THREE SELECTED AREAS IN KANSAS

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Water from shales in central and eastern Kansas and from limestone in eastern Kansas exhibited the highest median concentrations and highest incidence of concentrations above 10 milligrams per liter. Water from 10 percent of the wells in unconsolidated Quaternary deposits in western Kansas and almost 30 percent of the wells in eastern Kansas had nitrate-nitrogen concentrations that exceeded 10 milligrams per liter. Shallow wells in shales, limestones, and unconsolidated Quaternary deposits are highly susceptible to nitrate contamination. Water from unconsolidated Tertiary deposits produced a low incidence of nitrate-nitrogen concentrations greater than 10 milligrams per liter, indicating minimal nitrate contamination from sources at or near the land surface. Sandstones in all areas exhibited the lowest median and lowest incidence of nitrate-nitrogen concentrations above 10 milligrams per liter.

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UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

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CONVERSION FACTORS

The factors for converting from inch-pound units used in this report to the International System (SI) of Metric Units are given below:

Multiply inch-pound unit	by	To obtain SI unit
foot	0.3048	meter
mile	1.609	kilometer
gallon per minute	0.06309	liter per second
degree Fahrenheit (°F)	([1])	degree Celsius (°C)

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[1] °C = (°F - 32)/1.8.

NITRATE-NITROGEN CONCENTRATIONS IN GROUND WATER FROM THREE SELECTED AREAS IN KANSAS

by

Timothy B. Spruill

ABSTRACT

Nitrate-nitrogen data collected during 1976-79 from 333 wells in Kansas were summarized and statistically analyzed on the basis of area, aquifer, and well depth. Nitrate-nitrogen concentrations exceeding the 10 milligrams per liter maximum allowable concentration in public-water supplies were observed in 4 percent of the wells analyzed in western Kansas, 16 percent in central Kansas, and 29 percent in eastern Kansas. Concentrations exceeding 10 milligrams per liter generally occurred in wells less than 100-feet deep. Data indicate that nitrate-nitrogen concentrations in ground water greater than 10 milligrams per liter generally are derived from nitrogen sources at or near the land surface, although some soluble nitrogen may be derived from fine-grained sediments in some aquifers.

Water from shales in central and eastern Kansas and limestones in eastern Kansas exhibited highest median concentrations and the highest incidence of concentrations greater than 10 milligrams per liter. Water from 10 percent of the wells in unconsolidated Quaternary deposits in western Kansas and almost 30 percent of the wells in eastern Kansas had nitrate-nitrogen concentrations that exceeded 10 milligrams per liter. Shallow wells in shales, limestones, and unconsolidated Quaternary deposits are highly susceptible to nitrate contamination. Wells in unconsolidated Tertiary deposits produced water with a low incidence of concentrations greater than 10 milligrams per liter, indicating minimal contamination from sources at or near the land surface. Water from sandstone in all areas had the lowest median nitrate-nitrogen concentrations and the lowest incidence of concentrations greater than 10 milligrams per liter.

INTRODUCTION

Since the 1940's, the occurrence of nitrate in ground water has been recognized as a potential health hazard to infants. In 1976, the U.S. Environmental Protection Agency established a maximum allowable concentration of nitrate in drinking water, expressed as nitrogen (NO_3-N), of 10 mg/L (milligrams per liter). Exceedence of this maximum concentration in water supplies is potentially dangerous to public health and is grounds for terminating a public-supply source in violation of the standard (U.S. Environmental Protection Agency, 1976). Additional data are needed by planning and regulatory agencies in Kansas for relating high nitrate-nitrogen concentrations to probable sources and to areal occurrence in ground-water supplies. It is necessary to evaluate the cause and magnitude of the problem before appropriate management procedures or localized investigative studies may be implemented effectively.

The Kansas Ground-Water-Quality Monitoring Network was established in 1976 by the Kansas Department of Health and Environment and the U.S. Geological Survey as part of the cooperative program. Data from wells in the network provide statewide information on the chemical quality of ground water for use in comprehensive management decisions.

The purpose of this report is: (1) To provide statistical data summaries that show the areal occurrence of nitrate-nitrogen concentrations in water from wells included in the Kansas Ground-Water-Quality Monitoring Network; (2) to indicate typical nitrate-nitrogen concentrations, and the associated percentages exceeding 10 mg/L, in water from principal aquifers and lithologic units within three selected areas of Kansas; and (3) to indicate typical nitrate-nitrogen concentrations, and the associated percentages exceeding 10 mg/L, in water from shallow and deep wells within the three selected areas of Kansas.

DATA COLLECTION

Samples were collected from more than 600 domestic, stock, irrigation, and public-supply wells throughout Kansas between 1976 and 1979. Locations of these wells are shown in figure 1. The wells were pumped prior to sampling for approximately 5 minutes or until specific conductance and temperature of the water stabilized. The samples were filtered through 0.45-micron filters and chilled to 5°C immediately following collection. Chemical analyses of the samples were performed by the Division of Laboratories, Kansas Department of Health and Environment, Topeka, Kansas, in accordance with procedures outlined in "Standard Methods for the Examination of Water and Wastewater" (American Public Health Association, 1975).

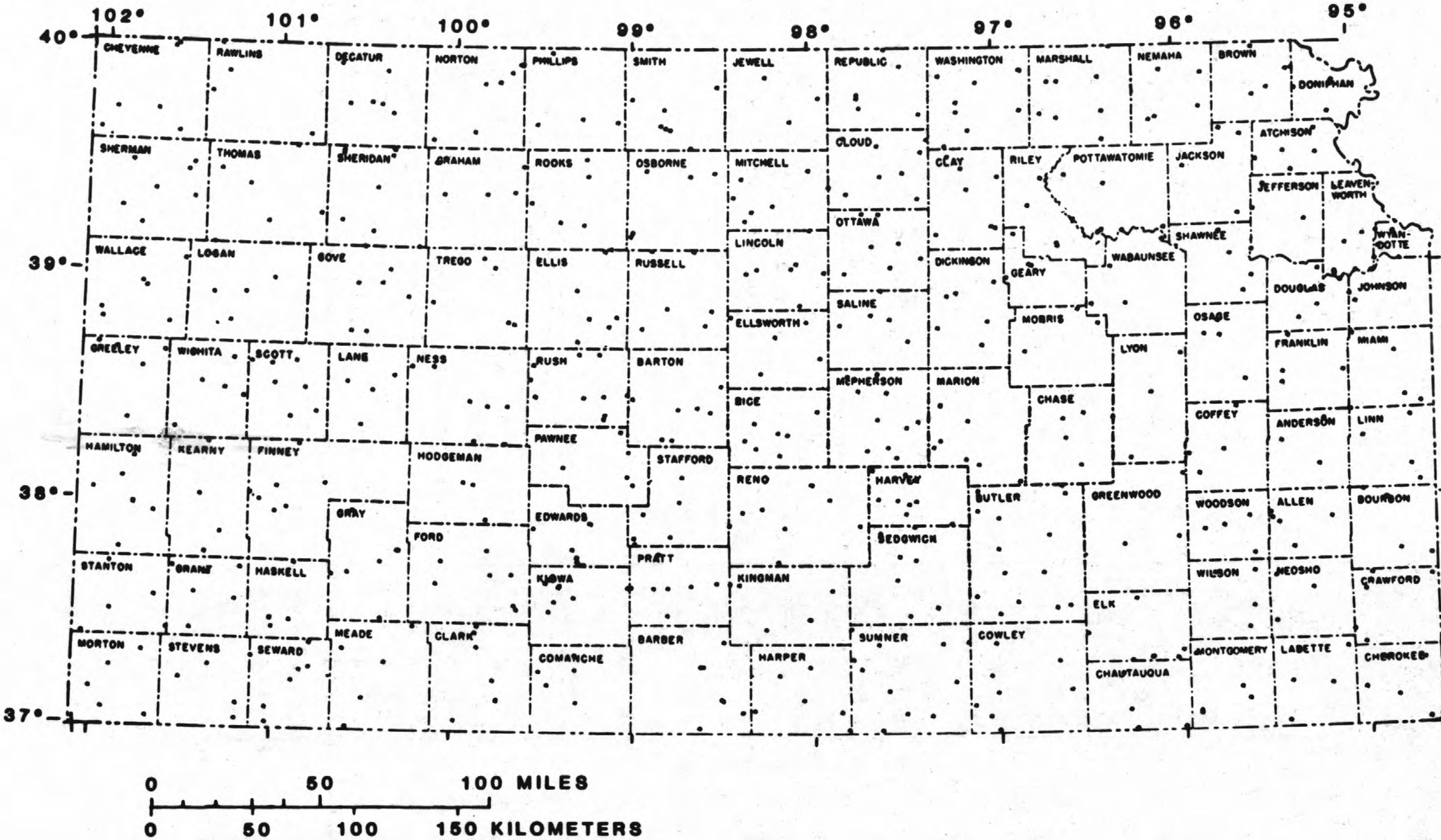

Figure 1.--Location of wells in Kansas Ground-Water-Quality Monitoring Network, 1976-79.

Three areas of Kansas were arbitrarily selected for statistical analysis of the data (fig. 2). Data retrieval was restricted to 25 counties or less per area. Each area is relatively homogeneous in terms of land-use, rainfall, and climatic characteristics. Reference in the text to western, central, or eastern Kansas refers to the areas specified in this report.

Nitrate-nitrogen data collected from 333 wells in 74 counties are included. Values for each site used in the statistical evaluations are derived from either a single analysis or an average of from two to four analyses. Only data from sites having adequate depth and aquifer information were utilized. Data from well sites in each area are summarized in "Appendices A, B, and C." These data have been published annually in "Water Resources Data for Kansas" (U.S. Geological Survey, 1976-79).

Tables in the report show occurrence of nitrate-nitrogen concentrations in milligrams per liter for the 25th, 50th, 75th, and 100th percentiles by area, aquifer or lithologic unit, and depth. This nonparametric approach was used because, in most cases, frequency distributions of the sample populations were highly non-normal and skewed to the right. Therefore, classical parametric statistics, such as the mean and standard deviation, would not be meaningful population estimators. The percentage of wells with water exceeding the State and Federal maximum allowable concentration of 10 mg/L also is shown in the tables.

In the discussions of nitrate-nitrogen concentration by depth, the word "shallow" is used with wells that are 100 feet or less in depth, and "deep" is used with wells that are greater than 100 feet in depth, unless noted otherwise. Sampling points are assumed to be representative of typical water-supply wells within each area, and no attempt was made to determine the existence of proper well construction or presence of local pollution sources.

Because the data for area, aquifer, and depth were strongly skewed to the right and the variances and sample sizes were generally unequal, a nonparametric statistical test, the Wilcoxon-Mann-Whitney test or "W-test" (Wonnacott and Wonnacott, 1977), was applied to the data. The W-test has 95 percent of the efficiency[1] of the "t-test" when used for testing normally distributed populations and is much more efficient than the parametric "t-test" used for evaluating non-normally distributed populations. In addition, the W-test may be used with independent groups and requires only that the populations are identically shaped--that is, they are skewed the same way--to be valid (Wonnacott and Wonnacott, 1977).

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1 The relative efficiency of two tests is defined as the ratio of sample sizes required to yield tests with the same probability of committing Type-I or Type-II errors. A more efficient test is one that has the same probability of committing Type-I and Type-II errors as a comparable test with fewer samples.

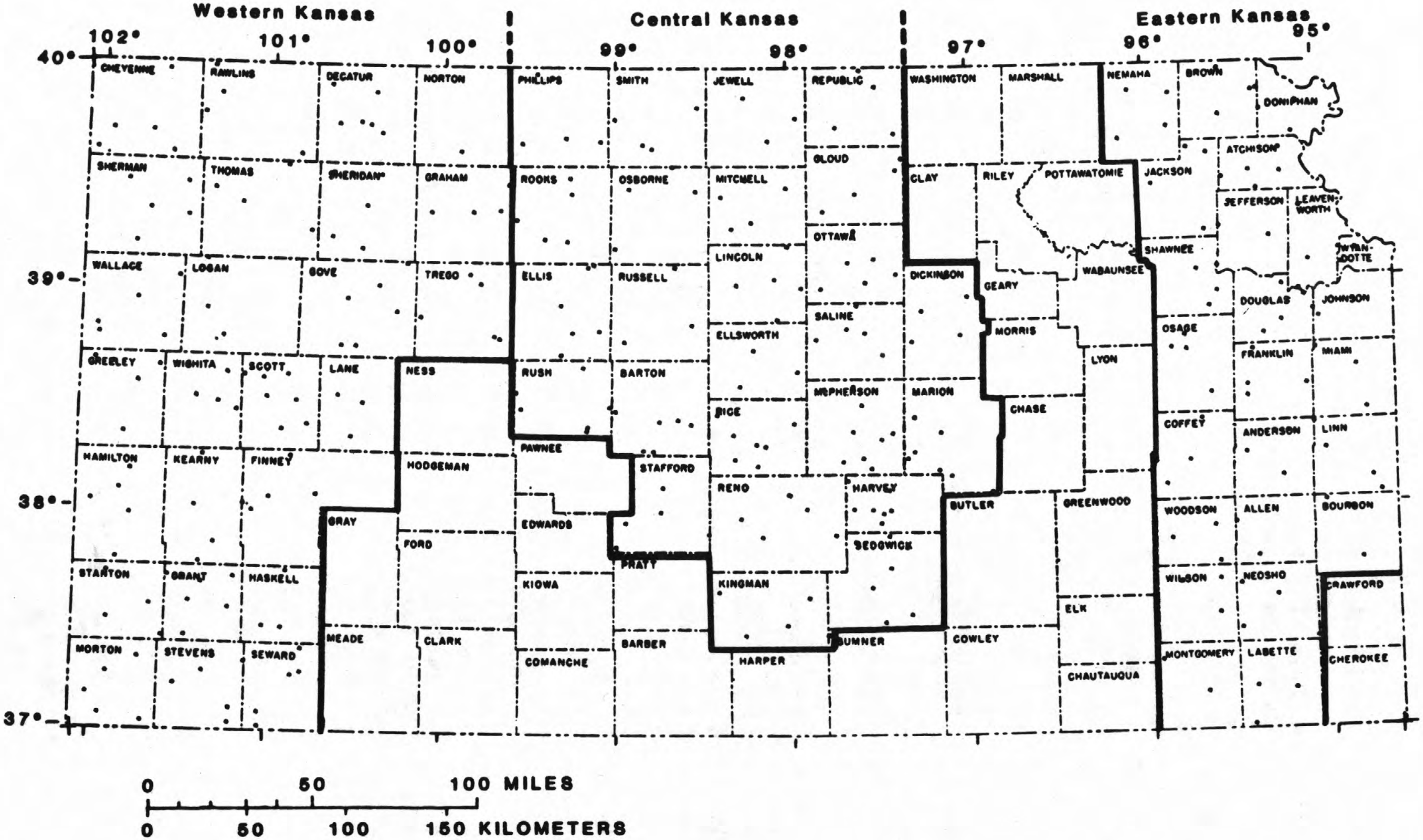

Figure 2.--Western, central, and eastern areas of Kansas selected for data analyses.

The results of the W-test will be presented according to the following format:

$$W = a; Z = b; \text{and Prob} > /Z/ = C;$$

where a is the rank sum or W-statistic of the population with the fewest samples, and b is the Z -score computed by:

$$\frac{W - \mu_W}{\sigma_W},$$

where W is the observed W-statistic, μ_W is the expected W under the null hypothesis, H_0, and σ_W is the standard deviation. The expected value, μ_W, is computed by:

$$1/2\ m\ (m+n+1)\quad ,$$

where m and n are sample sizes of the two compared populations, and $m \leq n$. The standard deviation, σ_W, is computed from:

$$\sqrt{\frac{1}{12}\ mn\ (m+n+1)}\quad .$$

The symbol C is the one-sided probability value that the two populations are identical. Where $C \leq 0.05$, it is concluded that there is a significant difference between the two populations at the 5-percent alpha level[2]. Values of b (or Z-scores) and associated one-sided probability values may be found in Table IV of Wonnacott and Wonnacott (1977).

RESULTS

Western Kansas

The median nitrate-nitrogen concentration in water from 118 wells in western Kansas was 3.8 mg/L (table 1). Water from approximately 4 percent of the wells sampled exceeded the 10-mg/L standard.

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2 The alpha level, α, is the probability that the null hypothesis will be rejected when it is true. Where $\alpha > 0.05$, it does not necessarily mean that there is no difference between compared populations, however. It may mean that the test was not sensitive enough to reject the null hypothesis because the sample size was too small to detect a difference.

Table 1.--Nitrate-nitrogen concentrations in water from wells in western Kansas

[Concentrations expressed in milligrams per liter (mg/L)]

Sample size	Percentile: 25th	50th (Median concentration)	75th	100th (Maximum concentration)	Percentage of concentrations greater than 10 mg/L
118	2.5	3.8	5.5	35	4.2

Median nitrate-nitrogen concentrations were highest in water from unconsolidated deposits of Tertiary and Quaternary age (also referred to as Tertiary and Quarternary aquifers), as shown in table 2. Although there was no significant difference between concentrations in water from these two sources at the 5-percent level of significance (W = 979.5; Z = 1.54; Prob > /Z/ = 0.06), 10 percent of the wells in Quaternary aquifers exceeded 10 mg/L compared to 3 percent in Tertiary aquifers. The highest observed concentration (35 mg/L) and the widest range of concentrations (0-35 mg/L) occurred in water from the Quaternary aquifer.

Table 2.--Nitrate-nitrogen concentrations in water from aquifers in western Kansas

[Concentrations expressed in milligrams per liter (mg/L)]

Aquifer and lithologic unit	Sample size	Percentile: 25th	50th (Median concentration)	75th	100th (Maximum concentration)	Percentage of concentrations greater than 10 mg/L
Quaternary						
Fluvial and eolian deposits	21	0.50	3.2	6.6	35	10
Tertiary						
Fluvial deposits	91	2.8	3.8	5.6	14	3.3
Cretaceous						
Sandstones	6	0.05	0.55	1.5	1.5	0

Water from sandstones of Cretaceous age (also referred to as Cretaceous aquifer) exhibited the lowest median nitrate-nitrogen concentration (0.55 mg/L). Concentrations in water from these sandstones were significantly lower than concentrations observed in water from unconsolidated Tertiary and Quaternary deposits (W = 33.5; Z = -3.89; Prob > /Z/ = 0.0001).

The highest median concentration was observed in the deep wells (table 3), although the highest observed concentration (35 mg/L) and the largest range of nitrate-nitrogen concentrations (0-35 mg/L) occurred in water from shallow wells. Almost 7 percent of the shallow wells produced water that exceeded 10 mg/L versus 3 percent of the deep wells. There was no significant difference between depth categories at the 5-percent level of significance (W = 1515; Z = 1.31; Prob > /Z/ = 0.09).

Table 3.--Nitrate-nitrogen concentrations in water from wells of selected depths in western Kansas

[Concentrations expressed in milligrams per liter (mg/L)]

Well depth (feet)	Sample size	Percentile				Percentage of concentrations greater than 10 mg/L
		25th	50th (Median concentration)	75th	100th (Maximum concentration)	
100 or less	27	0.85	3.2	6.6	35	6.9
More than 100	91	2.6	3.8	5.4	14	3.4

Central Kansas

The median nitrate-nitrogen concentration in water from 133 wells in central Kansas was 4.2 mg/L (table 4). Water from approximately 16 percent of the wells sampled exceeded the 10-mg/L standard.

Table 4.--Nitrate-nitrogen concentrations in water from wells in central Kansas

[Concentrations expressed in milligrams per liter (mg/L)]

Sample size	Percentile				Percentage of concentrations greater than 10 mg/L
	25th	50th (Median concentration)	75th	100th (Maximum concentration)	
133	0.90	4.2	7.7	99	16.5

Median concentrations were highest in water from shales of Permian age (also referred to as Permian aquifers), (7.1 mg/L) and in fluvial and eolian deposits of Quaternary age (4.9 mg/L), as shown in table 5. There was no significant difference in nitrate-nitrogen concentrations in water from these two sources at the 5-percent level of significance (W = 347; Z = 0.89; Prob > /Z/ = 0.19). The highest observed nitrate-nitrogen concentration (33 mg/L) and the widest range of values (0-33 mg/L) occurred in water from Quaternary aquifers, although 33 percent of the wells in Permian aquifers produced water with nitrate-nitrogen concentrations in excess of 10 mg/L compared with about 20 percent of the wells in the Quaternary aquifers.

Sandstones in Cretaceous aquifers produced water with the lowest median concentration (0.65 mg/L). This was significantly lower than the median concentration in Quaternary aquifers (W = 757; Z = 3.97; Prob > /Z/ = 0.0001) and Permian aquifers (W = 199; Z = 1.88; Prob > /Z/ = 0.03). Although the data were not included in table 5 because there were too few samples for statistical evaluation, concentrations of 3, 20, and 98 mg/L were observed in water from shales of Cretaceous age.

Table 5.--Nitrate-nitrogen concentrations in water from aquifers in central Kansas

[Concentrations expressed in milligrams per liter (mg/L). Only wells with sufficient lithologic information were utilized]

Aquifer and lithologic unit	Sample size	Percentile				Percentage of concentrations greater than 10 mg/L
		25th	50th (Median concentration)	75th	100th (Maximum concentration)	
Quaternary						
Fluvial and eolian deposits	82	2.5	4.9	9.2	33	19.5
Cretaceous						
Sandstones	24	0.10	0.65	3.0	28	8
Permian						
Shales	9	1.0	7.1	14	18	33

The highest median nitrate-nitrogen concentration (4.9 mg/L) occurred in water from shallow wells (table 6). This concentration was significantly higher than the median concentration of 0.70 mg/L in the deep wells ($W = 1,000$; $Z = 3.92$; $Prob > /Z/ = 0.0001$). Concentrations in water from shallow wells ranged from 0 to 99 mg/L, with 20 percent of the wells producing water with concentrations exceeding 10 mg/L. No concentrations exceeding 10 mg/L were observed in water from deep wells.

Table 6.--Nitrate-nitrogen concentrations in water from wells of selected depths in central Kansas

[Concentrations expressed in milligrams per liter (mg/L)]

Well depth (feet)	Sample size	Percentile 25th	Percentile 50th (Median concentration)	Percentile 75th	Percentile 100th (Maximum concentration)	Percentage of concentrations greater than 10 mg/L
100 or less	108	1.9	4.9	8.7	99	20.2
More than 100	25	0.1	0.7	4.2	8.7	0

Eastern Kansas

The median nitrate-nitrogen concentration in water from 82 wells in eastern Kansas was 4.8 mg/L (table 7). Approximately 29 percent of these wells produced water exceeding the 10-mg/L standard. About one-half of the wells sampled in eastern Kansas obtained water from unconsolidated deposits of Quaternary age, and one-half obtained water from consolidated rocks of Pennsylvanian age (also referred to as Pennsylvanian aquifer).

Table 7.--Nitrate-nitrogen concentrations in water from wells in eastern Kansas

(Concentrations expressed in milligrams per liter (mg/L)]

Sample size	Percentile 25th	Percentile 50th (Median concentration)	Percentile 75th	Percentile 100th (Maximum concentration)	Percentage of concentrations greater than 10 mg/L
82	1.0	4.8	11.8	160	29.3

Shales and limestones in the Pennsylvanian aquifer and unconsolidated deposits in the Quaternary aquifer produced water with median concentrations of nitrate-nitrogen ranging from 5.9 to 8.7 mg/L (table 8). There was no significant difference in nitrate-nitrogen concentrations in water from unconsolidated deposits, in water from shales (W = 287; Z = 0.63; Prob > /Z/ = 0.26), or in water from limestones (W = 216.5; Z = 0.212; Prob > /Z/ = 0.41) at the 5-percent level of significance. Sandstones in the Pennsylvanian aquifer exhibited the lowest median concentration (0.55 mg/L). This was significantly lower than the median in the unconsolidated deposits (W = 218; Z = 3.70; Prob > /Z/ = 0.0001).

Table 8.--Nitrate-nitrogen concentrations in water from aquifers in eastern Kansas

[Concentrations expressed in milligrams per liter (mg/L). Only wells with sufficient lithologic information were utilized]

Aquifer and lithologic unit	Sample size	Percentile				Percentage of concentrations greater than 10 mg/L
		25th	50th (Median concentration)	75th	100th (Maximum concentration)	
Quaternary						
Lacustrine and fluvial deposits	33	1.9	5.9	16	160	27.3
Pennsylvanian						
Limestones	7	3.7	6.6	15.5	20	42
Sandstones	15	0.13	0.55	2.18	7.2	0
Shales	10	1.8	8.7	19.2	126	40

The median concentration of nitrate-nitrogen in water from shallow wells was 6.6 mg/L (table 9). Thirty-four percent of these shallow wells produced water that exceeded the 10-mg/L standard. Eleven percent of the deep wells produced water with concentrations exceeding 10 mg/L. The median concentration in these deep wells was 0.75 mg/L. Water from the deep wells had concentrations of nitrate-nitrogen that were significantly lower than concentrations in the shallow wells (W = 446; Z = 3.37; Prob > /Z/ = 0.0004).

Table 9.--Nitrate-nitrogen concentrations in water from wells of selected depths in eastern Kansas

[Concentrations expressed in milligrams per liter (mg/L)]

Well depth (feet)	Sample size	Percentile				Percentage of concentrations greater than 10 mg/L
		25th	50th (Median concentration)	75th	100th (Maximum concentration)	
100 or less	64	2.23	6.6	16	160	34.4
More than 100	18	0.25	0.75	4.0	20	11.1

DISCUSSION

There were statistically significant differences in nitrate-nitrogen concentrations in water from shallow and deep wells in eastern and central Kansas, whereas no apparent differences were observed in western Kansas. One possible reason for this inconsistency may be that nearly all wells in western Kansas produced water from unconsolidated deposits, whereas most shallow wells in central and eastern Kansas produced water from unconsolidated deposits and most deep wells produced water from sandstones. In western Kansas (table 2), median concentrations in water from deep wells in Tertiary aquifers (3.8 mg/L) were similar to median concentrations from shallow wells in Quaternary aquifers (3.2 mg/L). In central and eastern Kansas, however, deep wells produced water mostly from consolidated sandstone aquifers where median concentrations were less than 0.75 mg/L. These concentrations were much lower than median concentrations of more than 4 mg/L in the shallow wells (tables 6 and 9). Shallow wells in central and eastern Kansas were developed primarily in Quaternary deposits with a few wells in shales of Cretaceous and Pennsylvanian age.

The highest concentrations and the largest percentages of samples with concentrations of more than 10 mg/L occurred in shallow wells in all three areas (tables 3, 6, and 9). Locations of sites where mean nitrate-nitrogen concentrations exceeded 10 mg/L are shown in figure 3. Less than 4 percent of the deep wells produced water that had concentrations of more than 10 mg/L as compared with almost 23 percent of the shallow wells. Although there was no significant difference in nitrate-nitrogen concentrations at the 5-percent level of significance between areas, concentrations exceeded 10 mg/L in water sampled from 29 percent of the wells in eastern Kansas, 16 percent of the wells in central Kansas, and only 4 percent of the wells in western Kansas. The smaller percentage of shallow wells in western Kansas (32 percent), as compared to central (81 percent) and eastern Kansas (78 percent), probably accounts for the low incidence of undesirable nitrate-nitrogen concentrations.

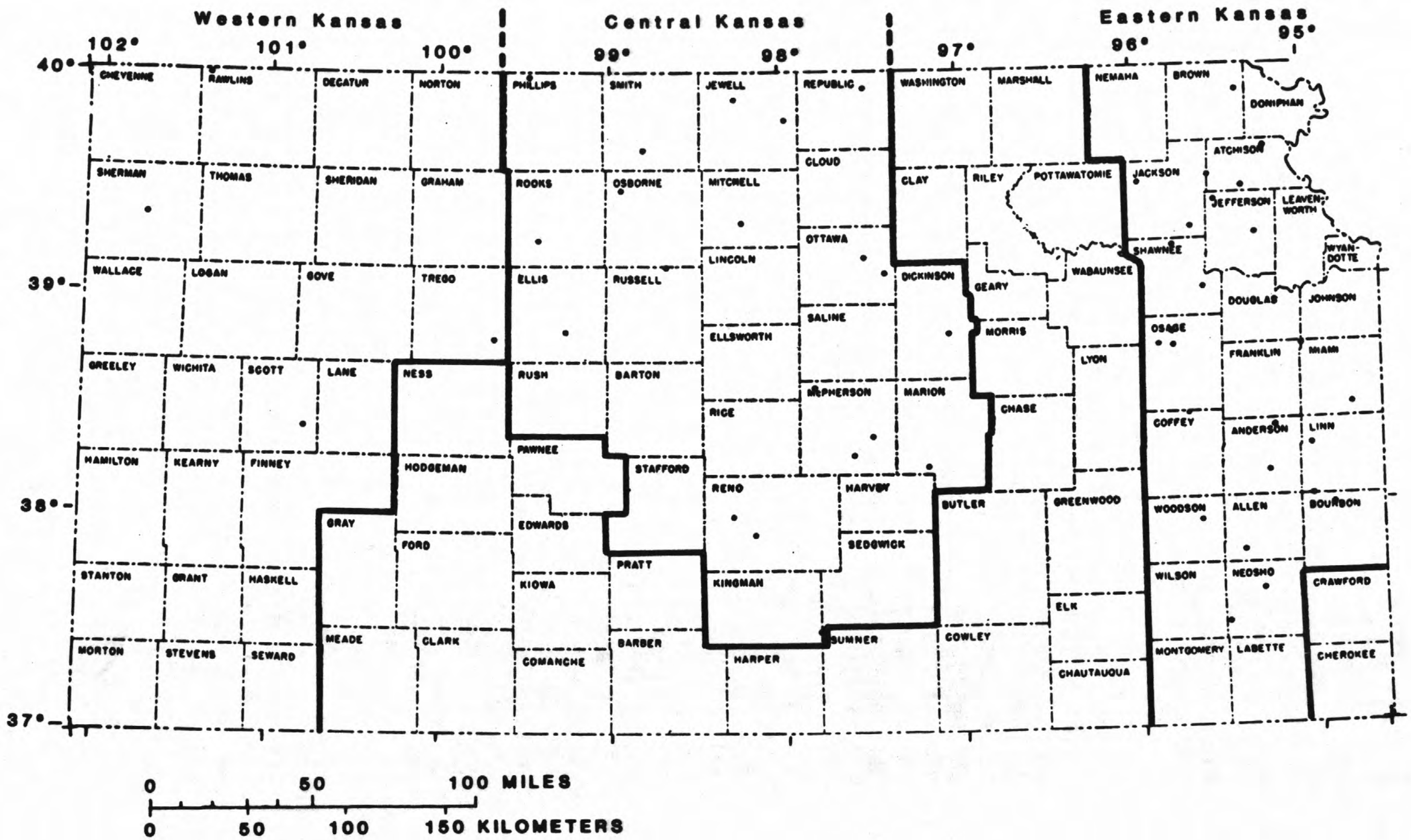

Figure 3.--Sites where mean nitrate-nitrogen concentrations exceeded 10 milligrams per liter.

These results suggest that nitrogen sources at or near the land surface are principally responsible for the occurrence of most nitrate-nitrogen concentrations of more than 10 mg/L in ground water. However, water in some aquifers already may have higher concentrations than in others due partially to dissolution of nitrogenous materials from aquifer sediments. Thus, in areas where additional nitrogen sources at the land surface contribute to concentrations in ground water, aquifers also may be more likely to have concentrations of more than 10 mg/L.

Nitrate-nitrogen concentrations in ground water from the three areas differed according to the lithology of the aquifer. Median nitrate-nitrogen concentrations in water from wells in consolidated rocks ranged from 0.55 mg/L in sandstones of western Kansas to 8.7 mg/L in shales of eastern Kansas (tables 2, 5, and 8). Water from all lithologic units considered, except sandstones, had median concentrations of 3.2 mg/L or more.

The highest median concentrations observed were 7.1 mg/L from shales in central Kansas, 8.7 mg/L from shales in eastern Kansas, and 6.6 mg/L from limestones in eastern Kansas. Wells developed in shales and limestones in these areas also produced the largest percentage of samples with concentrations above 10 mg/L. Wlotzka (1970, p. 7-K-1) reported that shales contain the highest amounts of nitrogen of all sedimentary rock types. This information, coupled with findings in this report, strongly suggests that nitrogenous material contained within sediments composing certain shales may provide a partial source of soluble nitrogen to the contained water. Because the limestones in eastern Kansas generally are interbedded with shale, nitrogenous material from the shales and possibly the limestone as well may contribute nitrate to water in these aquifers, resulting in high median concentrations. Thus, shallow wells in fine-grained, low-yielding aquifers (less than 10 gallons per minute), such as limestones of eastern Kansas and shales of central and eastern Kansas, may be especially susceptible to contamination from the land surface and are likely to yield water with concentrations higher than 10 mg/L. In addition, the long residence time of water in these fine-grained sediments and the consequent low flushing rate may allow a local buildup of nitrate and may account for extreme concentrations (greater than 50 mg/L of nitrate-nitrogen) observed in water from these aquifers.

Unconsolidated deposits, the source of most private and public water supplies in the State, produced water with median concentrations ranging from 3.2 mg/L in Quaternary aquifers of western Kansas to 5.9 mg/L in Quaternary aquifers of eastern Kansas. Water from 10 percent of the wells in Quaternary deposits in western Kansas to almost 30 percent of the wells in Quaternary deposits in eastern Kansas had nitrate-nitrogen concentrations that exceeded 10 mg/L. Because most of the wells in Quaternary aquifers were shallow (88 percent), ground water in Quaternary deposits is highly susceptible to localized nitrate contamination from sources at the land surface. None of the deep wells in unconsolidated aquifers produced water with concentrations above 10 mg/L, indicating that undesirable nitrate-nitrogen concentrations are produced from sources at or near the land surface. However, depending upon the nature of the eroded material, some nitrate may be dissolved from nitrogenous fine-grained sediments in unconsolidated aquifers as it is in consolidated aquifers.

With the exception of sandstones of Cretaceous and Paleozoic age, the Tertiary aquifer in western Kansas (the Ogallala Formation) produced water having the smallest percentage (3 percent) of concentrations that exceeded 10 mg/L. Ninety-three percent of the wells in this aquifer were deeper than 100 feet. These data suggest that no significant widespread nitrate pollution from nitrogen at the land surface has occurred in the Tertiary aquifer and that nitrate present in water produced from this aquifer is derived primarily from soluble nitrogen within the aquifer materials.

Water from sandstone aquifers in all areas had the lowest concentrations of nitrate-nitrogen and the lowest percentage of samples with concentrations exceeding 10 mg/L. The sandstone aquifers in Kansas generally produced water with nitrate-nitrogen concentrations of less than 3 mg/L.

SUMMARY

Nitrate-nitrogen concentrations in ground-water supplies in Kansas that do not meet drinking-water standards are almost exclusively a problem in wells that are less than 100-feet deep. Most concentrations of nitrate-nitrogen greater than 10 mg/L occurred in water from wells in the central and eastern areas of the State where wells generally are less than 100 feet in depth. The data indicate that nitrogen sources at or near the land surface are principally responsible for the occurrence of nitrate-nitrogen concentrations of more than 10 mg/L, although some soluble nitrogen may be derived from fine-grained sediments in some aquifers.

The highest median concentrations of nitrate-nitrogen and the highest incidence of concentrations of more than 10 mg/L were observed in water from shales in central and eastern Kansas and from limestones in eastern Kansas. Water from 10 percent of the wells in the Quaternary aquifer in western Kansas to almost 30 percent of the wells in the Quaternary aquifer in eastern Kansas had nitrate-nitrogen concentrations that exceeded 10 mg/L. Shallow wells in shale, limestone, and unconsolidated Quaternary deposits are highly susceptible to nitrate contamination from sources at or near the land surface. Water from unconsolidated Tertiary deposits in western Kansas produced water with a low incidence of nitrate-nitrogen concentrations greater than 10 mg/L, indicating minimal nitrate contamination from sources at or near the land surface. Water from sandstone in all areas produced water with the lowest incidence of concentrations greater than 10 mg/L and also the lowest median concentrations.

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APPENDICES

(Explanation of tabular headings used in the appendices)

SITE ID and WELL NUMBER indicate well locations and are explained in Spruill and Kenny (1981).

AQUIFER is a code designating the geologic name of the principal aquifer tapped by the well. Aquifer codes used in these appendices are explained in the following table:

AQUIFER CODE		GEOLOGIC NAME OF PRINCIPAL AQUIFER
111	CLVM	Colluvium
112	ALVM	Alluvium
112	CRET	Crete Formation
112	GDID	Grand Island Formation
112	ILNN	Illinoisan deposits
112	KGFV	Kansan Glacio-Fluvial deposits
112	KNSN	Kansan deposits
112	MCPR	McPherson Formation
112	MEDE	Meade Group
112	NBRK	Nebraskan deposits
112	NWMN	Newman terrace deposits
112	PLSC	Pleistocene deposits
112	TRRC	Terrace deposits
112	WSCS	Wisconsinan deposits
121	OGLL	Ogallala Formation
210	CRCS	Cretaceous System
211	CDLL	Codell Sandstone Member of the Carlile Shale
211	CLRD	Colorado Group
211	DKOT	Dakota Formation
211	GRNR	Graneros Shale
217	KIOW	Kiowa Shale
310	NNSC	Ninnescah Shale
310	WLNG	Wellington Formation
317	SMNR	Sumner Group
319	CCGV	Council Grove Group
319	CHSE	Chase Group
319	FRCK	Foraker Limestone

AQUIFER CODE		GEOLOGIC NAME OF PRINCIPAL AQUIFER
321	CHNT	Chanute Shale
321	CRVL	Cherryvale Shale
321	ELMN	Elmont Limestone Member of the Emporia Limestone
321	HPLR	Hepler Sandstone Member of the Seminole Formation
321	IRLD	Ireland Sandstone Member of the Lawrence Formation
321	TNGX	Tonganoxie Sandstone Member of the Stranger Formation
321	WCLD	White Cloud Shale Member of the Scranton Shale
322	DGLS	Douglas Group
322	SHWN	Shawnee Group
322	SVRY	Severy Shale
322	WBNS	Wabaunsee Group
323	GLBG	Galesburg Shale
323	IOLA	Iola Limestone
323	KSSC	Kansas City Group
323	LINN	Linn Subgroup
323	LNSG	Lansing Group
323	PLSN	Pleasanton Group
323	STNN	Stanton Limestone
323	VILS	Vilas Shale
323	WNDT	Wyandotte Limestone
324	EGLV	Englevale Sandstone Member of the Labette Shale
325	BNDR	Bandera Shale
325	FRSC	Fort Scott Limestone
325	LBTT	Labette Shale
325	PNNE	Pawnee Limestone

DEPTH is the total well depth, in feet.

USE is the principal use of the well, where H = domestic, S = stock, P = public supply, I = irrigation, and U = unused.

N is the number of analyses used in computing the mean nitrate-nitrogen concentration.

MEAN is the mean nitrate-nitrogen concentration value used in the statistical evaluations, in milligrams per liter.

MIN is the minimum observed nitrate-nitrogen concentration, in milligrams per liter.

MAX is the maximum observed nitrate-nitrogen concentration, in milligrams per liter.

Appendix A.--Data summary and selected well information for sites in western Kansas

SITE ID	WELL NUMBER	AQUIFER	DEPTH	USE	N	MEAN	MIN	MAX
370128101004001	35S34W10BBB	121OGLL	353.00	I	2	6.3	6.1	6.5
370218101103301	35S36W01AAA	121OGLL	400.00	I	1	3.7		
370224101394601	35S40W03BBB	121OGLL	385.00	I	1	2.2		
370418101540802	34S42W20DD	121OGLL	120.00	H,S	2	6.9	6.2	7.7
370523101004901	34S34W16DAA	121OGLL	458.00	I	1	3.5		
370619101102601	34S35W07BCC	121OGLL	456.00	I	1	2.9		
370946101582401	33S43W22DAA	121OGLL	116.00	H,S	2	3.8	3.7	4.0
371246101290701	33S38W06AAB	121OGLL	360.00	I	2	8.3	8.3	8.4
371524100495301	32S32W20BBB	121OGLL	475.00		1	2.7		
371531101514501	32S42W14CCC	121OGLL	187.00	I	2	2.4	2.3	2.5
371615100463701	32S32W14BBB	121OGLL	420.00	I	2	2.7	2.6	2.8
371621101194001	32S37W10DCC	121OGLL	480.00	I	2	2.2	2.1	2.3
371858101053601	31S35W26DCC	121OGLL	420.00	I	2	3.0	2.8	3.3
371945101412701	31S40W29ABB	121OGLL	215.00	I	2	3.7	3.7	3.8
372239100464501	31S32W03DAD	121OGLL	412.00	I	2	4.4	4.0	4.8
372543101333801	30S39W23BBB	121OGLL	405.00	I	2	2.8	2.7	2.9
372556101260201	30S38W13CCC	121OGLL	560.00	I	2	2.0	1.9	2.0
372827100533301	30S33W02AAB	121OGLL	412.00	I	2	1.5	1.4	1.7
372846100594901	29S34W36CBC	121OGLL	556.00	I	1	2.8		
373018101521101	29S42W24CCC	211DKOT	515.00	I	2	1.4	1.2	1.7
373339101112801	29S35W06BAA	121OGLL	376.00	I	2	3.3	3.2	3.4
373413101380001	28S39W31BCC	121OGLL	400.00	I	2	3.3	3.3	3.4
373516101245001	28S37W30BBD	121OGLL	285.00	I	2	3.1	3.0	3.2
374024101203601	27S37W26BCB	121OGLL	595.00	I	2	2.6	2.2	3.1
374044100395001	27S31W24CDC	121OGLL	206.00	I	3	6.1	5.4	7.0
374100101270501	27S38W23CB	121OGLL	235.00	U	2	13	13	14
374203101095101	27S35W17ADD	121OGLL	410.00	I	1	1.6		
374210101320301	27S39W13ACB	211DKOT	508.00	I	2	1.5	1.5	1.5
374249101524101	27S42W11DBB	121OGLL	252.00	I	2	2.5	2.4	2.7
374343100520801	27S32W06CBB	121OGLL	298.00	I	3	2.0	2.0	2.1
374557101215101	26S37W21DDD	121OGLL	330.00	I	2	2.6	2.5	2.7
374638101495001	26S41W20BBD	211DKOT	140.00	I	1	1.0		
375115101165801	25S36W28BBD	121OGLL	362.00	I	2	9.0	8.6	9.4
375841101453401	24S40W07CBB	112ALVM	58.00	I	1	2.5		
380010101040601	24S34W05AAB	121OGLL	320.00	I	3	6.7	6.3	7.2
380108101234301	23S37W28CCB	121OGLL	300.00	I	3	4.1		
380153101071302	23S35W25BBB	121OGLL	320.00	I	3	4.1	4.1	4.1
380210101584801	23S42W19CBB	112ALVM	74.00	I	2	8.1	7.8	8.5
380339100582401	23S33W17BBB	121OGLL	340.00	I	3	4.1	4.0	4.1
380435100423201	23S31W03DCC	121OGLL	180.00	I	3	6.8	6.7	6.9

Appendix A.--Data summary and selected well information for sites in western Kansas--Continued

SITE ID	WELL NUMBER	AQUIFER	DEPTH	USE	N	MEAN	MIN	MAX
380520101492001	22S41W33DCD	210CRCS	585.00	H,S	2	.05	.0	.1
381033101453701	21S40W31CCC	211DKOT	902.00		3	.03	.0	.1
381453100511001	21S32W08ABD	121OGLL	155.00	I	3	5.8	5.5	6.2
381458101211001	21S37W02CDD	121OGLL	134.00	H,S	2	5.7	5.7	5.8
382020100310501	20S29W03CCB	121OGLL	80.00	H,S	2	9.4	8.8	10
382037101482701	20S41W02ADD	121OGLL	184.00	H,S	2	4.3	4.2	4.4
382204100544001	19S33W25DCD	121OGLL	107.00	I	1	5.6		
382333100460001	19S31W20BAD	121OGLL	134.00	I	3	10	7.9	14
382711101101701	18S35W34ABB	121OGLL	143.00	I	3	4.0	4.0	4.0
382913101163001	18S36W15DAD	121OGLL	165.00	I	1	5.8		
382925100271801	18S28W18ACC	121OGLL	104.00	I	3	5.7	5.2	6.0
382947100495001	18S32W14BBB	121OGLL	180.00	I	3	5.4	4.9	5.7
383043101240301	18S37W03CCC	121OGLL	190.00	I	3	6.4	5.0	7.5
383046100594901	18S33W05CCC	121OGLL	119.00	I	1	2.6		
383130100354301	18S30W02AAA	121OGLL	130.00	I	3	4.9	4.5	5.5
383418101435701	17S40W15CCB	121OGLL	200.00	I	3	3.8	3.5	4.0
383553101005701	17S33W07BBB	121OGLL	202.00	U	2	2.8	2.7	3.0
383633101073401	17S34W06BCB	121OGLL	194.00	I	1	4.5		
383645100523901	17S32W05ABB	121OGLL	208.00	I	1	4.0		
383712101133001	16S35W31DBA	121OGLL	178.00	I	3	5.0	4.5	6.0
383816101264801	16S37W30ACB	121OGLL	220.00	I	3	6.0	5.5	6.3
383841101363801	16S39W22DCB	121OGLL	163.00	I	3	3.0	2.8	3.1
383915101522901	16S41W20BAD	121OGLL	250.00	I	2	8.0	7.7	8.4
384021101584801	16S42W08DDC		189.00	I	1	3.1		
384447100295801	15S29W13CCB	112ALVM	100.00	I	1	.1		
384458100345501	15S29W18DB	112TRRC	90.00		1	.0		
384616101353801	15S38W07BBB	121OGLL	178.00	I	2	4.7	4.3	5.1
384700099404801	15S21W05ABB	111CLVM	11.00	H,S	1	35		
384705101151701	15S35W06BAC	210CRCS	1145.00	H,S	1	.1		
384711101574701	15S42W02BBB	121OGLL	225.00	I	2	2.9	2.9	2.9
384734099423501	14S22W36ADD	112ALVM	25.00	H	1	1.5		
384927101582701	14S42W22BDD	121OGLL	432.00	I	3	4.3	2.7	5.8
385243100075401	13S25W32CBB	112TRRC	21.00	H,S	2	3.8	3.6	4.0
385405100160301	13S27W25ABB	121OGLL	87.00	I	3	1.0	1.0	1.1
383633101073401	17S34W06BCB	121OGLL	194.00	I	1	4.5		
385421101210002	13S36W20CCB	112ALVM	32.00	I	2	.3	.3	.3
385641101445301	13S40W10ABB	112ALVM	45.00	I	1	3.2		
385726100325502	13S29W04BAC	112ALVM	65.00	I	3	1.1	.6	2.0
390106100221301	12S28W12DDD	121OGLL	152.00	I	1	3.2		

Appendix A.--Data summary and selected well information for sites in western Kansas--Continued

SITE ID	WELL NUMBER	AQUIFER	DEPTH	USE	N	MEAN	MIN	MAX
390149099472801	12S22W08BAB	121OGLL	118.00	H	2	1.0	1.0	1.0
390254101305402	11S38W35CCC	121OGLL	189.00	I	2	2.5	2.4	2.6
390413099510201	11S23W26BCB	211CDLL	320.00	H,S	2	.3	.1	.6
390709100125401	11S26W04CDC	121OGLL	167.00	I	2	3.2	3.1	3.3
390735101212401	11S36W06DBB	121OGLL	284.00	I	2	6.8	6.6	7.1
391104100282301	10S28W17BDD	121OGLL	25.00	H,S	2	3.3	3.2	3.4
391158101460401	10S40W10ADC	112ALVM	68.00	I	3	3.9	2.9	4.7
391401100384601	09S30W35BBB	121OGLL	220.00	I	2	1.8	1.8	1.9
391539100455801	09S31W22ABD	121OGLL	194.00	I	2	5.4	4.6	5.6
391917101282301	08S37W32ABB	121OGLL	217.00	I	2	5.4	5.4	5.4
392104100044401	08S25W14DCC	112ALVM	72.00	I	2	.0	.0	.0
392107101413901	08S39W17DCD	121OGLL	300.00	I	3	13	11	15
392108099502101	08S23W13CD	121OGLL	52.00	P	2	.1	.1	.1
392138099410501	08S21W17ACB	112CRET	55.00	P	2	1.3	1.2	1.4
392235100270201	08S28W09ABC	121OGLL	206.00	I	2	4.8	4.6	5.1
392303101095401	08S34W06CBC	121OGLL	227.00	I	2	5.3	5.0	5.6
392652101192301	07S36W15ACB	121OGLL	285.00	I	2	5.2	4.6	5.8
392811101285301	07S37W05CCB	121OGLL	300.00	I	2	4.6	4.3	4.9
392829099381603	07S21W02BCC	121OGLL	100.00	H	2	3.0	2.9	3.2
392836101491801	07S40W06ADB	121OGLL	345.00	I	2	2.9	2.7	3.2
393057100221201	06S27W19DAB	121OGLL	60.00	I	1	6.9		
393131100383701	06S30W14CCD	121OGLL	205.00	I	1	2.4		
393315100541901	06S32W04CCC	121OGLL	130.00	H,S	1	5.1		
393618100495801	05S31W20BCC	121OGLL	70.00	H,S	2	3.8	1.8	5.9
393625101342401	05S38W22ACB	121OGLL	270.00	I	3	4.6	4.2	4.9
393658102003601	05S42W14CBC	121OGLL	221.00	I	5	4.9	4.7	5.1
393729099544901	05S23W16ABA		55.00	H	1	6.6		
394205101413101	04S39W15CCA	121OGLL	275.00	I	3	3.3	3.2	3.4
394208100221101	04S27W17DAC	121OGLL	165.00	I	1	1.7		
394218101551201	04S41W16DAA	112ALVM	38.00	I	3	8.2	4.5	11
394425100261401	04S28W02BBA		130.00	I	1	1.2		
394432100370401	03S29W31DCC	112ALVM	40.00	I	1	3.9		
394504100293601	03S28W32BCA	121OGLL	205.00	I	1	1.4		
394711101233201	03S36W17CCC	121OGLL	300.00	I	3	5.3	4.9	5.6
395224101180301	02S36W13DDD	121OGLL	262.00	I	2	7.9	7.9	8.0
395307100243001	02S28W13ABA	112ALVM	60.00	I	2	6.5	6.0	7.0
395505100395501	01S30W34DDD	112ALVM	60.00	I	2	.7	.3	1.1
395829101362501	01S38W08DCC	112ALVM	33.00	I	1	.1		
395941101203901	01S36W03DBB	112ALVM	40.00	H,S	2	20	9.7	31

Appendix B.--Data summary and selected well information for sites in central Kansas

SITE ID	WELL NUMBER	AQUIFER	DEPTH	USE	N	MEAN	MIN	MAX
372658098170301	30S09W10ADC	112PLSC	82.00	P	3	9.5	8.9	9.8
372659097491801	30S05W12CCA	112PLSC	63.00	I	3	10	4.2	14
372942098025101	29S07W26ADB		20.00	H	1	2.2		
373031097295401	29S02W23DDA	112PLSC	52.00	P	3	5.5	3.3	7.7
373233097205801	29S01E08CBB	112PLSC	36.00	H	2	6.0	5.8	6.2
373711097553301	28S06W12CDD	310NNSC	67.00	H,S	2	6.7	4.2	9.3
373846098255701	27S10W32DCC	112GDID	60.00	P	3	9.4	8.9	10
373954097341101	27S02W32BBB	112PLSC	54.00	P	3	2.1	.4	3.0
374508097275401	26S01W31AAC	112PLSC	40.00	I	1	2.6		
374934099002301	25S15W31DDB	112PLSC	90.00		1	5.2		
375039097222201	25S01W25DAD		40.00		1	.1		
375059099004001	25S15W30ABC		50.00		2	7.7	5.9	9.5
375211097393901	25S03W16CCC		90.00	P	1	.8		
375340098110901	25S08W10ABC	112MEDE	58.00		1	10		
375348097281901	25S01W07BAA	112PLSC	130.00	P	3	4.2	4.0	4.5
375408097462901	25S04W05DAD	112WSCS	54.00	P	3	7.3	4.3	9.4
375423098292301	25S11W01BCB	112PLSC	50.00	S	3	6.5	6.3	6.6
375718097305601	24S02W23BBB	112PLSC	80.00	I	3	.6	.1	1.1
375727098573201	24S15W15CDA	112MEDE	79.00	P	3	1.1	.1	2.8
375841098182301	24S09W10BCC	112CRET	36.00	H,S	2	10	9.2	12
375948097300801	24S02W02AAC	112PLSC	20.00		2	.1	.1	.1
380028098453601	23S13W33BDB	112MEDE	80.00	P	3	4.6	4.4	4.8
380041097273701	23S01W32BBC	112PLSC	133.00	P	3	3.1	2.1	5.0
380054097334901	23S02W29CDD	112MCPR	237.00	P	1	.4		
380107097400901	23S03W29DBD	112PLSC	135.00	I	3	3.5	3.3	3.8
380107097561201	23S06W25CBD	112TRRC	65.00		1	4.1		
380456098015501	23S06W06BCB	112PLSC	30.00		2	4.6	3.7	5.6
380509098021901	23S07W01ABA	112PLSC	30.00	I	1	9.7		
380535096531401	22S05E33CAA	121OGLL	155.00		1	8.5		
380608097281201	22S01W30DCC	112ALVM	48.00	H	3	25	24	27
380703098450301	22S13W21DDB	112PLSC	104.00	I	3	6.7	3.5	13
380845097421002	22S04W12DDD	112MCPR	88.00	P	3	1.1	.0	2.0
381002097065401	22S03E04BCC		105.00		1	.1		
381133097110701	21S02E26CBC	310WLNG	61.00	I,H	2	17	5.6	28
381207097341001	21S02W29BBA		139.00	P	1	4.1		
381252098124701	21S08W21BAC	112WSCS	92.00	P	1	5.9		
381359097434401	21S04W11DCC		92.00		1	.9		
381443098203301	21S09W08BAB	112ALVM	30.00	H,S	2	6.8	6.6	7.1
381444097214401	21S01E07BAA	112PLSC	40.00		3	3.1	2.5	3.9
381451097365701	21S03W02DCD	112PLSC	35.00	H	3	23	19	29

Appendix B.--Data summary and selected well information for sites in central Kansas--Continued

SITE ID	WELL NUMBER	AQUIFER	DEPTH	USE	N	MEAN	MIN	MAX
381626097192801	20S01E33ABB	310NNSC	90.00		2	.1		
381656098481801	20S13W30CAB	112PLSC	66.00	I	2	5.3	5.2	5.5
381708098513901	20S14W27BCA	112PLSC	80.00	S	3	5.6	5.2	5.9
381813098101101	20S08W23ABA	112PLSC	50.00	H	2	4.2	4.0	4.4
381846098131301	20S08W17ADD		67.00		1	2.9		
381958097304101	20S02W11BAA	112PLSC	40.00		2	14	5.6	23
382116098210601	19S09W31DAB	112WSCS	60.00	P	3	5.0	4.0	5.3
382136097265601	19S01W32AAC		103.00		1	.7		
382141097103101	19S02E35ABA		75.00		1	2.1		
382208097402002	19S03W29DBA	112PLSC	160.00	P	3	4.4	3.1	5.1
382216099105301	19S17W27ADD	211DKOT	185.00	H,S	1	.1		
382321099103701	19S17W23BBD		232.00		1	.1		
382407098352901	19S12W13ADA	112PLSC	34.00	H,S	2	9.1	9.0	9.2
382420098002301	19S06W17ABB				3	5.0	4.1	6.3
382453098462301	19S13W09BCC		127.00		1	.2		
382519098400201	19S12W05DDC	211DKOT	60.00	H,S	2	.8	.8	.9
382542097192801	19S01E04ACC	310NNSC	67.00	P	3	7.6	5.7	10
382555097192801	19S01E04ABC		120.00		1	.2		
382643098264501	18S10W32ADB	112ALVM	80.00	H,S	2	.2	.2	.3
382737099011101	18S15W30ACA	211DKOT	85.00		2	.3	.1	.5
382802099332201	18S20W20DCA	112PLSC	47.00	P	3	7.9	5.4	9.3
382842099030902	18S16W23AAA	112PLSC	75.00	P	3	1.9	1.6	2.1
382913097371801	18S03W14BDD	112PLSC	87.00	P	3	.2	.1	.3
383221097185501	17S01E27CCB	217KIOW	12.00	H	1	.3		
383234099350501	17S20W30CCB	211DKOT	325.00	H,S	2	.1	.1	.1
383328097500901	17S05W23DAB	112ALVM	41.00	P	3	15	14	17
383413097402001	17S03W17DBD	112ALVM	86.00	P	3	.7	.4	1.0
383420098185701	17S09W16DAB	211DKOT	210.00	P	3	.1	.0	.1
383817097591701	16S06W28ABB	112ALVM	65.00	H	2	3.4	3.1	3.7
383916099121801	16S17W16DCD	211DKOT	370.00	H,S	2	.1	.1	.1
384239099195401	15S18W33BAA	211DKOT	154.00	H,S	2	.7	.6	.9
384242097300901	15S02W26DDD	317SMNR	100.00	P	3	.1	.0	.1
384401098142301	15S08W20BCD	112ALVM	30.00	P	3	6.5	6.1	7.0
384610097200601	15S01E05DDD	310WLNG	60.00	H,S	1	7.1		
384614098582701	15S15W03DCD	112PLSC	12.00	S	1	5.3		
384658097525001	15S05W04ABB	211DKOT	80.00	P	3	.04	.0	.1
384750097034101	14S03E35ABA	317SMNR	50.00	H,S	2	10	9.4	11
384836097361501	14S03W25BAD	112ALVM	90.00	P	3	4.9	3.4	5.9
384845099160401	14S18W25AAB	112TRRC	28.00	H	2	12	12	13

Appendix B.--Data summary and selected well information for sites in central Kansas--Continued

SITE ID	WELL NUMBER	AQUIFER	DEPTH	USE	N	MEAN	MIN	MAX
384941097422401	14S04W13DDD	112ALVM	45.00	H,S	2	.0	.0	.1
385055098352901	14S11W07CAB	211DKOT	100.00	P	3	2.9	.6	5.0
385219098061101	13S07W33DCC	211DKOT	52.00	H,S	2	.2	.1	.3
385603097390801	13S03W09DA	112ALVM	50.00	H	2	.0	.0	.0
385609099200701	13S18W09CBB	112PLSC	59.00	P	3	2.9	2.6	3.3
385812097011101	12S04E31AAD	112ALVM	100.00	P	3	4.1	1.2	5.8
390035097511901	12S05W15ADD	112ALVM	50.00	P	3	5.7	5.2	5.9
390048097580801	12S06W15AAC	112ALVM	60.00	P	3	9.8	4.4	14
390141098201701	12S09W08AAC	211DKOT	30.00		2	.3	.3	.4
390213097360002	12S03W01DBA	112TRRC	47.00	P	3	4.5	3.2	5.7
390312098071701	11S07W32ACC	211DKOT	78.00	P	2	6.0	5.9	6.1
390334097085901	11S02E36AAA	319CHSE	96.00		1	3.1		
390430097253301	11S01W22CCC	217KIOW	20.00	H,S	2	98	87	110
390623098412701	11S12W07DDB	211DKOT	37.00	P	3	15	13	18
390623099105601	11S17W11CCA	112ALVM	20.00		2	2.0	1.6	2.0
390702099085901	11S17W12AAA	112PLSC	19.00	S	1	.4		
390740097420901	11S03W06BCA		150.00		1	.1		
390831097330701	10S02W33BCA	211DKOT	20.00	H	2	27	23	32
391123099014701	10S15W18AAA	112ALVM	80.00		2	4.4	4.2	4.7
391201098024901	10S07W12ACA	211DKOT	100.00	P	3	1.2	.1	2.2
391315099180901	09S18W35CCD	121OGLL	70.00	P	3	3.3	1.9	4.2
391354099254901	09S19W34BBD	121OGLL	70.00	P	2	10	8.6	12
391609097395801	09S03W17DAA	211DKOT	167.00	H,S	2	.5	.0	1.0
391649098220701	09S09W07DCB	211CLRD	23.00	H,S	2	3.7	3.7	3.8
391827098151501	08S08W31DCC	211GRNR	26.00	H,S	2	20	19	21
391901099353301	08S20W31ACB	112PLSC	34.00	P	3	7.7	6.9	8.4
392128097503001	08S05W14ACD	112TRRC	41.00	P	3	6.1	.3	16
392531098254501	07S10W22CCA	112TRRC	16.00	H,S	2	4.0	3.7	4.4
392603097392601	07S03W21BAD	211DKOT	342.00		1	1.4		
392606099164401	07S18W24BAD	112ALVM	54.00	P	3	2.2	.5	4.3
392702098342701	07S11W17BAB	112ALVM	59.00	H,S	2	3.0	.2	5.9
392736098571301	07S15W11ADD	112ALVM	60.00	P	4	10	1.3	16
392747098031201	07S07W12BAC	211CLRD	39.00	H,S	2	8.2	3.4	13
392958098173401	06S09W26CAD	112TRRC	48.00	P	3	11	2.2	27
393027099172501	06S18W26AAC	210CRCS	119.00		2	8.7	.4	17
393229097252701	06S01W10CCB	211DKOT	63.00	H,S	2	.05	.0	.1
393334098422901	06S12W06CBB	112ALVM	60.00	P	4	6.5	1.4	21
393538097233201	05S01W26ABD	211DKOT	158.00	P	3	.1	.1	.1
393603097512901	05S05W22DAD	112ILNN	140.00	P	3	4.5	2.5	5.7
393820098492801	05S13W07AAA	112TRRC	40.00	H,S	2	18	18	19

Appendix B.--Data summary and selected well information for sites in central Kansas--Continued

SITE ID	WELL NUMBER	AQUIFER	DEPTH	USE	N	MEAN	MIN	MAX
393927098524101	04S14W35CCB	112TRRC	53.00	H,S	2	1.3	.3	2.4
393940099335701	04S20W34CAB	112ALVM	54.00	P	3	.7	.1	1.8
394019099070801	04S16W27CCA	112TRRC	70.00	P	3	7.7	6.0	11
394030098093302	04S08W25DAB	112PLSC	52.00	P	3	8.1	7.7	8.6
394112099185701	04S18W23DCA	210CRCS	69.00	P	3	4.4	4.2	4.7
394222097255901	04S01W16ACC	211DKOT	100.00	P	4	2.3	.6	3.0
394400097461601	04S04W04DBB	112WSCS	59.00	I	2	1.7	1.4	2.0
394636098000201	03S06W21CAB	112ALVM	50.00	P	3	33.0	32.0	34.0
394618099021301	03S15W20DCC	211CLRD	60.00	P	3	9.7	9.5	9.9
394933098340301	03S11W04ACC	211CLRD	35.00	P	3	5.0	4.1	5.8
395209098180001	02S09W23BAC	112ALVM	62.00	P	3	24	22	26
395458097323501	01S02W33DCD	112PLSC	62.00	P	3	19	15	23
395827099290901	01S19W08DCD	112TRRC	60.00		2	31	24	38
395926097374801	01S03W02CCB	211DKOT	200.00	P	3	3.0	1.9	4.0

Appendix C.--Data summary and selected well information for sites in eastern Kansas

SITE ID	WELL NUMBER	AQUIFER	DEPTH	USE	N	MEAN	MIN	MAX
370115095265101	35S18E04CCC	325BNDR	190.00	H,S	2	.1	.0	.1
371030095420901	33S16E18BDD	323KSSC	106.00	H	3	6.8	2.2	11
371049095124901	33S20E09DDD	324EGLV	92.00	H	2	.05	.0	.1
371137095254501	33S18E10BBB	321HPLR	47.00	H,S	2	6.5	6.1	7.0
371920095571401	31S13E26ACC	322DGLS	16.00	H	2	7.2	6.3	8.1
372442095045601	30S21E26BAB	112ALVM	30.00	H	2	1.0	.9	1.1
373145095372601	29S16E14ABB	323LINN	50.00		1	.1		
373932095301101	27S17E36BBC	321CHNT	180.00	H,S	2	.7	.7	.7
373611095175801	28S19E14CDC	112WSCS	18.00	H	2	15	15	16
374032095495801	27S14E25BBB		60.00	H	1	0.0		
374056095370201	27S16E23DAA	323LNSG	10.00	H	2	2.8	.9	4.7
374537094485201	26S24E29BBB	325LBTT	36.00	H,S	3	7.5	6.2	8.9
374538095365401	26S16E25BBC	322DGLS	20.00	H,S	1	1.2		
374654095234701	26S18E13CBC	323IOLA	120.00	S	2	20	8.7	31
375208095525901	25S14E16CCB	322DGLS	30.00	H,S	2	2.1	.5	3.8
375523095381501	24S16E34ABB	112ALVM	19.00	H,S	1	160		
375608095310801	24S17E26BBD		50.00	H	1	4.5		
375910094530601	24S23E04DB	323PLSN	18.00	H,S	2	22	2.2	41
380127095003501	23S22E29AAA	323GLBG	18.00	H,S	3	10	2.6	19
380335094414701	23S25E07DAA	325PWNE	40.00	H,S	2	6.6	6.2	7.1
380651095541601	22S14E30AAA	322SHWN	20.00	H	2	8.1	.3	16
380739094442401	22S24E14DCC	325FRSC	228.00	H	2	5.0	2.6	8.0
380830095144301	22S20E18AAA	323VILS	23.00	S	3	127	110	140
381305095460801	21S15E16CDD	112WSCS	31.00	H,S	3	5.0	3.1	6.0
381455095265902	21S18E05DCA	112ALVM	175.00	H	3	5.0	3.1	6.0
381534095000701	20S22E32CDD	321CRVL	18.00	H	1	4.9		
381534095000702	20S22E32CDD		40.00	H	1	110.0		
382025095125101	20S20E05ADD	112ALVM	82.00	H,S	3	10	9.4	11
382235095035201	19S21E23CCC	321CHNT	23.00	H	1	.8		
382417095415201	19S15E13AAB	322SHWN	25.00	H	2	40	26	54
382601094455701	18S24E33CCC	323KSSC	40.00	H	1	16		
383008095261001	18S18E08ADA	321TNGX	280.00	S	3	2.1	1.0	3.2
383120095382901	17S16E33DDD	321IRLD	120.00	H	2	.2	.1	.4
383302095060601	17S21E21CCC		50.00	P	2	4.2	2.1	6.2

Appendix C.--Data summary and selected well information for sites in eastern Kansas--Continued

SITE ID	WELL NUMBER	AQUIFER	DEPTH	USE	N	MEAN	MIN	MAX
383304095260201	17S18E21CCC	322DGLS	50.00		1	.6		
383735094490001	16S23E25DBC	323WNDT	86.00	H,S	2	2.3	.5	4.1
384231095024201	15S21E35ABB	323STNN	23.00	H	1	14		
384232095240001	15S18E34BAA	321TNGX	246.00	H,S	3	.1	.0	.1
384305095463901	15S15E29BCC	322SVRY	35.00	H,S	1	11		
384332095514601	15S14E21CDD	112TRRC	21.00	H,S	2	48	44	53
384653095471301	15S15E06ABB	321WCLD	200.00	H,S	2	10	4.9	15
384658095200301	14S19E32CCC	322DGLS	245.00	S	3	.3	.1	.5
385020095135401	14S20E18ABB	322DGLS	23.00	H	3	2.8	1.7	4.1
385058095011201	14S21E12ADA	112KNSN	50.00	H,S	2	7.3	6.5	8.1
385302095030701	13S21E26CCD	112KNSN	43.00	H,S	2	2.7	2.5	3.0
385429097170301	13S01E23ACD	112ALVM	40.00	P	1	1.0		
385441095382102	13S16E21ABB	322SHWN	15.00	H	1	1.0		
385650095055901	13S21E05DBB	112ALVM	64.00	P	2	1.5	.1	3.0
385834095074901	12S21E30CBB	321TNGX	60.00	H,S	2	.1	.1	.1
385835095353401	12S16E25CBB	322SVRY	25.00	H,S	2	59	59	59
385953095133101	12S20E19AAA	112ALVM	60.00	P	2	1.1	1.0	1.3
390433095424002	11S15E23DBD	112ALVM	54.00	U	2	.6	.5	.7
390516094530401	11S23E17CCA	323KSSC	165.00	H,S	2	1.1	1.1	1.2
390525095352701	11S16E13CBD	112NWMN	78.00	I	2	6.8	6.8	6.8
390623095041301	11S21E10CBA	321TNGX	98.00	P	2	.1	.1	.1
390858094480501	10S23E25CBB	112PLSC	20.00		1	1.9		
390918094534801	10S23E30BBC	112PLSC	55.00	H,S	1	6.2		
391025095460801	10S15E17CDD	112KGFV	50.00	H,S	3	30.0	26.0	35.0
391302095172901	09S19E34CCC	322SHWN	40.00	H	2	32	28	37
391507095394001	09S16E20CAA	321ELMN	37.00	H,S	3	15	10	18
391600095342401	09S17E18CBB	322WBNS	11.00	H	2	3.5	2.6	4.5
392047095065601	08S21E19BAA	322DGLS	60.00	P	2	.1	.0	.3
392232095310001	08S17E09AAA	112TRRC	50.00	H	2	19	18	21
392601095212401	07S18E24BAA	112KGFV	72.00	H	3	60	52	72
392748095573501	07S13E10BBB	319FRCK	75.00	H,S	2	16	15	17
392906095331301	06S17E31DAA	112WSCS	55.00	H	2	31	27	35
393022095130201	06S20E29BBB	112KGFV	110.00	H	2	.2	.1	.4
393056095235201	06S18E22BCD	112NBRK	250.00	P	2	.8	0.0	1.6
393552095382201	05S16E20DDA	112KGFV	45.00	H,S	2	9.2	8.4	10
393637095131601	05S20E18CDC	112KGFV	30.00	H	2	27	25	29
393722095451401	05S15E17AAA	322WBNS	219.00	H	2	.0	.0	.0
394006096084501	04S11E26DDD		32.00	S	1	7.7		
394057095084001	04S20E23CDD	112KGFV	85.00	H,S	2	4.6	3.8	5.4
394315095515601	04S14E09BCB	112KGFV	215.00	H,S	2	.1	.1	.1

Appendix C.--Data summary and selected well information for sites in eastern Kansas--Continued

SITE ID	WELL NUMBER	AQUIFER	DEPTH	USE	N	MEAN	MIN	MAX
394604095334501	03S17E30BBB	112KGFV	42.00	H,S	2	8.0	7.7	8.3
394720095192801	03S19E18DAA	112DRFT	60.00	P	2	5.9	5.8	6.0
394912095065101	03S21E06BCC	112KGFV	97.00	H,S	2	5.9	3.4	8.5
395209095510202	02S14E21AAB	319CCGV	102.00	H	2	.1	.1	.1
395227095221001	02S18E14CAD	112KGFV	65.00	H,S	2	24	11	38
395246095202001	02S19E18BCB	112KGFV	160.00	H,S	2	3.6	2.6	4.6
395302096051001	02S12E16BBB	112KGFV	30.00	H,S	2	3.0	1.0	5.0
395833095334401	01S17E07CBC	112ALVM	40.00	P	1	9.3		

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