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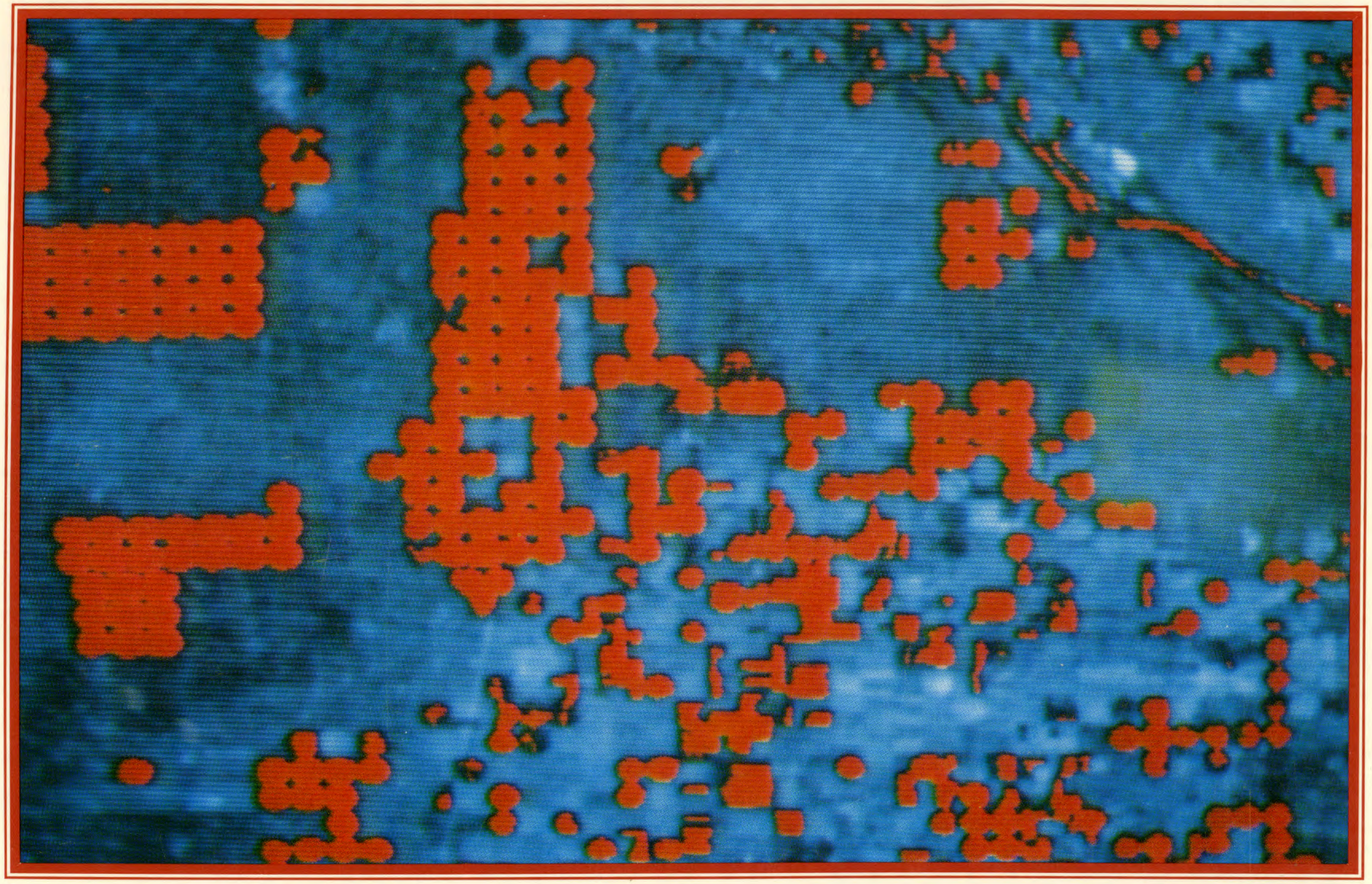

CHEMICAL QUALITY OF IRRIGATION WATERS IN HAMILTON, KEARNY, FINNEY, AND NORTHERN GRAY COUNTIES

CHEMICAL QUALITY SERIES 4

COVER PHOTO: Video color-enhanced imagery of Finney Co. southwest of Garden City based on LandSat band 5 (black and white) imagery. The Arkansas River and irrigated summer crops show as red, illustrating the large number of center-pivot irrigation systems in use. Photograph by Curtis D. Conley, Kansas Geological Survey.

CHEMICAL QUALITY OF IRRIGATION WATERS IN HAMILTON, KEARNY, FINNEY AND NORTHERN GRAY COUNTIES

CHEMICAL QUALITY SERIES 4

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EXECUTIVE SUMMARY

The utilization of irrigation waters in Kansas has increased dramatically since the drought period of the 1950's. With this development has come the need for information which can be used in the determination of compatability of groundwaters with soils and crops and in the management of the groundwater systems tapped for agricultural purposes. An important component of this information is the chemical character of the waters under consideration.

The chemical quality data contained in this report show that groundwater presently in use from the Arkansas River valley in Kearny, Hamilton, and Finney counties and a band north of the river in Finney County is of sufficiently poor quality that it could produce adverse effects upon soils and crop yields with uncontrolled long-term usage. In most cases, poorer quality groundwater is associated with the presence of saline soils and shallow water tables.

Further efforts in this study are being directed toward correlating the chemistry of the groundwaters with natural variables such as soil association, bedrock types, depth to water, and surface and bedrock topography, and using these correlations to produce areal presentations of the chemical quality data. With these correlations and more complete coverage of western Kansas, positive policy recommendations concerning the conservation and proper use of the groundwater supplies of the state will be possible. This series of studies was begun on a limited scale in 1974 with that goal in mind. Greeley, Wichita, Scott, Lane, and southern Wallace counties were covered in that year; the results were reported in Kansas Geological Survey Chemical Quality Series 2. This report covers work done in 1975. In 1976, the rest of the southwest portion of the state was sampled; a report on that area is in preparation. This summer the Great Bend Prairie area will be sampled.

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TABLES

CHEMICAL QUALITY OF IRRIGATION WATERS IN HAMILTON, KEARNY, FINNEY, AND NORTHERN GRAY COUNTIES

ABSTRACT

One-hundred-ninety-nine pumping irrigation wells were sampled in Hamilton, Kearny, Finney, and northern Gray counties and adjoining portions of Wichita, Scott, Grant, Stanton, and Haskell counties during late July 1975. Saline water of a SO_4 type is found in the western three-fourths of the Arkansas River valley and a zone north of the river in Finney County. A better quality water of a Ca - HCO_3 type exists in the sandy regions south of the river. Localized variations exist in the Scott -Finney Depression area.

Compiled chemical quality data and chemical quality maps are presented for the study area.

INTRODUCTION

A program to establish chemical quality base-line data for irrigation waters of the Central High Plains region of western Kansas was initiated in the west-central Kansas area in 1974 (Hathaway et al., 1975). The present 3 1/2 county study area lies immediately south of the west-central region, and represents the upper portion of the southwestern Kansas region of groundwater studies (Figure 1).

Irrigation waters in the present study are derived mainly from the Ogallala Formation of Pliocene age or undifferentiated Quaternary-Tertiary sequences. Alluvium associated with the Arkansas River valley, which trends in a southeastward direction through the study area, also serves as an aquifer for wells located in that valley.

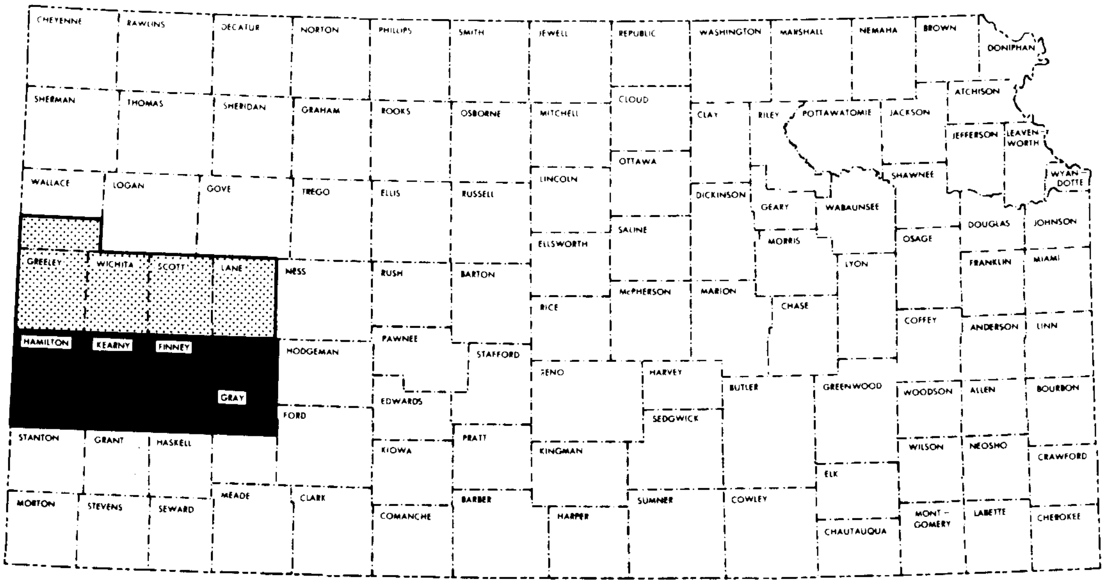


Figure 1. Index map of Kansas showing area covered by this report (shaded area). The region covered by the 1974 west-central Kansas chemical quality study is shown also (solid area).

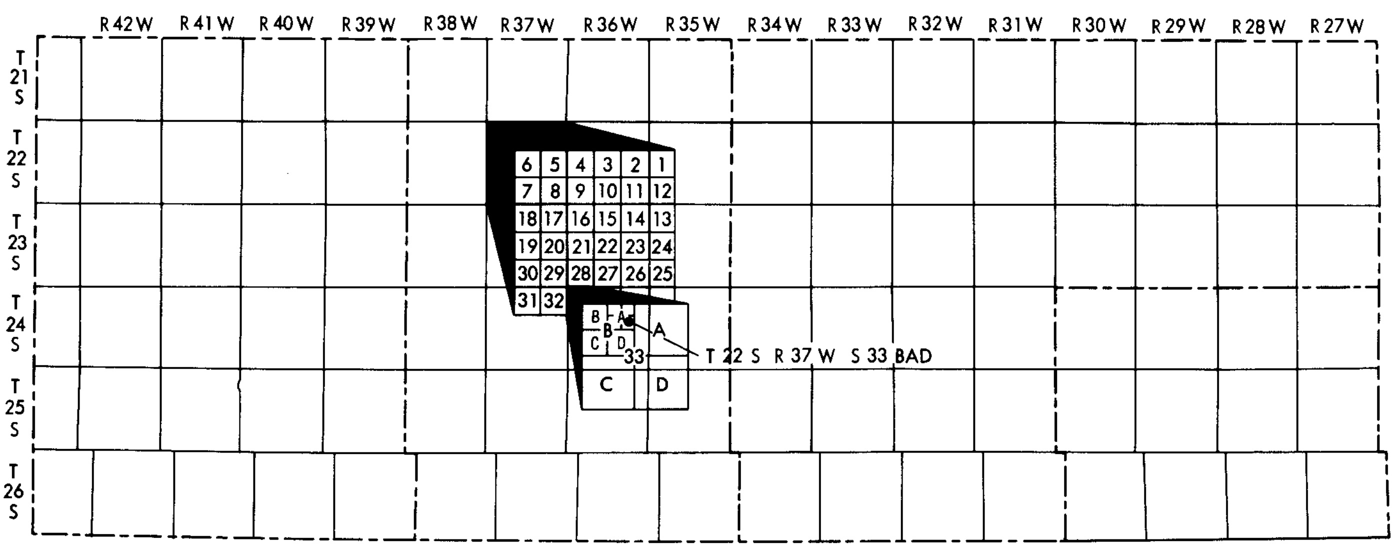


Figure 2. Well location system used in this report.

Well locations given in this report are based upon the Bureau of Land Management numbering system. The location is composed of the township, the range, and the section number followed by letters denoting the subdivision of the section on which the well is located (Figure 2).

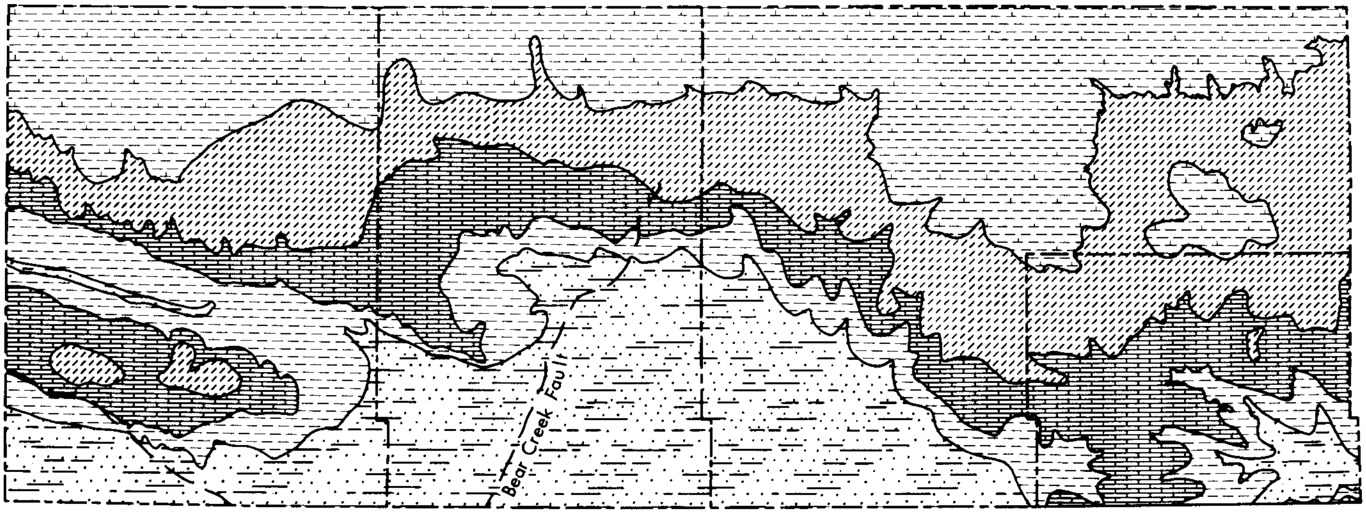
TOPOGRAPHY

The general topography of southwestern Kansas has been described by H.T.U. Smith (1941). The area covered by this report is characterized by a plains type topography. A general west to east slope of the land surface is noted for the study area. The Arkansas River is the major stream in this region and has a course which trends in a southeastward direction through the area covered by this report.

North of the Arkansas River at Garden City the plains are divided by the Scott-Finney depression which is a broad shallow depression extending northward to the Scott Basin. Little surface drainage occurs from this depression into the Arkansas River, and numerous smaller depressions are found upon the floor of this feature. The Pawnee River, located in the northeastern portion of the study area, joins the Arkansas River at some distance to the east of the region under investigation.

BEDROCK

The consolidated rocks of Cretaceous age underlying the unconsolidated deposits of Tertiary and Quaternary age serve as bedrock in the study area. Figure 3 shows that a general increase in age of the bedrock formations occurs in passing from north to south through much of the study area, i.e., Niobrara Formation to Carlile Shale to Greenhorn Limestone to Graneros Shale to undifferentiated lower Cretaceous--which



EXPLANATION

Undifferiented Lower Cretaceous

Graneros Shale

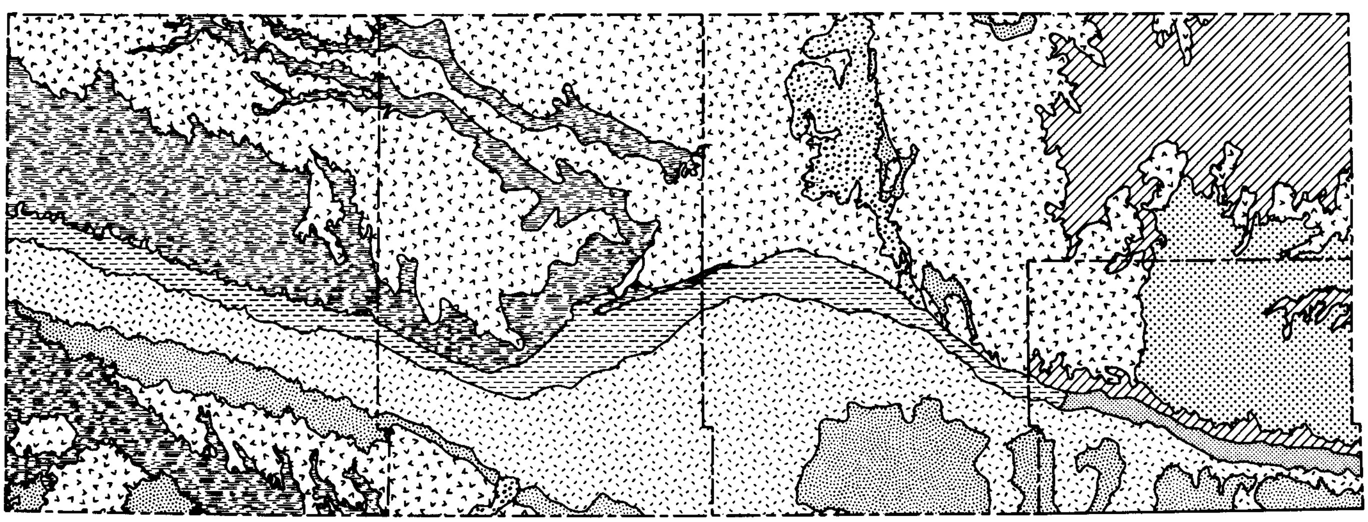
Carlile Shale

Greenhorn Limestone

Niobrara Formation

Bear Creek Fault

Figure 3. Bedrock geology of the study area.



EXPLANATION

Ulysses-Colby-Bridgeport-Goshen

Richfield-Ulysses

Mansic-Ulysses-Richfield

Las-Bridgeport-Las Animas

Spearville-Harney

Tivoli-Vona-Pratt

Ulysses, saline-Church-Drummond

Las Animas-Lesho-Bridgeport

Manter-Ulysses-Satanta

Figure 4. Soil association map of the study area. Saline conditions are generally associated with the Ulysses (saline)-Church-Drummond and Las-Bridgeport-Las Animas groups in the study area.

includes the Cheyenne Sandstone, the Kiowa Shale, and the Dakota Formation (H.E. McGovern and W.A. Long, 1974; E.D. Gutentag et al., 1972; D.H. Lobmeyer and C.G. Sauer, 1974; E.D. Gutentag, D.H. Lobmeyer and H.E. McGovern, 1972). This general trend is partially altered in southwest Hamilton County, presumably as a result of deep erosion by the ancestral Arkansas River and movement along the Bear Creek fault (D.H. Lobmeyer and C.G. Sauer, 1974).

SOILS

Figure 4 represents a general soil map for the study area which has been produced through a combination of the individual county general soil maps (Harner et al., 1965; Tomasu and Roth, 1968; McBee et al., 1961; Sallee et al., 1963). The continuity needed for the regional general soil map necessitated a certain amount of grouping of the various soil associations presented on the county general soil maps, or in some cases a regrouping of mapping units was needed to reflect the proportional pattern of soils in natural landscapes on a multi-county basis. The soil associations used on this regional map are listed in Table 1 along with a general description and the typical locations of these soil associations.

SAMPLING AND ANALYSIS

Groundwater samples were collected from 199 pumping wells over a four-day period during the high production portion of the season, July 28-31, 1975. Sampling procedures and field determinations were the same as those described for the west-central Kansas study. Historical chemical quality data was found to exist for about 14% of the wells sampled in

Table 1. Soil Associations for Hamilton, Kearny, Finney, and Northern Gray Counties.

Soil Association	Description
Tivoli-Vona-Pratt	These sandy soils are found on undulating and hilly landscapes. The dominant area of occurrence for these soils is south of the Arkansas River valley. They are also found locally in patches on the eastern edge of the Scott-Finney depression. Little or no runoff occurs from these areas to stream systems.
Manter-Ulysses-Satanta	Loamy soils occuring on nearly level and gently undulating landscapes. The dominant region is a transitional band between the sandhills and the silty loess areas south of the Arkansas River valley. Small areas also exist along the eastern edge of the Scott-Finney depression. Little or no runoff occurs from these areas to stream systems.
Ulysses-Colby-Bridgeport-Goshen	Most of this association consists of silty and loamy soils on nearly level to strongly sloping landscapes. These soils occur mainly in the western half of the study area along upland drainageways and on the north wall of the Arkansas River valley.
Las-Bridgeport-Las Animas	These loamy, sandy, and silty soils are on nearly level to gently undulating landscapes. These soils occupy the Arkansas River valley to about the Gray county line in the study area. Soils in the lower valley positions are slightly to moderately saline.
Richfield-Ulysses	These silty soils are on broad, nearly level landscapes. This is the dominant soil association of the uplands. Little or no runoff occurs from these areas to stream systems.
Spearville-Harney	These clayey and silty soils are located on broad, nearly level landscapes in the eastern one-fourth of the study area.

Mansic-Ulysses-Richfield	Loamy and silty soils occurring on nearly level to strongly sloping landscapes. Found in the eastern one-fourth of the study area along upland drainage ways and the north wall of the Arkansas River valley.
Ulysses (saline) -Church-Drummond	Silty and clayey soils found on nearly level landscapes. They are slightly to highly saline, and are found in the Scott-Finney depression.
Las Animas-Lesho-Bridgeport	These loamy, sandy, and silty soils are on nearly level to gently undulating landscapes. These soils occur in the Arkansas River valley through most of Gray County. The soils in the lower valley positions tend to be slightly to moderately saline.

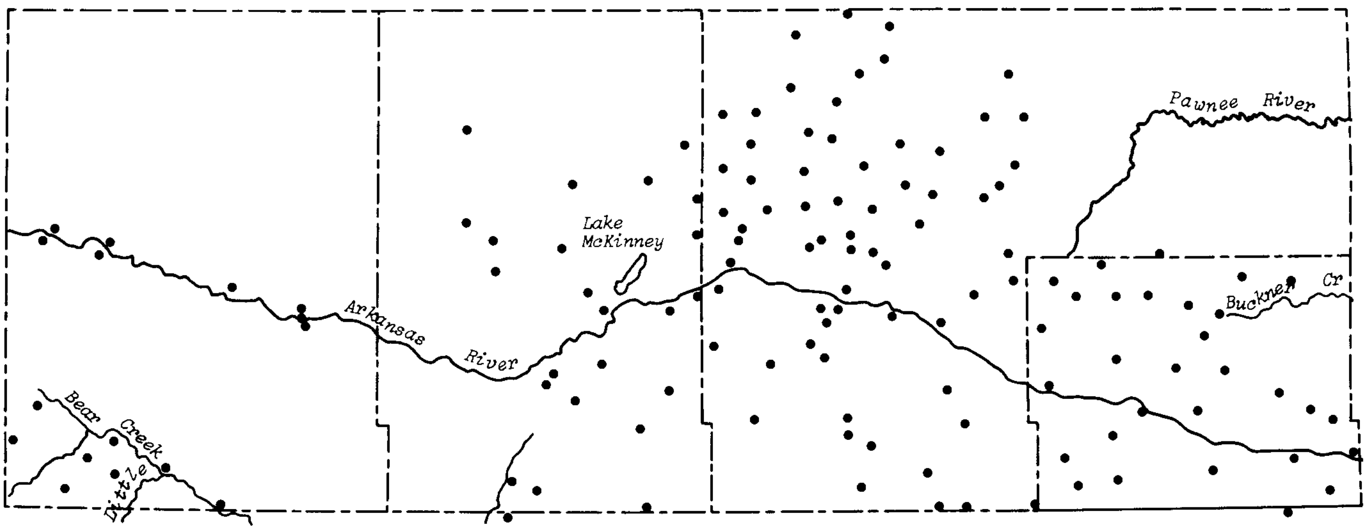


Figure 5. Distribution of irrigation wells sampled during study. Principal drainage systems in the area are also indicated.

this study. Duplicate sets of samples were collected at 15 sites distributed across the study area. These wells were located along the boundaries of individual field personnel sampling areas and thus each duplicate set represents different samplings of the same well by two people. The time interval between collection of the pair of samples at these duplicate sites ranged from the same day to two days.

Figure 5 indicates the locations of the wells sampled in this study. Wells were sampled in township 27 of Stanton, Grant, and Haskell counties and townships 19-21 of Wichita and Scott counties to provide greater control at the boundaries of the main 3 1/2 county study area during mapping of the chemical quality data. Analytical data for these control wells are listed in the compilation of chemical quality data of Appendix A, but are not included in the mapped areas of the chemical quality maps. The distribution of wells sampled for this study follows closely the regions shown as having pumping potentials of 100-500 gal./min. or greater on Map M-4A--General Availability of Ground Water and Normal Annual Precipitation in Kansas (C.K. Bayne et al., 1975).

Analytical procedures for all species except the trace elements iron (Fe) and manganese (Mn) were the same as described in the west-central Kansas report. The specific conductance and pH were measured at the time of collection. A field laboratory was established at Garden City and bicarbonate (HCO_3), chloride (Cl), and fluoride (F) analyses were performed there. All other chemical determinations were made at the Kansas Geological Survey laboratories in Lawrence. Iron, manganese, nickel (Ni), and copper (Cu) were determined by atomic absorption spectroscopy using flameless atomization via a graphite furnace. Preconcentration of these elements and removal from interfering salts was achieved through the use of ammonium pyrrolidine dithiocarbamate as a complexing agent and methylisobutyl ketone as an extraction solvent. The major advantages of this procedure over that used in the west-central Kansas study are lower detection limits, reduced influence of dissolved solids, and smaller volumes of samples necessary for analysis.

A variation of about 9% in the reported specific conductance values was obtained for the sets of duplicate samples. Variations in the analytical data for the major chemical species from these same sets average about 4%. The greater fluctuation noted in the specific conductance values probably results from variations in field equipment used and operator technique. Standard deviations for replicate determinations of a given sample are comparable to those listed in the west-central Kansas study.

Compiled chemical quality data for groundwater samples taken during this study are listed in the Appendix by county and location.

CORRELATION AND MAPPING OF CHEMICAL QUALITY DATA

Significant correlations are found to exist between the major chemical species of the groundwaters and areal parameters such as soil association, depth to water, bedrock and surface topographies, and bedrock type. The study area is divided roughly into three parts based upon these correlations: 1) area north of the Arkansas River, 2) Arkansas River valley, and 3) area south of the Arkansas River. These distinctions, however, become less clear in the eastern portion of the study area.

Due to the complexity of the study area and concentration distributions of the various chemical species, the simple computerized plotting routine used in the west-central Kansas chemical quality study was found to be inadequate for mapping the present study area. Chemical quality maps presented in this report were plotted manually using the soil associations as the principal guide. Mapping was cut off along the <100 gal/min boundary of the water quantity map M-4A. Work is currently underway to develop methods for using the correlation relationships between areal parameters and observed concentrations of the various chemical species to produce computer plotted areal chemical quality maps.

RESULTS AND DISCUSSION

Figures 6 and 7 are areal representations of the specific conductance and total dissolved solids data, respectively, for irrigation waters from the study region. Both figures indicate the greatest dissolved salts load is associated generally with groundwaters from the Arkansas River valley in Hamilton, Kearny, and Finney counties, with the amount of dissolved solids decreasing from west to east. The soil association in this area is the Las-Bridgeport-Las Animas group which is saline. Waters of higher specific conductance and total dissolved solids are found to extend out of the river valley in a band north and west of Garden City in Finney County to about the Kearny-Finney county line. In Gray County, groundwaters from the river valley, which are associated with the Las Animas-Lesho-Bridgeport soil group, appear to be more similar in character to waters from the sandy regions south of the Arkansas River than to groundwaters from the western two-thirds of the river valley system in the study area.

Areal concentration distributions for Na and SO_4 are presented in Figures 8 and 9, respectively. The chemical quality data for the study area are also presented in a modified Piper diagram (Piper, 1944) in Figure 10. Factors for conversion from parts per million (ppm) to milliequivalents per liter are listed in Table 2. Water type classifications used in this report are based upon percent milliequivalent contributions of the various chemical species to the total number of milliequivalents per liter of cations or anions.

Figures 8 and 9 indicate high levels of Na and SO_4 are found in waters from the Arkansas River valley in Hamilton, Kearny, and Finney counties, immediately north of the river valley in Finney County in a

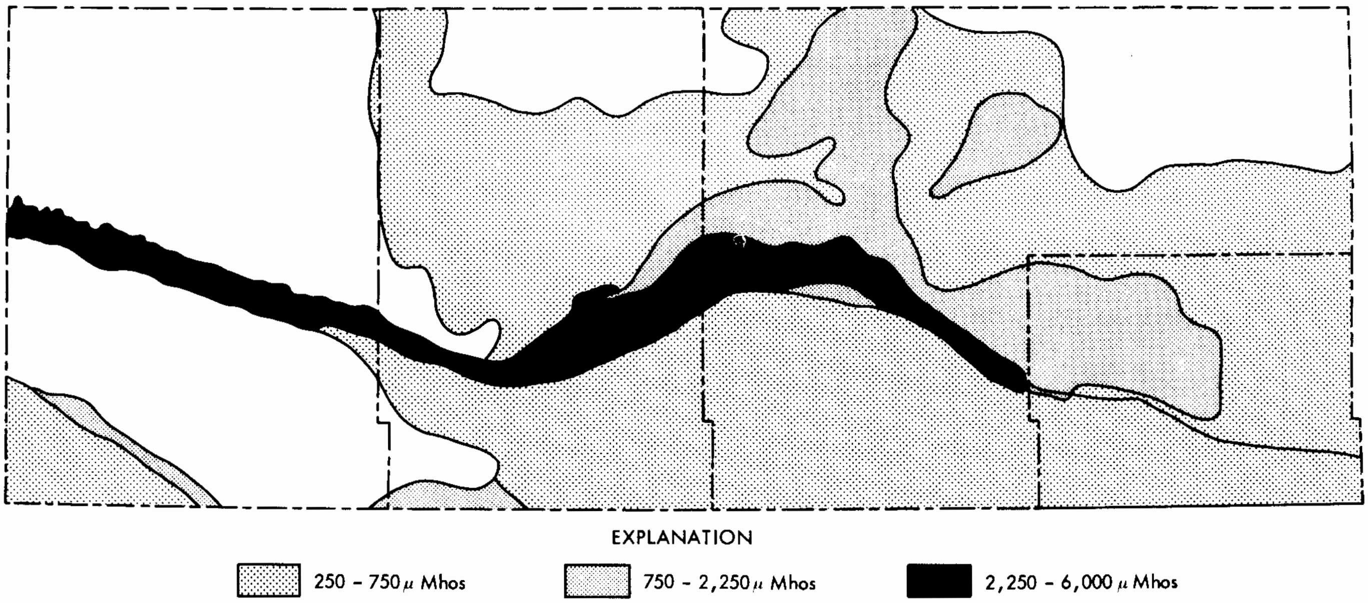


Figure 6. Map of specific conductance for the study area. Levels correspond to medium, high, and very high salinity hazard ranges.

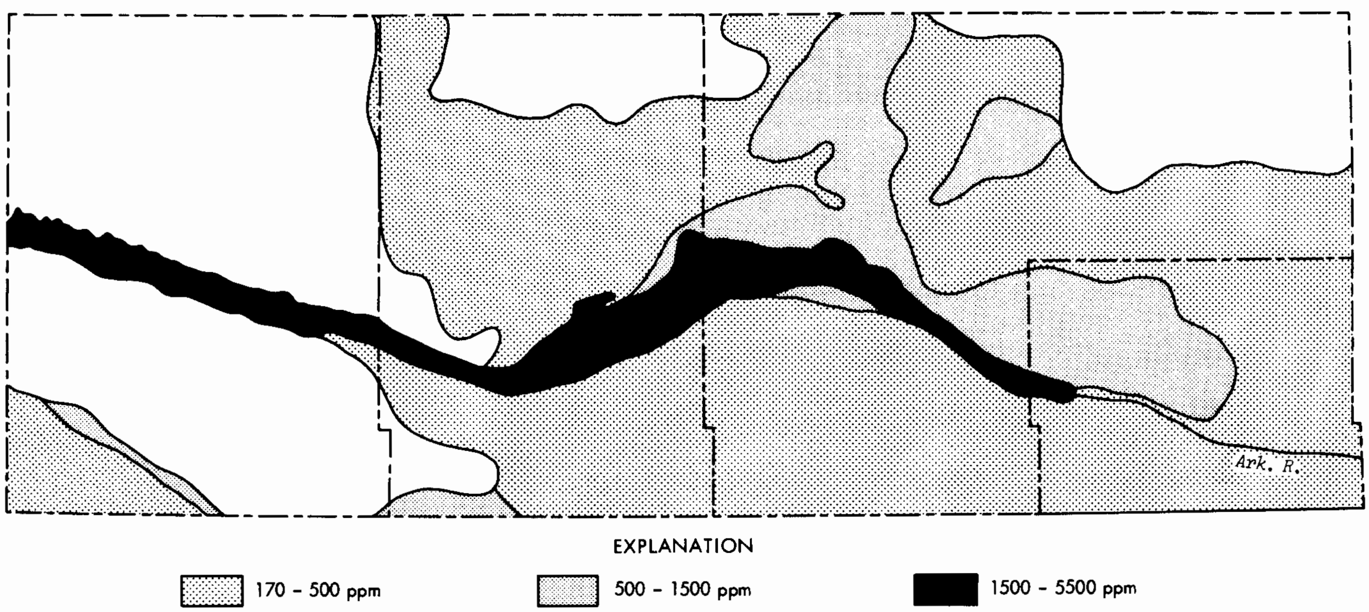


Figure 7. Map of total dissolved solids for the study area.

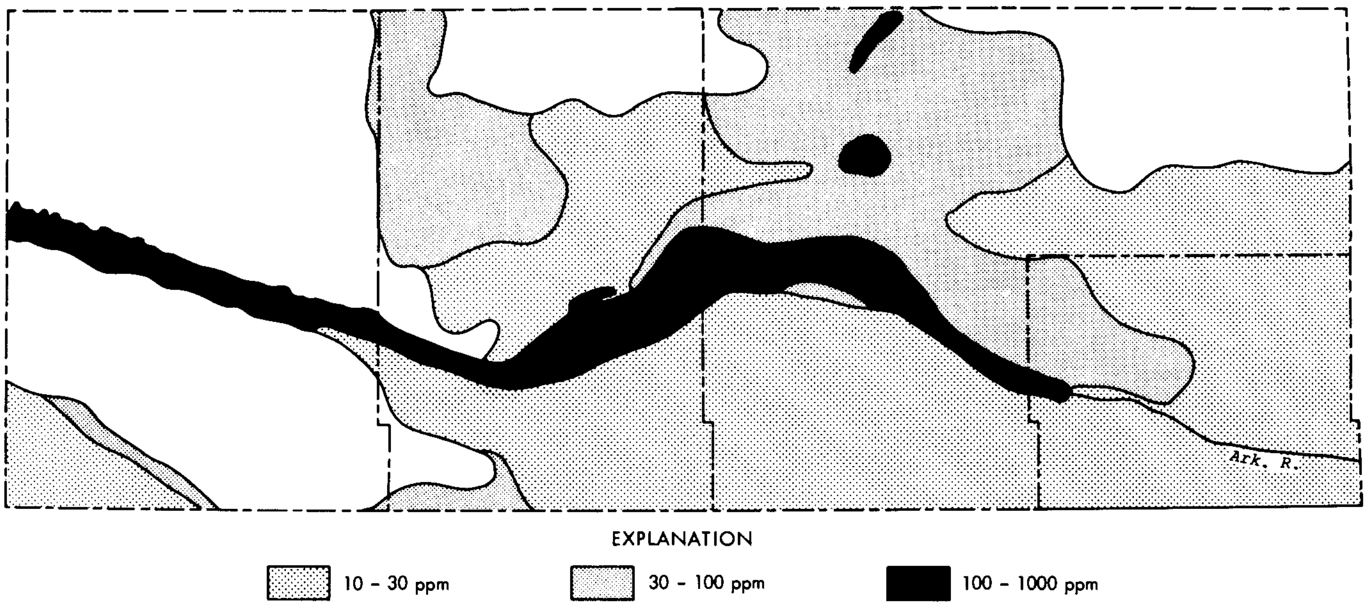


Figure 8. Map of concentration level of sodium for the study area.

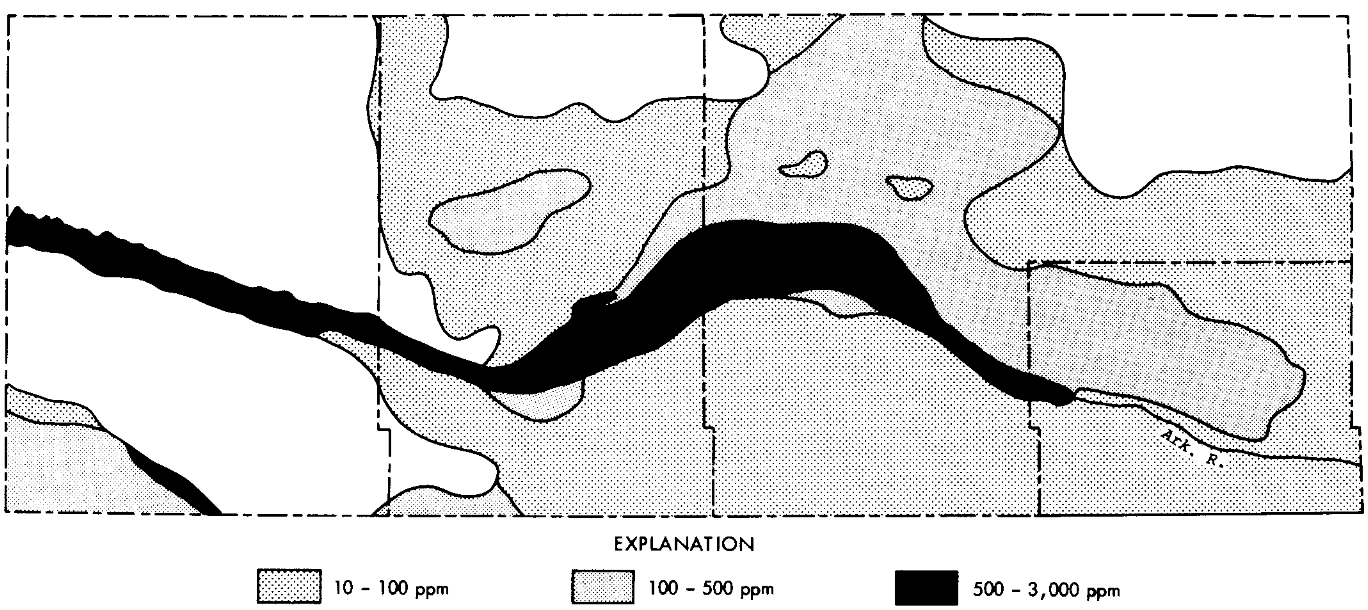


Figure 9. Map of concentration levels of sulphate for the study area.

Table 2

Factors for Conversion of Parts Per Million to Milliequivalents Per Liter

Species	Multiply by
Calcium	0.04990
Magnesium	0.08226
Sodium	0.04350
Potassium	0.02557
Strontium	0.02283
Bicarbonate	0.01639
Sulfate	0.02082
Chloride	0.02821
Fluoride	0.05264
Nitrate	0.01613

band extending north and west from Garden City, and locally for Na in the Scott-Finney depression. Waters from this portion of the river valley are clustered in the upper left portion of Figure 10. These are SO_4 type waters in which no single cationic species makes a contribution to the total number of cation milliequivalents which is equal to or greater than 50%. The cation ranking varies from Na > Ca > Mg in Hamiltion County to a Ca > Na > Mg ranking in eastern Finney County. The more saline SO_4 waters from the band north of the river in Finney County generally exhibit a ranking of Ca > Mg > Na. The boundary for the SO_4 type waters in this region north of the river valley extends slightly beyond that of the high SO_4 level of Figure 9. In western Gray County the SO_4 type waters are found to extend into a narrow zone north of the river. These waters are of lower salinity than those in the band north of the river in Finney County, but possess the same ranking of cations (Ca > Mg > Na).

The greater Na, SO_4, and total dissolved solids contents of groundwaters in the band north of the river valley near Garden City may be related to buried saline soil horizons in the lower portions of the Scott-Finney depression and/or irrigation practices using water from the Arkansas River which have produced a saline soil in this area (Harner et al., 1965; Meyer, Gutentag, and Lobmeyer, 1970). The latter authors have noted that higher concentrations of total dissolved solids in Finney County are associated with regions having high water tables or depressions where water collects and salts are enriched through evaporation. Irrigation in areas of saline soils and higher water tables can be expected to lead to deterioration of the local groundwater quality as salts are flushed down into the water table.

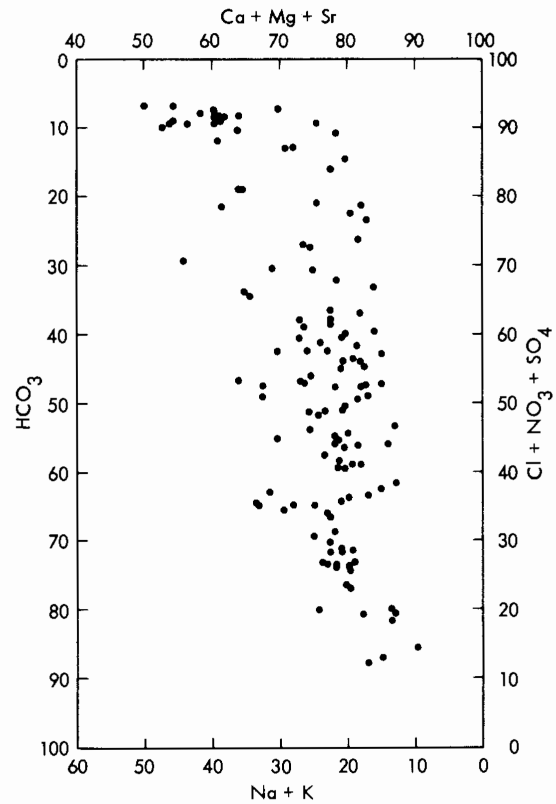


Figure 10. Modified Piper diagram for ground waters in the study area. Values represented are the milliequivalent contributions of chemical species to the total milliequivalents per liter of cations or anions.

Groundwater from wells in the eastern three-fourths of the Arkansas River valley in Gray County is relatively low in its Na and SO_4 content. These waters are Ca-HCO_3 in character, plot in the lower one-third of the central portion of Figure 10, and appear to be more closely related to waters from the sandy areas south of the river than to waters from the western two-thirds of the river valley in the study area. Meyer et al., (1970) have noted that the Arkansas River tends to be a losing stream in Finney County, and McGovern and Long (1974) indicate it becomes a gaining stream in Gray County. Preliminary evaluation of the chemical quality data suggests the change in character of the river valley waters in Gray County is dominated by inflow of groundwater from the sandy regions south of the river.

Groundwater samples from north of the Arkansas River, excluding the band of SO_4 type water near Garden City, tend to be mixed type waters for the most part in which Ca > Mg > Na and $HCO_3 > SO_4$. Locally within the Scott-Finney depression, areas exist where $SO_4 \geq 50\%$ and Na or Mg become the dominate cationic species. Notable exceptions to the above trends are: 1) $HCO_3 \geq 50\%$ for an area northwest of Lakin in Kearny County and for much of the outer perimeter of the mapped area north of the river in Kearny, Finney, and Gray counties, and 2) Ca $\geq$ 50% in waters from an area along the Kearny-Finney county line north of the river.

Values of total dissolved solids and specific conductance for groundwaters from the sandy regions south of the Arkansas River in Kearny, Finney, and Gray counties include the lowest measured in the study area. The waters from this area are a Ca-HCO_3 type and tend to cluster in the lower one-third of Figure 10.

Samples from southwestern Hamilton tend to be Ca-HCO_3-SO_4 type waters, except for samples taken from wells located along Bear Creek. In these wells there is an enrichment in dissolved salts and the waters tend to be of a Ca-SO_4 type. The water classifications for the entire study area are summarized in Figures 11 and 12. Areas shown as having no control within the mapped region are those areas in which samples were not available for extension of the water type boundaries.

The Arkansas River has a strong influence on the distribution patterns of K, Mg, and Cl as well as that already noted for Na and SO_4. The highest K concentrations (10-20 ppm) are observed in the river valley westward from Finney-Gray county border and the band of SO_4 type waters north of the river in Finney County. The lowest K concentrations (1.9-2.8 ppm) occur in portions of the sandy regions of Kearny and Finney counties south of the river. The distribution of high (90-236 ppm) concentrations of Mg is similar to that of K. Moderately high concentrations of Mg occur locally in the Scott-Finney depression. The sandy regions of Kearny, Finney, and Gray counties south of the river exhibit the lowest Mg concentrations (5.9-12 ppm). The highest Cl concentrations (106-331 ppm) occur in Hamilton and Kearny counties in the river valley and in Finney in the band of SO_4 type waters north of the river, the river valley eastward from Garden City to the Finney-Gray County border, and locally within the Scott-Finney depression. Very low Cl concentrations (<2 ppm) occur in portions of the sandy areas of Kearny and Finney counties south of the river.

Levels of F greater than 1.5 ppm are generally associated with waters from north of the Arkansas River in Finney and Gray counties, and are mainly concentrated above a line running from the northwest corner

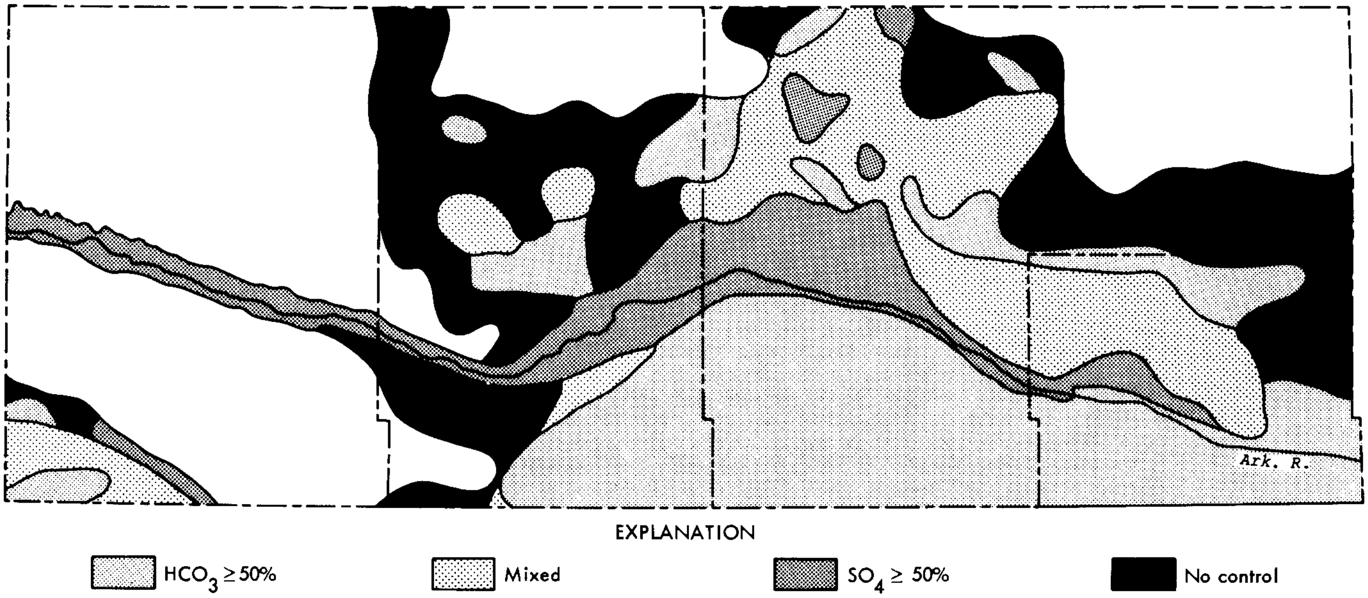


Figure 11. Groundwater classification by anion type.

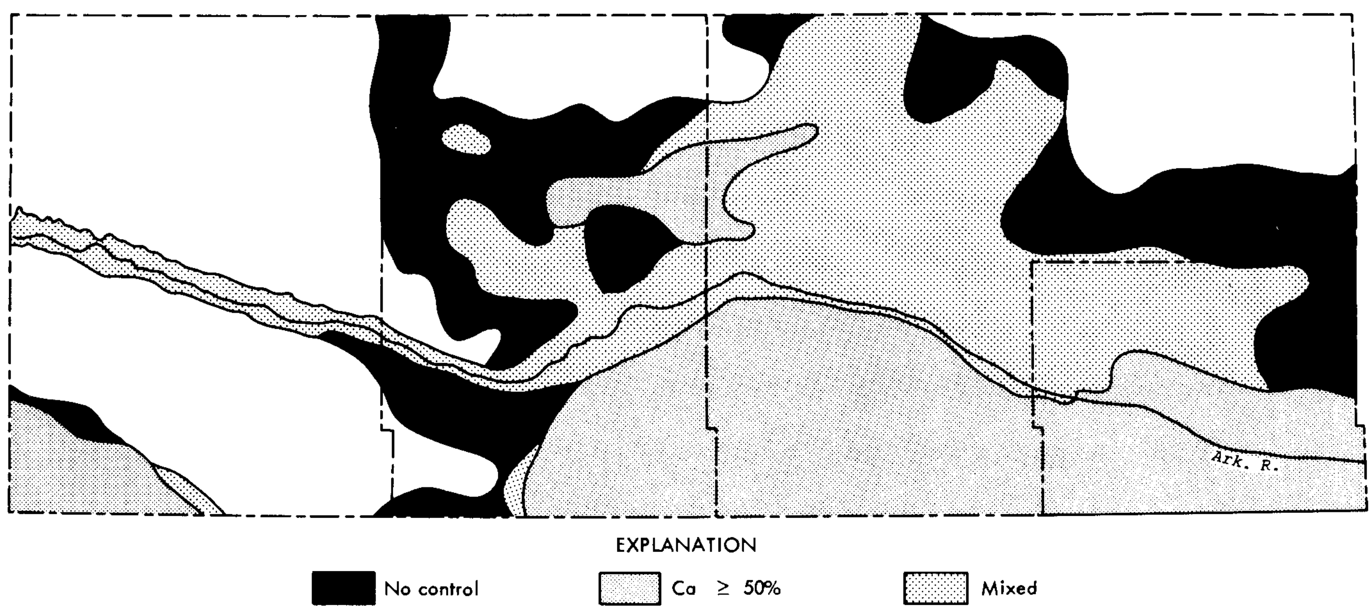


Figure 12. Groundwater classification by cation type.

of Finney County to the river at the Finney-Gray County border. In Gray County, high fluoride levels coincide fairly well with the occurrence of HCO_3 type waters. General trends for NO_3 are much less apparent than those noted for other species.

The foregoing discussion has treated chemical quality aspects of the study area as if the area was only two dimensional, i.e., no variation in quality with depth in the aquifer. This is necessitated in most cases by a lack of information regarding screened intervals in the wells used in this study. Meyer, Gutentag, and Lobmeyer (1970) have found concentration variations in the total dissolved solids for waters from Tertiary and Quaternary deposits along a north-south traverse in Finney County (through the Garden City area). Variations in chemical quality of groundwaters generally can be expected to be smeared out downdip of the water table, however intensive pumping of wells neighboring and somewhat updip of zones of poorer water quality might be able to cause a local deterioration of groundwater quality under favorable hydrologic conditions which lead to a local reversal of the water table gradient.

Figure 13 is an areal presentation of the sodium-adsorption-ratio (SAR) for the study area. SAR values are computed using the equation

$$SAR = \frac{(Na)}{\sqrt{\frac{(Ca) + (Mg)}{2}}}$$

where values in parentheses are milliequivalents per liter of the specified ions. SAR and specific conductance values can be used to evaluate alkali and salinity hazards, respectively, in regard to suitability of a water for irrigation purposes (U.S. Salinity Laboratory

Staff, 1954). Levels for specific conductance in Figure 6 correspond to medium, high, and very high salinity hazard classifications.

The general range of SAR values for the SO_4 type waters of the Arkansas River valley in Hamilton, Kearny, and Finney counties and localized sites in the Scott-Finney depression is 3-9. Values in the range of 0.2-1 are typical for most of the study area south of the river and north of the river in Gray County. Figure 14 relates SAR values to specific conductance values for determining the suitability of a water for irrigation.

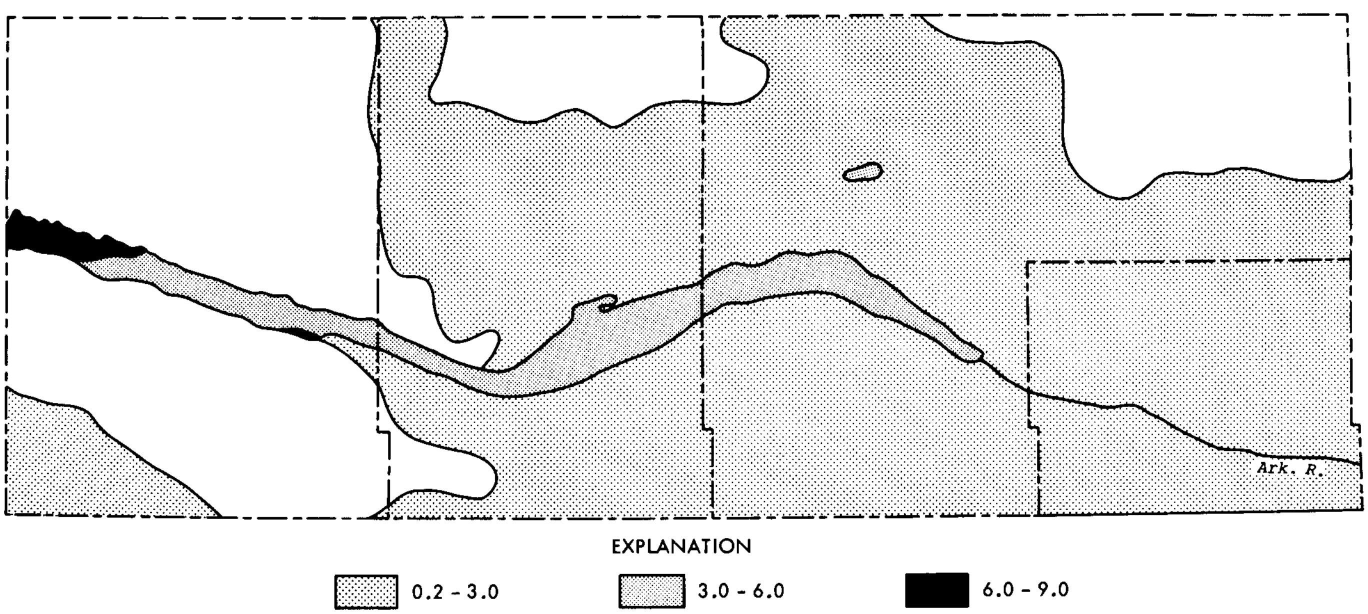


Figure 13. Map of values of the sodium adsorbtion ratio for the study area.

In summary, the chemical quality of groundwaters in the study is complex, with sandy areas south of the Arkansas River exhibiting the best chemical quality (low total dissolved solids, SAR, etc.) and the western three-fourths of the Arkansas River valley and portions of the Scott-Finney depression exhibiting the poorest chemical quality. Poorer water quality tends to correlate with the presence of saline soils and the existance of a high water table and/or small, poor draining shallow depressions. The similarity between water from the Arkansas River valley in Gray County and water from the sandy areas south of the river in that region suggests that groundwater movement from the sandy regions is a dominant factor in the change in chemical quality of waters of the river valley near the Finney-Gray County border.

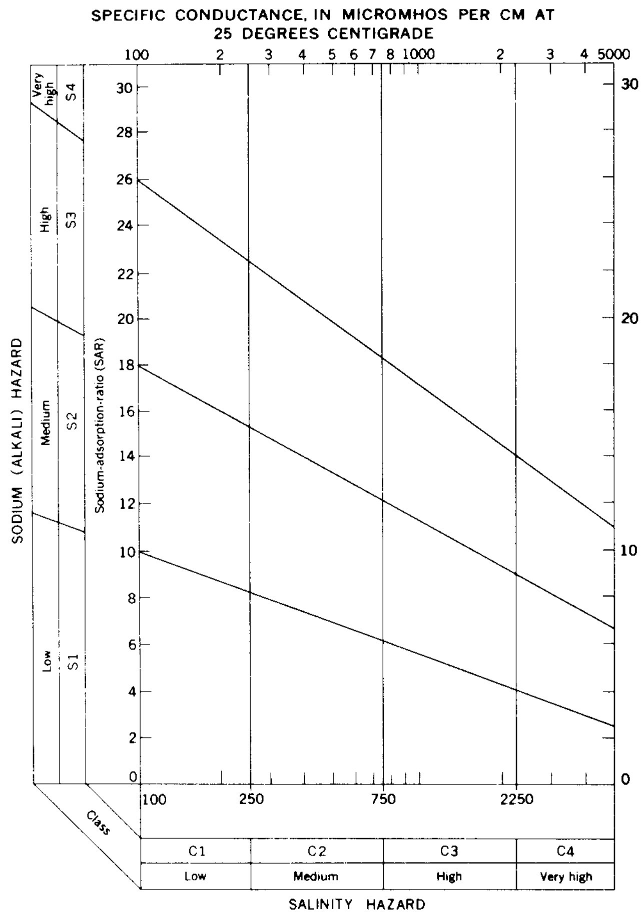


Figure 14. Diagram showing the relationship between specific conductance and the sodium adsorption ratio in evaluation of salinity and alkali hazards for irrigation waters.

ACKNOWLEDGMENTS

The services of personnel from the U.S.G.S office in Garden City, Kansas, in collection of the water samples; and A.M. Diaz of the U.S.G.S. office in Lawrence, Kansas, in operation of the field laboratory are gratefully acknowledged. The authors are also indebted to G.W. James, K.G.S., for help in preparation of maps, and J. Budai, K.G.S., for help in the field laboratory.

A special note of thanks is due Dr. H. Goode, Superintendent of Schools, and Mr. M. Wiederstein, Principal, Alta Brown Elementary School, Garden City, Kansas, for making school facilities available for the field laboratory.

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APPENDIX

Chemical Quality Data

Finney County

Well Location	Geological Unit*	Historical Data**	SiO_2 ppm	Ca ppm	Mg ppm	Na ppm	K ppm	Sr ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	F ppm	NO_3 ppm
21-31W-26CCC	TO		64	36	28	35	6.8	1.3	244	50	25	5.0	5.2
21-32W-8ABD	Qu		66	112	66	110	8.5	2.9	312	444	70	3.2	22
21-32W-20CBD	Qu,TO		70	65	46	74	6.4	2.0	308	187	48	4.2	9.0
21-33W-2ACB	Qu		43	82	40	60	5.1	1.8	244	233	52	2.5	5.8
21-33W-7DDA	Qu		50	38	37	53	7.2	1.3	301	74	30	4.4	5.1
21-33W-25CAA	Qu,TO		53	54	68	100	4.4	2.0	282	307	79	3.7	4.1
21-33W-31CBB3	Qu,TO		36	138	59	82	8.2	2.7	204	400	133	1.5	22
22-31W-9DCC	Qu,TO		55	79	32	52	7.6	1.3	229	210	31	2.3	6.1
22-31W-12CDC2	Qu,TO		62	67	38	39	7.3	1.6	204	152	63	3.3	13
22-31W-35ABB	Qu,TO		55	70	36	61	6.8	1.4	246	186	42	2.7	15
22-32W-21CCD	Qu,TO		36	98	53	67	7.4	2.6	250	272	107	1.5	16
22-32W-25BBB	Qu,TO		43	50	28	50	5.4	1.1	227	132	27	2.6	12
22-33W-3DBC	Qu,TO		33	110	52	77	7.9	2.4	222	362	76	1.8	9.3
22-33W-17DCD	Qu,TO		24	167	48	58	7.7	2.3	195	408	110	1.0	11
22-33W-22BAA	Qu,TO		24	67	24	39	5.2	1.3	203	127	38	1.4	7.8
22-33W-32CBC	Qu,TO		24	53	19	27	4.2	1.1	195	82	19	1.0	4.5
22-33W-36AAA	Qu,TO		26	86	43	170	7.6	2.1	289	466	48	1.5	6.7
22-34W-8BCB	KN		24	53	22	32	5.6	.9	200	74	34	1.3	14
22-34W-10ADD	Qu,TO		25	73	26	34	5.5	1.3	216	110	48	1.1	15
22-34W-22CCC	Qu,TO		20	86	25	35	5.1	1.3	197	134	63	1.2	11
22-34W-32BCB	Qu,TO		20	58	22	25	4.8	1.0	188	92	32	1.0	11
23-29W-34CDD	TO		50	54	22	25	5.4	.8	215	71	20	2.4	13
23-31W-3DCD	Qu,TO		50	59	25	38	5.6	1.1	211	115	40	2.1	18
23-31W-9DBB	Qu,TO		22	58	22	28	4.5	.4	218	92	27	.8	4.6
23-31W-35CCC	Qu,TO		43	52	27	28	5.2	1.2	214	82	26	2.3	15
23-32W-4DDD	Qu,TO		37	48	18	41	4.5	.9	241	72	16	2.0	5.9
23-32W-11ADC	Qu,TO		36	70	28	44	5.1	1.3	207	118	62	2.1	18
23-32W-18BCD	Qu,TO		26	104	47	54	6.4	2.6	232	309	53	1.1	7.5
23-32W-22DAB	Qu,TO		28	53	26	33	4.8	1.2	213	101	30	1.3	12
23-32W-31CA	Qu,TO		23	167	78	120	7.3	3.7	206	661	106	1.3	11
23-33W-10DCC	Qu,TO		24	59	30	40	5.0	1.5	238	124	32	1.3	6.8
23-33W-17BBB	Qu,TO		24	111	46	45	6.1	2.5	197	313	81	1.1	7.2
23-33W-26ABB	Qu,TO		26	161	89	97	8.4	4.6	200	663	113	1.2	9.8
23-33W-28CDC	Qu,TO		25	168	85	220	8.9	4.3	196	959	121	1.1	5.6
23-33W-32ABB	Qu,TO		26	112	60	130	6.9	2.6	200	562	80	1.2	9.7
23-33W-35ACC	Qu,TO		29	327	145	360	13	7.0	305	1804	183	.8	8.9
23-34W-3BCB	Qu,TO		24	67	25	29	4.9	1.3	188	110	50	1.1	7.9
23-34W-14BDC	Qu,TO		26	104	43	65	6.0	2.1	205	346	50	1.0	12
23-34W-17CCC	Qu,TO		22	121	33	37	5.8	1.3	161	241	116	.6	12
23-34W-21DDC	Qu,TO		30	178	58	73	7.4	3.0	162	565	127	.8	11
23-34W-28CDA	Qu,TO		29	300	108	170	12	6.0	186	1230	142	.8	7.9
24-31W-11DBD	Qu,TO		42	70	36	49	6.0	1.6	218	184	50	1.8	14
24-31W-17DDD	Qu,TO		34	64	32	46	5.0	1.4	233	158	26	1.8	9.9
24-32W-5BCB	Qu,TO		24	218	97	169	11	4.6	227	983	152	.9	14
24-32W-25CBB2	QA		22	226	96	270	11	3.6	403	879	185	2.0	23
24-32W-29AC	QA		19	46	6.8	9.2	2.3	.4	166	26	<1	.7	4.7
24-33W-14BBB	QA		19	72	24	65	4.0	.8	192	251	22	.9	4.5
24-33W-21CAB	Qu,TO		19	45	10	19	2.7	.6	181	50	2.4	.8	5.5
24-33W-22DCA	Qu,TO		19	67	12	29	3.2	.6	182	114	9.6	.8	6.9
24-33W-28DAA	Qu,TO		17	49	11	21	2.7	.7	184	56	5.3	.8	5.3
24-34W-5AA	Qu,TO		28	370	172	310	14	8.6	214	1841	179	.8	13
24-34W-17BBC	Qu,TO		20	423	158	500	13	4.8	314	2336	206	1.3	38
25-32W-24DDA	Qu,TO		20	55	8.8	19	3.0	.5	200	48	4.3	.5	9.7
25-33W-5ABD	Qu,TO		17	49	9.8	20	2.6	.6	179	59	4.4	.7	6.0
25-33W-9ABD	Qu,TO		17	47	9.4	22	2.6	.7	172	61	4.2	.8	5.4

*Geological Unit: QA, Alluvium; Qu, Quaternary Undifferentiated; TO, Ogallala Formation; KN, Niobrara Chalk; KJ, Undifferentiated Lower Cretaceous and Upper Jurassic Deposits.

** a - Chemical Quality of Irrigation Waters in West-Central Kansas

b - U.S.G.S. Kansas Ground Water Data Base

All wells sampled tested below 0.1 ppm Ortho Phosphate

Fe ppb	Mn ppb	Cu ppb	Ni ppb	Temperature °C	Total Solids (Residue at 180°C)	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ Non-Carbonate ppm	Specific Conductance (micromhos at 25°C)	SAR	pH
10	.3	2.0	7.6	16.0	388	206	7	600	1.06	7.7
47	1.6	20	3.2	16.0	1091	554	299	1500	2.03	7.6
39	3.8	1.4	3.0	16.0	670	354	101	1000	1.71	7.7
16	3.8	1.8	13	15.5	683	371	171	935	1.35	7.8
24	4.2	3.4	2.2	17.0	451	248	2	700	1.46	7.6
53	1.0	1.6	7.0	16.0	820	417	186	1275	2.13	7.6
8.6	.2	1.6	4.3	15.0	1035	590	423	1480	1.47	7.4
22	.3	1.4	9.8	16.0	603	330	143	870	1.24	7.4
22	.3	1.2	9.0	16.0	586	325	158	820	.94	7.6
19	.5	2.0	11	16.0	618	324	123	900	1.47	7.6
16	.4	1.1	7.5	16.0	845	465	261	1240	1.35	7.3
21	1.2	2.9	8.2	16.0	461	241	55	690	1.40	7.6
16	.5	.7	4.9	17.0	903	491	309	1240	1.51	7.8
16	2.4	1.0	3.7	15.0	1031	617	457	1460	1.02	7.3
15	.4	1.3	6.4	16.0	476	267	101	750	1.04	7.5
15	.4	1.0	7.5	16.0	349	212	52	560	.81	7.5
20	.8	1.0	6.4	17.0	1013	394	157	1440	3.73	7.5
18	1.0	4.7	19	19.0	384	224	60	580	.93	7.6
18	1.5	2.0	7.5	16.0	457	291	114	730	.87	7.5
10	.2	1.5	11	16.0	509	319	157	780	.85	7.6
42	2.9	5.2	8.1	16.0	395	236	82	630	.71	7.7
42	.6	1.1	9.8	16.0	386	226	50	630	.72	7.7
18	.4	2.2	7.5	16.0	442	251	78	660	1.04	7.6
16	4.8	.7	8.9	17.0	399	236	57	620	.79	7.6
12	.2	1.6	5.4	16.0	415	242	67	610	.78	7.8
12	.2	2.7	17	16.0	382	195	0	480	1.28	7.6
14	2.2	1.5	8.0	16.0	504	291	122	770	1.12	7.5
4.5	.3	1.8	6.4	17.0	788	456	266	1100	1.10	7.8
20	.4	1.6	13	16.0	439	241	66	650	.93	7.6
19	2.2	1.2	7.8	17.0	1343	742	573	1560	1.92	7.3
17	.6	1.1	17	16.0	444	272	77	680	1.05	7.5
21	.4	1.4	5.8	16.0	752	469	308	1120	.90	7.7
52	10	23	22	17.0	1365	773	609	1560	1.52	7.5
18	.6	.8	12	18.0	1776	774	613	2200	3.44	7.7
18	.3	5.0	10	19.0	1130	529	365	1600	2.46	7.7
38	1.8	1.6	11	18.0	3134	1420	1170	3600	4.16	7.1
24	2.3	6.4	6.4	16.0	434	271	117	700	.77	7.5
19	.6	1.0	9.5	17.0	778	439	271	1140	1.35	7.7
12	.6	4.8	35	17.0	677	439	307	1120	.77	7.3
40	1.6	3.2	11	17.0	1193	686	553	1700	1.21	7.7
24	.5	1.0	14	18.0	2251	1200	1047	2500	2.14	7.5
14	.6	3.5	9.2	16.5	578	325	146	860	1.18	7.5
18	1.9	2.2	3.4	17.0	514	293	102	830	1.17	7.4
24	.5	1.4	11	16.0	1809	948	762	2350	2.39	7.2
21	.7	1.7	5.5	20.0	1993	963	633	2810	3.79	7.1
11	.5	2.4	7.2	18.0	237	143	7	450	.33	7.5
18	3.1	.9	5.8	16.0	587	279	122	1050	1.69	7.7
11	.3	3.6	9.6	18.0	236	154	6	450	.67	7.6
18	3.8	126	11	18.0	358	217	68	610	.86	7.5
20	2.0	3.1	8.0	18.0	260	168	18	560	.70	7.5
46	10	6.1	16	16.5	3256	1640	1465	3780	3.33	7.3
57	8.7	1.6	13	15.0	3936	1710	1453	4800	5.26	7.3
21	.9	1.2	12	18.0	269	174	10	560	.63	7.6
12	.2	4.5	10	18.5	261	163	17	555	.68	7.7
12	.5	3.1	24	19.0	247	157	16	495	.76	7.6

Finney County (cont.)

Well Location	Geological Unit	Historical Data	SiO_2 ppm	Ca ppm	Mg ppm	Na ppm	K ppm	Sr ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	F ppm	NO_3 ppm
25-33W-35CCA	Qu,TO		20	55	7.4	15	2.7	.4	205	12	3.6	.6	6.7
25-34W-6BAD	Qu,TO		17	57	11	22	2.8	.2	173	75	9.5	.8	9.7
25-34W-11DDD	Qu,TO		17	49	8.2	19	2.5	.5	188	45	3.2	.5	3.9
25-34W-34DBD	Qu,TO		17	48	7.2	10	2.4	.4	181	25	1.4	.7	5.0
26-31W-6BBC	Qu,TO		18	56	8.5	17	2.8	.5	196	36	9.2	.5	6.7
26-31W-31CDC	Qu,TO		19	54	7.9	22	2.7	.5	201	36	11	.4	6.8
26-31W-36CAC2	Qu,TO		20	50	8.0	20	2.8	.5	200	42	4.8	.5	8.2
26-32W-22ABB	Qu,TO		17	79	11	25	3.3	.6	214	67	32	.4	9.1
26-32W-35CDA	Qu,TO		19	74	10	26	2.9	.7	226	48	31	.5	9.1
26-33W-3DBB	Qu,TO		17	60	9.3	20	2.6	.6	212	21	13	.5	12
26-33W-12BDC	Qu,TO		19	67	8.0	17	3.2	.5	203	55	21	.5	8.4
26-33W-26ABB	Qu,TO		15	49	6.5	11	2.3	.4	184	16	1.1	.6	3.6

Grant County

Well Location	Geological Unit	Historical Data	SiO_2 ppm	Ca ppm	Mg ppm	Na ppm	K ppm	Sr ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	F ppm	NO_3 ppm
27-35W-17ADD	Qu,TO		19	62	7.5	13	2.5	.4	174	49	24	.4	4.4
27-35W-34BBA	Qu,TO		18	48	8.4	12	2.1	.6	171	28	7.9	.5	9.6
27-36W-15DDD	Qu,TO		18	50	13	27	3.0	.8	211	57	8.0	.9	4.8
27-36W-18DCB	Qu,TO		29	64	32	64	4.4	1.8	278	176	18	1.7	22
27-37W-4ABB	Qu,TO		23	68	38	67	6.1	1.8	271	217	23	1.9	10
27-37W-11ABA	Qu,TO		25	46	28	55	4.5	1.3	258	123	9.5	2.3	7.1
27-37W-22BBB	Qu,TO		29	81	32	38	4.6	1.8	253	183	18	1.4	10
27-37W-26BCB	Qu,TO		24	63	26	75	4.3	1.5	242	215	18	1.4	6.1
27-37W-29CBB	Qu,TO		24	85	31	55	4.6	2.0	231	188	56	1.6	13
27-38W-22CBB	Qu,TO		24	86	29	45	4.8	1.7	244	168	29	1.2	27
27-38W-25BBB	Qu,TO		24	92	32	50	4.2	2.0	199	224	36	1.3	30
27-38W-32BBC	Qu,TO		23	76	27	46	4.4	1.7	202	202	20	1.2	4.6

Gray County

Well Location	Geological Unit	Historical Data	SiO_2 ppm	Ca ppm	Mg ppm	Na ppm	K ppm	Sr ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	F ppm	NO_3 ppm
24-27W-8CCC	Qu,TO		49	58	24	25	5.6	1.0	210	83	32	2.3	9.1
24-28W-10ADD	Qu,TO		47	55	20	23	5.5	.9	210	69	20	2.0	15
24-28W-28BBA	Qu,TO		45	52	24	27	5.4	1.2	233	63	16	1.4	8.2
24-28W-31DD	Qu,TO		42	67	31	26	5.6	1.5	210	129	32	1.1	11
24-29W-16DCA	Qu,TO		41	69	32	21	5.9	1.4	201	125	49	1.5	16
24-29W-18CCB	Qu,TO		43	65	33	27	5.9	1.4	206	111	61	2.0	10
24-29W-24ADD	Qu,TO		43	52	25	21	5.0	1.1	210	66	27	1.5	12
24-30W-1BCB	Qu,TO	b	55	56	24	28	5.5	1.1	209	88	25	2.6	8.9
24-30W-8DCD	Qu,TO		45	70	33	41	6.2	1.5	211	165	45	1.8	9.8
24-30W-15CCC	Qu,TO		40	81	34	42	6.2	1.6	208	194	45	1.5	13
24-30W-31ABB	Qu,TO		32	79	33	34	5.1	1.6	218	184	21	1.3	8.6
25-27W-19CCC	Qu,TO		37	70	28	17	5.4	1.3	217	107	24	1.3	7.7
25-27W-33ABB	Qu,TO		37	60	25	16	5.0	1.2	215	91	24	1.5	8.0
25-27W-35CDC	Qu,TO		36	55	26	14	4.7	1.2	228	74	19	1.6	8.4
25-28W-16BBB	Qu,TO		39	72	32	22	5.6	1.7	216	140	27	.9	9.6
25-28W-31BBC	Qu,TO		25	92	28	27	5.0	1.5	204	204	26	.8	4.8
25-29W-7BCB	Qu,TO		30	97	35	36	5.4	1.8	218	240	32	1.0	6.9
25-29W-14ABB	Qu,TO	b	29	96	35	36	6.0	1.7	243	190	50	1.0	12
25-29W-33BBC	QA		19	72	13	25	3.6	.6	229	71	9.8	.6	14
25-30W-20BCB	Qu,TO		14	199	58	186	7.1	1.6	267	806	55	1.2	24
26-27W-13BBC	Qu,TO		20	54	10	21	3.3	.6	204	42	4.7	.6	3.9
26-27W-18ADC	Qu,TO		20	66	13	22	3.4	.7	227	46	8.0	.8	15
26-27W-27CDD	Qu,TO		21	62	9.3	26	4.1	.5	242	29	8.4	.5	8.0
26-28W-19ABD	Qu,TO		20	55	8.8	21	3.3	.5	200	41	5.4	.6	6.2
26-30W-1CDA	Qu,TO		18	51	9.0	21	2.7	.6	190	49	4.4	.6	3.3
26-30W-17AD	Qu,TO		17	59	9.1	19	3.2	.5	208	34	6.7	.5	14
26-30W-24DDD	Qu,TO		20	64	10	21	3.4	.5	232	38	14	.5	7.8
26-30W-28ADD	Qu,TO		17	59	8.7	20	2.9	.5	208	35	6.7	.5	6.8
27-27W-6BBB	Qu,TO		22	63	9.2	19	3.8	.4	224	38	8.7	.5	6.0
27-27W-7ADC	Qu,TO		21	65	9.5	19	3.7	.5	240	30	7.3	.6	23

Fe ppb	Mn ppb	Cu ppb	Ni ppb	Temperature °C	Total Solids (Residue at 180°C)	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ Non-Carbonate ppm	Specific Conductance (micromhos at 25°C)	SAR	pH
18	.4	1.7	8.9	16.5	253	168	0	464	.50	7.5
18	3.0	15	16	17.0	315	188	46	575	.70	7.5
7.2	.1	14	2.1	17.0	270	157	2	440	.66	7.6
13	.2	4.8	10	18.0	227	150	2	448	.36	7.7
150	19	1.7	5.5	19.0	279	175	15	550	.56	7.5
23	4.5	1.4	4.9	17.5	294	168	3	570	.74	7.6
21	2.6	40	6.4	17.5	278	158	0	570	.69	7.6
13	1.6	.8	6.7	20.0	376	243	68	756	.70	7.5
31	2.9	1.2	3.1	17.0	373	227	41	690	.75	7.5
62	11	1.6	8.3	16.5	297	189	15	348	.63	7.6
24	.1	2.1	3.1	17.5	319	201	34	570	.52	7.5
22	8.2	1.2	2.1	17.0	199	149	0	460	.39	7.9

Fe ppb	Mn ppb	Cu ppb	Ni ppb	Temperature °C	Total Solids (Residue at 180°C)	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ Non-Carbonate ppm	Specific Conductance (micromhos at 25°C)	SAR	pH
27	5.2	1.8	3.0	20.0	279	186	43	460	.41	7.9
16	.1	1.5	6.1	19.0	223	155	15	330	.42	7.5
24	.9	1.4	12	19.0	317	179	6	475	.88	7.6
37	2.0	4.0	2.8	19.0	569	293	66	825	1.63	7.9
20	.3	1.5	9.5	18.0	623	328	106	930	1.61	7.4
27	.8	1.8	17	19.0	466	231	20	690	1.57	7.8
23	.7	2.5	2.4	18.0	545	336	128	740	.90	7.6
14	.5	2.4	2.1	19.0	585	266	68	880	2.00	7.6
15	.3	2.3	3.0	18.0	613	342	153	825	1.29	7.7
18	.4	2.8	3.2	17.0	584	336	136	750	1.07	7.6
19	.3	44	3.6	19.0	610	363	200	815	1.14	7.5
38	4.0	1.8	11	18.5	528	303	137	765	1.15	7.7

Fe ppb	Mn ppb	Cu ppb	Ni ppb	Temperature °C	Total Solids (Residue at 180°C)	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ Non-Carbonate ppm	Specific Conductance (micromhos at 25°C)	SAR	pH
255	10	408	25	16.0	427	245	72	705	.70	7.7
19	.7	1.1	8.0	16.0	376	221	48	582	.67	7.7
11	.8	1.6	9.8	16.0	377	230	39	580	.77	7.7
11	.9	1.1	3.8	16.5	481	296	124	770	.66	7.7
13	.6	6.8	40	17.0	526	305	141	775	.52	7.8
16	.1	4.9	9.9	16.0	513	300	131	820	.68	7.7
22	1.0	1.2	5.0	16.0	382	234	62	615	.60	7.7
8.7	1.7	1.9	7.1	16.0	422	240	68	655	.79	7.8
18	.3	3.2	2.0	16.0	543	312	139	865	1.01	7.7
23	.6	1.8	3.2	16.0	590	344	173	875	.99	7.8
20	.8	4.2	6.3	16.0	533	335	156	790	.81	7.6
16	.3	11	24	17.5	477	291	113	650	.43	7.4
33	.9	20	9.0	17.0	395	254	78	640	.44	7.7
22	4.0	1.0	8.2	18.0	399	246	59	632	.39	7.6
14	.3	1.4	2.6	16.5	521	313	136	740	.54	7.7
13	.3	2.8	7.6	16.0	551	346	179	810	.63	7.7
16	.9	3.8	7.6	16.0	637	388	209	910	.79	7.7
6.4	.1	1.3	2.3	16.5	612	385	186	915	.80	7.5
126	6.2	2.8	5.2	16.0	370	234	46	570	.71	7.5
24	.8	7.6	8.6	15.0	1530	737	518	2120	2.98	7.3
8.6	1.0	2.5	5.4	16.0	288	177	9	425	.69	7.8
12	.2	2.9	5.9	15.5	342	218	33	510	.65	7.8
19	.6	2.6	5.2	16.0	323	194	0	495	.81	7.6
14	.4	2.8	10	17.0	279	174	10	490	.69	7.6
12	.3	2.9	9.6	17.0	274	165	9	350	.71	7.8
9.0	.7	1.8	6.6	16.0	293	185	15	440	.61	7.6
14	.1	4.9	4.7	16.0	323	201	11	460	.64	7.7
7.9	.1	4.7	2.2	16.0	295	184	13	430	.64	7.7
8.6	.2	1.8	10	17.0	273	195	12	570	.59	7.5
11	.3	1.9	5.7	16.5	334	202	5	475	.58	7.4

Gray County (cont.)

Well Location	Geological Unit	Historical Data	SiO_2 ppm	Ca ppm	Mg ppm	Na ppm	K ppm	Sr ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	F ppm	NO_3 ppm
27-27W-19BBD	Qu,TO		20	59	8.0	19	3.8	.4	222	29	4.5	.5	11
27-28W-30CCA	Qu,TO		20	54	8.2	20	3.3	.5	205	31	4.5	.6	14
27-29W-9DA	Qu,TO		18	59	9.9	22	3.7	.6	224	38	7.0	.5	6.8
27-29W-18DBB	Qu,TO		19	58	8.7	21	3.3	.5	214	36	5.3	.6	8.8
27-29W-23ADC	Qu,TO		18	56	8.0	18	3.6	.5	206	29	4.7	.6	7.9
27-29W-33CCC	Qu,TO		20	62	9.2	17	3.3	.5	226	25	6.8	.5	24
27-30W-8BB	Qu,TO		20	110	17	38	4.0	.9	229	109	82	.4	9.0
27-30W-25CCB	Qu,TO		17	72	11	20	3.0	.6	200	52	36	.5	10
27-30W-34CCC	Qu,TO		18	71	11	20	2.8	.6	217	55	19	.5	6.8
28-30W-6BBA	Qu,TO		16	60	8.2	18	2.7	.5	204	31	14	.4	10

Hamilton County

Well Location	Geological Unit	Historical Data	SiO_2 ppm	Ca ppm	Mg ppm	Na ppm	K ppm	Sr ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	F ppm	NO_3 ppm
23-42W-19CBB	QA,Qu	b	31	430	174	715	20	7.0	431	2757	206	.9	18
23-42W-27DDB	QA		16	389	176	647	15	5.9	285	2622	221	1.0	9.9
23-42W-34CBB	QA	b	12	295	123	469	10	3.4	258	1818	179	.9	17
23-43W-25CBD	QA		14	436	214	890	13	5.3	335	3094	331	.6	3.8
24-39W-19CBC	QA		14	443	152	560	11	3.7	294	2354	201	.8	15
24-39W-30BBD	QA		13	339	145	504	11	4.1	303	2093	151	1.0	3.4
24-39W-30CAD	QA		17	413	236	769	14	5.6	447	2981	230	1.2	2.4
24-40W-17BBB	QA		18	522	145	550	11	5.3	334	2389	252	.8	12
25-43W-26DDD	Qu,TO		13	58	16	20	3.7	1.1	178	95	5.5	.8	5.3
26-41W-20BBD	Qu,TO		21	213	66	83	8.4	4.3	283	640	89	1.1	4.0
26-41W-36CC	Qu,TO		28	97	37	49	5.9	2.1	232	280	20	1.4	8.5
26-42W-10BB2	Qu,TO		10	108	33	33	5.1	2.0	203	291	22	1.1	2.5
26-42W-17CB	Qu,TO,KJ	b	14	72	16	22	4.1	1.1	176	122	15	.6	9.8
26-42W-22CDB	Qu,TO		14	68	16	22	4.0	1.1	174	117	12	.6	3.9
26-43W-8ADB	Qu,TO		12	64	14	18	4.2	.9	160	121	4.9	.6	3.7
26-43W-25DCC	Qu,TO,KJ		14	63	16	25	3.9	1.0	180	124	6.9	.7	2.6

Haskell County

Well Location	Geological Unit	Historical Data	SiO_2 ppm	Ca ppm	Mg ppm	Na ppm	K ppm	Sr ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	F ppm	NO_3 ppm
27-31W-7BDA	Qu,TO		18	62	8.0	17	2.7	.5	209	23	17	.5	9.5
27-31W-24CDC	Qu,TO		18	63	8.9	16	2.7	.6	199	37	19	.4	7.9
27-32W-6CBB	Qu,TO		17	44	7.4	17	2.1	.6	170	25	<1	.6	3.4
27-32W-19CCD	Qu,TO		17	54	7.0	14	2.3	.4	189	10	12	.4	7.8
27-33W-27CAD	Qu,TO		18	46	7.6	15	2.1	.2	174	18	3.4	.5	5.2
27-33W-29DAA	Qu,TO		18	47	7.3	14	2.2	.4	172	36	7.4	.4	5.2
27-33W-33DCD	Qu,TO		17	56	9.3	22	2.3	.6	174	31	36	.5	3.8
27-34W-16DDD	Qu,TO		20	70	9.6	21	2.6	.5	212	63	17	.4	15
27-34W-23DDA	Qu,TO		20	62	9.6	17	2.4	.2	188	45	22	.4	6.8
27-34W-28DA	QU,TO		18	58	14	20	2.8	.7	174	52	36	.8	9.0

Kearny County

Well Location	Geological Unit	Historical Data	SiO_2 ppm	Ca ppm	Mg ppm	Na ppm	K ppm	Sr ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	F ppm	NO_3 ppm
22-35W-23CDD	TO		22	59	14	14	4.7	1.0	201	36	17	.7	42
22-37W-18CCD	TO		20	44	20	36	4.4	1.2	192	87	17	1.4	13
23-35W-5ACC	TO		19	46	12	27	3.8	.7	192	53	12	1.0	12
23-35W-12CCC	Qu,TO		22	76	22	31	5.0	.9	182	145	42	.7	7.6
23-35W-25BBB2	Qu,TO	b	26	334	64	130	12	2.2	198	1063	130	.4	11
23-36W-4CBB	TO		18	69	23	30	4.5	1.2	187	127	34	.8	7.6
23-36W-32BBB	TO		20	31	17	29	4.4	1.0	181	55	12	1.7	9.3
23-37W-19BCC	TO		20	40	25	49	5.4	1.4	194	134	21	1.7	11
23-37W-28CCB	TO		18	47	29	30	5.1	1.6	170	106	45	1.2	15
24-35W-13CCD2	QA		20	412	146	460	12	4.4	298	2096	158	1.6	31
24-35W-22CCC	QA	b	18	393	136	460	12	3.6	295	1997	168	.9	14
24-36W-15BCB	Qu,TO		20	49	29	26	5.0	1.6	227	70	22	1.2	44
24-36W-23CBB2	Qu,TO	b	21	227	105	172	9.5	5.3	238	1065	128	1.0	7.6
24-37W-4CDD	TO		15	35	15	17	3.4	.8	171	46	5.6	1.2	5.6
25-35W-22CAA	Qu		14	47	8.4	17	2.4	.5	174	44	3.9	.8	2.9

Fe ppb	Mn ppb	Cu ppb	Ni ppb	Temperature °C	Total Solids (Residue at 180°C)	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ Non-Carbonate ppm	Specific Conductance (micromhos at 25°C)	SAR	pH
12	.4	1.5	7.6	16.5	270	181	0	470	.62	7.6
12	.2	6.3	4.0	17.0	286	169	1	430	.67	7.4
14	.2	2.3	21	17.0	294	189	5	500	.70	7.5
17	.3	12	10	16.0	297	181	6	430	.68	7.5
12	.1	1.2	8.7	16.5	255	173	4	420	.59	7.5
28	.4	2.4	12	17.0	285	193	8	510	.53	7.5
18	.4	.9	4.7	16.0	536	345	158	780	.89	7.3
8.9	.2	1.4	2.5	16.0	352	226	62	530	.58	7.7
20	1.0	6.1	10	16.5	348	223	45	500	.58	7.7
11	1.5	1.6	6.8	17.0	290	184	17	520	.58	7.8

Fe ppb	Mn ppb	Cu ppb	Ni ppb	Temperature °C	Total Solids (Residue at 180°C)	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ Non-Carbonate ppm	Specific Conductance (micromhos at 25°C)	SAR	pH
9.8	.3	7.1	30	15.5	4715	1796	1443	5160	7.34	7.4
9.6	8.2	1.4	6.8	16.0	4366	1701	1468	4680	6.82	7.5
22	.2	.9	9.0	15.0	3172	1246	1034	3600	5.78	7.5
65	3.7	1.1	8.0	14.5	5443	1974	1700	5850	8.71	7.4
14	135	3.4	7.7	14.5	4028	1735	1494	4560	5.85	7.3
15	1.8	9.5	33	14.5	3547	1447	1199	3960	5.76	7.5
38	2.0	2.1	12	15.0	5123	2008	1641	5750	7.47	7.4
10	90	3.2	9.7	15.0	4268	1905	1631	4560	5.48	7.1
64	5.2	1.6	11	19.0	349	212	66	495	.60	7.2
249	35	3.0	5.8	16.0	1325	808	576	1638	1.27	7.3
36	.7	5.9	6.2	17.0	669	397	206	948	1.07	7.5
34	40	2.3	5.8	18.0	635	407	241	874	.71	7.4
20	.2	2.0	4.6	17.0	405	247	102	560	.61	7.6
34	.4	2.8	5.1	17.0	381	237	94	504	.62	7.5
24	.9	4.4	4.9	19.0	368	218	87	495	.53	7.5
11	.4	2.9	9.9	18.0	364	224	77	482	.73	7.7

Fe ppb	Mn ppb	Cu ppb	Ni ppb	Temperature °C	Total Solids (Residue at 180°C)	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ Non-Carbonate ppm	Specific Conductance (micromhos at 25°C)	SAR	pH
12	1.5	1.2	4.2	16.5	287	188	17	580	.54	7.6
18	.8	1.4	5.6	16.5	300	194	31	520	.50	7.6
15	.4	1.8	4.0	19.5	232	141	2	436	.62	7.7
13	3.3	1.4	2.5	17.5	272	164	9	570	.48	7.8
26	.6	4.2	5.7	19.0	230	146	4	440	.54	7.8
9.1	.5	2.7	7.5	18.0	251	148	7	450	.50	7.8
72	11	2.2	4.2	19.0	285	179	36	550	.72	7.7
36	.5	4.6	6.4	19.0	367	215	41	660	.62	7.5
62	3.4	6.7	18	17.5	293	194	40	570	.53	7.5
16	1.6	2.2	7.1	20.0	334	203	60	575	.61	7.8

Fe ppb	Mn ppb	Cu ppb	Ni ppb	Temperature °C	Total Solids (Residue at 180°C)	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ Non-Carbonate ppm	Specific Conductance (micromhos at 25°C)	SAR	pH
26	.6	5.2	13	17.0	308	206	41	515	.42	7.7
14	.4	1.9	9.1	17.5	342	193	36	521	1.13	7.6
16	.4	1.2	8.8	17.0	278	165	8	440	.91	7.3
38	2.2	4.0	5.6	17.0	496	281	132	700	.80	7.6
65	1.3	2.9	8.0	17.0	1844	1099	937	2050	1.71	7.3
17	.7	1.8	6.8	16.0	421	268	115	612	.80	7.5
16	.4	2.4	6.8	17.5	310	148	0	403	1.04	7.6
24	.4	1.8	10	17.0	410	204	45	591	1.49	7.7
13	.3	2.5	7.9	19.0	395	238	99	604	.85	7.6
14	.8	2.6	9.0	15.0	3524	1633	1389	4200	4.95	7.2
15	.2	1.7	5.0	15.0	3477	1544	1302	4200	5.09	7.1
22	.4	489	11	17.0	394	243	57	635	.73	7.7
28	9.5	1.4	8.2	16.0	1840	1004	809	2350	2.36	7.3
16	.2	1.4	9.2	18.0	375	150	10	357	.60	7.6
32	3.4	3.3	14	18.0	240	152	10	390	.60	7.6

Kearny County (cont.)

Well Location	Geological Unit	Historical Data	SiO_2 ppm	Ca ppm	Mg ppm	Na ppm	K ppm	Sr ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	F ppm	NO_3 ppm
25-36W-11CBC	QA		13	413	122	424	8.8	4.0	261	2018	166	1.2	20
25-36W-18ACC	TO	b	13	400	115	438	9.6	3.3	236	2018	162	.8	25
25-36W-19BBB	Qu,TO		13	332	67	281	7.8	2.1	187	1397	113	.6	12
25-36W-28BBD	Qu,TO		13	70	12	20	2.7	.8	159	130	13	.7	6.4
26-35W-6BBD	Qu,TO		17	42	6.1	5.7	1.9	.5	154	8.1	4.1	.6	6.2
26-35W-31DCA	Qu,TO		21	46	5.9	9.0	2.0	.4	168	27	<1	.4	3.0
26-37W-21DDD	Qu,TO	b	21	56	21	32	3.9	1.1	258	73	7.4	1.1	3.8
26-37W-26DBC	Qu,TO		20	43	12	14	2.6	.8	199	27	2.6	.9	6.0

Scott County

Well Location	Geological Unit	Historical Data	SiO_2 ppm	Ca ppm	Mg ppm	Na ppm	K ppm	Sr ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	F ppm	NO_3 ppm
18-32W-20CBB	TO	a	59	67	37	40	6.8	1.4	233	154	44	2.4	13
18-33W-35AAA	QA,TO		58	66	28	40	5.7	1.3	258	115	26	2.1	7.4
19-33W-12DDC	QA,TO	b	47	292	196	297	16	8.4	367	1572	236	2.0	14
19-33W-15DBD	TO	a	52	63	30	63	4.7	1.4	290	107	42	3.9	13
19-33W-25DCD	QA,TO	a	38	91	42	48	7.7	1.7	308	178	40	2.2	11
19-33W-29CBB2	QA,TO	a	44	56	30	32	6.0	1.6	251	40	38	1.8	26
19-33W-34DCC	QA,TO	a	30	47	16	22	5.5	.8	231	26	13	1.5	5.5
20-33W-2DBB	QA,TO	a	31	58	21	32	6.0	1.0	254	42	31	1.4	6.8
20-33W-21ABD	QA,TO	a	39	82	32	30	7.5	1.5	227	138	56	1.1	10
20-33W-26CBB	TO		37	47	18	23	5.6	.8	218	49	17	2.0	6.9
20-33W-35DBA	QA,TO	a	38	44	17	22	4.7	.7	212	38	14	2.0	4.2
20-33W-36CCD	TO		40	44	20	32	4.5	.9	225	46	21	2.3	4.6

Stanton County

Well Location	Geological Unit	Historical Data	SiO_2 ppm	Ca ppm	Mg ppm	Na ppm	K ppm	Sr ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	F ppm	NO_3 ppm
27-39W-23ACC	Qu,TO		30	112	36	37	5.4	2.0	281	180	28	1.0	66
27-39W-27BBA	Qu,TO		27	86	26	37	4.4	1.7	205	178	30	1.0	6.1
27-40W-15DBC	Qu,TO		19	98	33	43	4.8	2.1	203	263	28	1.0	4.9
27-40W-25CBC	Qu,TO		18	86	24	29	3.9	1.6	160	176	36	.9	6.9
27-40W-28CDD	Qu,TO		16	59	19	23	3.8	1.2	180	99	11	1.0	8.5
27-41W-19BAD	Qu,TO		16	63	18	28	3.9	1.1	174	127	9.7	.8	5.6
27-41W-35CCC	Qu,TO		18	59	20	29	3.8	1.3	172	136	9.4	.9	4.8
27-42W-11DBB	Qu,TO		13	63	18	28	4.0	1.1	178	135	7.7	.7	2.4
27-42W-17DCC	Qu,TO		13	62	16	28	3.9	1.1	178	124	12	.8	5.7
27-42W-31CCC	Qu,TO,KJ		12	50	13	23	3.3	.7	167	86	6.6	1.0	3.1
27-43W-12BCC	Qu,TO		12	57	14	25	3.8	1.0	170	109	9.4	.8	10

Wichita County

Well Location	Geological Unit	Historical Data	SiO_2 ppm	Ca ppm	Mg ppm	Na ppm	K ppm	Sr ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	F ppm	NO_3 ppm
19-38W-14AAB	TO	a	49	30	18	37	5.0	1.0	201	46	7.9	2.5	12
19-38W-18DCC	TO	a	50	29	18	28	4.2	1.0	193	29	8.8	2.8	9.5
19-38W-26CCB	TO	a	51	41	15	31	4.8	.8	209	47	10	1.7	7.9
19-38W-31CBC	TO		44	39	22	25	5.4	1.4	183	73	20	1.0	9.4
19-38W-35BAB	TO	a	51	43	13	27	4.3	.7	191	34	9.5	1.4	13

Fe ppb	Mn ppb	Cu ppb	Ni ppb	Temperature °C	Total Solids (Residue at 180°C)	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ Non-Carbonate ppm	Specific Conductance (micromhos at 25°C)	SAR	pH
17	1.6	1.4	8.3	16.0	3390	1537	1323	3750	4.70	7.3
13	.1	1.3	8.8	15.0	3363	1475	1281	4100	4.96	7.4
22	1.6	2.0	7.3	18.0	2254	1106	953	2800	3.68	7.3
15	.2	1.5	2.6	18.0	365	225	95	565	.58	7.7
16	.2	2.3	19	18.0	179	130	4	295	.22	7.8
15	.2	3.3	8.1	19.0	185	139	2	290	.33	7.7
17	.7	28	15	17.0	365	227	16	520	.92	7.3
15	.4	1.5	15	18.0	241	158	0	370	.49	7.5

Fe ppb	Mn ppb	Cu ppb	Ni ppb	Temperature °C	Total Solids (Residue at 180°C)	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ Non-Carbonate ppm	Specific Conductance (micromhos at 25°C)	SAR	pH
43	5.1	1.1	11	15.5	579	321	130	760	.97	8.1
14	3.5	3.6	8.5	14.0	496	281	70	730	1.04	7.7
24	26	1.6	9:5	15.0	3003	1544	1244	3450	3.29	7.5
30	5.9	18	11	14.5	539	282	45	830	1.63	7.8
11	.6	1.2	12	15.0	642	402	149	990	1.04	7.8
44	6.2	2.1	6.6	16.0	453	265	59	640	.86	7.7
24	.4	.9	3.2	14.5	324	184	0	460	.71	7.9
23	7.2	1.8	5.8	14.0	384	232	24	580	.91	7.5
14	.9	3.9	8.4	15.0	591	338	152	750	.71	7.8
82	1.8	3.9	21	17.0	327	192	14	480	.72	8.0
47	3.7	3.3	12	15.0	310	180	7	430	.71	8.0
43	.9	14	2.5	16.0	348	193	9	560	1.00	7.9

Fe ppb	Mn ppb	Cu ppb	Ni ppb	Temperature °C	Total Solids (Residue at 180°C)	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ Non-Carbonate ppm	Specific Conductance (micromhos at 25°C)	SAR	pH
17	.6	6.4	10	17.5	668	430	200	965	.78	7.4
440	193	8.1	8.3	20.0	532	323	155	743	.89	7.8
112	1.1	12	7.0	19.0	615	383	216	715	.96	7.7
74	1.6	5.9	9.5	17.0	511	315	184	667	.71	7.7
14	.4	2.7	5.9	18.0	370	227	79	529	.66	7.7
17	.2	2.4	9.9	18.0	378	232	90	546	.80	7.6
19	.5	3.0	6.4	18.0	380	231	90	549	.83	7.6
21	.8	1.3	3.6	17.0	378	232	87	546	.80	7.5
15	.1	1.6	10	18.0	372	222	76	552	.82	7.9
76	3.1	3.2	11	17.0	292	179	42	449	.75	7.8
14	3.7	2.4	8.3	18.0	339	201	62	483	.77	7.9

Fe ppb	Mn ppb	Cu ppb	Ni ppb	Temperature °C	Total Solids (Residue at 180°C)	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ Non-Carbonate ppm	Specific Conductance (micromhos at 25°C)	SAR	pH
12	1.7	3.9	7.8	15.0	313	150	0	460	1.31	8.0
34	3.4	.8	1.4	16.0	279	148	0	420	1.00	8.0
11	1.5	1.6	9.0	14.5	327	165	0	430	1.05	8.0
14	.8	5.2	3.8	15.0	361	189	39	550	.79	8.1
11	.6	1.2	9.0	15.0	306	162	5	440	.92	8.0

Chemical Quality of Irrigation Waters in Hamilton, Kearny, Finney, and Northern Gray Counties   Hathaway and Others