Surface-Water-Quality Assessment of the Lower Kansas River Basin, Kansas and Nebraska: Distribution of Trace-Element Concentrations in Dissolved and Suspended Phases, Streambed Sediment, and Fish Samples, May 1987 through April 1990

By D.Q. TANNER

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 94-4201

Prepared as part of the
NATIONAL WATER-QUALITY
ASSESSMENT PROGRAM

Lawrence, Kansas
1995

U.S. DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS

Multiply	By	To obtain
mile	1.609	kilometer
square mile	2.590	square kilometer
gallon per day	0.003785	cubic meter per day
cubic foot per second	0.02832	cubic meter per second
pound per day	453.6	gram per day

Water Year: Water year is the 12-month period, October 1 through September 30. The water year is designated by the year in which it ends. Thus the year ending September 30, 1990, is called the "1990 water year."

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Abstract

The distribution of trace elements in the dissolved and suspended phases, streambed sediment, and fish samples is described for principal streams in the lower Kansas River Basin of Kansas and Nebraska from May 1987 through April 1990. Relatively large median concentrations of dissolved lithium and strontium in the Kansas River were related to saline ground-water discharge, and large concentrations of dissolved strontium in Mill Creek near Paxico, Kansas, possibly were derived from Permian limestone and shale upstream of the sampling site.

Concentrations of suspended arsenic, chromium, and lead tended to be larger downstream from three reservoirs, which may indicate resuspension of sediment in turbulent flow near the dams or release of water from near the bottom of the reservoirs. Relatively large concentrations of several trace elements in streambed sediment near Aurora, Nebr., may be derived from municipal wastewater-treatment plant discharges, and larger concentrations at two sampling sites near Kansas City, Kans., may be due to wastewater discharge or urban runoff. Large concentrations of trace elements in streambed sediments at a sampling site down-stream from Perry Lake, Kans., may be the result of redeposition of sediments that were suspended at the dam and outlet.

The median and 90th-percentile concentrations of cadmium, copper, lead, and zinc in fish samples did not change appreciably from 1979–86 to 1987–90.

INTRODUCTION

During the past two decades, public awareness of the importance of water-quality issues has increased substantially. This increased awareness has fostered commitments by Federal, State, and local governments and industries for the assessment and protection of water quality. In 1986, the Congress appropriated funds for the U.S. Geological Survey to test and refine a National Water-Quality Assessment (NAWQA) Program (Hirsch and others, 1988). The long-term goals of the NAWQA program are to: (1) provide a nationally consistent description of current water-quality conditions for a large part of the Nation's water resources; (2) define long-term trends (or lack of trends) in water quality; and (3) identify, describe, and explain the major factors that affect observed water-quality conditions and trends.

The NAWQA program began with a pilot phase to test and modify assessment concepts and approaches. Seven pilot projects (four surface-water projects and three ground-water projects) were initiated. The lower Kansas River Basin in Kansas and Nebraska is one of the four surface-water pilot projects (see report cover). The lower Kansas River Basin was selected as a pilot project because it is typical of the very productive Midwestern agricultural area that includes irrigated and nonirrigated crop, pasture, and rangeland. The basin also includes typical uses of water for irrigation, municipal, and industrial purposes.

Background

Trace elements in natural water generally are considered to be those elements that occur in concentrations less than 1.0 mg/L (milligrams per liter) (Hem, 1985, p. 129). Some trace elements are beneficial or essential to plants and animals in small concentrations, yet are toxic in large concentrations. Trace elements are important from an ecological standpoint, as reflected by certain Maximum Contaminant Levels[1] established by the U.S. Environmental Protection Agency for public water supplies. The concentrations of trace elements can be affected by both natural and human-induced factors. Natural sources of trace elements include the dissolution and disaggregation of soils and geologic materials. Human-induced sources include agriculture, mining, manufacturing, and municipal waste.

Trace elements occur in several different states or phases in surface-water systems. If they are in aqueous solution, they are said to be dissolved. Trace elements forming the matrix of, or adsorbed to, suspended-sediment particles comprise the suspended phase. Streambed sediment typically contains relatively large concentrations of some trace elements. Finally, trace elements may be incorporated into biota, including fish tissue, in the aquatic environment.

This report is the third of three reports dealing with metallic and related elements in the lower Kansas River Basin. The first report (Tanner and others, 1990) presented the methods of data collection and data for major metals and trace elements in streambed sediment of first- and second-order streams, and principal streams. The second report graphically related geology and land use to the concentrations of metals and other selected elements in streambed sediments of first- and second-order streams (Tanner and Ryder, 1995).

[1]Maximum Contaminant Levels are enforceable health-based regulations.

Purpose and Scope

In support of the NAWQA program goals, this report describes the distribution of trace-element concentrations in dissolved and suspended phases, streambed sediment, and fish samples in principal streams of the lower Kansas River Basin from May 1987 through April 1990. The following 16 trace elements are discussed: arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, lithium, mercury, molybdenum, nickel, silver, strontium, vanadium, and zinc. When possible, the concentrations of these trace elements are related to natural and anthropogenic (human-induced) factors.

This report includes interpretation for trace-element concentrations in the dissolved and suspended phases of samples collected monthly or more frequently from May 1987 through April 1990 at 13 fixed-station, surface-water sampling sites. Samples for streambed-sediment analyses were collected during October 1987 at 62 sampling sites on principal streams. State agencies collected 34 fish samples for trace-element analysis at 12 sites from May 1987 through April 1990.

Acknowledgments

The author thanks the State and Federal agencies that have provided water-quality and ancillary data that are used in this report. Specifically, the assistance provided by the Kansas Department of Health and Environment, the Nebraska Department of Environmental Control, and the U.S. Environmental Protection Agency, Region VII, is appreciated. The data concerning trace-element concentrations in fish samples were provided by the Kansas Department of Health and Environment and the Nebraska Department of Environmental Control.

DESCRIPTION OF STUDY UNIT

The lower Kansas River Basin (fig. 1) drains about 15,300 square miles of northeastern Kansas and southeastern Nebraska and coincides with the area defined by the U.S. Water Resources Council as hydrologic subregion 1027 (Seaber and others, 1984). The study unit includes the Big Blue River Basin in Nebraska and Kansas, as well as basins of smaller tributaries to the 170-mile Kansas River from Junction City to Kansas City, Kans.

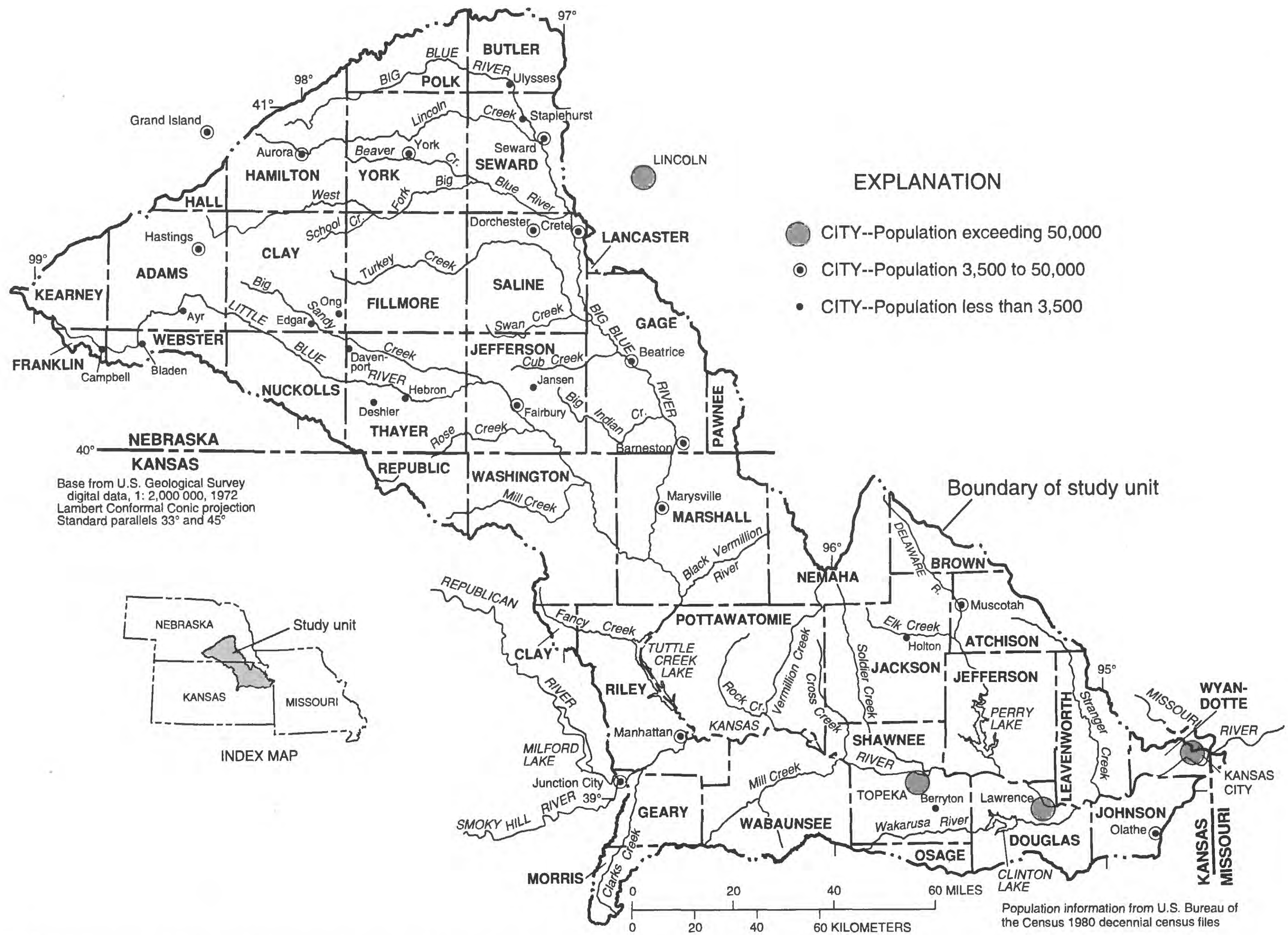

Figure 1. Major streams, surface-water impoundments, cities, and other geographic reference features in and near lower Kansas River Basin.

The Kansas River is formed by the confluence of the Smoky Hill and Republican Rivers at Junction City, Kans., but the latter two rivers are not included in the study unit. Three reservoirs, Tuttle Creek Lake, Perry Lake, and Clinton Lake, lie within the Kansas part of the study unit. The lower Kansas River Basin has been described by Stamer and others (1987).

The lower Kansas River Basin is characterized by the four physiographic divisions shown in figure 2 (Fenneman, 1946). Smooth plains with little local relief dominate the High Plains division, and fluvial and eolian deposits comprised of sand, gravel, silt, and clay underlie this part of the study unit (Fenneman, 1931). The Plains Border physiographic division is more dissected than the High Plains and thus has more local relief. The Dissected Till Plains division is characterized by dissected deposits of glacial till comprised of silt, clay, sand, gravel, and boulders that overlie bedrock of primarily shale and limestone, with some sandstone. The Osage Plains are south of the limit of glaciation and are underlain primarily by shale and limestone, with some sandstone (Fenneman, 1931).

Surficial Geology and Soils

The surficial geology of the lower Kansas River Basin is depicted in figure 3. The northwestern part of the study unit is composed primarily of Quaternary loess deposits, whereas the eastern part is composed primarily of Quaternary glacial drift. A small area in the west-central part of the study unit is composed of Cretaceous sandstone and limestone. The southern part of the study unit consists of Permian and Pennsylvanian shale and limestone. Quaternary alluvium fills the major river valleys throughout the study unit.

Soil characteristics are important to an understanding of the overall hydrology and water quality of the study unit. Such processes as overland runoff, infiltration, ground-water recharge, evapotranspiration, and irrigation can be assessed based on the principal hydrologic characteristics of permeability, slope, depth to seasonally high water table, and thickness of the soil profile. Soil characteristics can affect the water quality of streams because water percolating through the soil profile or flowing over the soil surface interacts with the soil particles.

The predominant soil order of the lower Kansas River Basin is the Mollisol (fig. 4). Mollisols have a surface horizon that is thick, dark-colored, high in base saturation, and granular in structure (Dugan, 1984, p. 6). Entisols, Inceptisols, and Alfisols also are present in the study unit. Entisols, which are soils with no diagnostic horizon, occur on sandy parent material (psamments) in the western part of the study unit and on soil formed from alluvial deposits (fluvents). Inceptisols are considered to be immature soils resembling their parent material (Buol and others, 1980, p. 240), and Alfisols are characterized by an argillic or clay-rich horizon.

Land Use

Land use in the lower Kansas River Basin (fig. 5) is predominantly agricultural. Corn, grain sorghum, wheat, and soybeans are the principal crops. The most intensely cultivated and irrigated land is in the northwestern part of the study unit. In a 1987 inventory of land use (U.S. Soil Conservation Service, written commun., data tables, 1990), estimates for drainage areas in the northwestern part of the basin indicate that more than 55 percent of the cropland in that area is irrigated. Estimates from the same inventory indicate that, although only about 3 percent of the study unit is covered by woodland, nearly 10 percent of the southeastern part is wooded, and less than 3 percent of the study unit consists of urban or industrial areas. The principal urban developments include part of the Kansas City metropolitan area, Topeka, and Lawrence, Kans. The large area of mostly rangeland in the southwestern part of the study unit, known as the Flint Hills, accounts for most of the pasture and rangeland that together cover about 25 percent of the basin.

Point Sources of Wastewater

Wastewater that enters a stream at a discrete point is referred to as a point source and, as such, is not necessarily related to the geology, soils, or land use of the drainage area. The U.S. Environmental Protection Agency issues discharge permits under the National Pollutant Discharge Elimination System (NPDES). These permits specify the allowed limits for rate of discharge and chemical composition of the wastewater effluent.

There are 28 municipal and industrial facilities in the study unit that are permitted by the U.S. Environmental Protection Agency to discharge

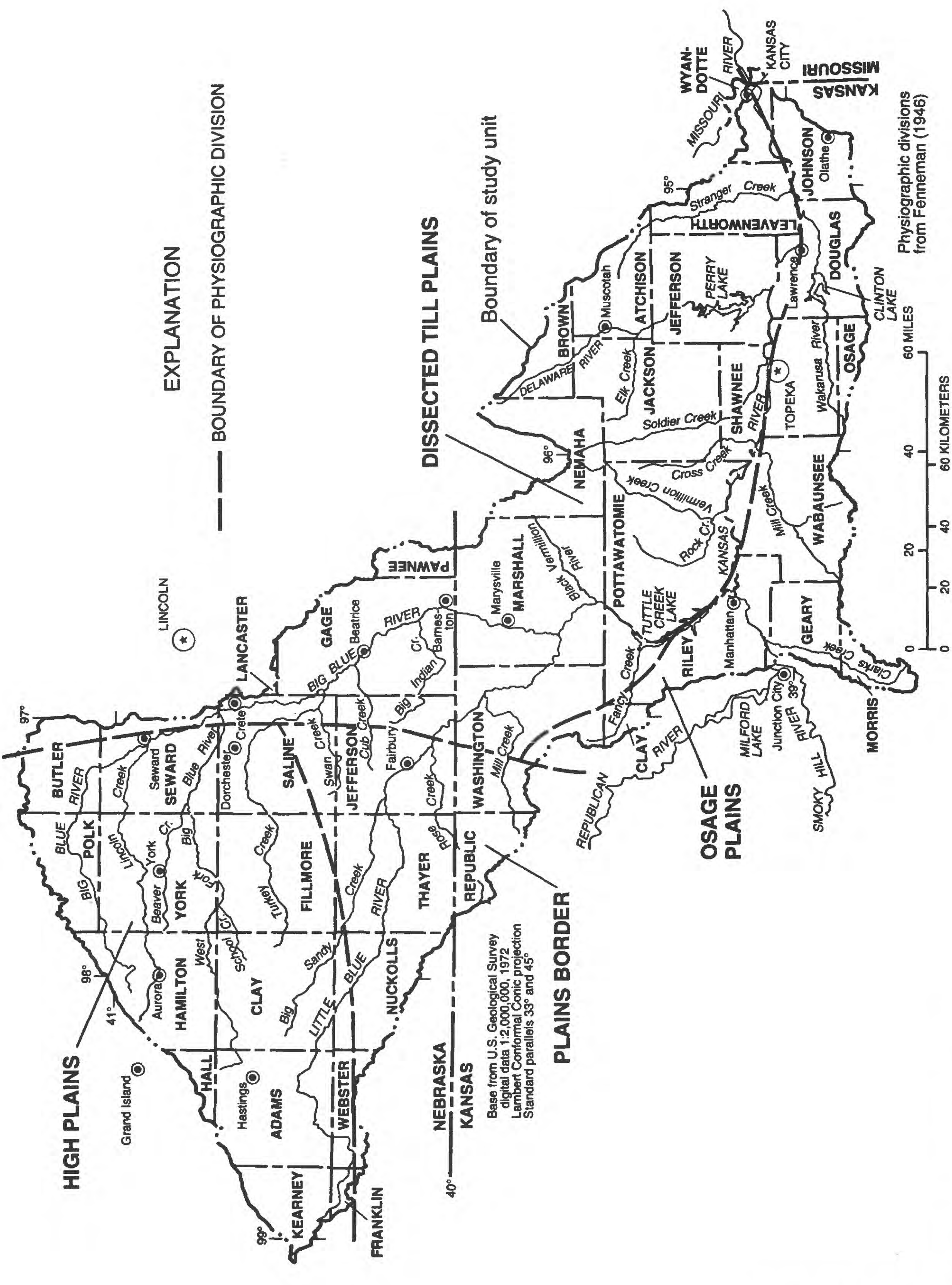

Figure 2. Physiographic divisions.

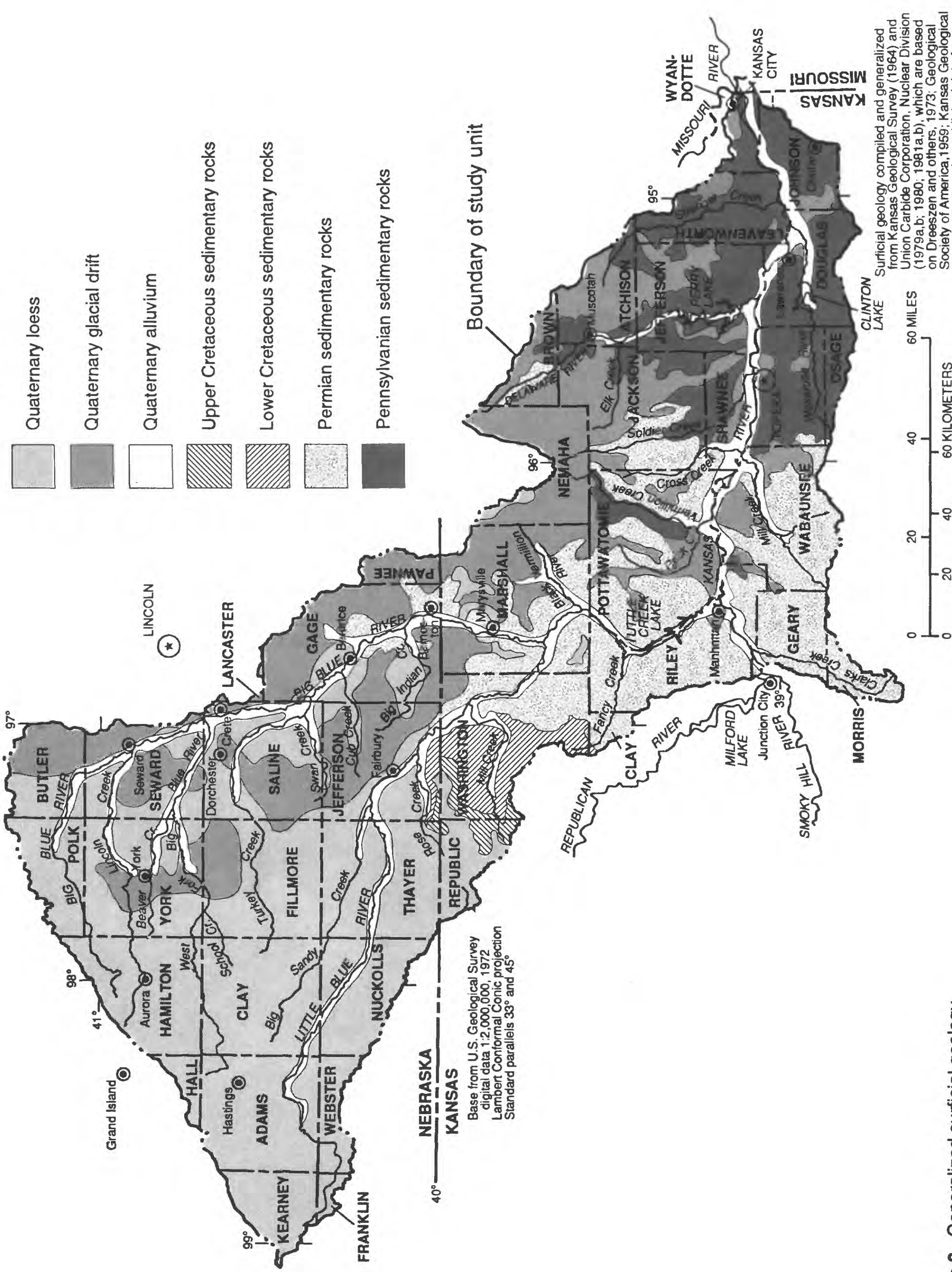

Figure 3. Generalized surficial geology.

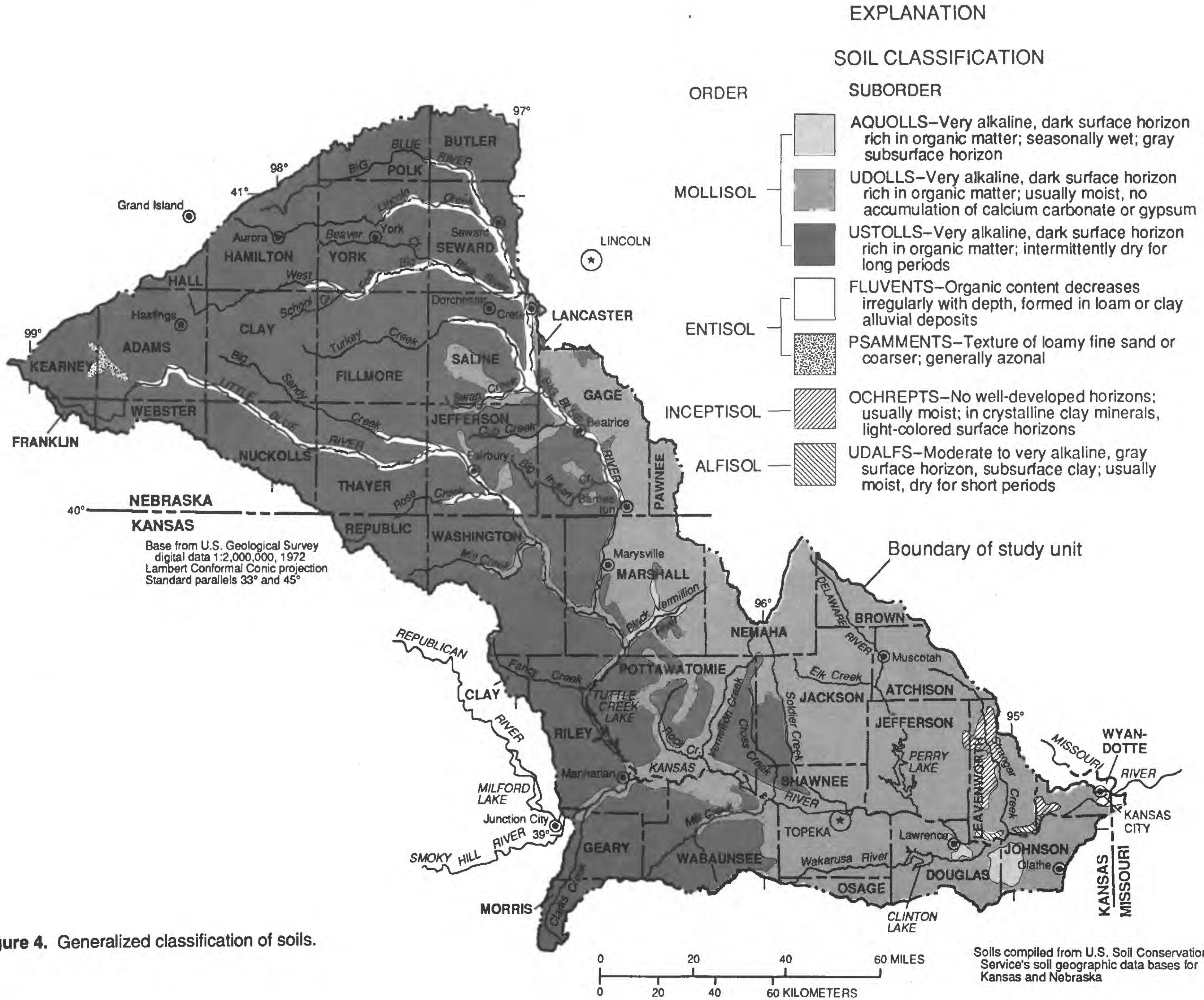

Figure 4. Generalized classification of soils.

Figure 5. Generalized land use and land cover.

wastewater at a rate of 1.0 or more million gallons per day. Of these facilities, 16 are municipal wastewater-treatment plants, and 12 are industrial discharges of wastewater. Location of these facilities and a municipal wastewater facility 2 miles upstream of the confluence of the Republican and Smoky Hill Rivers are shown in figure 6. Most point sources of wastewater are in the southeastern part of the study unit, which is more urbanized than the remainder of the basin.

Industrial wastewater effluents can contain large concentrations of trace elements, depending on the manufacturing process taking place at the industrial facility. Municipalities sometimes discharge trace elements from wastewater-treatment plants and storm sewers, which contain undocumented amounts of trace metals from domestic or industrial waste.

METHODS OF DATA COLLECTION

From May 1987 to April 1990, samples for the analysis of trace elements were collected throughout the lower Kansas River Basin. Samples used for this report were collected and analyzed by the U.S. Geological Survey, with the exception of a small number of the water-quality analyses, which were performed by the Kansas Department of Health and Environment (Topeka) and all of the fish samples. Data and quality-assurance information for dissolved phase, suspended phase, and streambed sediment were from Fallon and McChesney (1993). Data for fish samples for 1987–90 were from Christiansen (1988), Kansas Department of Health and Environment (1988), Christiansen and others (1989), Cringan (1989; 1991), and Callam and others (1990).

Dissolved Phase

Thirteen fixed-station, surface-water sampling sites were established in the lower Kansas River Basin to determine constituent transport, time trends, and to establish baseline water quality (fig. 7, table 1). The sites were sampled monthly from May 1987 through April 1990, with additional samples during high- and low-flow conditions. To ensure representative sampling of the water-sediment mixture, all samples were collected from several verticals using depth-integrating methods as discussed by Guy and Norman (1970). The samplers were coated with epoxy paint to prevent trace-metal contamination. Samples were composited in a polypropylene churn splitter, and a representative proportion was filtered through a 0.45-micrometer membrane filter immediately after collection. To minimize the loss of solutes by oxidation or precipitation, the filtrate was collected in acid-rinsed polyethylene bottles and acidified with nitric acid to a pH of less than 2.0.

The filtered and acidified samples, representing the dissolved phase, were analyzed at the U.S. Geological Survey laboratory in Arvada, Colo. Several samples were analyzed also by the Kansas Department of Health and Environment, Topeka. The methods used by the U.S. Geological Survey for the analysis of dissolved trace elements are summarized in table 2 and fully described by Fishman and Friedman (1989). The analytical data are stored in the U.S. Geological Survey National Water Information System (NWIS) data base.

Suspended Phase

Water-sediment samples for suspended-phase analysis were collected concurrently with the samples for dissolved-phase analysis. In the laboratory, an aliquot of each water-sediment sample was centrifuged (Horowitz, 1986). If enough solid material was present for analysis, the supernatant material was decanted and discarded, and the settled solid material was freeze-dried. A strong-acid digestion of the solid material yielded a liquid that was analyzed by the methods listed in table 2. Suspended trace-element concentrations, in micrograms per gram, are stored in the U.S. Geological Survey NWIS data base.

This method of determining suspended trace-element concentrations can be contrasted to a more commonly used method. Commonly, a mild-acid digestion of the water-sediment mixture is analyzed to give the total-recoverable concentration, an operationally defined quantity of the amount of trace element adsorbed to and comprising the suspended-sediment particles. The dissolved concentration is subtracted from the total-recoverable concentration to yield a calculated concentration of suspended trace element.

The method used in this study may be more accurate because the measurement is more direct and less derived. One disadvantage, however, is that in samples from clear streams (low-flow conditions) there often was insufficient sediment remaining after centrifugation to perform the analyses. This accounts for some missing suspended trace-element data.

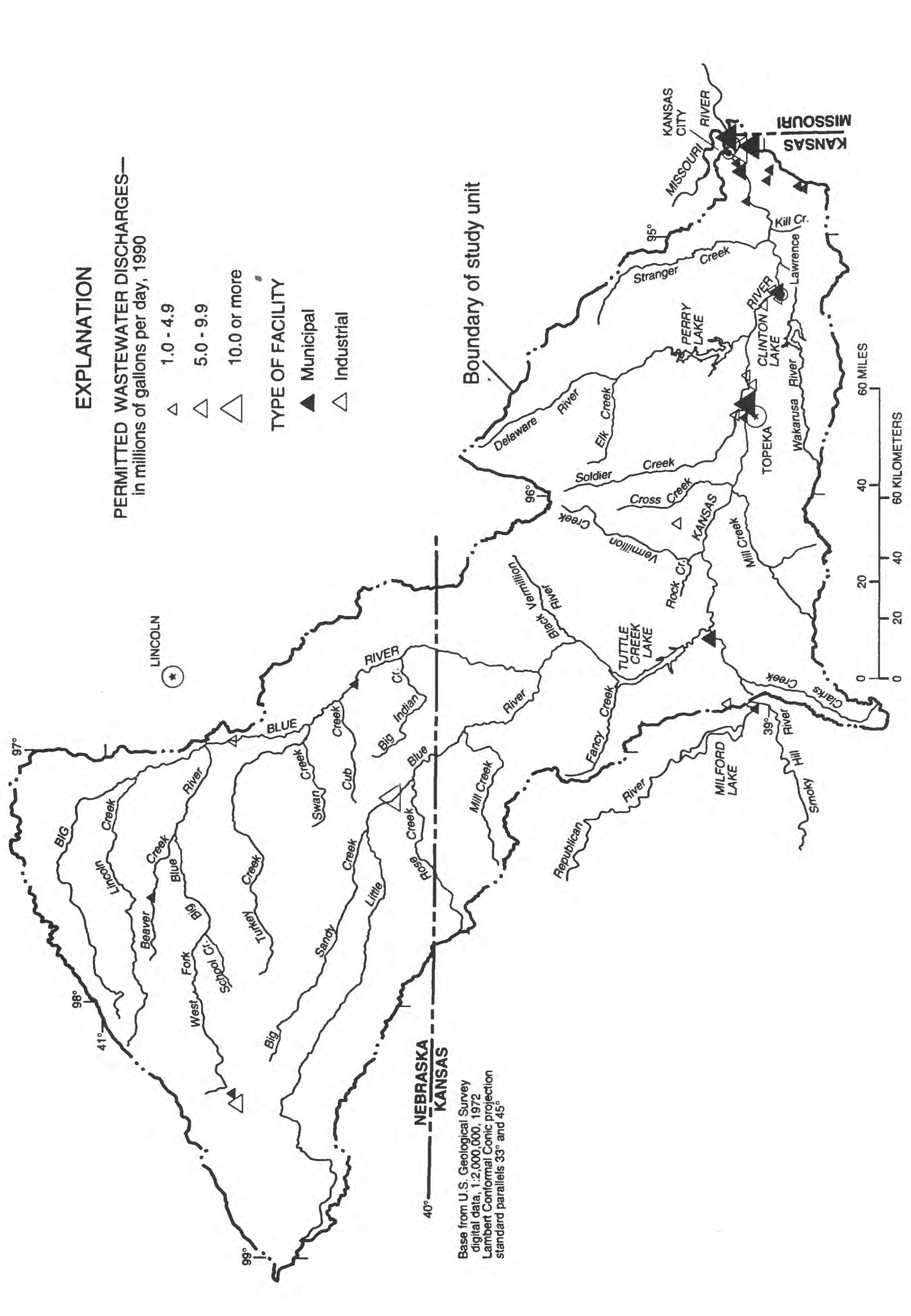

Figure 6. Location and volume of permitted wastewater discharges, 1990 (data from U.S. Environmental Protection Agency National Pollutant Discharge Elimination System).

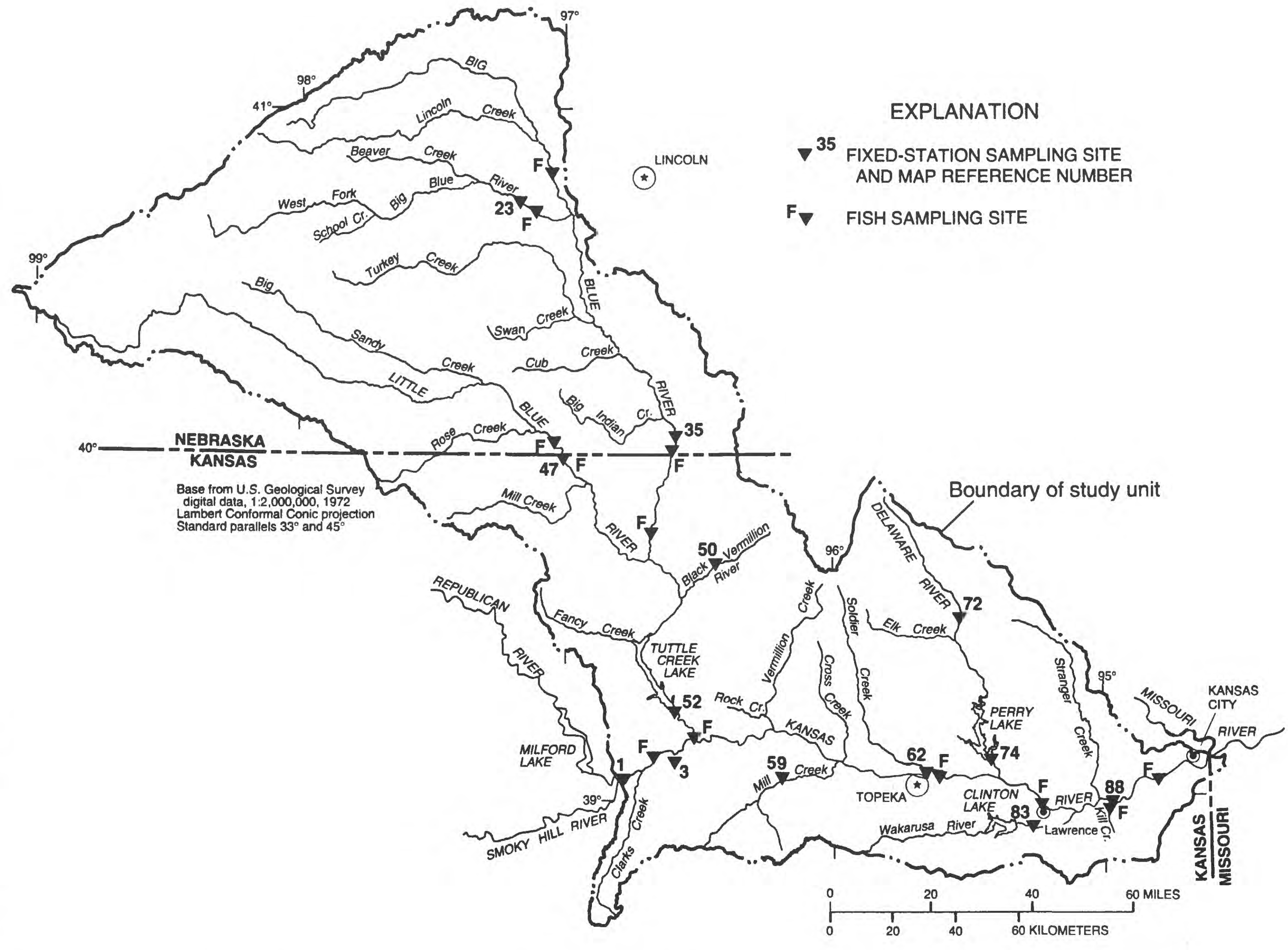

Figure 7. Location and map reference number for fixed-station and fish sampling sites, May 1987–April 1990.

Table 1. Selected streamflow characteristics of fixed-station sampling sites

[Streamflow data used are for water years through 1986 and May 1987-April 1990. Streamflow is in cubic feet per second. Percentile is percentage of time that streamflow was less than rate indicated. Index of variability, dimensionless, is the 90th- minus the 10th-percentile streamflow divided by the median streamflow]

Map reference number (fig. 7)	Site number	Sampling-site name	Drainage area, in square miles	Streamflow data used	Mean streamflow	Streamflow at indicated percentile: 10	50 (median)	90	Index of variability
1	06879100	Kansas River at Fort Riley, Kans.	44,870	1968–90	2,540	409	1,180	6,030	4.8
3	06879650	Kings Creek near Manhattan, Kans.	4.09	1980–90	2.8	0	1.0	6.8	6.8
23	06880800	West Fork Big Blue River near Dorchester, Nebr.	1,206	1959–90	178	44	78	295	3.2
35	06882000	Big Blue River at Barneston, Nebr.	4,447	1933–90	816	95	252	1,650	6.2
47	06884025	Little Blue River at Hollenberg, Kans.	2,752	1975–90	492	106	200	826	3.6
50	06885500	Black Vermillion River near Frankfort, Kans.	410	1954–90	152	3.5	24	213	8.7
52	06887000	Big Blue River near Manhattan, Kans.	9,640	1965–90	2,330	162	937	5,960	6.2
59	06888500	Mill Creek near Paxico, Kans.	316	1955–90	177	4.4	55	322	5.8
62	06889000	Kansas River at Topeka, Kans.	56,720	1968–90	5,990	976	2,900	14,700	4.7
72	06890100	Delaware River near Muscotah, Kans.	431	1970–90	266	5.6	46	427	9.2
74	06890900	Delaware River below Perry Dam, Kans.	1,117	1971–90	689	25	102	2,030	20
83	06891500	Wakarusa River near Lawrence, Kans.	425	1981–90	261	7.9	35	882	25
88	06892350	Kansas River at DeSoto, Kans.	59,756	1971–90	8,210	1,180	3,980	21,200	5.0

Table 2. Methods of trace-elements analysis, U.S. Geological Survey National Water-Quality Laboratory, Arvada, Colo., and Branch of Geochemistry Laboratories, Denver, Colo.

[--, indicated data for this element are not included in this report]

	Analytical method[1]	
	U.S. Geological Survey National Water-Quality Laboratory, Arvada, Colo.	U.S. Geological Survey Branch of Geochemistry Laboratories, Denver, Colo.
Trace element	Dissolved analysis	Suspended-sediment and streambed-sediment analysis
Arsenic	--	Hydride-AAS
Barium	ICP-AES	ICP-AES
Beryllium	--	ICP-AES
Cadmium	--	ICP-AES
Chromium	--	ICP-AES
Cobalt	ICP-AES	ICP-AES
Copper	--	ICP-AES
Lead	--	ICP-AES
Lithium	ICP-AES	ICP-AES
Mercury	--	Cold vapor-AAS
Molybdenum	ICP-AES	ICP-AES
Nickel	ICP-AES	ICP-AES
Silver	ICP-AES	ICP-AES
Strontium	ICP-AES	ICP-AES
Vanadium	ICP-AES	ICP-AES
Zinc	--	ICP-AES

[1]Hydride-AAS, hydride reduction and atomic-absorption spectrometry; ICP-AES, inductively coupled plasma-atomic emission spectrometry; Cold vapor-AAS, cold-vapor generation and atomic-absorption spectrometry.

Streambed Sediment

The streambed-sediment data discussed in this report are from the analyses of the less-than 63-micrometer-sized fraction of samples collected during October 1987 at 62 sites along the main stem of the Big Blue, Little Blue, and Kansas Rivers and their major tributaries. Streambed-sediment samples were collected at least once every 50 stream miles and near known point sources where trace-element enrichment might be expected. The location of these sampling sites is shown in figure 8. Trace-element concentrations in streambed sediment were determined by the methods listed in table 2 and stored in the U.S. Geological Survey NWIS data base. The methods of sample collection, analysis, and quality control, and the data, were published in Tanner and others (1990).

Fish Samples

Fish samples were collected for trace-element analysis as part of the U.S. Environmental Protection Agency's Regional Ambient Fish Tissue Monitoring Program (RAFTMP). The fish samples were collected by the Kansas Department of Health and Environment in Kansas and by the Nebraska Department of Environmental Control in Nebraska (Christiansen, 1988; Kansas Department of Health and Environment, 1988; Christiansen and others, 1989; Cringan, 1989, 1991; Callam and others, 1990). From May 1987 to April 1990, 34 fish samples were collected at 12 stream sites in the lower Kansas River Basin (fig. 7). All samples were of carp *(Cyprinus carpio)*, except for one sample of channel catfish *(Ictalurus punctatus)*. Composited samples of whole fish were collected in accordance with U.S. Environmental Protection Agency Standard Operating Procedure No. FW019C. The samples were processed and analyzed by the Environmental Monitoring and Compliance Branch of the Region VII, U.S. Environmental Protection Agency laboratory in Kansas City, Kans.

DISTRIBUTION OF TRACE ELEMENTS

The concentrations of trace elements varied considerably among and within each of the four sampled phases or media considered. The following sections will describe the distribution of concentrations of trace elements in dissolved and suspended phases, in streambed sediment, and in fish samples. Natural and human-induced factors affecting these concentrations also will be considered.

Dissolved Phase

Statistical summaries of dissolved concentrations for eight trace elements at selected fixed-station sampling sites in the lower Kansas River Basin are presented in table 3. Most of the trace elements were present only in small concentrations in the dissolved phase. The median concentration was smaller than the lower level of detection at more than one-half of the

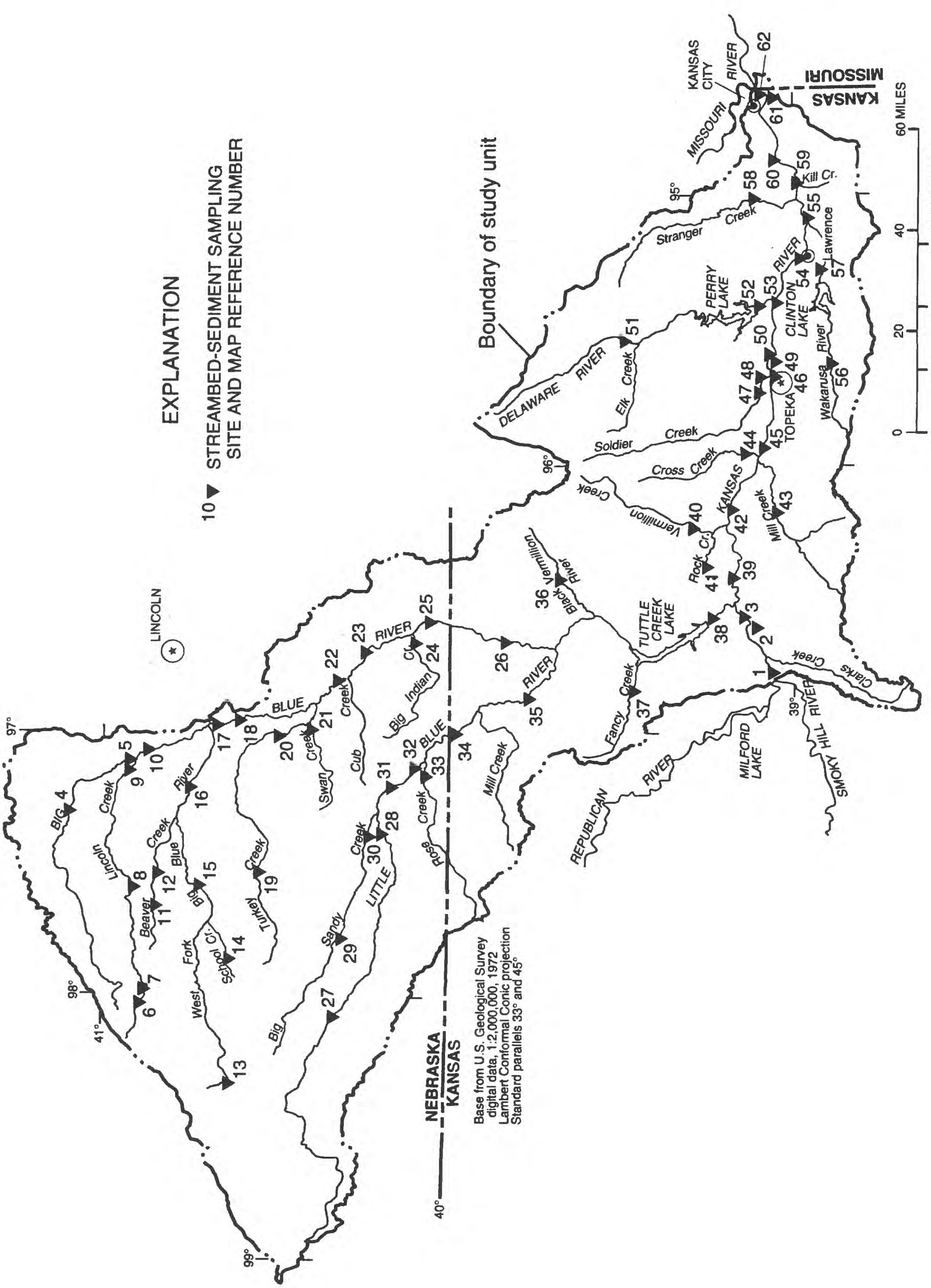

Figure 8. Location and map reference number for streambed-sediment sampling sites on principal streams, October 1987.

Table 3. Statistical summaries of data on dissolved trace elements in water from selected sampling sites in lower Kansas River Basin, May 1987–April 1990

[Concentrations in micrograms per liter. The 10- and 90-percentile values are not shown for sites having fewer than 30 analyses; --, indicates no value; <, indicates less than]

Map reference number (fig. 7)	Sampling-site name	Number of analyses	Concentration at indicated percentile				
			10	25	50	75	90
		Barium, dissolved					
1	Kansas River at Fort Riley, Kans.	38	98	120	130	140	150
3	Kings Creek near Manhattan, Kans.	23	--	80	110	110	--
23	West Fork Big Blue River near Dorchester, Nebr.	43	71	140	160	170	190
35	Big Blue River at Barneston, Nebr.	40	88	110	140	150	170
47	Little Blue River at Hollenberg, Kans.	39	84	130	150	160	190
50	Black Vermillion River near Frankfort, Kans.	41	89	130	160	170	190
52	Big Blue River near Manhattan, Kans.	36	110	120	130	140	150
59	Mill Creek near Paxico, Kans.	39	76	110	130	150	160
62	Kansas River at Topeka, Kans.	36	100	110	130	140	160
72	Delaware River near Muscotah, Kans.	34	96	130	160	190	230
74	Delaware River below Perry Dam, Kans.	32	74	82	100	120	150
83	Wakarusa River near Lawrence, Kans.	28	--	70	80	85	--
88	Kansas River at DeSoto, Kans.	38	97	110	120	140	150
		Cobalt, dissolved					
1	Kansas River at Fort Riley, Kans.	38	<3	<3	<3	<3	<3
3	Kings Creek near Manhattan, Kans.	24	--	<3	<3	<3	--
23	West Fork Big Blue River near Dorchester, Nebr.	43	<3	<3	<3	<3	<3
35	Big Blue River at Barneston, Nebr.	40	<3	<3	<3	<3	<3
47	Little Blue River at Hollenberg, Kans.	39	<3	<3	<3	<3	<3
50	Black Vermillion River near Frankfort, Kans.	41	<3	<3	<3	<3	<3
52	Big Blue River near Manhattan, Kans.	36	<3	<3	<3	<3	<3
59	Mill Creek near Paxico, Kans.	38	<3	<3	<3	<3	<3
62	Kansas River at Topeka, Kans.	36	<3	<3	<3	<3	<3
72	Delaware River near Muscotah, Kans.	17	--	<3	<3	<3	--
74	Delaware River below Perry Dam, Kans.	15	--	<3	<3	<3	--
83	Wakarusa River near Lawrence, Kans.	15	--	<3	<3	<3	--
88	Kansas River at DeSoto, Kans.	38	<3	<3	<3	<3	<3

Table 3. Statistical summaries of data on dissolved trace elements in water from selected sampling sites in lower Kansas River Basin, May 1987–April 1990—Continued

Map reference number (fig. 7)	Sampling-site name	Number of analyses	Concentration at indicated percentile				
			10	25	50	75	90
		Lithium, dissolved					
1	Kansas River at Fort Riley, Kans.	38	20	32	38	48	56
3	Kings Creek near Manhattan, Kans.	24	--	8	11	16	--
23	West Fork Big Blue River near Dorchester, Nebr.	43	5	16	21	24	27
35	Big Blue River at Barneston, Nebr.	40	8	14	21	25	28
47	Little Blue River at Hollenberg, Kans.	39	7	15	18	19	22
50	Black Vermillion River near Frankfort, Kans.	41	4	9	13	16	17
52	Big Blue River near Manhattan, Kans.	36	7	10	14	16	17
59	Mill Creek near Paxico, Kans.	38	7	10	15	18	20
62	Kansas River at Topeka, Kans.	36	14	18	25	31	34
72	Delaware River near Muscotah, Kans.	16	--	9	13	16	--
74	Delaware River below Perry Dam, Kans.	15	--	4	5	6	--
83	Wakarusa River near Lawrence, Kans.	15	--	4	5	6	--
88	Kansas River at DeSoto, Kans.	38	9	15	22	27	30
		Molybdenum, dissolved					
1	Kansas River at Fort Riley, Kans.	38	<10	<10	<10	10	10
3	Kings Creek near Manhattan, Kans.	24	--	<10	<10	<10	--
23	West Fork Big Blue River near Dorchester, Nebr.	43	<10	<10	<10	<10	<10
35	Big Blue River at Barneston, Nebr.	40	<10	<10	<10	<10	<10
47	Little Blue River at Hollenberg, Kans.	39	<10	<10	<10	<10	<10
50	Black Vermillion River near Frankfort, Kans.	41	<10	<10	<10	<10	<10
52	Big Blue River near Manhattan, Kans.	36	<10	<10	<10	<10	<10
59	Mill Creek near Paxico, Kans.	39	<10	<10	<10	<10	<10
62	Kansas River at Topeka, Kans.	37	<10	<10	<10	<10	10
72	Delaware River near Muscotah, Kans.	18	--	<10	<10	<10	--
74	Delaware River below Perry Dam, Kans.	15	--	<10	<10	<10	--
83	Wakarusa River near Lawrence, Kans.	15	--	<10	<10	<10	--
88	Kansas River at DeSoto, Kans.	38	<10	<10	<10	<10	10

Table 3. Statistical summaries of data on dissolved trace elements in water from selected sampling sites in lower Kansas River Basin, May 1987–April 1990—Continued

Map reference number (fig. 7)	Sampling-site name	Number of analyses	Concentration at indicated percentile				
			10	25	50	75	90
		Nickel, dissolved					
1	Kansas River at Fort Riley, Kans.	37	<10	<10	<10	<10	10
3	Kings Creek near Manhattan, Kans.	22	--	<10	<10	<10	--
23	West Fork Big Blue River near Dorchester, Nebr.	43	<10	<10	<10	<10	<10
35	Big Blue River at Barneston, Nebr.	40	<10	<10	<10	<10	<10
47	Little Blue River at Hollenberg, Kans.	38	<10	<10	<10	<10	<10
50	Black Vermillion River near Frankfort, Kans.	40	<10	<10	<10	<10	10
52	Big Blue River near Manhattan, Kans.	35	<10	<10	<10	<10	10
59	Mill Creek near Paxico, Kans.	36	<10	<10	<10	<10	<10
62	Kansas River at Topeka, Kans.	35	<10	<10	<10	<10	10
72	Delaware River near Muscotah, Kans.	31	<10	<10	<10	10	20
74	Delaware River below Perry Dam, Kans.	27	--	<10	<10	<10	--
83	Wakarusa River near Lawrence, Kans.	23	--	<10	<10	<10	--
88	Kansas River at DeSoto, Kans.	37	<10	<10	<10	<10	10
		Silver, dissolved					
1	Kansas River at Fort Riley, Kans.	37	<1	<1	<1	<1	2
3	Kings Creek near Manhattan, Kans.	22	--	<1	<1	<1	--
23	West Fork Big Blue River near Dorchester, Nebr.	43	<1	<1	<1	<1	<1
35	Big Blue River at Barneston, Nebr.	40	<1	<1	<1	<1	<1
47	Little Blue River at Hollenberg, Kans.	38	<1	<1	<1	<1	<1
50	Black Vermillion River near Frankfort, Kans.	39	<1	<1	<1	<1	1
52	Big Blue River near Manhattan, Kans.	35	<1	<1	<1	<1	1
59	Mill Creek near Paxico, Kans.	36	<1	<1	<1	<1	1.3
62	Kansas River at Topeka, Kans.	35	<1	<1	<1	<1	1
72	Delaware River near Muscotah, Kans.	31	<1	<1	<1	<1	1.8
74	Delaware River below Perry Dam, Kans.	30	<1	<1	<1	<1	1
83	Wakarusa River near Lawrence, Kans.	32	<1	<1	1	1	2
88	Kansas River at DeSoto, Kans.	37	<1	<1	<1	<1	1.2

Table 3. Statistical summaries of data on dissolved trace elements in water from selected sampling sites in lower Kansas River Basin, May 1987–April 1990—Continued

Map reference number (fig. 7)	Sampling-site name	Number of analyses	Concentration at indicated percentile				
			10	25	50	75	90
		Strontium, dissolved					
1	Kansas River at Fort Riley, Kans.	38	410	750	980	1,200	1,300
3	Kings Creek near Manhattan, Kans.	24	--	560	960	1,000	--
23	West Fork Big Blue River near Dorchester, Nebr.	43	63	250	350	370	380
35	Big Blue River at Barneston, Nebr.	40	130	260	360	410	440
47	Little Blue River at Hollenberg, Kans.	39	110	270	310	340	360
50	Black Vermillion River near Frankfort, Kans.	41	200	560	670	760	810
52	Big Blue River near Manhattan, Kans.	36	260	350	470	510	540
59	Mill Creek near Paxico, Kans.	39	570	930	1,200	1,500	1,800
62	Kansas River at Topeka, Kans.	36	370	580	760	860	930
72	Delaware River near Muscotah, Kans.	18	--	620	720	1,000	--
74	Delaware River below Perry Dam, Kans.	15	--	260	330	340	--
83	Wakarusa River near Lawrence, Kans.	15	--	240	250	290	--
88	Kansas River at DeSoto, Kans.	38	330	500	660	750	880
		Vanadium, dissolved					
1	Kansas River at Fort Riley, Kans.	38	<6	<6	<6	6	8
3	Kings Creek near Manhattan, Kans.	24	--	<6	<6	<6	--
23	West Fork Big Blue River near Dorchester, Nebr.	43	<6	<6	7	8	10
35	Big Blue River at Barneston, Nebr.	40	<6	<6	6	8	13
47	Little Blue River at Hollenberg, Kans.	39	<6	<6	<6	7	8
50	Black Vermillion River near Frankfort, Kans.	41	<6	<6	<6	8	10
52	Big Blue River near Manhattan, Kans.	36	<6	<6	<6	<6	7
59	Mill Creek near Paxico, Kans.	38	<6	<6	<6	<6	<6
62	Kansas River at Topeka, Kans.	36	<6	<6	<6	<6	8
72	Delaware River near Muscotah, Kans.	17	--	<6	<6	<6	--
74	Delaware River below Perry Dam, Kans.	15	--	<6	<6	<6	--
83	Wakarusa River near Lawrence, Kans.	15	--	<6	<6	<6	--
88	Kansas River at DeSoto, Kans.	38	<6	<6	<6	6	8

sampling sites for the following: cobalt, molybdenum, nickel, silver, and vanadium. There was no discernible pattern to the distribution of concentrations of any trace elements except lithium and strontium.

Dissolved lithium had the largest median concentrations at the three fixed-station sampling sites on the main stem Kansas River, and the median concentration decreased in the downstream direction (fig. 9). Lithium concentrations in the Kansas River probably are due largely to saline ground-water discharge to the Smoky Hill River upstream of the study unit, which was described by Gillespie and Hargadine (1981). Decreasing median concentrations downstream between Fort Riley (site 1) and DeSoto (site 88) probably are the result of saline water from the Smoky Hill River being diluted as other streams flow into the Kansas River.

The relation between dissolved-lithium concentrations and streamflow in the Kansas River at Fort Riley (fig. 10) also suggests a ground-water source of lithium. As streamflow increased at Fort Riley, the concentration of dissolved lithium decreased. Large streamflows are associated with precipitation and runoff, which would tend to dilute the concentrations of lithium contributed by saline ground-water discharge.

Dissolved strontium was similar to dissolved lithium in that median concentrations were relatively large in the Kansas River and decreased downstream (fig. 11). Also, like lithium, strontium concentrations decreased with increasing streamflow in the Kansas River at Fort Riley (fig. 12). Strontium probably also is a component of the saline ground-water discharge to the Smoky Hill River. Large concentrations of dissolved strontium also occurred in Mill Creek near Paxico (site 59 in fig. 11). Permian limestone and shale (fig. 3) upstream of the Mill Creek sampling site are a possible source of dissolved strontium.

Suspended Phase

Statistical summaries for 12 trace elements in the suspended phase at selected fixed-station sampling sites are presented in table 4. There were fewer than 10 analyses at every sampling site for barium, lithium, mercury, and strontium, so analyses for those trace elements were not summarized.

Concentrations of suspended arsenic, chromium, and lead tended to be relatively large at sampling sites directly downstream from the three reservoirs (fig. 7). Concentrations of suspended arsenic were largest in the Delaware River below Perry Dam, Kans. (site 74 in fig. 13; not shown in table 4 because there were fewer than 10 analyses). The median concentration of suspended chromium was largest (100 µg/g, micrograms per gram) in the Wakarusa River near Lawrence, Kans. (table 4), which is downstream from Clinton Lake. The median concentration of suspended lead was largest (120 µg/g) in the Big Blue River near Manhattan, Kans. (table 4), which is downstream from Tuttle Creek Lake. It is possible that turbulence near the dams or the release of water from near the bottom of the reservoirs resulted in resuspension of sediment and the larger suspended concentrations of arsenic, chromium, and lead that were measured. Although large concentrations of arsenic, chromium, and lead in suspended sediment were measured downstream from the reservoirs, the actual amount of transport of these elements is small because, generally, there are small concentrations of suspended sediment downstream of dams. These findings, however, may indicate that storage and transport of trace elements are occurring due to the reservoirs.

Streambed Sediment

To evaluate the effects of human-induced point sources, streambed-sediment samples from principal streams were inspected. Human-induced point sources contain waste materials of complex nature that may cause relatively large concentrations of several trace elements simultaneously in the same streambed-sediment sample. Relatively large, for this purpose, is defined as concentrations exceeding the 90th-percentile concentration of samples from all 62 sampling sites on principal streams in the lower Kansas River Basin. Data from sites having more than two trace elements with concentrations exceeding the respective 90th-percentile concentrations are shown in table 5.

Sampling site 7 on Lincoln Creek is downstream of the wastewater-treatment plant at Aurora, Nebr. (fig. 8). The large concentrations of barium, copper, lead, mercury, and zinc in streambed sediment may originate from the wastewater discharges. There is little streamflow at this upstream site to dilute or transport the wastewater. Except for sampling site 7, there were no large increases in trace-element concentrations in a downstream direction that would have

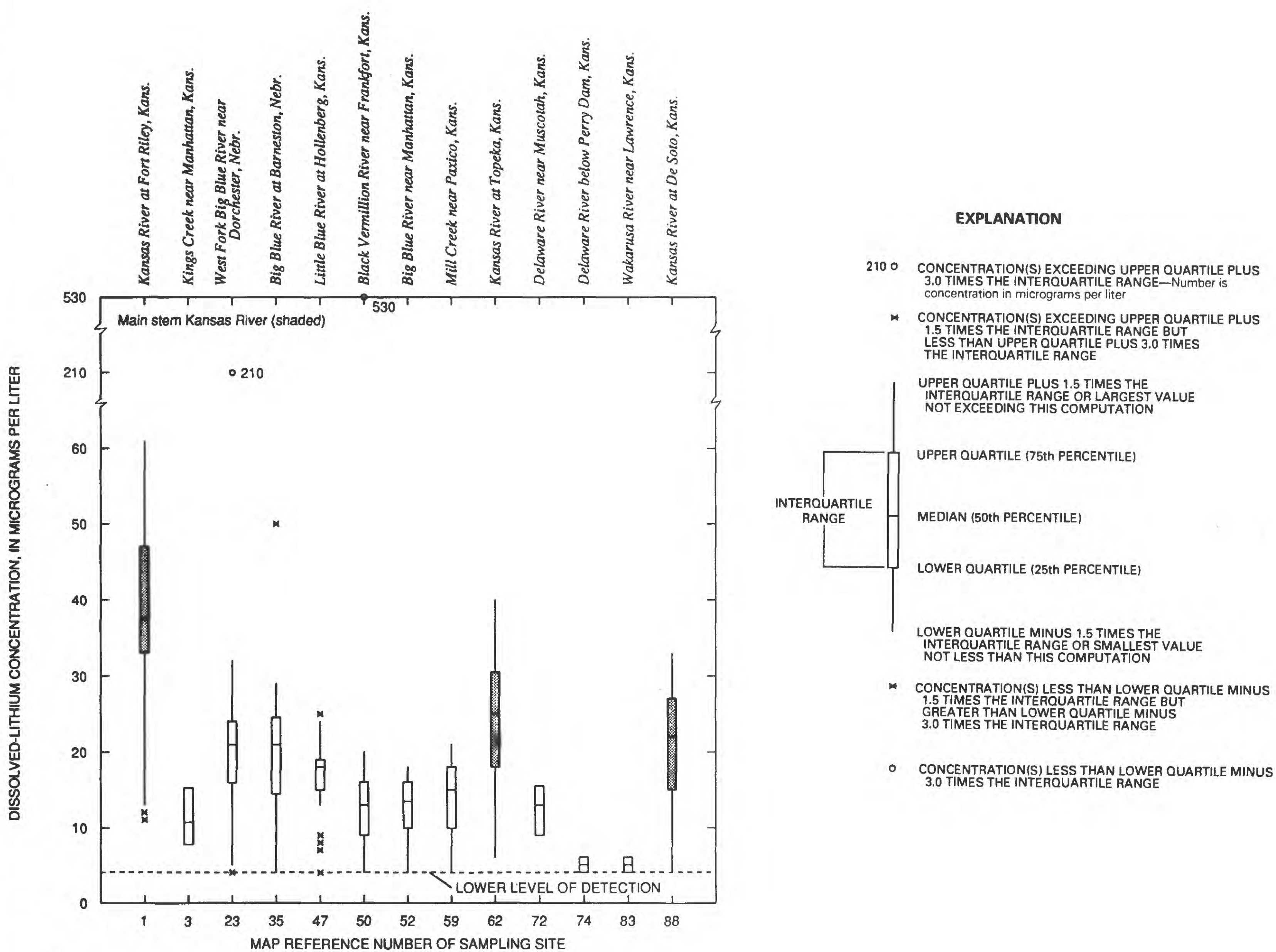

Figure 9. Dissolved-lithium concentrations at fixed-station sampling sites, May 1987–April 1990.

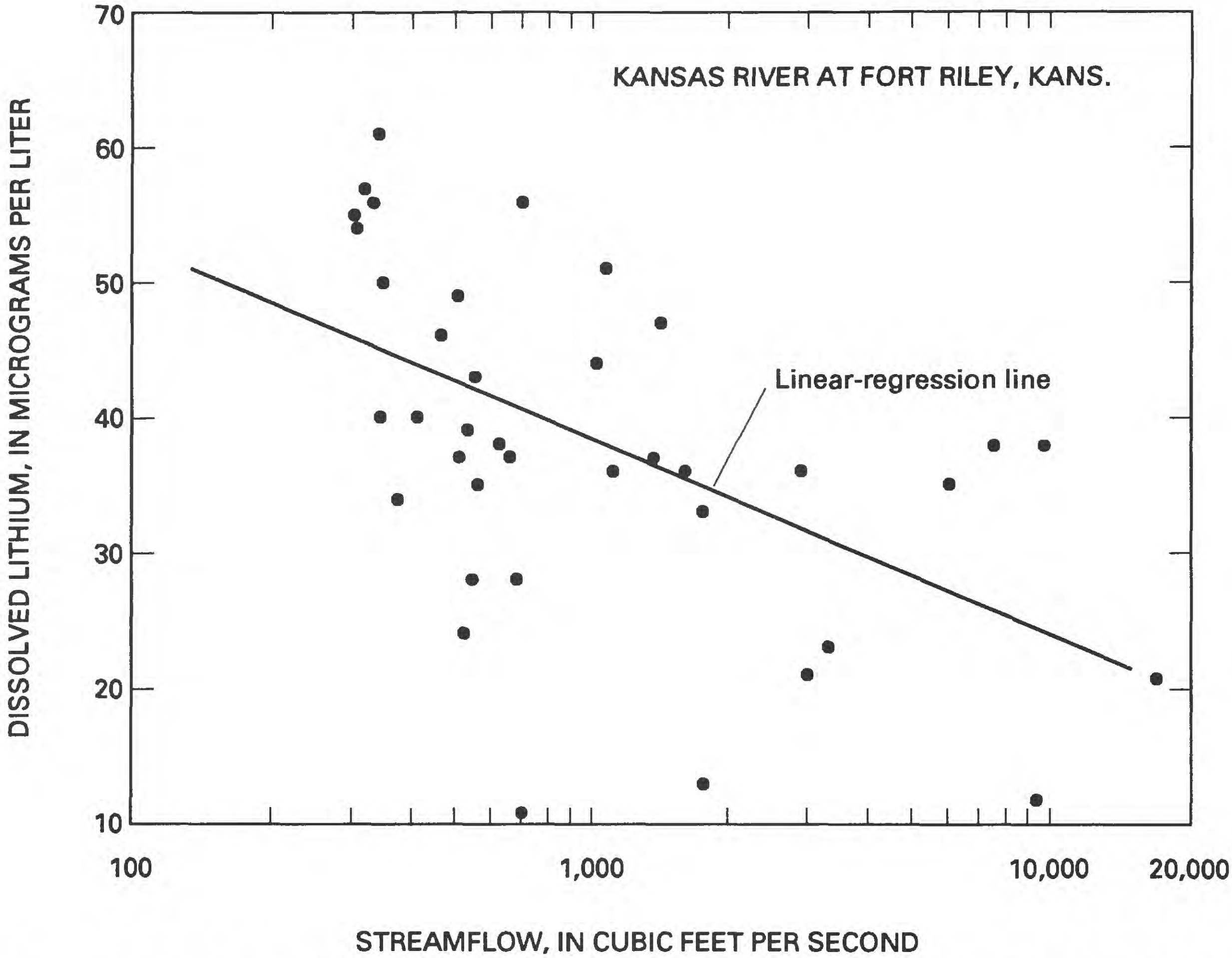

Figure 10. Relation between dissolved-lithium concentrations and streamflow in Kansas River at Fort Riley, Kans., May 1987–April 1990.

indicated a point-source contribution between any two adjacent sampling sites on the same stream.

Sampling site 52 is on the Delaware River below Perry Dam, Kans. (fig. 8). Arsenic, chromium, cobalt, copper, lead, lithium, nickel, vanadium, and zinc concentrations in streambed sediments at this site exceeded the 90th-percentile concentrations. These trace elements probably were resuspended from bottom material in Perry Lake, flushed through the outlet, and settled out as stream velocity decreased downstream of the dam. This idea is supported by the fact that suspended arsenic had the largest concentrations at the fixed-station sampling site on the Delaware River below Perry Dam, Kans. (site 74 in figure 13).

Sampling sites 61 and 62 are in the Kansas City metropolitan area (figs. 5 and 8). Both of these sites had large concentrations of chromium, copper, mercury, nickel, and zinc. These trace elements may originate from wastewater discharge or urban runoff (fig. 6).

Fish Samples

Available fish-sample data for the lower Kansas River Basin are summarized in table 6. Median and 90th-percentile concentrations were compared for five trace elements for two time periods, 1979–86 and 1987–90. Concentrations of four of the elements did not change appreciably between the two time periods. For mercury, the median and the 90th-percentile concentrations approximately doubled from the first time period to the second; these results may be questionable because the other elements did not show such a change. The maximum mercury concentration in any sample from 1987–90 was 275 µg/kg (micrograms per kilogram) from Kill Creek in the southeastern part of the basin (fig. 7). This concentration is still less than the guideline for mercury in fish tissue of 500 µg/kg (National Academy of Sciences and National Academy of Engineering, 1973).

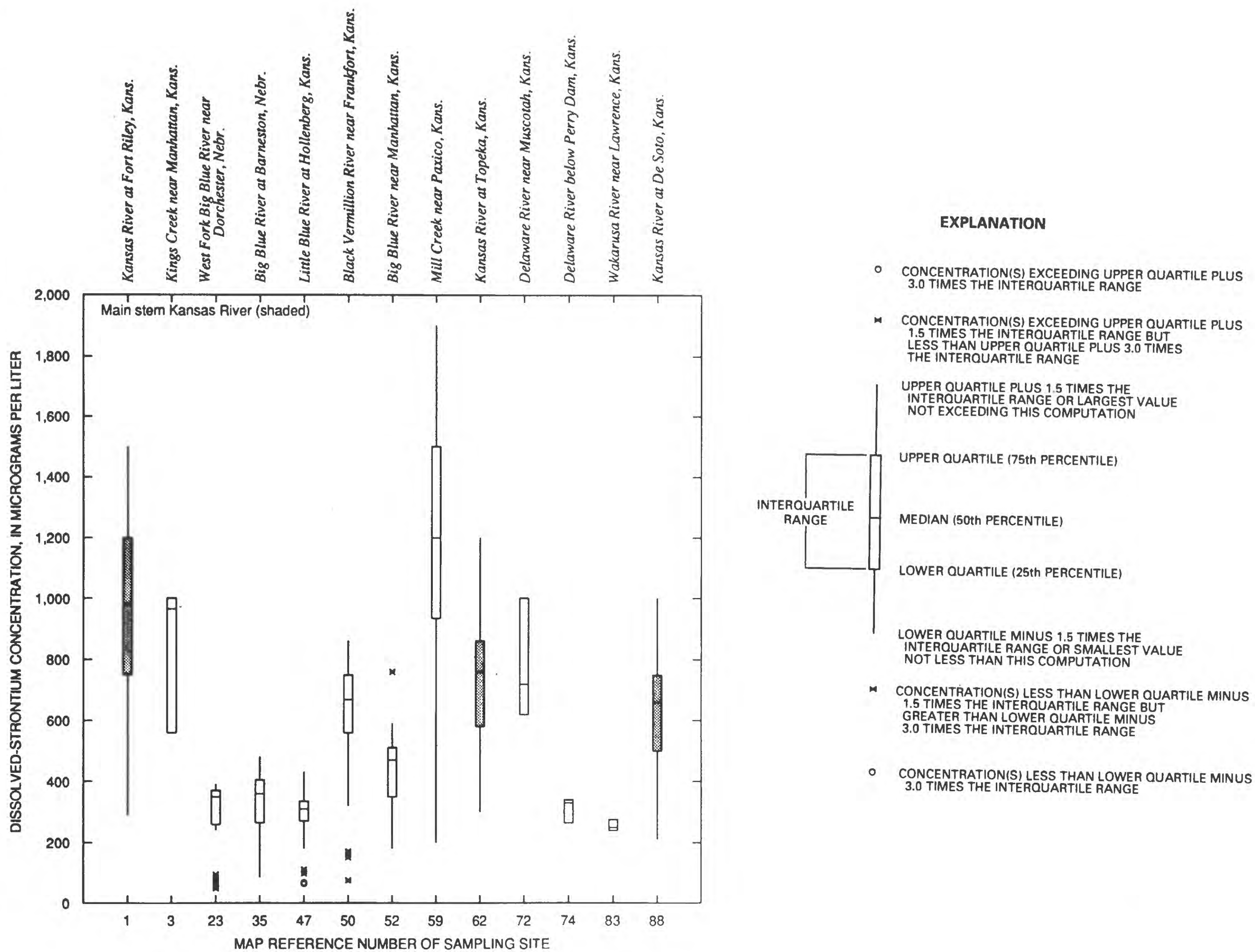

Figure 11. Dissolved-strontium concentrations at fixed-station sampling sites, May 1987–April 1990.

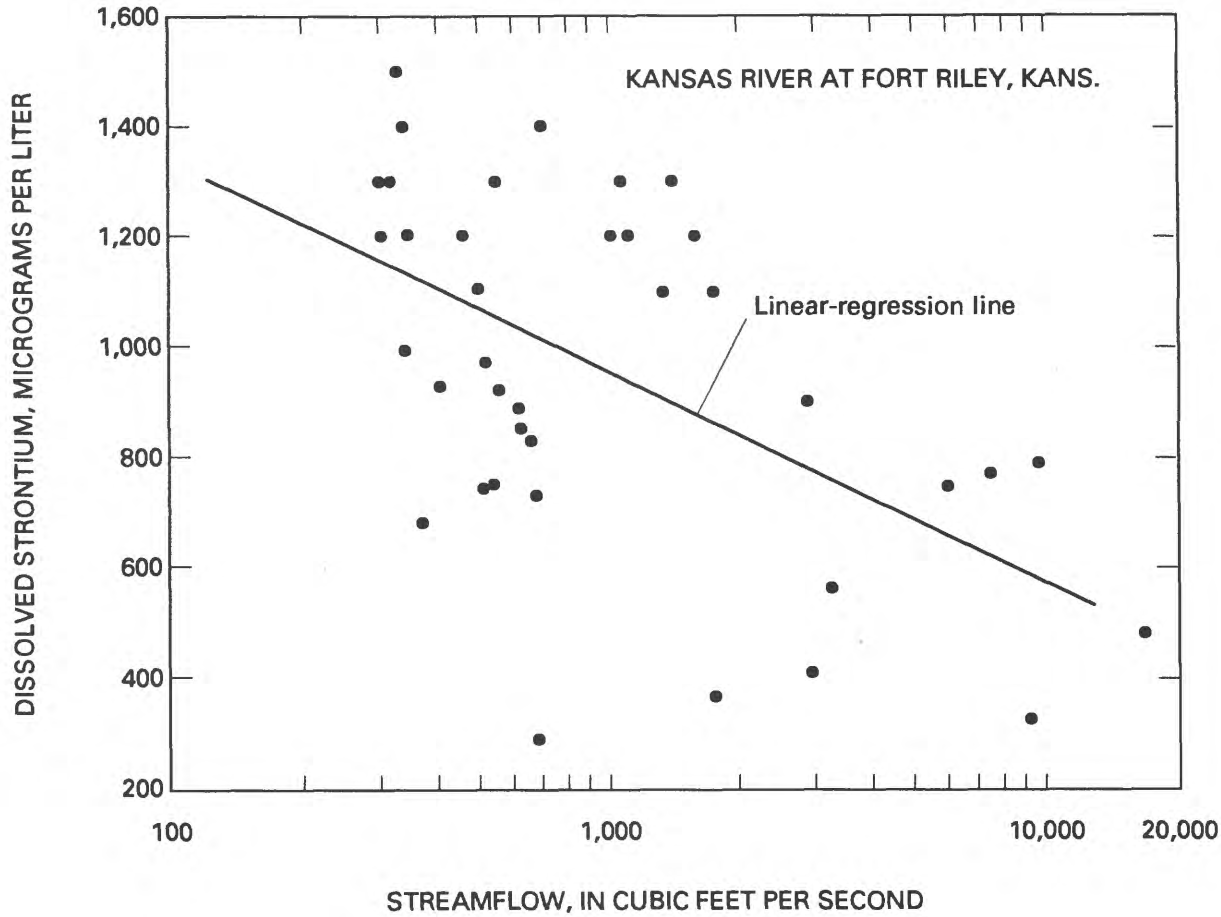

Figure 12. Relation between dissolved-strontium concentrations and streamflow in Kansas River at Fort Riley, Kans., May 1987–April 1990.

CONCLUSIONS

The distribution of trace elements in the dissolved and suspended phases, streambed sediment, and fish samples is described for principal streams in the lower Kansas River Basin of Kansas and Nebraska from May 1987 through April 1990. Relatively large concentrations of some of the trace elements are related to natural and human-induced factors.

Median concentrations of dissolved lithium and strontium generally were largest in water from three sampling sites on the main stem Kansas River, decreased in the downstream direction, and decreased with increased streamflow at the Fort Riley, Kans., fixed-station sampling site. All of these relations indicate that the source of lithium and strontium probably was saline ground-water discharge to the Smoky Hill River upstream of the study unit. Large concentrations of dissolved strontium in Mill Creek near Paxico possibly were derived from Permian limestone and shale upstream from the sampling site.

Concentrations of suspended arsenic, chromium, and lead tended to be large immediately downstream from the three reservoirs in the study unit. This may indicate resuspension of sediment due to turbulent flow near the dams or release of water from near the bottom of the reservoirs.

Relatively large concentrations of several trace elements in streambed sediment near Aurora, Nebr., may be derived from municipal wastewater-treatment plant discharges, and large concentrations at two sampling sites near Kansas City, Kans., may be due to wastewater discharge or urban runoff. Large concentrations of trace elements in streambed sediments at a

Table 4. Statistical summaries of data on trace elements in the suspended phase from selected sampling sites in lower Kansas River Basin, May 1987–April 1990

[Results of analyses in micrograms per gram. This table includes only those stations having 10 or more analyses; the 10- and 90-percentile values are not shown for stations having fewer than 30 analyses; --, indicates no value; <, indicates less than]

Map reference number (fig. 7)	Sampling-site name	Number of analyses	Concentration at indicated percentile				
			10	25	50	75	90
		***Arsenic*, sediment, suspended**					
1	Kansas River at Fort Riley, Kans.	30	5.7	7.2	9.8	12	15
23	West Fork Big Blue River near Dorchester, Nebr.	19	--	7.6	12	14	--
35	Big Blue River at Barneston, Nebr.	13	--	11	13	15	--
47	Little Blue River at Hollenberg, Kans.	19	--	5.4	7.7	13	--
50	Black Vermillion River near Frankfort, Kans.	27	--	13	15	18	--
52	Big Blue River near Manhattan, Kans.	11	--	11	13	14	--
59	Mill Creek near Paxico, Kans.	15	--	7.0	8.8	15	--
62	Kansas River at Topeka, Kans.	27	--	7.2	10	12	--
72	Delaware River near Muscotah, Kans.	25	--	11	13	15	--
83	Wakarusa River near Lawrence, Kans.	25	--	10	12	15	--
88	Kansas River at DeSoto, Kans.	31	4.9	8.0	9.6	12	15
		***Beryllium*, sediment, suspended**					
1	Kansas River at Fort Riley, Kans.	29	--	<2	<2	2	--
23	West Fork Big Blue River near Dorchester, Nebr.	19	--	2	3	3	--
35	Big Blue River at Barneston, Nebr.	13	--	2	3	3	--
47	Little Blue River at Hollenberg, Kans.	19	--	<2	2	3	--
50	Black Vermillion River near Frankfort, Kans.	26	--	2	2	2	--
52	Big Blue River near Manhattan, Kans.	10	--	<2	2	3	--
59	Mill Creek near Paxico, Kans.	14	--	<2	2	3	--
62	Kansas River at Topeka, Kans.	27	--	<2	<2	2	--
72	Delaware River near Muscotah, Kans.	23	--	<2	2	2	--
83	Wakarusa River near Lawrence, Kans.	23	--	2	3	3	--
88	Kansas River at DeSoto, Kans.	28	--	<2	2	2	--
		***Cadmium*, sediment, suspended**					
1	Kansas River at Fort Riley, Kans.	30	0.8	1.4	2.5	4.5	11
23	West Fork Big Blue River near Dorchester, Nebr.	19	--	.7	1.1	1.4	--
35	Big Blue River at Barneston, Nebr.	13	--	.7	1.5	2.7	--
47	Little Blue River at Hollenberg, Kans.	19	--	.7	1.0	2.4	--
50	Black Vermillion River near Frankfort, Kans.	27	--	1.2	1.8	5.4	--
52	Big Blue River near Manhattan, Kans.	11	--	2.5	4.0	7.6	--
59	Mill Creek near Paxico, Kans.	15	--	1.5	3.2	16	--
62	Kansas River at Topeka, Kans.	27	--	1.4	2.5	5.0	--
72	Delaware River near Muscotah, Kans.	25	--	1.1	2.0	8.9	--
83	Wakarusa River near Lawrence, Kans.	24	--	2.1	2.8	6.7	--
88	Kansas River at DeSoto, Kans.	31	.7	1.1	1.7	4.1	10

Table 4. Statistical summaries of data on trace elements in the suspended phase from selected sampling sites in lower Kansas River Basin, May 1987–April 1990—Continued

Map reference number (fig. 7)	Sampling-site name	Number of analyses	Concentration at indicated percentile: 10	25	50	75	90
			***Chromium*, sediment, suspended**				
1	Kansas River at Fort Riley, Kans.	23	--	45	61	75	--
23	West Fork Big Blue River near Dorchester, Nebr.	14	--	64	74	76	--
47	Little Blue River at Hollenberg, Kans.	13	--	47	66	73	--
50	Black Vermillion River near Frankfort, Kans.	19	--	70	79	81	--
52	Big Blue River near Manhattan, Kans.	11	--	68	81	90	--
59	Mill Creek near Paxico, Kans.	15	--	65	74	84	--
62	Kansas River at Topeka, Kans.	27	--	36	51	63	--
72	Delaware River near Muscotah, Kans.	25	--	62	80	90	--
83	Wakarusa River near Lawrence, Kans.	25	--	94	100	110	--
88	Kansas River at DeSoto, Kans.	31	25	45	54	76	87
			***Cobalt*, sediment, suspended**				
1	Kansas River at Fort Riley, Kans.	30	6	8	11	12	13
23	West Fork Big Blue River near Dorchester, Nebr.	19	--	13	14	15	--
35	Big Blue River at Barneston, Nebr.	13	--	11	14	15	--
47	Little Blue River at Hollenberg, Kans.	19	--	10	12	14	--
50	Black Vermillion River near Frankfort, Kans.	26	--	15	16	19	--
52	Big Blue River near Manhattan, Kans.	11	--	11	13	15	--
59	Mill Creek near Paxico, Kans.	15	--	13	15	16	--
62	Kansas River at Topeka, Kans.	27	--	9	11	12	--
72	Delaware River near Muscotah, Kans.	25	--	13	19	25	--
83	Wakarusa River near Lawrence, Kans.	25	--	14	17	18	--
88	Kansas River at DeSoto, Kans.	31	6	9	12	13	14
			***Copper*, sediment, suspended**				
1	Kansas River at Fort Riley, Kans.	30	17	30	34	52	62
23	West Fork Big Blue River near Dorchester, Nebr.	19	--	31	35	50	--
35	Big Blue River at Barneston, Nebr.	13	--	38	47	76	--
47	Little Blue River at Hollenberg, Kans.	19	--	20	32	51	--
50	Black Vermillion River near Frankfort, Kans.	26	--	29	36	54	--
52	Big Blue River near Manhattan, Kans.	11	--	32	60	84	--
59	Mill Creek near Paxico, Kans.	15	--	34	36	48	--
62	Kansas River at Topeka, Kans.	27	--	25	33	47	--
72	Delaware River near Muscotah, Kans.	25	--	30	48	70	--
83	Wakarusa River near Lawrence, Kans.	25	--	34	45	66	--
88	Kansas River at DeSoto, Kans.	31	23	29	39	48	74

Table 4. Statistical summaries of data on trace elements in the suspended phase from selected sampling sites in lower Kansas River Basin, May 1987–April 1990—Continued

Map reference number (fig. 7)	Sampling-site name	Number of analyses	Concentration at indicated percentile: 10	25	50	75	90
		Lead, sediment, suspended					
1	Kansas River at Fort Riley, Kans.	30	22	26	38	57	170
23	West Fork Big Blue River near Dorchester, Nebr.	19	--	28	31	49	--
35	Big Blue River at Barneston, Nebr.	13	--	28	37	43	--
47	Little Blue River at Hollenberg, Kans.	19	--	20	27	35	--
50	Black Vermillion River near Frankfort, Kans.	27	--	30	43	62	--
52	Big Blue River near Manhattan, Kans.	11	--	38	120	190	--
59	Mill Creek near Paxico, Kans.	15	--	31	40	87	--
62	Kansas River at Topeka, Kans.	27	--	23	28	36	--
72	Delaware River near Muscotah, Kans.	25	--	30	40	66	--
83	Wakarusa River near Lawrence, Kans.	24	--	31	38	48	--
88	Kansas River at DeSoto, Kans.	31	20	25	32	43	110
		Molybdenum, sediment, suspended					
1	Kansas River at Fort Riley, Kans.	24	--	1.5	2.8	3.9	--
23	West Fork Big Blue River near Dorchester, Nebr.	14	--	.8	.9	1.1	--
47	Little Blue River at Hollenberg, Kans.	13	--	.6	.9	1.0	--
50	Black Vermillion River near Frankfort, Kans.	20	--	.9	1.4	2.2	--
52	Big Blue River near Manhattan, Kans.	11	--	.9	2.9	5.1	--
59	Mill Creek near Paxico, Kans.	15	--	.7	1.1	2.0	--
62	Kansas River at Topeka, Kans.	27	--	1.4	2.0	3.6	--
72	Delaware River near Muscotah, Kans.	25	--	1.1	3.2	5.3	--
83	Wakarusa River near Lawrence, Kans.	24	--	1.1	1.3	1.7	--
88	Kansas River at DeSoto, Kans.	31	.8	1.2	1.7	3.0	5.6
		Nickel, sediment, suspended					
1	Kansas River at Fort Riley, Kans.	23	--	25	33	38	--
23	West Fork Big Blue River near Dorchester, Nebr.	14	--	33	38	48	--
47	Little Blue River at Hollenberg, Kans.	13	--	28	34	52	--
50	Black Vermillion River near Frankfort, Kans.	19	--	35	43	48	--
52	Big Blue River near Manhattan, Kans.	11	--	34	37	52	--
59	Mill Creek near Paxico, Kans.	15	--	32	41	44	--
62	Kansas River at Topeka, Kans.	27	--	22	29	34	--
72	Delaware River near Muscotah, Kans.	25	--	34	51	62	--
83	Wakarusa River near Lawrence, Kans.	25	--	42	48	57	--
88	Kansas River at DeSoto, Kans.	31	20	25	35	40	45

Table 4. Statistical summaries of data on trace elements in the suspended phase from selected sampling sites in lower Kansas River Basin, May 1987–April 1990—Continued

Map reference number (fig. 7)	Sampling-site name	Number of analyses	Concentration at indicated percentile				
			10	25	50	75	90
		***Silver*, sediment, suspended**					
1	Kansas River at Fort Riley, Kans.	30	<0.1	<0.1	0.2	0.5	0.7
23	West Fork Big Blue River near Dorchester, Nebr.	19	--	.1	.2	.5	--
35	Big Blue River at Barneston, Nebr.	13	--	.1	.2	.5	--
47	Little Blue River at Hollenberg, Kans.	19	--	.1	.2	.4	--
50	Black Vermillion River near Frankfort, Kans.	27	--	.1	.2	.3	--
52	Big Blue River near Manhattan, Kans.	11	--	.2	.2	.7	--
59	Mill Creek near Paxico, Kans.	15	--	.1	.2	.3	--
62	Kansas River at Topeka, Kans.	27	--	.2	.2	.4	--
72	Delaware River near Muscotah, Kans.	25	--	.1	.2	.4	--
83	Wakarusa River near Lawrence, Kans.	24	--	.2	.3	.4	--
88	Kansas River at DeSoto, Kans.	31	.2	.2	.3	.5	.8
		***Vanadium*, sediment, suspended**					
1	Kansas River at Fort Riley, Kans.	30	29	60	92	130	150
23	West Fork Big Blue River near Dorchester, Nebr.	19	--	100	110	140	--
35	Big Blue River at Barneston, Nebr.	13	--	110	130	140	--
47	Little Blue River at Hollenberg, Kans.	19	--	72	92	130	--
50	Black Vermillion River near Frankfort, Kans.	26	--	110	130	130	--
52	Big Blue River near Manhattan, Kans.	11	--	83	110	130	--
59	Mill Creek near Paxico, Kans.	15	--	72	86	110	--
62	Kansas River at Topeka, Kans.	27	--	59	76	110	--
72	Delaware River near Muscotah, Kans.	25	--	82	110	120	--
83	Wakarusa River near Lawrence, Kans.	25	--	120	120	130	--
88	Kansas River at DeSoto, Kans.	31	36	62	90	120	130
		***Zinc*, sediment, suspended**					
1	Kansas River at Fort Riley, Kans.	23	--	120	160	190	--
23	West Fork Big Blue River near Dorchester, Nebr.	14	--	120	160	200	--
47	Little Blue River at Hollenberg, Kans.	13	--	130	160	190	--
50	Black Vermillion River near Frankfort, Kans.	19	--	130	150	190	--
52	Big Blue River near Manhattan, Kans.	11	--	170	180	220	--
59	Mill Creek near Paxico, Kans.	15	--	100	140	180	--
62	Kansas River at Topeka, Kans.	27	--	110	120	170	--
72	Delaware River near Muscotah, Kans.	25	--	140	160	210	--
83	Wakarusa River near Lawrence, Kans.	25	--	170	190	230	--
88	Kansas River at DeSoto, Kans.	31	73	110	140	160	220

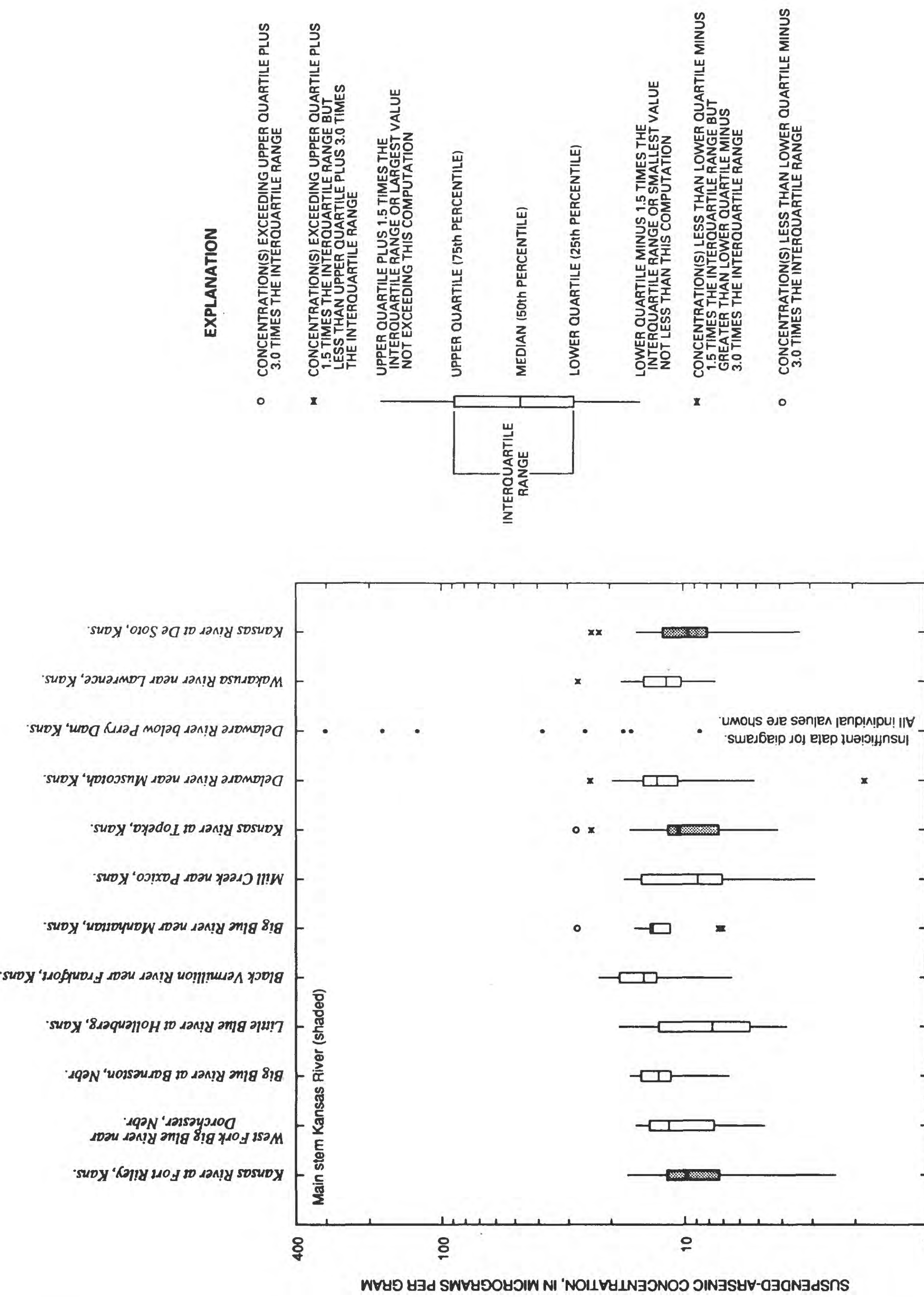

Figure 13. Suspended-arsenic concentrations at fixed-station sampling sites, May 1987–April 1990.

Table 5. Trace-element concentrations exceeding 90th-percentile concentrations in streambed sediment at selected sampling sites on principal streams, October 1987

[µg/g, micrograms per gram; <, indicates less than]

Map reference number (fig. 8)	Location of sampling site	Element	Concentration exceeding 90th-percentile concentration (µg/g)	90th-percentile concentration[1] (µg/g)
7	Lincoln Creek downstream from Aurora, Nebr.	barium	830	800
		copper	24	23
		lead	35	32
		mercury	.10	.08
		zinc	120	94
52	Delaware River below Perry Dam, Kans.	arsenic	17	8.9
		chromium	92	77
		cobalt	17	13
		copper	28	23
		lead	34	32
		lithium	42	36
		nickel	37	29
		vanadium	120	92
		zinc	96	94
61	Turkey Creek near Kansas City, Kans.	chromium	93	77
		copper	48	23
		lead	61	32
		lithium	39	36
		mercury	.24	.08
		nickel	33	29
		silver	8	<2
		zinc	200	94
62	Kansas River near Kansas City, Kans.	arsenic	9.0	8.9
		chromium	82	77
		copper	28	23
		mercury	.10	.08
		nickel	30	29
		vanadium	110	92
		zinc	100	94

[1]90th-percentile concentration of samples at 62 sites on principal streams in lower Kansas River Basin.

sampling site downstream from Perry Lake, Kans., may be the result of redeposition of sediments that were suspended at the dam and outlet.

The median and 90th-percentile concentrations of cadmium, copper, lead, and zinc in fish samples did not change appreciably from 1979–86 to 1987–90.

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Table 6. Summary of data on trace elements in composite samples of whole fish from 14 sampling sites in the lower Kansas River Basin, 1979–86, and from 12 sampling sites, 1987–90

[Concentrations are in micrograms per kilogram; 90th-percentile values are not shown for constituents having fewer than 30 analyses. Source of data is the U.S. Environmental Protection Agency STORET system and Lowe and others (1985, p. 385). --, indicates no value; <, indicates less than]

Element	Number of samples		Median concentration		90th-percentile concentration	
	1979–86	1987–90	1979–86	1987–90	1979–86	1987–90
Cadmium	45	33	70	90	290	250
Copper	41	11	980	1,000	1,600	--
Lead	[1]12	33	150	<500	--	500
Mercury	44	32	50	100	95	220
Zinc	41	10	52,000	51,000	78,000	--

[1]Excludes samples in which analyses had a lower level of detection of 500 micrograms per kilogram.

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☆U.S. GOVERNMENT PRINTING OFFICE: 1995- 659-226/20068