Concentrations, Loads, and Yields of Selected Water-Quality Constituents During Low Flow and Storm Runoff From Three Watersheds at Fort Leavenworth, Kansas, May 1994 Through September 1996

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 98–4001

Prepared in cooperation with the
DEPARTMENT OF ARMY, FORT LEAVENWORTH,
KANSAS

Cover photograph: Sampling site on unnamed tributary at Stimson Avenue, Fort Leavenworth, Kansas.

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By PATRICK P. RASMUSSEN

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For additional information write to:

District Chief
U.S. Geological Survey
4821 Quail Crest Place
Lawrence, Kansas 66049–3839

Copies of this report can be purchased from:

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

Multiply	By	To obtain
acre	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
cubic foot (ft^3)	0.02832	cubic meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
foot per hour (ft/hr)	0.3048	meter per hour
foot per minute (ft/min)	0.3048	meter per minute
gallon (gal)	3.785	liter
inch (in.)	2.54	centimeter
liter (L)	0.2642	gallon
microgram per liter (µg/L)	1.0	part per billion
mile (mi)	1.609	kilometer
milligram per liter(mg/L)	1.0	part per million
picocurie per liter (pCi/L)	0.037	becquerel per liter
pound (lb)	453.6	gram
pound per acre (lb/acre)	1.121	kilogram per hectare
square mile (mi^2)	2.590	square kilometer

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32.$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32) / 1.8.$$

Elevation, as used in this report, refers to distance above or below sea level.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 ˚C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L), micrograms per liter (µg/L), or picocuries per liter (pCi/L).

Water Year: A water year is a 12-month period, from October 1 through September 30, designated by the calendar year in which it ends. Years are water years in the report unless otherwise stated.

Sea Level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Concentrations, Loads, and Yields of Selected Water-Quality Constituents During Low Flow and Storm Runoff From Three Watersheds at Fort Leavenworth, Kansas, May 1994 Through September 1996

By Patrick P. Rasmussen

Abstract

A study of the effects of storm runoff from urban areas on water quality at Fort Leavenworth, Kansas, was conducted from May 1994 through September 1996. The purpose of this report is to present information to assess the current (1994–96) conditions and possible methods for anticipating future water-quality effects from storm runoff and changes in land use. Three sampling sites were established to monitor streamflow and water quality from three watersheds draining the study area. Streamflow was monitored continuously, and water-quality samples were collected during low-flow (12 samples) and storm-runoff (21 samples) conditions to determine mean annual constituent loads.

Constituent concentrations for the most part were smallest during low flow with the exception of major ions, dissolved solids, and some nutrients. Concentrations of suspended solids and total recoverable metals at all three sites were much larger in storm-runoff samples than in low-flow samples—typically an order of magnitude larger than low-flow concentrations. Mean low-flow nutrient concentrations were either larger than or smaller than storm-runoff concentrations depending on the watershed.

Total chloroform and total tetrachloroethylene were the only two volatile organic compounds detected, and acid-base/neutral organic compounds were not detected in any of the samples collected. Eight pesticides were detected in low-flow samples, and 15 pesticides were detected in storm-runoff samples. The only mean concentrations of the selected constituents in this study that exceeded either the U.S. Environmental Protection Agency's Maximum Contaminant Level or the Secondary Maximum Contaminant Level were dissolved solids and total recoverable iron and manganese.

Mean annual loads for 10 selected constituents were estimated for each watershed. Overall, storm runoff contributed more than one-half of the total mean annual loads for 8 of the 10 selected constituents. In fact, more than 70 percent of the mean annual loads for suspended solids and total recoverable copper, lead, and zinc were contributed by storm runoff. More than one-half the mean annual load was contributed during low flow for dissolved solids at all watersheds.

Mean annual yields (mass per unit area) of selected constituents from each watershed indicated few differences between watersheds. The lack of variability of yields among the three watersheds indicates that differences in land uses are small enough that few distinctions can be made between watersheds. Overall, storm runoff contributed more than one-half of the mean annual yields for chemical oxygen demand, suspended solids, most of the selected nutrient constituents, and total recoverable copper, lead, and zinc. Large yields of chemical oxygen demand, suspended

solids, and total recoverable metals during storm runoff from one of the watersheds are probably related to the erosion of exposed soils at construction sites within the watershed. Low yields of suspended solids and total recoverable copper and zinc from another watershed are probably related to retention-storage effects from lakes upstream from the sampling site.

INTRODUCTION

Potential contaminants in storm runoff from urban areas may degrade local water quality and downstream receiving water even though concentrations of many contaminants in runoff from urban areas often are small compared to industrial and municipal wastewater discharges (U.S. Environmental Protection Agency, 1996a). In response to concerns about the quality of storm runoff from urban areas, the U.S. Environmental Protection Agency (EPA), under section 402 of the Water Quality Act of 1987, currently (1998) requires that municipalities with a population of 100,000 or greater, or facilities associated with industrial activities, obtain a National Pollutant Discharge Elimination System (NPDES) permit and monitor the quality of their storm runoff. Many large military installations are required to obtain a NPDES permit because of industrial activities associated with the installation. Relatively small installations, similar to Fort Leavenworth (population of about 6,200 in 1996; U.S. Army, Fort Leavenworth, oral commun., 1997), are not required to obtain a NPDES permit. Nevertheless, Fort Leavenworth is attempting to meet at least some of the NPDES requirements by monitoring the quality of their storm runoff.

Following some of EPA's NPDES requirements, the U.S. Geological Survey (USGS), in cooperation with the U.S. Army Environmental Office at Fort Leavenworth, Kansas, began a 2.5-year study in 1994 to:

1. Characterize the quantity and quality of water discharging during low-flow and storm-runoff conditions at selected sampling sites that represent different combinations of land uses at Fort Leavenworth. This characterization includes an evaluation of water-quality constituent concentrations and loads at selected stream sampling sites.
2. Determine if previously developed equations by Driver and Tasker (1990) for estimating constituent loads and mean concentrations in urban stormwater can be used to reasonably estimate loads and concentrations for urban watersheds in the Fort Leavenworth area.

Results of this study will provide improved understanding of characterization and evaluation of water quality in urban areas similar to Fort Leavenworth.

Purpose and Scope

The purpose of this report is to present information to assess stream water-quality conditions and possible methods for anticipating future water-quality effects from storm runoff and changes in land use. The report includes: (1) presentation of estimates of annual mean concentrations, loads, and yields of selected water-quality constituents during low-flow and storm-runoff conditions and (2) evaluation of previously developed procedures to estimate loads and mean concentrations.

Description of Study Area

Fort Leavenworth is located in Leavenworth County, northeast Kansas, about 10 mi north of Kansas City, Kansas, along the Kansas-Missouri State line (fig. 1). The fort is bounded along the north and east sides by the Missouri River. The city of Leavenworth and U.S. Department of Justice property (Leavenworth Federal Penitentiary) are adjacent to the south boundary, and wooded acreage and farmland are found along the west boundary.

Fort Leavenworth was established in 1827 and is the oldest fort west of the Mississippi River still in existence (Frontier Army Museum, Fort Leavenworth, oral commun., 1997). For 30 years it was the chief base of operations for the frontier, providing a military buffer zone between settlers and Native American tribes. During the 1830s and 1840s thousands of wagons bound for the Oregon and Santa Fe Trails crossed the Missouri River and passed through the fort. Between 1846 and 1848, the fort was the outfitting post for the Army of the West during the war with Mexico. The National Cemetery, dedicated by President Abraham Lincoln in 1862, has more than 19,000 veterans buried, representing every war America has participated in since 1912. In 1873, the U.S. Disciplinary Barracks (DB) was established, and today (1998) is the only military maximum security facility. A school, which later became the Command and General Staff

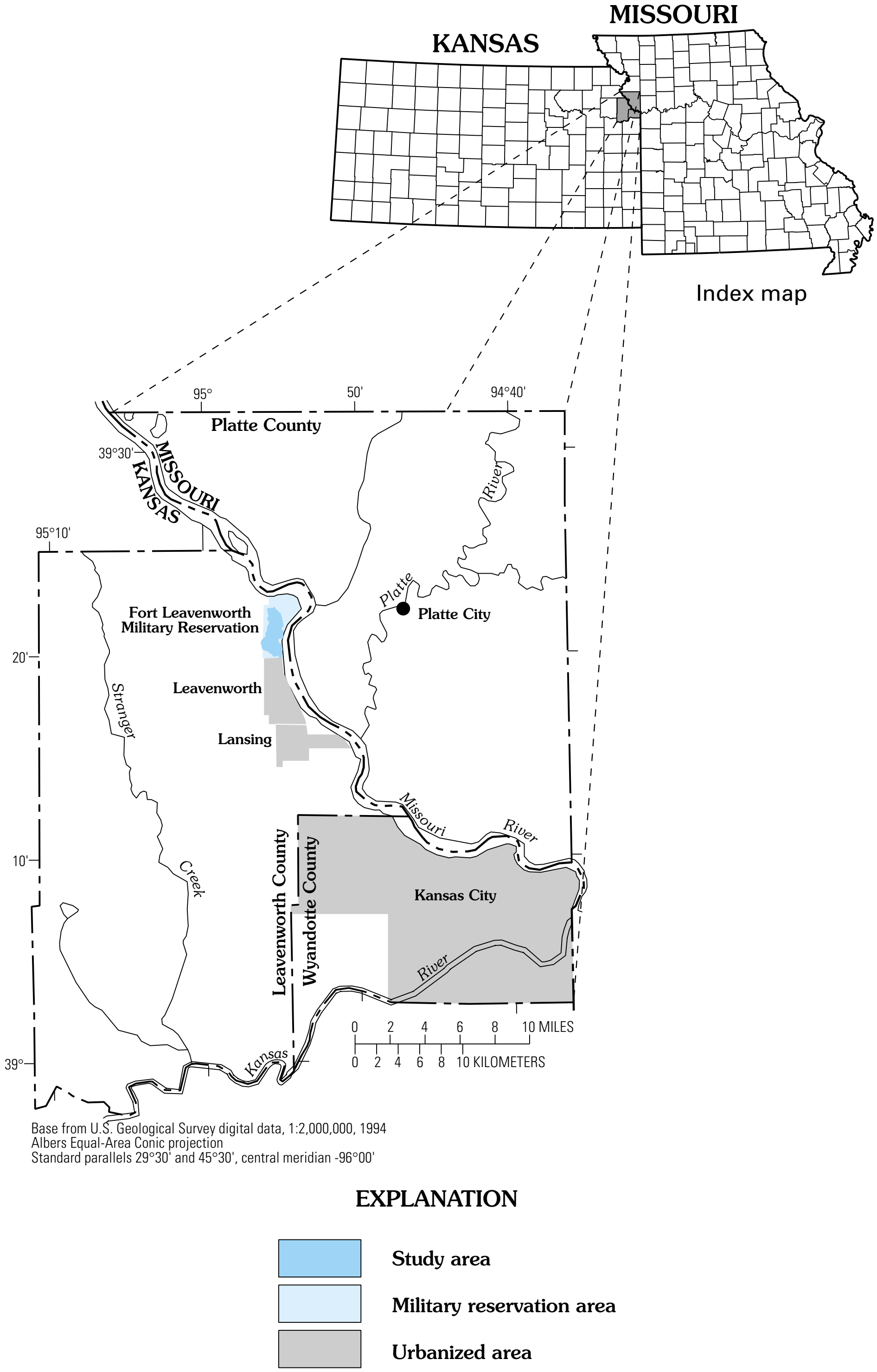

Figure 1. Location of Fort Leavenworth Military Reservation and study area, northeast Kansas.

College (CGSC), was established in 1881. CGSC is the most advanced school of military tactics in the Army educational system, and today is the primary function at Fort Leavenworth.

Topography and Soils

Fort Leavenworth occupies about 9 mi^2 of land along the Missouri River. Most of the fort was built on the uplands adjacent to the Missouri River. About 4 mi^2 are in the flat bottoms of the Missouri River flood plain. The flood plain has soils of deep, silty-clay loam that are nearly level and somewhat poorly drained (Zaresky and Boatright, 1977). The slope within the flood plain is less then 1 percent. Soils on the upland, rolling hills were formed in loess and are a silt loam and silty-clay loam. The soils along steep slopes and in the upland areas are thick and well drained. The soils in the low-land areas of the rolling hills are poor to moderately well drain and are thick. The slope in the hilly section of the fort ranges from 4 to 35 percent. Land surfaces within the fort's boundary range from about 755 ft above sea level at the Missouri River to about 1,080 ft above sea level on the highest ridge along the west boundary (fig. 2).

Land Use

The activities at Fort Leavenworth are atypical of activities at most Army installations. There is almost no heavy equipment (tanks, artillery, or helicopters) at the installation. The major activities at Fort Leavenworth are the CGSC, the DB, Sherman Army Airfield, and associated administrative functions.

Land use at Fort Leavenworth is similar to a small city. The fort has single- and multiple-family housing, with three elementary schools and one junior high school, shopping centers, a hospital, bank, and a golf course. The remainder of the urban area consists of CGSC buildings, DB buildings, Sherman Army Airfield, roads, parking lots, urban-open spaces, and administration buildings. There are several small lakes at the fort; the two largest lakes are Merritt and Smith Lakes near the center of the urban area. Agricultural and undisturbed native grasses and forest areas surround the urban area.

A 1993 digital computer map provided by Fort Leavenworth was used to determine the areas of land use and watersheds within and near the fort's boundary. Land uses were delineated by six general classifications: (1) nonurban, (2) urban open area, (3) residential, (4) commercial, (5) industrial, and (6) lakes or open-water areas. The areal distribution of the six land-use classifications within the study area during 1993 is shown in figure 3. Specific land uses for each classification are as follows:

Nonurban—Cropland, pasture, forest, rural vacant, and undisturbed native grass.

Urban open area—All open grassland or wooded areas within the urban part of the study area, such as parks, a golf course, cemeteries, greenbelts along waterways, vacant undeveloped land, and open tracts of land.

Residential—Single- and multiple-family housing.

Commercial—Schools, offices, retail businesses, a hospital, and a bank.

Industrial—Warehouses, an airfield, and a vehicle maintenance shop.

Forty-six percent of the land use within the study area in 1993 was nonurban. Urban open areas were 26 percent of the land use in the study area. The remaining lands in the study area were mostly residential and commercial areas, and less than 1 percent were classified as industrial.

Climate

The Fort Leavenworth area has a wide range of monthly temperature extremes and uneven rainfall distribution throughout the year. Mean annual temperature and precipitation for 1961–90 at Leavenworth, Kansas, is 56.6 ^oF and 40.5 in., respectively (National Oceanic and Atmospheric Administration, NOAA, 1992). The mean air temperature for January is 27 ^oF and for July is 76 ^oF. Seventy percent of the mean annual rainfall occurs during the warm growing season, April through September.

Precipitation data from the NOAA precipitation gage in Leavenworth, Kansas, indicated that monthly rainfall totals during the study period, May 1994 through September 1996, were mostly less than the 30-year mean monthly totals with two notable exceptions (fig. 4). Precipitation totals for May 1995 and June 1996 were the largest ever recorded at that site for May and June since 1948 (Mary Knapp, State Climatologist, Kansas State University, oral commun., 1997).

Surface-Water Hydrology

The main surface-water features in Leavenworth County are the Kansas and Missouri Rivers and their tributaries. The west and south parts of Leavenworth

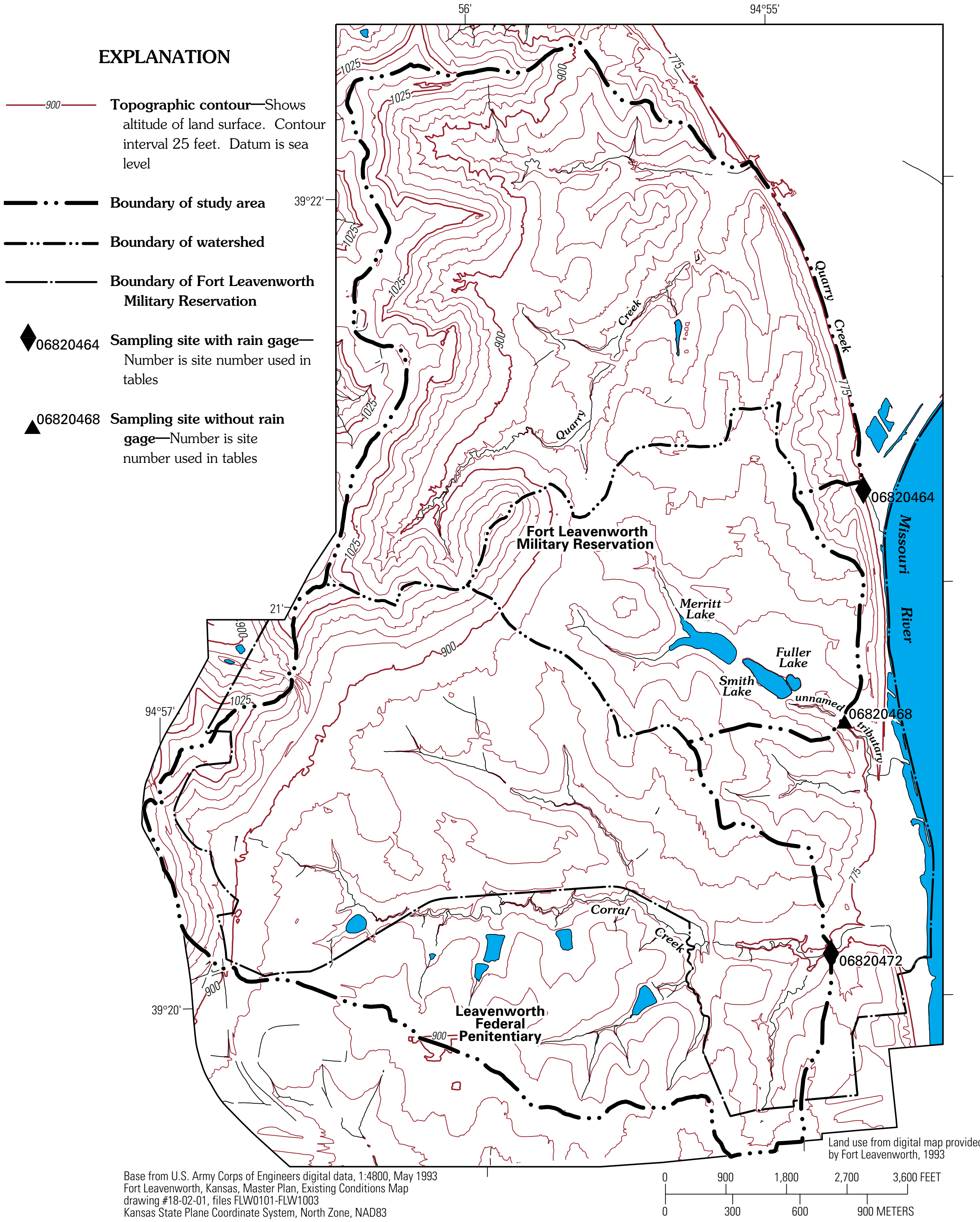

Figure 2. Topography, watershed boundaries, and sampling sites in study area.

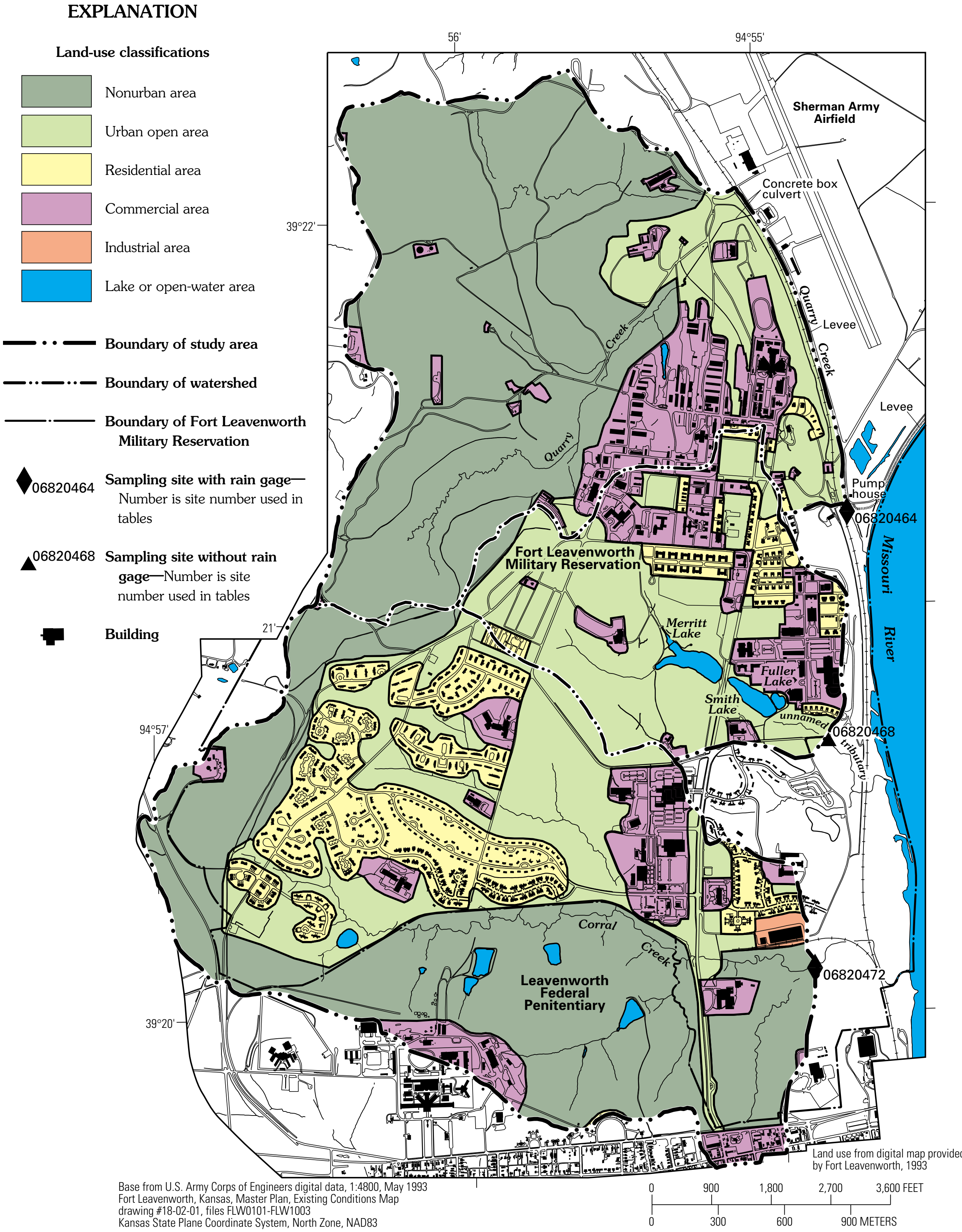

Figure 3. Land use in study area at Fort Leavenworth, Kansas.

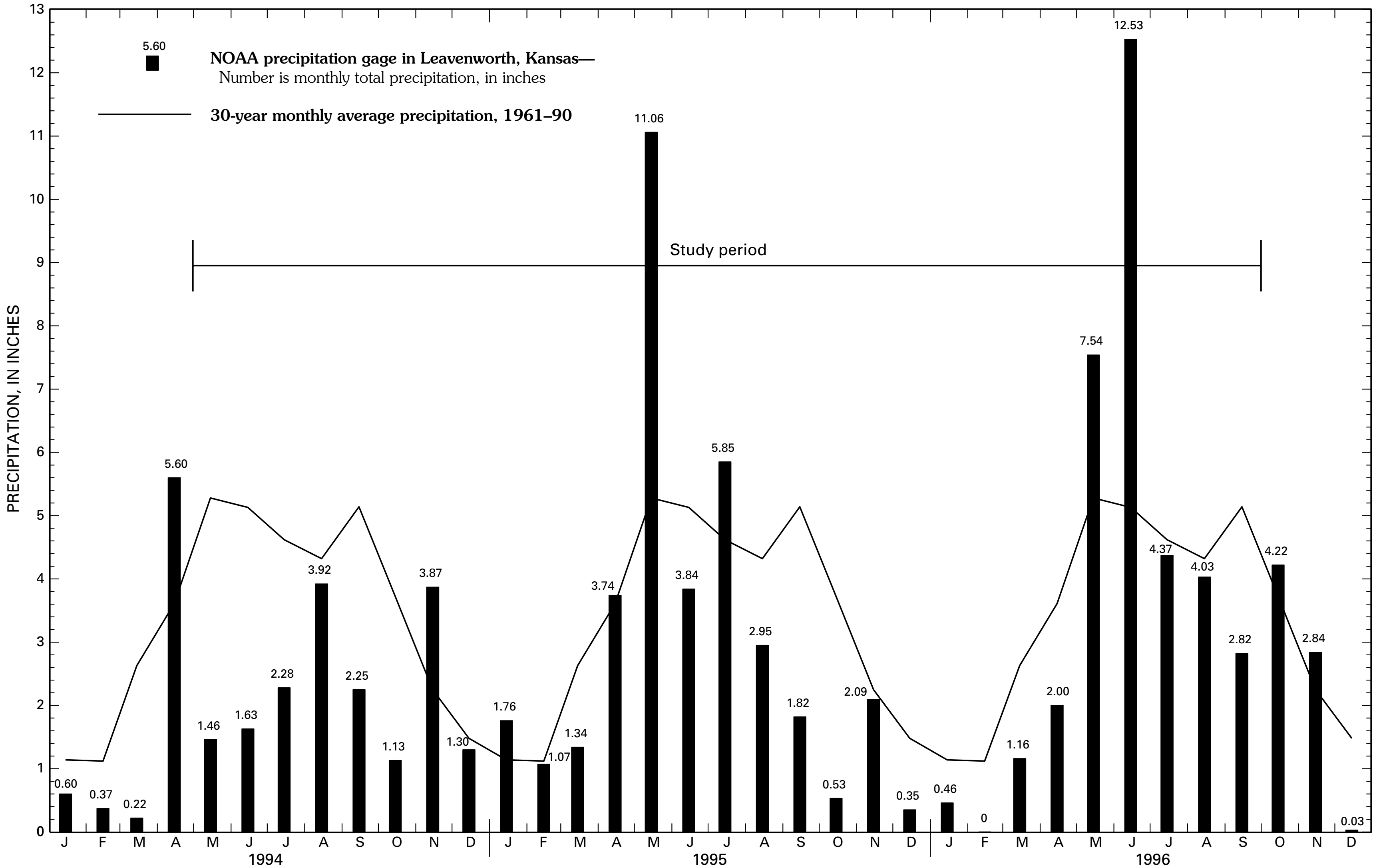

Figure 4. Comparison of monthly total precipitation from January 1994 through December 1996 at National Oceanic and Atmospheric Administration (NOAA) precipitation gage in Leavenworth, Kansas, with mean monthly precipitation for 1961–90 (NOAA, 1992, 1994–96).

County are drained by the Kansas River and its tributaries. The width of the Kansas River Valley along the south boundary of the county is slightly more than 1 mi. The east part of Leavenworth County drains into the Missouri River and its tributaries. The Missouri River Valley is 2 to 3 mi wide in the vicinity of the study area.

The study area is drained by Quarry and Corral Creeks and an unnamed tributary to the Missouri River (fig. 2). Each stream flows from the upland area of Fort Leavenworth, east to the Missouri River. Runoff within the study area flows overland either into one of the three streams or through a storm-water drainage system that consists of gutters, grates, and concrete pipes and then into one of the streams. There are three lakes along the unnamed tributary—Merritt, Smith, and Fuller Lakes (fig. 2).

Acknowledgments

The author expresses appreciation to Ronald Banks, Environmental Specialist, and the entire Environmental Office at Fort Leavenworth, for assistance in coordinating the study and for providing information about Fort Leavenworth.

DESCRIPTION OF SAMPLING SITES

Sampling sites were selected on the basis of the location of urban areas within the fort, the size of the contributing watersheds, and the proximity of the Missouri River. Sites were selected that would represent the maximum urban drainage area of the watersheds while minimizing the effects of backwater from the Missouri River. Three sampling sites were selected in open channels that drain three separate watersheds: (1) Quarry Creek at the Missouri River (site 06820464, fig. 2), (2) unnamed tributary at Stimson Avenue, Fort Leavenworth (site 06820468, fig. 2), and (3) Corral Creek at Fort Leavenworth (site 06820472, fig. 2). Together, the three sites represent about 83 percent of Fort Leavenworth's urban area and about 38 percent of the fort's total area. Sixty-two percent of the fort's impervious area is contained within the three watersheds (fig. 3). A description of selected land-use data for the three watersheds is listed in table 1.

Site 06820464 (fig. 2) is located on Quarry Creek 400 ft upstream from the Missouri River. Quarry Creek drains about 1.45 mi^2 (table 1) of the north, hilly part of Fort Leavenworth. The natural stream channel for the upstream part of the watershed mostly drains nonurban and urban open areas and includes some commercial areas. As the main stem of the stream flows northeast towards the Missouri River flood plain, the stream channel is confined to an underground concrete box culvert for about 1,700 ft (fig. 3). The main stem of Quarry Creek combines with a major tributary from the northwest and flows south parallel to the train tracks and steep hills along the west bank and a levee along the east bank. As the stream flows south, five corrugated steel pipes that drain impervious areas of the watershed outfall along the west bank. The location of sampling site 06820464 was selected primarily to collect runoff and water-quality information from the watershed, including the five outfalls draining into the stream. Some of the runoff within the watershed is drained downstream from the sampling site. This location was ideal for collecting representative runoff from nearly all the watershed; however, it had a high potential for being affected by backwater from the Missouri River. When the stage of the Missouri River is greater than the elevation of the sampling site, the water at the site becomes a mixture of Missouri River water and water from the Quarry Creek watershed.

The Missouri River flood plain is adjacent to the eastern part of the Quarry Creek watershed boundary (figs. 2 and 3). A levee surrounds the west part of the flood plain where Sherman Army Airfield and several water-supply wells are located. The levee helps prevent the Missouri River from flooding this section of Fort Leavenworth. Runoff in the south part of this area flows towards a pump on the southwest part of the flood plain near the levee. The water is pumped from the flood plain into Quarry Creek 30 ft upstream from the sampling site on Quarry Creek.

Site 06820468 (fig. 2) is located 2,000 ft upstream from the Missouri River at the intersection of an unnamed tributary and Stimson Avenue. The drainage area upstream from the site is about 0.67 mi^2 of the upland part of the fort adjacent to the Quarry Creek watershed. The unnamed tributary's watershed includes three lakes near the center of the area. More than one-half of the drainage area is urban open area (golf course and historical site), and 37 percent of the watershed is classified as commercial and residential (CGCS and administrative buildings). The upstream part of the watershed contains a golf course and some impervious, urban areas. Runoff from this upstream area drains into Merritt Lake and subsequently into a

Table 1. Description of and selected land-use data for sampling sites at Fort Leavenworth, Kansas

[<, less than]

Sampling site number (fig. 2)	Site name	Latitude and longitude	Watershed drainage area (square miles)	Percentage of impervious area in watershed	Watershed land-use classification	Percentage of total watershed area[1]
06820464	Quarry Creek at Missouri River, Fort Leavenworth, Kansas	39°49'18" 94°54'44"	1.45	10	Nonurban	70
					Urban open area	14
					Residential	<1
					Commercial	15
					Industrial	0
					Lakes or open water	<1
06820468	Unnamed tributary at Stimson Avenue, Fort Leavenworth, Kansas	39°20'50" 94°54'42"	.67	54	Nonurban	2
					Urban open area	58
					Residential	13
					Commercial	24
					Industrial	1
					Lakes or open water	2
06820472	Corral Creek at Fort Leavenworth, Kansas	39°20'09" 94°55'01"	1.91	13	Nonurban	45
					Urban open area	23
					Residential	20
					Commercial	11
					Industrial	<1
					Lakes or open water	<1

[1]The sum of the land-use percentages may not equal 100 percent due to rounding errors.

150-ft long pipe that drains into Smith Lake. Some of the impervious and urban areas for the watershed drain directly into Smith and Fuller Lakes. Seven storm-drainage pipes from nearby parking lots outfall along the banks of the two lakes. Smith and Fuller Lakes are hydrologically connected. Each lake drains separately into the unnamed tributary about 800 ft upstream from the sampling site. Three outfalls, primarily draining impervious areas (parking lots and buildings), discharge into the unnamed tributary between the lake outfalls and the sampling site.

The elevation of the unnamed tributary sampling site is about 4 ft higher than the elevation of the Quarry Creek site. Therefore, the potential for the unnamed tributary sampling site to be affected by backwater from the Missouri River is somewhat less than the backwater potential at the Quarry Creek site.

Site 06820472 (fig. 2) is located on Corral Creek about 2,200 ft upstream from the Missouri River. The drainage area represented by this site is about 1.91 mi^2 of the Corral Creek watershed. The watershed includes about 1.3 mi^2 of the southern, most hilly section of the fort and about 0.6 mi^2 of land that is outside the Fort Leavenworth boundary. The land use of the watershed outside of the fort's boundary consists of commercial and agricultural areas associated with Leavenworth Federal Penitentiary and a commercial area of the city of Leavenworth. The land use of the watershed within the fort's boundary consists of mostly nonurban and urban open areas and the largest residential area of the three watersheds. Runoff for most of the impervious areas of the watershed flows through storm-drainage pipes and discharges at 43 locations along Corral Creek or its tributaries.

The main stem of Corral Creek begins in the high bluffs along the fort's west boundary. The stream generally flows in an easterly direction and receives drainage from the large residential area and from about one-half of the Leavenworth Federal Penitentiary area. The contributing drainage area from the penitentiary is mostly nonurban. Downstream from the penitentiary, Corral Creek combines with a large tributary that drains the residential area north of the main stem. Land use along Corral Creek downstream from this confluence consists of commercial, nonurban, and urban open areas. Some of the nonurban and urban open areas include dense timber. Much of the nonurban land is pasture for cattle. A herd of about 25 cows grazed upstream from the Corral Creek sampling site during the first 1.5 years of the study. As observed during site visits, the cattle frequently stood in and near Corral Creek just upstream from the sampling site during warm weather. During the winter of 1996, the cattle were removed from this area of the watershed.

The Corral Creek watershed contained two large construction sites during the study period. Vegetation was cleared from these sites exposing soils for construction of buildings, parking lots, and access roads.

DATA COLLECTION AND ANALYSIS

Streamflow and water-quality data were collected from May 1994 through September 1996 to characterize the water quality and evaluate procedures for estimating mean storm-runoff loads for selected properties and constituents in streams draining Fort Leavenworth. Samples were collected manually during low flow and with automatic samplers during storm runoff so that water quality could be characterized for both flow conditions. Precipitation data were collected at two of the three sampling sites (fig. 2).

Streamflow and Precipitation

Continuous stream-stage (water-surface elevation) data were collected at the three sampling sites from May 1994 through September 1996 with USGS stream-gaging equipment. Each sampling site was equipped with a Sutron model 8200 or 8210 data logger/transmitter. The logger was programmed to collect stream-stage data according to rate of change in stream stage. Stream-stage data were collected hourly during steady (rate of change less than 0.01 ft/hr) low-flow conditions and as frequently as every 5-minutes during rapid stream-stage, storm-runoff fluctuations (rate of change greater than 0.01 ft/min). The stream stage was measured with a gas-purge system and a nonsubmersible, pressure transducer. The gas-purge system reacted to changes in stream stage with proportional changes in pressure. The pressure transducer measured the pressure in the gas-purge system and converted the pressure reading to a reading of unit length (feet). The converted measurements were stored by the data logger to await subsequent transmittal and determination of how much the stream stage was changing and to determine whether to log the reading or wait for the next measurement. Streamflow measurements (Rantz and others, 1992) were made manually throughout the study period to develop, verify, and adjust stage-streamflow relationships that were used to calculate instantaneous and daily mean streamflow values according to procedures presented in Kennedy (1983). Daily mean streamflow is presented in table 7 in the “Supplemental Information” section of this report. Hydrographs for the three sites are shown in figure 5.

Annual streamflow was analyzed and separated into low flow and storm runoff to characterize both types of conditions. Low flow for this study was defined as streamflow that was unaffected by storm runoff. For daily mean streamflow affected by storm runoff, a low-flow component was estimated on the basis of the previous and the following mean daily streamflows that were not affected by storm runoff. Streamflow data for the period of May through September 1994 is included in table 7 in the "Supplemental Information" section of this report and shown in figure 5 but only data for October 1994 through September 1996 were used to compute mean annual flow volume shown in table 2. Total low flow for the three sites during 1995 and 1996 was about 1,840 acre-ft or one-half of the total flow (3,700 acre-ft, table 2).

Daily mean streamflow for all three sampling sites was estimated on some days during the summers of 1995 and 1996 due to backwater effects from high flow of the Missouri River and during the winter months when ice cover affected the stream-stage relation. During periods of backwater, the stage of the Missouri River was high enough to alter the stream-stage relation at the three sampling sites. Therefore, daily mean streamflow during periods of backwater was estimated using previous and subsequent precipitation and flow data collected at these sites. During cold periods when ice cover affected the stream-stage relation, the daily streamflows were estimated on the basis of precipitation and temperature data and the daily mean streamflow prior to and following the ice-affected period. Estimated daily mean streamflow at the three sampling sites are identified in table 7 in the "Supplemental Information" section of this report with an “e” next to the daily mean value. Estimated daily mean values accounted for 19 to 25 weeks of the total study period and 29 to 49 percent of the total flow for

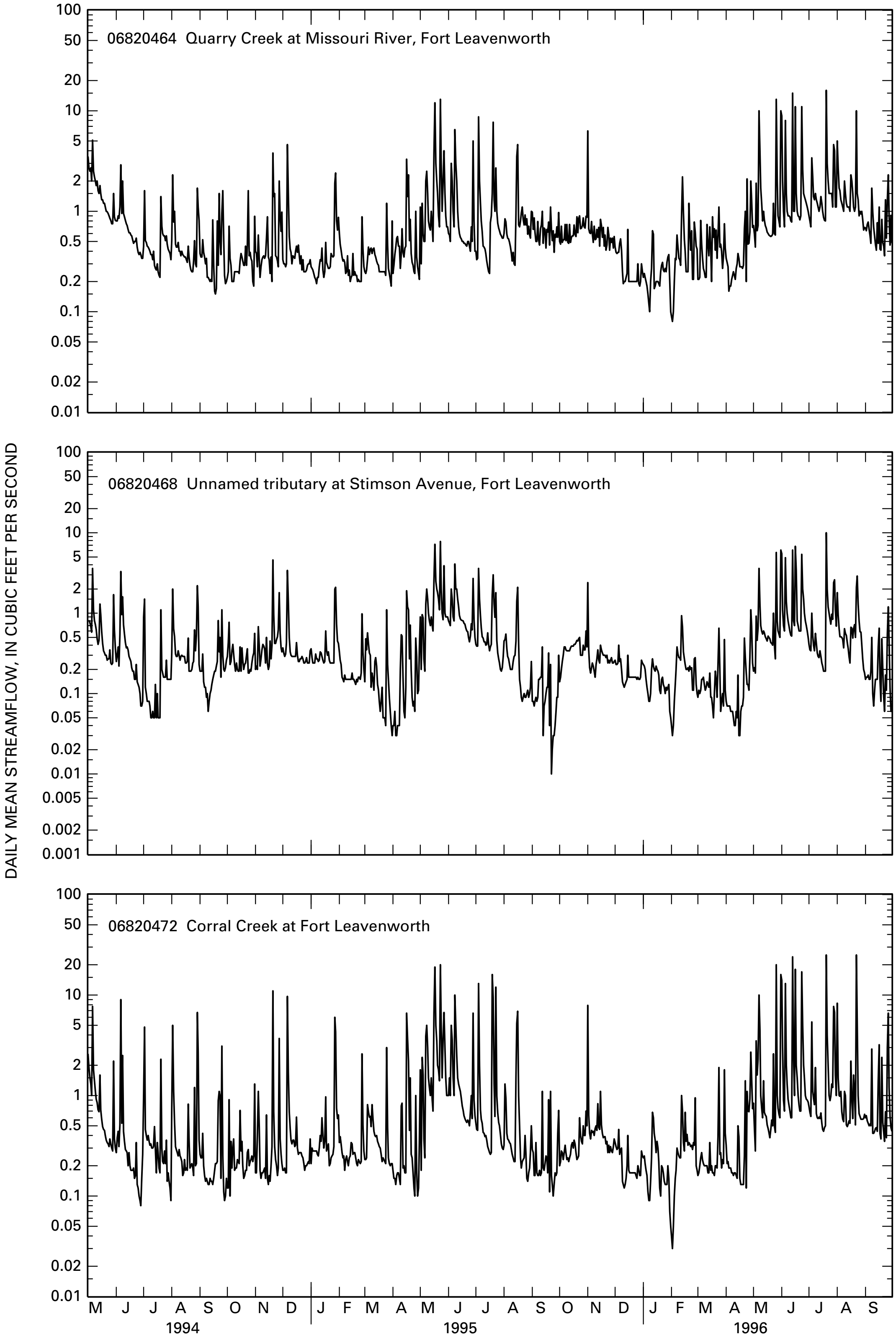

Figure 5. Daily mean streamflow at sampling sites at Fort Leavenworth, Kansas, May 1994 through September 1996.

Table 2. Total and mean annual flow volumes during low-flow and storm-runoff conditions at sampling sites at Fort Leavenworth, Kansas, October 1994 through September 1996

[All values are in acre-feet]

Sampling site number (fig. 2)	Sampling-site name	Water years and flow conditions					
		1995		1996		1995–96 (mean annual)	
		Low flow	Storm runoff	Low flow	Storm runoff	Low flow	Storm runoff
06820464	Quarry Creek	320	240	460	300	390	270
06820468	Unnamed tributary	230	150	220	160	220	160
06820472	Corral Creek	310	440	300	570	300	500
	Total	**860**	**830**	**980**	**1,030**	**910**	**930**

the study. Samples were not collected during periods when streamflow was estimated.

Streamflow data for Quarry Creek represent flow from the Quarry Creek watershed as well as flow from the levee pump 30 ft upstream from the sampling site. This pump moves water from inside the leveed area of the fort into Quarry Creek. The pump was activated up to three or four times a day, depending on the amount of ponded water inside the levee near the pump intake. When a large volume of water was present, the pump would run for 15 to 60 minutes, discharging between 1.5 and 5.0 ft^3/s.

Rain gages were installed at the Quarry Creek and Corral Creek sampling sites (fig. 2). Rainfall amounts for each storm sampled are listed in table 3. The primary purpose of the rain gages was to provide the data loggers with rainfall information to determine if a storm was large enough to be sampled. Overhead clearance at each rain-gage site was not ideal. Nearby trees may have obstructed the openings of the rain gages; therefore, the recorded rainfall data may underestimate actual rainfall amounts.

Water Quality

Low-flow samples for the analysis of selected inorganic water-quality constituents were obtained manually using a 1-L Teflon bottle dipped into the centroid of flow of the stream. The dipped samples were composited in a 9-L polyethylene churn splitter, as described in Horowitz and others (1994), and split into subsamples for analysis of inorganic compounds. Bottles designated for analysis of organic constituents were individually filled onsite. Samples were preserved and sent to the USGS National Water-Quality Laboratory (NWQL) in Arvada, Colorado, for analysis according to methods presented in Fishman (1993).

The storm-runoff samples that were collected during the study represented a wide range of storm characteristics and antecedent conditions. Rainfall amounts for each storm sampled were always more than 0.10 in. The largest rainfall amount for a sampled storm was 1.86 in. on July 19, 1995 (table 3). Durations for the storms sampled ranged from 35 minutes to 6.5 hours. To follow NPDES sampling guidelines, attempts were made to sample storms with 3-day antecedent rainfall of less than 0.10 in. About one-half the storm-runoff samples collected met this condition.

Storm-runoff samples were collected from May 1995 through August 1996 using ISCO model 3700 automatic-pumping samplers. The samplers consisted of Teflon-lined, water-intake tubing, a stainless-steel screen (hereinafter referred to as the screen) attached to the stream end of the intake tubing, a peristaltic pump, and four 1-gal glass sample jars. The automatic sampler, on a signal from the Sutron data logger, pumped water from the stream through the intake tubing into the glass sample jars. The data logger was programmed to monitor rainfall and streamflow to determine when to signal the automatic sampler to collect a sample. After a pre-assumed amount of rain and rainfall rate were reached, the data logger used a programmed, stream-stage relation to calculate streamflow. The data logger was programmed to signal the automatic sampler once a pre-assumed volume of runoff was recorded. Because samples were collected at equal streamflow increments (pre-assumed volumes), each discrete 1-gal sample was flow weighted. For the purpose of laboratory analyses, these discrete samples

Table 3. Precipitation and runoff characteristics for storm-runoff samples collected at sampling sites at Fort Leavenworth, Kansas, 1995–96

[>, greater than]

Date (month-day-year)	Total precipitation[1] (inches)	Time since previous storm greater than 0.10 inch (days)	Duration of rainfall (minutes)	Runoff (cubic feet)	Percentage of runoff sampled	Duration of runoff (minutes)	Peak flow (cubic feet per second)
06820464 Quarry Creek at Missouri River, Fort Leavenworth, Kansas (fig. 2)							
11–01–95	1.74	1.9	330	427,000	42	675	34
03–24–96	.50	1.5	125	60,800	100	390	12
04–22–96	.42	>3	35	102,000	100	390	16
05–23–96	.36	>3	80	59,000	86	420	5.7
08–19–96	.14	>3	110	13,800	88	300	3.2
08–23–96	1.68	.2	55	419,000	47	310	49
06820468 Unnamed tributary at Stimson Avenue, Fort Leavenworth, Kansas (fig. 2)							
05–27–95	.77	.6	200	76,300	90	405	12
06–28–95	1.12	2.2	240	85,800	100	300	20
07–9–95	1.86	>3	290	191,000	85	360	40
05–04–96	.54	>3	160	46,200	100	250	6.0
06–13–96	1.08	>3	75	38,000	100	120	14
07–28–96	.68	1.6	85	57,200	71	175	29
06820472 Corral Creek at Fort Leavenworth, Kansas (fig. 2)							
06–28–95	1.12	2.2	240	450,000	51	450	43
08–15–95	.93	.8	35	342,000	80	285	89
11–01–95	1.74	1.9	330	611,000	38	645	59
03–24–96	.50	1.5	125	135,000	100	345	23
04–22–96	.42	>3	35	112,000	97	345	37
05–04–96	.56	>3	160	219,000	68	295	41
05–23–96	.36	>3	80	105,000	94	240	28
06–13–96	1.08	>3	75	229,000	99	295	43
08–16–96	.53	>3	390	107,000	100	335	18

[1]Precipitation totals are an average of the values from the Quarry Creek and Corral Creek rain gages.

were composited into one flow-weighted composite sample.

The final flow-weighted composite sample represented a pre-assumed storm-runoff volume. However, storm-runoff volumes varied substantially between storms which produced differences in sample representation. For an event where the total storm-runoff volume was greater than the pre-assumed volume, the composite sample represented only part of the total storm-runoff volume (table 3). Water-quality constituent concentrations determined from a composite sample collected in this manner represented mean concentrations for that part of the storm sampled and not the entire storm. In a case where the total storm-runoff volume was less than the pre-assumed total storm volume, then the resulting composite sample represented the entire storm runoff; however, not all four sample jars would be filled. This reduction in sample volume, reduced the number of analyses from the full suite of 272 properties and constituents.

Storm-runoff samples were transported to the laboratory at the USGS in Lawrence, Kansas, and split into subsamples using a Teflon cone splitter (Horowitz and others, 1994) and a polyethylene churn splitter. The cone splitter was used to initially split the flow-weighted, discrete 1-gal samples into subsamples for analysis of organic and inorganic constituents. From these two subsamples, samples for analysis of organic compounds were split using the cone splitter, and samples for analysis of inorganic compounds were split using the churn splitter. Samples were preserved and sent to the NWQL in Arvada, Colorado, for analysis.

All equipment used to collect water samples were cleaned and placed in plastic bags prior to use. Glass and Teflon sample bottles, Teflon-lined tubing, churn splitter, and cone splitter were cleaned using a 2.5-percent nonphosphate detergent solution, rinsed using deionized water, soaked for 30 minutes in a 10-percent hydrochloric acid solution, and rinsed with organic-free water. The screen at the stream end of the intake tubing was cleaned frequently by removing debris and algae accumulation.

Quality Control

Quality-control (QC) samples were collected and analyzed to assure the integrity of the water-quality data for this study. Analytical results from the QC samples helped determine if procedures used for collection and processing of samples maintained representativeness. Six QC samples were collected during this study—four equipment blanks and two replicates.

Equipment-blank samples were collected and processed as if they were actual storm-runoff samples to inspect the cleanliness of the equipment. Blank water (highly purified, free of contamination) was passed through all or some of the equipment used to collect storm-runoff samples. Blank samples were processed following the identical procedures used to process storm-runoff samples and sent to the NWQL for analysis. Equipment-blank samples were labeled QC–1, QC–2, QC–3, and QC–4, and the results of analyses of these samples are included in table 8 in the "Supplemental Information" section of this report. Samples QC–1 and QC–2 were collected and processed exactly like a storm-runoff sample using all the sample-collection and processing equipment. Blank water for sample QC–3 was passed through all the sample-collection and processing equipment, except the automatic sampler was without the screen at the end of the Teflon-lined tubing. Sample QC–4 was blank water passed through the sample-processing equipment only. Samples that passed through all of the equipment were compared to samples that were passed through just some of the equipment to determine if a specific piece or group of equipment was a possible source of contamination.

Most of the values and concentrations of constituents in equipment blanks were less than the analytical reporting level, indicating there was little contamination from the sampling and/or processing equipment. Silica and total organic carbon were detected in all of the blank samples (table 8 in the "Supplemental Information" section of this report). None of the concentrations were more than five times the analytical reporting level. A possible source for the silica and total organic carbon concentrations is contaminated blank water. The concentrations of silica and total organic carbon in blank samples probably are insignificant relative to environmental concentrations that generally are one to two orders of magnitude larger (table 8).

Samples QC–1, 2, and 3 had detectable concentrations of calcium and iron. These constituents are found in natural water samples at concentrations 100 to 1,000 times the largest concentration detected in the blank samples. The concentrations detected may be from some small amounts of water or residue inside the pump intake tubing that may have contaminated the blank samples.

Suspended solids were detected in samples QC–1 and 2 at concentrations of 3 and 6 mg/L, respectively. The source for these concentrations may be the screen at the stream end of the intake tubing. The blank samples collected without the screen in place had no detections of suspended solids.

Magnesium, manganese, and mercury were detected in sample QC–1. Magnesium and manganese concentrations were at the analytical reporting level for the constituents, and the mercury concentration was three times the analytical reporting level. These constituents may have been contributed from the screen or the pump tubing. Samples QC–2 (tubing with screen) and QC–3 (tubing without screen) had no detections of these constituents.

Replicate samples of low flow were collected concurrently to determine variability in sample-collection and processing techniques. Variability in concentrations of constituents between samples can occur if collection and/or processing techniques differ between samples. Large differences between sample concentrations for some constituents can reflect variability in either or both sample-collection and processing techniques. Minor differences between samples assure that any variability in sample-collection or processing techniques are insufficient to affect environmental concentrations.

The percentage difference for values and concentrations in concurrent replicate samples was less than 5 percent for all but 14 constituents. The range of differences in the 14 constituents was from 5.3 to 71.4 percent. Most of the variability in the concurrent replicate samples was hundredths of a milligram per liter or less and probably within the analytical variability of the laboratory's measurements. The largest variation occurred between samples collected for oil and grease. The variability is most likely due to the sample-collection technique. When collecting samples for oil and grease, a sample bottle is dipped into the stream, filled, preserved, and capped. Because it was impossible to collect two samples at once from the exact same location in the stream, samples were collected one at a time, concurrently. This method of collection is the most likely reason for the variability between the samples.

Measurements of specific conductance and pH were occasionally made during sample collection or hours after sample collection during sample processing at the laboratory in Lawrence, Kansas. Measurements of specific conductance and pH were usually made at the NWQL within days or weeks of sample collection. The variability between the values measured in Lawrence and the values measured at the NWQL ranged from about 1 to 23 percent difference. Probably the most significant explanation for this variability is the time difference of when the samples were measured for specific conductance and pH. The measurements made in Lawrence were within hours of collection when the sample was still approaching a chemical equilibrium. The measurements made at the NWQL were days or weeks after sample collection when the sample had had more time to reached a chemical equilibrium, altering specific conductance and pH.

CONCENTRATIONS OF SELECTED WATER-QUALITY CONSTITUENTS

Sources of streamflow and land-use activities within a watershed typically are determining factors in resulting concentrations of water-quality constituents in streams. The major components of streamflow are ground water and surface runoff. Ground water contributes to streamflow any time the elevation of the stream is less than the elevation of the ground-water surface. During periods of low flow, ground water is the primary source of streamflow; therefore, the water-quality constituent concentrations in streamflow reflect concentrations in ground water. When the elevation of the stream is greater than the ground-water surface elevation, some water flows from the stream into the ground water. This may occur during storms and backwater conditions. The primary source of streamflow during and immediately following a storm is surface-water runoff. Rainfall on impervious and saturated surfaces within the study area eventually flows into one of the three study streams. As the water flows across these surfaces, contaminants can be transported into the streams. Depending on land use, different contaminants can accumulate during dry periods. For example, on paved surfaces, contaminants from automobiles and trucks may accumulate until a large enough storm occurs to wash the contaminants from the pavement and into the streams.

Thirty-nine water-quality samples were collected from August 1994 through September 1996—12 low-flow samples, 21 storm-runoff samples, and 6 quality-control (QC) samples. Samples were analyzed for as many as 272 properties and constituents. Table 8 in the "Supplemental Information" section of this report lists the properties measured and inorganic, radionuclide, and detected organic constituents. Table 9 in the "Supplemental Information" section of this report lists all the organic constituents analyzed and their analytical reporting level. Some of the properties measured and constituents analyzed included specific conductance, pH, chemical oxygen demand, major ions, dissolved and suspended solids, nutrients, bacteria, total recoverable metals, radionuclides, total organic carbon, phenols, oil and grease, volatile organic compounds, acid-base/neutral organic compounds, and pesticides. Although the water in these streams is not used by humans for drinking, concentrations of the constituents were compared to the most stringent Federal regulations, the Maximum Contaminant Levels (MCLs) and Secondary Maximum Contaminant Levels (SMCLs) established by EPA drinking-water regulations (U.S. Environmental Protection Agency, 1996b).

Low Flow

Characterization of water quality during low flow was necessary to establish a basis for assessing the water-quality changes caused by storm runoff. Low-flow samples were collected during August or September in each of the years 1994, 1995, and 1996 to represent summer low-flow conditions and during March 1996 to represent late winter or early spring low-flow conditions. Two water samples from Corral Creek were collected when cattle were immediately upstream from the sampling site, and two samples were collected after the cattle were gone. In February 1996, stream conditions in the unnamed tributary had changed considerably. The water at the sampling site had an odor, and the stream bottom was covered with a brown organic deposit. The condition continued until April 1996 when a damaged, municipal sewer pipe was repaired. The damaged pipe was located along the southwest bank of the unnamed tributary about 750 ft upstream from the sampling site and just downstream from the lake outfalls. The top of the pipe was damaged, so it leaked only when the pipe was full. The damaged pipe was intermittently discharging untreated municipal sewage into the unnamed tributary. A low-flow water sample was collected from the unnamed tributary during March 1996, when the broken, municipal sewer pipe was discharging into the stream. Because of the unusual water-quality conditions during the period of the broken sewer pipe, this sample was not used for calculating selected, low-flow, mean constituent concentrations in water from the unnamed tributary (table 4).

Specific conductance and pH were measured onsite and at the NWQL for each low-flow water sample. Specific conductance and pH measured at the NWQL varied less than 6 percent from the onsite measurements. Laboratory measurements of specific conductance ranged from 503 to 1,040 µS/cm at 25 °C, and pH ranged from 7.2 to 8.2 standard units (table 4). The largest mean measurements of specific conductance and pH were in samples from Quarry Creek and were 1,010 µS/cm at 25 °C and 7.9 standard units. The lowest mean measurements of specific conductance and pH were in samples from the unnamed tributary at 576 µS/cm at 25 °C and 7.3 standard units. All of the pH measurements were within the SMCL range of 6.5 to 8.5 (U.S. Environmental Protection Agency, 1996b).

Determination of chemical oxygen demand is one of several methods to quantitatively evaluate the organic contamination load (Hem, 1985). Chemical oxygen demand is the amount of oxygen required for chemical oxidation of organic matter to carbon dioxide and water (Hammer, 1986). Generally speaking, the greater the chemical oxygen demand the greater the organic contamination load. For instance, the maximum chemical oxygen demand concentration was 100 mg/L (more than two times the next largest low-flow concentration at any sampling site) in water from the sampling site on the unnamed tributary when untreated municipal sewage was discharging into the stream (table 8). Mean concentrations of chemical oxygen demand for low-flow samples were 13 mg/L for water from Quarry Creek, 23 mg/L for water from the unnamed tributary, and 23 mg/L for water from Corral Creek (table 4).

Low-flow concentrations of major ions were generally largest in water samples from Quarry Creek. The largest concentrations of calcium, magnesium, sulfate, and chloride were measured in water samples collected from Quarry Creek (table 8). The largest concentrations of sodium and potassium were in samples collected from Corral Creek. A water sample from the unnamed tributary had the largest concentration of silica. None of the concentrations exceeded the MCLs or the SMCLs (U.S. Environmental Protection Agency, 1996b) for sulfate (250 mg/L), chloride (250 mg/L), or fluoride (4.0 mg/L).

Dissolved and suspended solids concentrations in low-flow water samples varied considerably between sampling sites. Dissolved solids concentrations ranged from 298 mg/L in water from the unnamed tributary to 702 mg/L in water from Quarry Creek (table 4). The mean dissolved solids concentration in samples from Quarry Creek (669 mg/L) was 55 percent larger than the mean concentrations in samples from the unnamed tributary and Corral Creek (433 and 432 mg/L, respectively) and 34 percent larger than the SMCL (500 mg/L). Mean concentrations of suspended solids varied in samples from each site—22 mg/L in water from Quarry Creek, 7 mg/L in water from the unnamed tributary, and 38 mg/L in water from Corral Creek. The largest discrete suspended solids concentration, 92 mg/L, was measured in water from Corral Creek when cattle were present, and the smallest concentration, less than 1 mg/L, was measured in water from Corral Creek when no cattle were present. These data appear to indicate that cattle may have disturbed streambed sediment and bank material and subsequently increased the amount of suspended material in the water. This interpretation should be viewed with

Table 4. Summary statistics for selected properties and constituents associated with low-flow samples from sampling sites at Fort Leavenworth, Kansas, 1994–96

[ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than]

Property or constituent	06820464 Quarry Creek at Missouri River (fig. 2)				06820468 Unnamed tributary at Stimson Avenue (fig. 2)				06820472 Corral Creek at Fort Leavenworth (fig. 2)			
	Number of samples	Minimum	Maximum	Mean	Number of samples	Minimum	Maximum	Mean	Number of samples	Minimum	Maximum	Mean
Instantaneous low-flow discharge (ft^3/s)	4	0.20	0.84	0.40	3	0.10	0.47	0.30	4	0.15	0.74	0.40
Specific conductance (µS/cm)	3	962	1,040	1,010	2	503	648	576	3	620	761	702
pH (standard units)	4	7.7	8.2	7.9	3	7.3	7.4	7.3	4	7.2	7.8	7.6
Chemical oxygen demand (mg/L)	4	<10	25	13[1]	3	15	33	23	4	<10	44	23[1]
Dissolved solids (mg/L)	4	622	702	669	3	298	564	433	4	382	472	432
Suspended solids (mg/L)	4	6	48	22	3	6	10	7	4	<1	92	38[1]
Total ammonia plus organic nitrogen, as nitrogen (mg/L)	4	.30	.70	.45	3	.50	.60	.57	4	.20	2.5	1.3
Total nitrogen[2] (mg/L)	4	1.1	2.6	2.1	3	1.9	3.6	2.9	4	.44	2.6	1.5
Total phosphorus (mg/L)	4	.11	.32	.19	3	.20	.26	.23	4	.08	.36	.21
Dissolved phosphorus (mg/L)	3	.11	.33	.19	2	.23	.23	.23	3	.07	.17	.12
Total recoverable cadmium (µg/L)	4	<1.0	<1.0	.5[1]	3	<1.0	<1.0	.5[1]	4	<1.0	<1.0	.5[1]
Total recoverable copper (µg/L)	4	1.0	3.0	2.0	3	1.0	4.0	2.0	4	1.0	5	3.0
Total recoverable iron (µg/L)	3	110	1,000	550	2	210	260	235	3	100	3,400	1,300
Total recoverable lead (µg/L)	4	<1.0	4.0	2.0[1]	3	<1.0	1.0	.7[1]	4	<1.0	8.0	5.0[1]
Total recoverable manganese (µg/L)	3	180	380	260	2	190	200	200	3	60	570	290
Total recoverable zinc (µg/L)	4	<10	20	16[1]	3	<10	<10	5.0[1]	4	10	40	19[1]
Total organic carbon (mg/L)	4	3.2	5.6	4.0	2	4.2	6.3	5.2	4	3.7	10	5.9

[1]The mean was calculated by making the nondetection value equal to one-half the analytical reporting level (<1.0⇒0.5).

[2]Total nitrogen was calculated by adding total nitrate plus nitrite as nitrogen and total ammonia plus organic nitrogen as nitrogen.

caution for the number of samples collected (four) may be too small for definitive evaluation.

Low-flow mean concentrations of total nitrogen (calculated by adding total ammonia plus organic nitrogen and total nitrite plus nitrate) and total and dissolved phosphorus were largest in water samples from the unnamed tributary. The mean concentration of total ammonia plus organic nitrogen as nitrogen was largest in water from Corral Creek. The mean concentration of total ammonia plus organic nitrogen as nitrogen for the two water samples collected from Corral Creek when cattle were present in and along the stream near the sampling site was 2.3 mg/L. In contrast, the mean concentration of the two samples collected in 1996, when no cattle were present in these areas, was 0.25 mg/L. Although this comparison seems to indicate an effect on nutrient concentrations from cattle with direct access to the stream, the number of samples collected (four) may be too small for definite evaluation. The water sample collected on March 28, 1996, from the unnamed tributary had the largest concentrations of dissolved ammonia, total ammonia plus organic nitrogen as nitrogen, total phosphorus, dissolved phosphorus and dissolved orthophosphorus of all the low-flow samples (table 8). None of the samples exceed the 10-mg/L MCL (U.S. Environmental Protection Agency, 1996b) for dissolved nitrite plus nitrate as nitrogen.

Bacteria samples were collected from sampling sites only during low flow. Fecal coliform and fecal streptococci residing in the intestinal tract of humans and other warmblooded animals are excreted in large numbers in feces (Hammer, 1986). Untreated domestic wastewater generally may contain more than 3 million col/100 mL [colonies (organisms) per 100 milliliters of water] of fecal coliform. The largest counts of fecal coliform and fecal streptococci were measured in samples from the unnamed tributary during March 1996 when untreated municipal sewage leaked into the stream. The fecal coliform count was about 2,500,000 col/100 mL (100 times the next largest count), and the fecal streptococci count was about 42,000 col/100 mL (six times the next largest count) (table 8). The range for fecal coliform counts in low-flow water samples (not including nonideal counts) was 89 to 14,000 col/100 mL in samples from Quarry Creek, 2,100 to 2,500,000 col/100 mL in samples from the unnamed tributary, and 1,900 to 24,000 col/100 mL in samples from Corral Creek. Fecal streptococci counts ranged from 135 to 12,000 col/100 mL in samples from Quarry Creek, 5,400 to 42,000 col/100 mL in samples from the unnamed tributary, and less than 1,500 to 6,700 col/100 mL in samples from Corral Creek. Samples collected from Corral Creek averaged 18,000 col/ 100 mL fecal coliform and 4,600 col/100 mL fecal streptococci when cattle were within the drainage area and 980 col/100 mL fecal coliform and 1,500 col/100 mL fecal streptococci when they were not. Although this comparison seems to indicate that cattle with direct access to the stream may affect the amount of instream bacteria, the number of samples collected (four) may be too small for definitive evaluation.

Concentrations of total recoverable metals such as antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc were small (less than 50 μg/L) in low-flow samples; in fact, all concentrations for beryllium, cadmium, mercury, silver, and thallium were less than analytical reporting levels. Concentrations of total recoverable manganese for all three sites ranged from 60 to 570 μg/L. None of the low-flow concentrations for total recoverable metals exceeded MCL or SMCL values established by EPA (U.S. Environmental Protection Agency, 1996b).

A sample for radionuclide analysis was collected from each site during low flow. The only radionuclide detections were for dissolved gross alpha (6.5 μg/L) in water from Corral Creek and dissolved gross beta (7.9 pCi/L) in water from the unnamed tributary.

Total organic carbon concentrations in water from all three sampling sites ranged from 3.2 to 10 mg/L for samples not affected by sewer leakage. The mean concentration of total organic carbon was largest (5.9 mg/L) for samples from Corral Creek. Mean concentrations of total organic carbon in water from Quarry Creek and the unnamed tributary were 4.0 and 5.2 mg/L, respectively. A sample collected from the unnamed tributary in March 1996 (during the period of sewer leakage) was 29 mg/L.

Total phenols were detected in at least one low-flow water sample from each of the three sampling sites, ranging in concentration from less than 1 to 15 μg/L (table 8). The two largest concentrations were 15 and 7 μg/L in samples from Corral Creek. There were two water samples with no detection of phenols from Quarry and Corral Creeks and three samples with no detection of phenols from the unnamed tributary. The only detection of phenols in samples from the unnamed tributary occurred during the period of sewer leakage. The Corral Creek watershed has the only substantial percentage of industrial land use of the three watersheds. Some industrial activities potentially can contribute to phenol concentrations in surface water.

Oil and grease were detected in two low-flow samples from the unnamed tributary. A concentration of 5 mg/L was detected in the sample collected when sewage was leaking into the stream, and a concentration of 3 mg/L was detected in the replicate sample collected in August 1996. Oil and grease concentrtions were less than analytical reporting levels for all other samples.

Two volatile organic compounds where detected in low-flow water samples. Chloroform was detected in whole-water samples from the Quarry Creek and Corral Creek sampling sites during March 1996; concentrations were 0.2 and 0.5 µg/L, respectively. Tetrachloroethylene was detected at 0.3 µg/L in the March 1996 sample from Quarry Creek.

No acid-base/neutral organic compounds were detected in any of the 12 low-flow samples collected. Eight pesticides were detected in low-flow samples. These include atrazine; chlorpyrifos; 2,4–D; p,p' DDD; DDE; malathion; prometon; and simazine. Atrazine, prometon, and simazine were detected in samples from all three sampling sites. Concentrations of 2,4–D were detected in samples from the unnamed tributary and Corral Creek. Malathion was detected in samples from Quarry Creek and the unnamed tributary. Chlorpyrifos was detected in a sample from the unnamed tributary, and p,p' DDD was detected in samples from Quarry Creek. None of the pesticide concentrations exceeded the MCL values established by EPA (U.S. Environmental Protection Agency, 1996b).

Storm Runoff

Selected properties and concentrations of constituents in storm-runoff streamflow were determined to assess the changes in water quality of receiving streams caused by storm runoff. Storm-runoff samples were collected in 1995 and 1996 during three seasons and during unusual conditions that may have affected storm-runoff constituent concentrations. Eleven samples were collected during the spring, eight during the summer, and two during the fall. Cattle were present at and near the Corral Creek sampling site during the collection of the first three storm-runoff samples. The storm-runoff sample collected August 19, 1996, at the Quarry Creek sampling site was affected by pump discharge from the adjacent Missouri River levee (fig. 2) and, therefore, was not included in the calculation of water-quality constituent concentration mean values (table 5).

Mean measurements of specific conductance measured at the NWQL ranged from 157 µS/cm at 25 °C in water from the unnamed tributary to 743 µS/cm at 25 °C in water from Quarry Creek (table 5). Measurements of pH varied little from site to site, ranging from 6.9 to 7.7 standard units. Mean measurements of specific conductance and pH in storm-runoff samples were smaller than mean measurements in low-flow samples. All pH measurements were within the SMCL range of 6.5 to 8.5 (U.S. Environmental Protection Agency, 1996b).

Mean concentrations of chemical oxygen demand in storm samples were largest in samples from Corral Creek, 100 mg/L. Mean concentrations in water from Quarry Creek and the unnamed tributary were 68 and 38 mg/L, respectively. Mean storm-runoff concentrations were larger than mean low-flow sample concentrations in water from all sampling sites, indicating that storm runoff is contributing a larger concentration of chemical oxygen demand compared to low-flow concentrations, as shown in figure 6.

The largest concentrations of major ions were in samples from Quarry Creek. Overall, concentrations of major ions in storm-runoff samples were smaller than concentrations in low-flow samples (fig. 6). None of the concentrations exceeded the MCL or the SMCL (U.S. Environmental Protection Agency, 1996b) for sulfate, chloride, or fluoride (table 8).

Not all storm-runoff samples were analyzed for dissolved solids because of insufficient sample volume. Three of the six storm-runoff samples from Quarry Creek and one of the six samples from the unnamed tributary were not analyzed for dissolved solids. Of the samples from the three sites for which dissolved solids were analyzed, concentrations ranged from 46 to 480 mg/L among samples. Maximum concentrations in samples from Quarry Creek, the unnamed tributary, and Corral Creek were 480, 142, and 236 mg/L, respectively. Mean concentrations of dissolved solids in storm-runoff samples were at least twice the mean concentrations in low-flow samples at each of the three sites (fig. 6). None of the concentrations exceeded the SMCL of 500 mg/L (U.S. Environmental Protection Agency, 1996b).

Concentrations of suspended solids in storm-runoff samples were largest in water from Corral Creek. The mean concentration of suspended solids was

Table 5. Summary statistics for selected properties and constituents associated with storm-runoff samples from sampling sites at Fort Leavenworth, Kansas, 1995–96

[ft[3]/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than]

Property or constituent	06820464 Quarry Creek at Missouri River (fig. 2)				06820468 Unnamed tributary at Stimson Avenue (fig. 2)				06820472 Corral Creek at Fort Leavenworth (fig. 2)			
	Number of samples	Minimum	Maximum	Mean	Number of samples	Minimum	Maximum	Mean	Number of samples	Minimum	Maximum	Mean
Event average storm-runoff/streamflow discharge (ft^3/s)	6	1.8	25	8.4	6	3.5	9.8	6.4	9	5.8	22	12.6
Specific conductance (µS/cm)	5	401	943	743	5	92	242	156	9	177	439	320
pH (standard units)	5	7.1	7.7	7.4	5	6.9	7.7	7.2	9	7.1	7.5	7.4
Chemical oxygen demand (mg/L)	6	23	110	68	6	27	52	38	9	55	160	100
Dissolved solids (mg/L)	3	216	480	348	5	46	142	91	9	82	236	172
Suspended solids (mg/L)	6	98	864	496	6	76	594	304	9	258	3,360	1,645
Total ammonia plus organic nitrogen, as nitrogen (mg/L)	6	.50	4.5	2.2	6	.80	2.7	1.2	9	.80	5.5	2.0
Total nitrogen[1] (mg/L)	6	1.61	5.8	3.3	6	1.1	3.2	1.7	9	1.3	6.2	2.5
Total phosphorus (mg/L)	6	.24	1.3	.72	6	.14	.64	.32	9	.23	1.8	.72
Dissolved phosphorus (mg/L)	6	.06	.38	.17	6	.09	.28	.17	9	.08	.25	.14
Total recoverable cadmium (µg/L)	6	<1	2	1.0[2]	5	<1	<1	.5[2]	8	<1	3	2[2]
Total recoverable copper (µg/L)	6	6	37	20	5	5	11	8	8	10	58	29
Total recoverable iron (µg/L)	6	3,200	18,000	10,000	5	2,700	52,000	15,000	8	6,100	69,000	27,000
Total recoverable lead (µg/L)	6	8	82	41	5	17	68	43	8	15	110	64
Total recoverable manganese (µg/L)	6	160	3,200	1,300	5	310	810	540	8	410	2,600	1,900
Total recoverable zinc (µg/L)	6	40	230	150	5	40	140	100	8	80	390	240
Total organic carbon (mg/L)	6	7.1	31	22	6	7.9	19	11	9	14	56	34

[1]Total nitrogen was calculated by adding total nitrate plus nitrite as nitrogen and total ammonia plus organic nitrogen as nitrogen.

[2]The mean was calculated by making the nondetection value equal to one-half the analytical reporting level (<1.0⇒0.5).

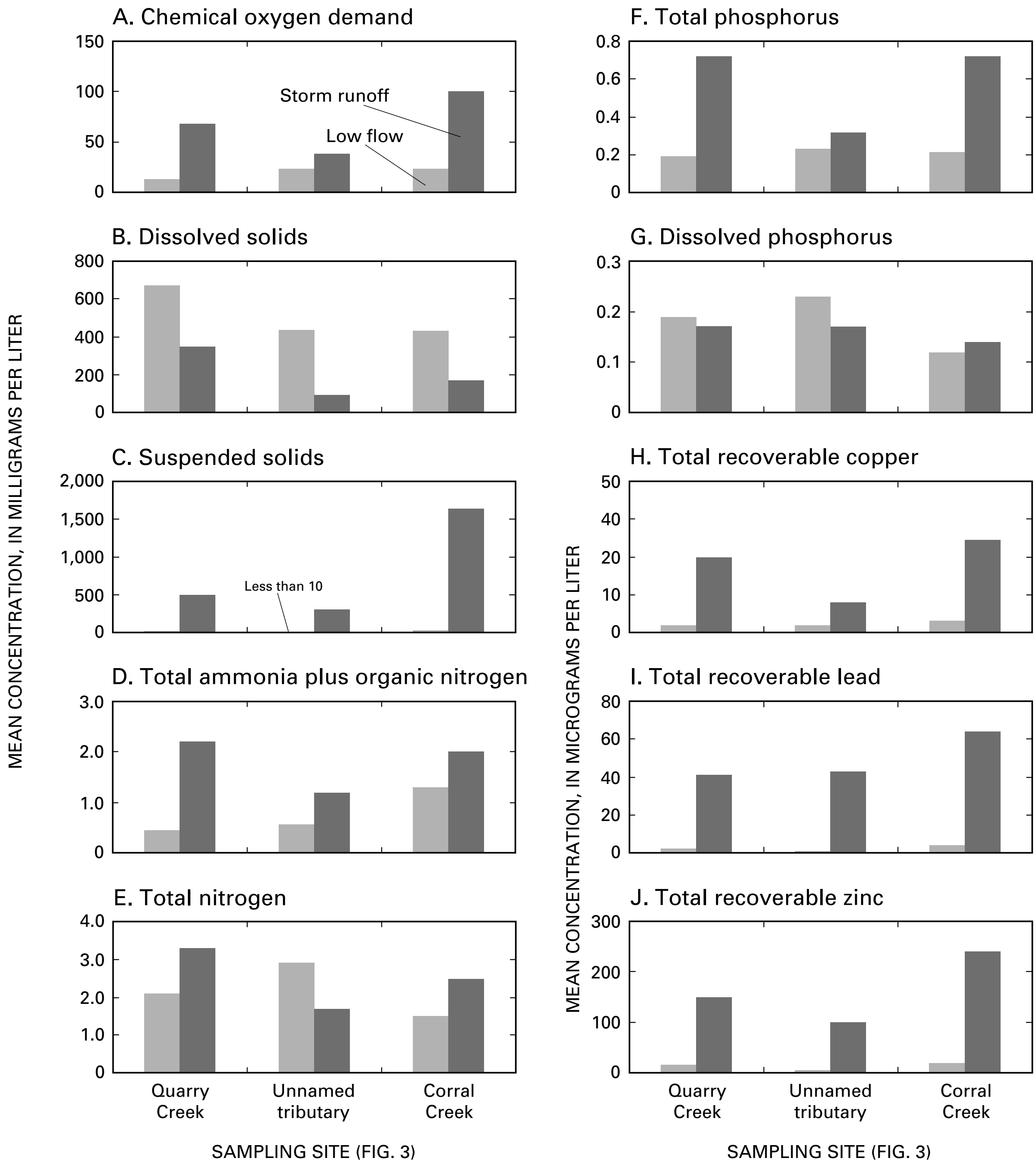

Figure 6. Mean concentrations of selected constituents in samples collected during low flow and storm runoff from sampling sites at Fort Leavenworth, Kansas, 1994–96.

1,645 mg/L (table 5), which was more than three times the mean concentration in samples from Quarry Creek (496 mg/L) and more than five times the mean concentration in samples from the unnamed tributary (304 mg/L). A major source for suspended solids in water from Corral Creek may have been areas of exposed soil at the construction sites within the watershed. Mean concentrations of suspended solids in storm-runoff samples were at least 24 times larger than the mean concentrations in low-flow samples, indicating that storm runoff greatly contributes to suspended solids concentrations.

Mean concentration of dissolved nitrite plus nitrate as nitrogen, total ammonia plus organic nitrogen as nitrogen, and total and dissolved phosphorus in storm runoff varied among sampling sites. Mean concentrations for most nutrient constituents in water samples from Quarry Creek were larger than or nearly equal to the mean concentrations in water samples from the unnamed tributary and Corral Creek. Large nutrient concentrations in the Quarry Creek samples could be associated with the fact that the watershed has the largest percentage of nonurban land use of the three watersheds. Common activities related to nonurban land use are agricultural application of fertilizers and livestock grazing, both of which can contribute to nutrient concentrations in storm runoff. Mean concentrations of all four selected nutrient constituents in storm-runoff samples from Corral Creek were larger than or equal to mean concentrations in low-flow samples (fig. 6). In storm-runoff samples from Quarry Creek, three of the four selected nutrient constituents had mean concentrations larger than mean low-flow concentrations. Mean concentrations of total nitrogen and total phosphorus in samples from the unnamed tributary were larger during low flow than during storm runoff (table 5). All the concentrations of dissolved nitrite plus nitrate as nitrogen were less than the 10-mg/L MCL (U.S. Environmental Protection Agency, 1996b).

Samples of water for analyses of fecal coliform and fecal streptococci bacteria were not collected during storm-runoff conditions. The sample-collection technique using the automatic sampler is such that the samples collected could not be used for bacteria analysis because of potential cross contamination of the samples. The automatic sampler pumps water through Teflon-lined tubing and into a glass bottle. Neither the tubing nor the bottles were autoclaved as part of the cleaning process; therefore, the samples would not accurately represent the number of bacteria in the streamwater.

Total recoverable metals such as copper, iron, lead, manganese, and zinc in storm-runoff samples from all three sampling sites were detected at concentrations larger than analytical reporting levels. Copper concentrations in all water samples from all sites ranged from 5 to 58 μg/L (table 5), the smallest in samples from the unnamed tributary and the largest in samples from Corral Creek. Samples from Corral Creek also had the largest mean concentrations of copper, iron, lead, manganese, and zinc, at 29, 26,000, 64, 1,900, and 244 μg/L, respectively. Samples from Quarry Creek and the unnamed tributary had mean concentrations for copper of 20 and 8 μg/L, for iron of 10,000 and 15,000 μg/L, for lead of 41 and 43 μg/L, for manganese of 1,300 and 540 μg/L, and for zinc of 150 and 100 μg/L, respectively. Cadmium concentrations were less than the analytical reporting level (1.0 μg/L) for one-half the water samples from Quarry Creek, all of the water samples from the unnamed tributary, and two of the eight water samples from Corral Creek (table 5). The largest cadmium concentration was 3 μg/L in water from Corral Creek. Concentrations of total recoverable metals in storm-runoff samples were much larger than concentrations determined in low-flow samples. The smallest storm-runoff concentrations of total recoverable copper, iron, lead, and zinc were equal to or larger than the maximum low-flow concentrations. None of the MCL or SMCL values established by the EPA (U.S. Environmental Protection Agency, 1996b) were exceeded for copper, lead, and zinc. Concentrations for iron and manganese in all the storm samples were larger than the SMCL values established by the EPA (U.S. Environmental Protection Agency, 1996b) (300 μg/L for iron and 50 μg/L for manganese).

Three storm-runoff samples from Corral Creek were analyzed for dissolved gross alpha and dissolved gross beta concentrations (table 8). Of the three storm samples, dissolved gross alpha and beta were each detected twice. Gross alpha was detected at 3.1 and 6.8 μg/L, and gross beta was detected at 4.2 and 4.9 pCi/L.

Total organic carbon concentrations in water from all three sampling sites ranged from 7.1 to 56 mg/L (table 5). Mean concentrations of total organic carbon in storm-runoff samples were 22 mg/L from Quarry Creek, 11 mg/L from the unnamed tributary, and 34 mg/L from Corral Creek. Mean storm-runoff concentrations of total organic carbon were at least two times larger than the mean low-flow concentrations.

Total phenols were detected in storm runoff from all three sampling sites, ranging in concentration from less than 1 to 5 μg/L (table 8). Industrial activities are a potential source of phenols. During storm runoff, phenols can be mobilized by the runoff and result in increased concentrations in surface water. The Corral Creek watershed is the only watershed with a substantial percentage of industrial land use. Total phenols were detected at about the same frequency in storm-runoff samples as in low-flow samples and in slightly smaller concentrations.

Oil and grease were detected at concentrations larger than 1 mg/L in at least one storm-runoff sample from each of the three sampling sites (table 8). In storm-runoff samples from Quarry Creek, the detected oil and grease concentration was 3 mg/L, in samples from the unnamed tributary it was 11 mg/L, and in samples from Corral Creek they were 2 and 4 mg/L. Storm-runoff and low-flow samples had concentrations that were less than or slightly more than the 1-mg/L analytical reporting level, indicating that oil and grease concentrations were small during both streamflow conditions.

Samples for analysis of volatile organic compounds were collected during three storms at the unnamed tributary. Concentrations of volatile organic compounds were not greater than the analytical reporting levels (table 9 in the "Supplemental Information" section) in any of the three storm-runoff samples. Storm-runoff samples collected from all three sampling sites for analysis of base-neutral/acid organic compounds had concentrations less than analytical reporting levels for base-neutral/acid constituents listed in table 9 in the "Supplemental Information" section.

Fifteen pesticides were detected in the storm-runoff samples collected from all three sampling sites (table 8). In samples from Quarry Creek, p,p' DDD; DDE; p,p' DDE; p,p' DDT; malathion, and 2,4–D were detected in more than one-half of the samples collected. More than one-half of the samples collected from the unnamed tributary had detections of DDE; p,p' DDT; malathion; and 2,4–D. Chlordane, chlorpyrifos, Diazinon, malathion, and 2,4–D were detected in more than one-half the samples collected from Corral Creek. A sample collected from Quarry Creek on August 22, 1996, was the only sample without a detection of 2,4–D.

DDT was banned from use in the 1970s, yet DDT and derivatives of DDT were detected in water samples. The presence of these organochlorine compounds some 20 years later indicates the persistence of DDT. None of the pesticide concentrations exceeded the MCL values established by EPA drinking-water regulations (U.S. Environmental Protection Agency, 1996b).

CALCULATED ANNUAL LOADS AND YIELDS OF SELECTED WATER-QUALITY CONSTITUENTS

The load (mass) of a water-quality constituent in a stream is a function of the concentration and the streamflow. An examination of annual constituent loads in water from the three sampling sites at Fort Leavenworth indicates the mass contribution of constituents by each watershed to the receiving stream. Examination of constituent yields (mass per unit area) for each site enables comparisons of normalized watershed contributions and possibly identifies differences in contributions as a function of land use. Loads and yields were calculated for this study using water-quality data for September 1994 through August 1996 and streamflow data for water years 1995 and 1996.

NPDES permitting requires estimation of annual loads for 12 properties and constituents. For this study, 11 of the 12 constituents required by NPDES permitting were analyzed. The 11 constituents analyzed were chemical oxygen demand, dissolved solids, suspended solids, total ammonia plus organic nitrogen as nitrogen, total nitrogen, total phosphorus, dissolved phosphorus, total recoverable cadmium, total recoverable copper, total recoverable lead, and total recoverable zinc. The constituent required for NPDES permitting but not sampled for in this study was 5-day biological oxygen demand. Samples for determining biological oxygen demand were not collected because of an inability to analyze samples within 24 hours of sample collection as required by sample-processing protocols. Total recoverable cadmium concentrations determined during this study were mostly less than the analytical reporting level (table 8); therefore, loads and yields were not estimated for total recoverable cadmium.

Annual Loads

Mean annual loads of selected constituents for each site were estimated from a summation of calculated load for low-flow and storm-runoff conditions (fig. 7). Annual low-flow loads were calculated by multiplying mean low-flow concentrations (table 4) by the mean annual low-flow volumes (table 2) and by factors that account for the unit conversions of liters to cubic feet, acre-feet to cubic feet, and milligrams or micrograms to pounds. Mean storm-runoff loads were calculated in the same manner using mean storm-runoff concentrations (table 5) and mean annual storm-runoff volumes (table 2) and factors that account for appropriate unit conversions. Mean annual constituent loads were calculated by adding mean annual low-flow loads to the mean annual storm-runoff loads.

Figure 7 shows the estimated mean annual loads for low flow and storm runoff for 10 constituents. Of

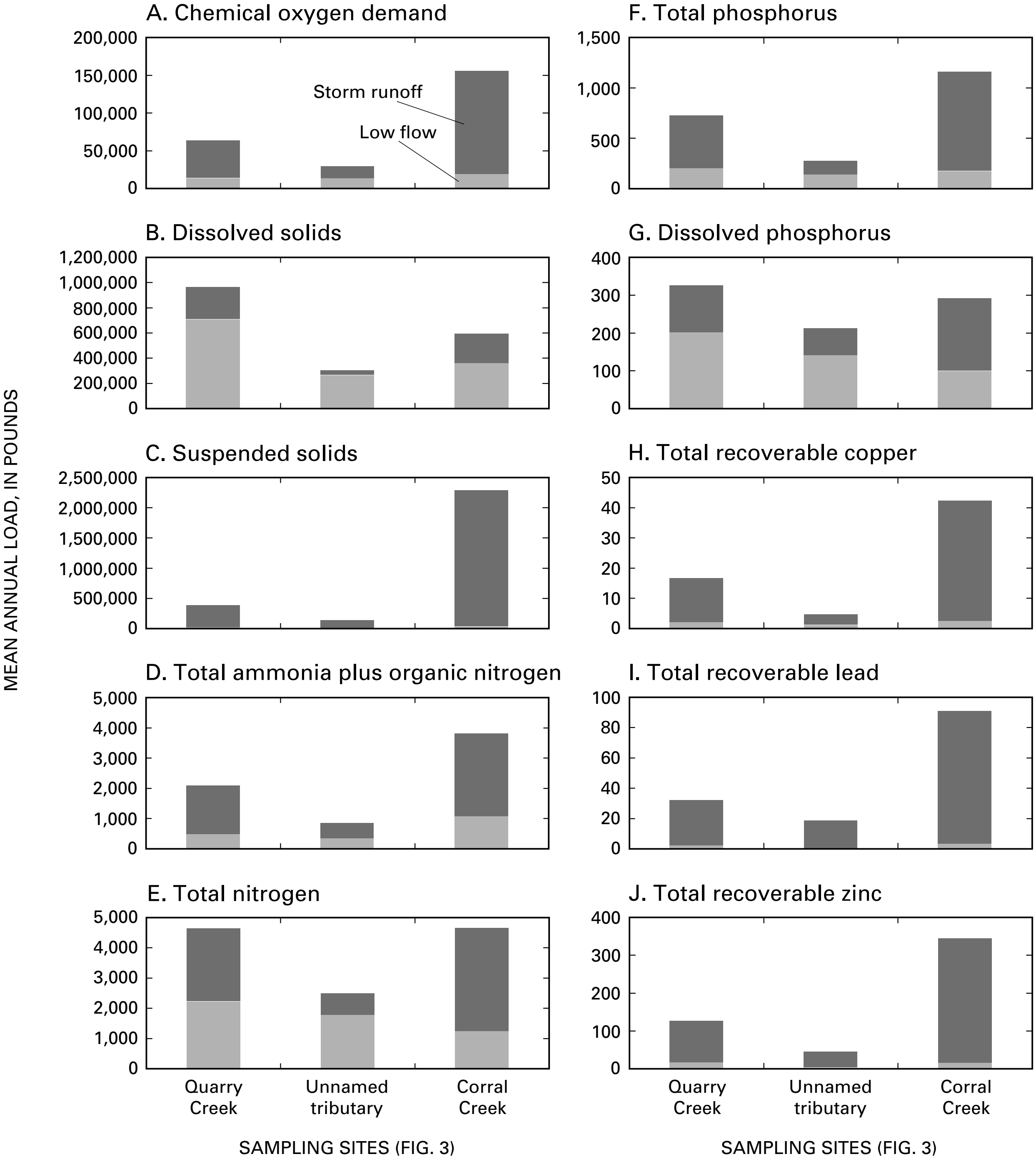

Figure 7. Mean annual low-flow and storm-runoff loads of selected constituents estimated for sampling sites at Fort Leavenworth, Kansas, 1994–96.

the three sites, Corral Creek contributed the most mass for 8 of the 10 constituents. Quarry Creek exceeded the mean annual loads in Corral Creek for dissolved solids and dissolved phosphorus. The unnamed tributary contributed the least mass of the three watersheds for all 10 constituents.

Storm runoff contributed more than one-half of the mean annual loads for most of the 10 constituents. More than 70 percent of the mean annual loads for suspended solids and total recoverable copper, lead, and zinc were contributed by storm runoff. Low flow contributed more than one-half the mean annual loads of dissolved solids at all three sampling sites, total nitrogen at the unnamed tributary site, and dissolved phosphorus at the Quarry Creek and the unnamed tributary sites.

Annual Yields

Mean annual yields of the 10 selected constituents for each site were estimated by dividing the loads (fig. 7) by the area of the respective watershed. The watershed area, shown in table 1, was converted from square miles to acres as part of the calculation. Mean annual constituent yields were calculated by adding mean annual low-flow yields to the mean annual storm-runoff yields.

The mean annual yield of chemical oxygen demand for Corral Creek was nearly twice the amount of the yields from the other two watersheds (fig. 8). Yields during storm runoff contributed more than one-half of the mean annual yields of chemical oxygen demand estimated for all three sampling sites, the most being for Corral Creek where 80 percent of the annual chemical oxygen demand yield was from storm runoff.

Mean annual yields of dissolved solids were about 1,000 lb/acre from Quarry Creek, 700 lb/acre from the unnamed tributary, and 500 lb/acre from Corral Creek. Low flow contributed more than one-half of the mean annual yields of dissolved solids for all three watersheds. Low-flow yields of dissolved solids for the Quarry Creek watershed were more than total yields contributed from the other two watersheds.

The Corral Creek watershed yielded about four times the amount of suspended solids per acre as the other two watersheds contributed. A possible explanation for this large yield is construction activities within the Corral Creek watershed that took place during the study. Vegetation was cleared at two different sites to construct new buildings, parking lots, and access roads. When storms occurred, runoff from these construction sites probably transported large amounts of suspended solids from the exposed soils into Corral Creek. The amount of suspended solids contributed during low flow was insignificant at all sites when compared to the amounts contributed during storm runoff.

The yields of nutrient constituents from the three watersheds varied among sites. The unnamed tributary watershed had the largest yields of total nitrogen and dissolved phosphorus of the three watersheds. Fertilizers used to maintain lawns and the golf course within this watershed are possible sources for these large yields. Most of the mean annual yields of nutrient constituents were contributed during storm runoff. The exceptions were total nitrogen from the unnamed tributary watershed and dissolved phosphorus from the Quarry Creek and the unnamed tributary watersheds, where low flow contributed larger yields than storm runoff.

Mean annual yields of total recoverable copper, lead, and zinc were largest from the Corral Creek watershed. The unnamed tributary watershed had the smallest mean annual yield of total recoverable copper and zinc, and the second highest mean annual yield of lead.

Generally, small variability of yields among the three watersheds indicates the differences in land uses are small enough that distinction among watersheds is unclear. Large yields of chemical oxygen demand, suspended solids, and total recoverable metals from the Corral Creek watershed during storm runoff are probably related to the erosion of exposed soils from two construction sites within the watershed. The small yields of suspended solids and total recoverable copper and zinc from the unnamed tributary watershed are probably related to the flow-retention characteristics of the lakes upstream from the sampling site. Discharges from the lakes during a storm increase depending on the amount of inflow into the lakes. However, increased discharge from the lakes is not necessarily storm runoff from that particular storm. In fact, water entering the lakes could be impounded for days, weeks, or months depending on the amount of subsequent inflow. Once storm runoff enters the lakes, velocities are greatly reduced, and suspended solids settle out. Also, dissolved contaminants in the storm runoff may be diluted by residual lake water. For these reasons, water discharging from the lakes during storm runoff probably has smaller concentrations of dissolved constituents, suspended solids, and total recoverable metals compared to inflowing storm-runoff concentrations.

APPLICATION OF REGIONAL REGRESSION MODELS

Multiple regression models for estimating single-storm runoff loads and mean concentrations developed by Driver and Tasker (1990) were used for 10 of the constituents addressed in this study. These regression models were developed from data collected during

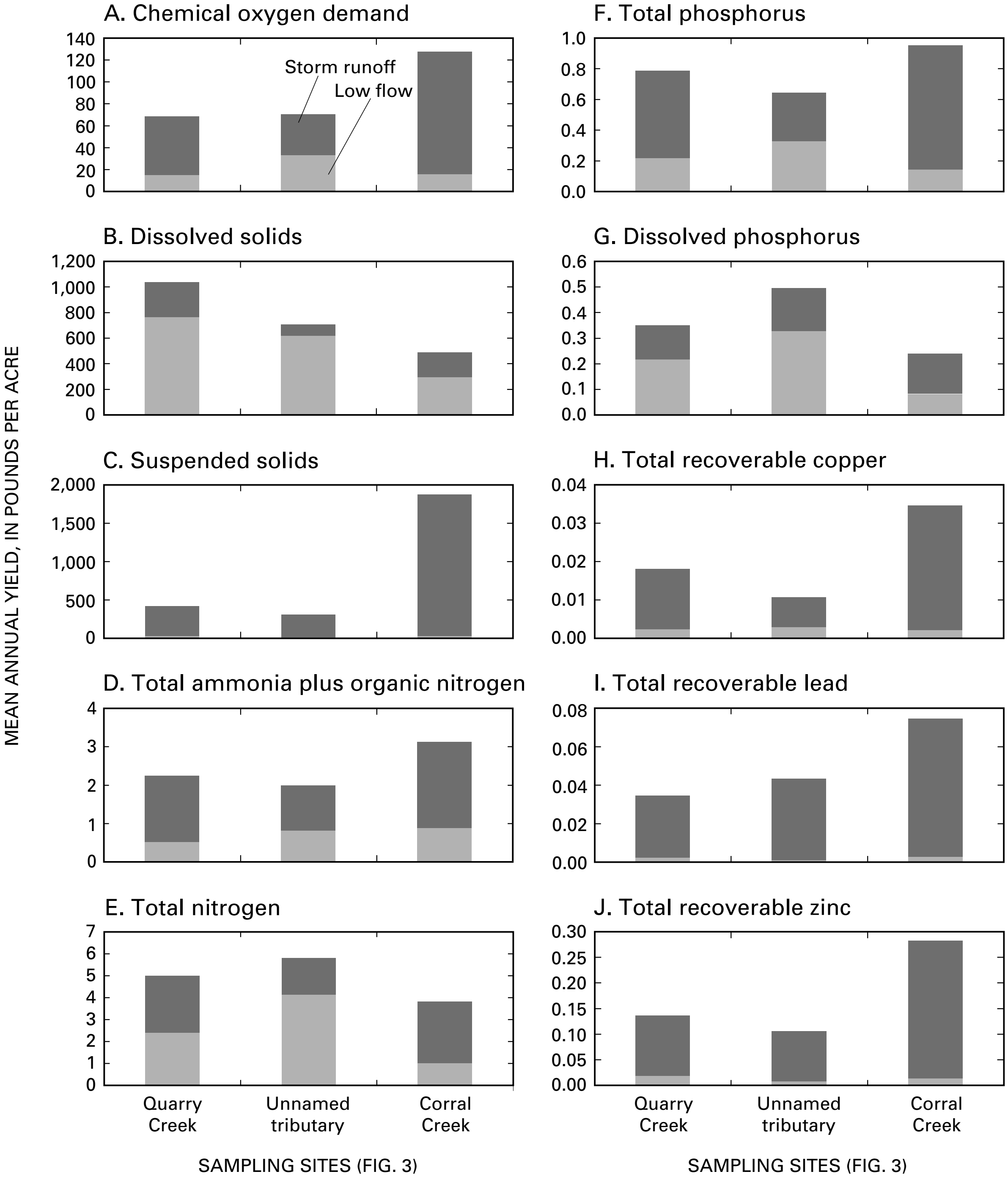

Figure 8. Mean annual low-flow and storm-runoff yields of selected constituents estimated for sampling sites at Fort Leavenworth, Kansas, 1994–96.

EPA's Nationwide Urban Runoff Program (NURP; U.S. Environmental Protection Agency, 1983) in the late 1970s and early 1980s and include three groups delineated on the basis of mean annual rainfall. Region I models were used in areas with mean annual rainfall between 0 and 20 in., Region II models were used in areas with mean annual rainfall between 20 and 40 in., and Region III models were used in areas with mean annual rainfall amounts greater than 40 in. Although the 30-year (1961–90) mean annual rainfall at Leavenworth, Kansas, is 40.34 in. (NOAA, 1992), the models for Region II were used for this study because the mean annual rainfall is only slightly larger than 40 in. and Region II models were developed using data from nearby Kansas City, Missouri. All the models were developed using ordinary least-squares regression. Ordinary least-squares regression cannot be used with censored data. Nine of 21 cadmium concentrations determined for this study were less than the analytical report level (censored data); therefore, cadmium loads and concentrations were not modeled.

Storm-runoff loads, volumes, and mean concentrations were modeled using some or all of the following climatic, physical, and land-use characteristics (Driver and Tasker, 1990):

Climatic characteristics

1. Total storm rainfall (TRN), in inches (NOAA, 1994–96).
2. Maximum 24-hour precipitation intensity that has a 2-year recurrence interval (INT), in inches (Hershfield, 1961).
3. Mean annual rainfall (MAR), in inches (NOAA, 1992).
4. Mean annual nitrogen load in precipitation (MNL), in pounds of nitrogen per acre (NOAA/NTN, 1995).
5. Mean minimum January temperature (MJT), in degrees Fahrenheit (NOAA, 1992).

Physical and land-use characteristics

1. Total contributing drainage-basin area (DA), in square miles.
2. Impervious area (IA), as a percentage of total contributing drainage-basin area.
3. Industrial land use (LUI), as a percentage of total contributing drainage-basin area.
4. Commercial land use (LUC), as a percentage of total contributing drainage-basin area.
5. Residential land use (LUR), as a percentage of total contributing drainage-basin area.
6. Nonurban land use (LUN), as a percentage of total contributing drainage-basin area.
7. Population density (PD), in people per square mile (6,200 in 1996; U.S. Army, Fort Leavenworth, oral commun., 1997).

Table 3 of Driver and Tasker (1990) lists the three-variable load models. These models were developed using TRN, DA, and IA. Table 1 of Driver and Tasker (1990) lists the multivariate load models for estimating selected storm-runoff loads. These models were developed using all 12 of the climatic, physical, and land-use characteristics. Multivariate models for estimating selected mean concentrations of storm runoff are listed in table 5 of Driver and Tasker (1990). These models were developed considering all 12 of the climatic, physical, and land-use characteristics.

Calculated Single-Storm Loads

Constituent loads during storm runoff are dependent on several physical parameters such as storm characteristics, antecedent conditions, and land use. Storm-runoff loads were calculated for each storm sample. Storm-runoff loads were calculated by multiplying the mean storm-runoff concentration (table 8) by the total storm-runoff volume (table 2) and by factors that account for the unit conversions of liters to cubic feet and milligrams or micrograms to pounds. The total storm-runoff volume for each storm was calculated using the streamflow hydrograph and rainfall data. One of the six storm-runoff samples collected at Quarry Creek was affected by flow contributed by the levee pump upstream from the site.

The maximum storm-runoff load for most of the selected constituents occurred most often at the Corral Creek sampling site. Storm-runoff loads of dissolved solids and dissolved phosphorus were largest at the Quarry Creek sampling site. The storms with the smallest loads for all 10 constituents occurred at the unnamed tributary sampling site. These observations are probably a function of watershed size.

Estimated Single-Storm Loads and Concentrations

The regression models developed for Region II were not applicable to the unnamed tributary sampling site because of the three lakes upstream from the site. The models were originally developed for watersheds without lakes upstream from sampling sites; therefore, the regression models were used to estimate loads and concentrations for only the Quarry Creek and Corral Creek sampling sites.

Storm-runoff loads and concentrations for 10 of the 12 NPDES properties and constituents were estimated for each storm sampled using Region II regression models presented in Driver and Tasker (1990). Correlation analysis was performed to determine how well the regression-derived loads and mean concentrations compared to the calculated loads and mean concentrations determined during this study. Correlations with coefficients (r) of 0.70 or greater indicate that the regression-model results can explain about 50 percent

(r^2, coefficient of variation) or more of the variability in the storm-runoff load or concentration data collected during this study. The level of significance (p-value) was calculated for each correlation to determine the probability that correlation between the calculated and estimated values is not significant. A level of significance less than 0.05 indicates that the correlation between the calculated and estimated values is significant. For the purpose of this report, a level of significance equal to or greater than 0.05 indicates that the correlation between the actual and estimated values is not significant. Therefore, for the constituents with correlation coefficients equal to or greater than 0.70 and a level of significance less than 0.05, the regional regression models presented in Tasker and Driver (1990) are considered adequate for estimating storm-runoff loads and concentrations in the Quarry and Corral Creek watersheds.

Overall, the regional-regression load models estimated the calculated storm-runoff loads much better than the regional-regression concentration models estimated the mean concentrations. The correlation coefficients for the three-variable load models were the largest for all constituents except dissolved solids. The correlation coefficients for the three-variable load models ranged from 0.63 to 0.95 and levels of significance less than 0.05 (table 6). The multivariate load models had correlation coefficients that ranged from 0.58 to 0.95 and levels of significance less than 0.05. Eight of the 10 correlations for both types of load models had coefficients equal to or greater than 0.70 and are, therefore, acceptable for estimating storm-runoff loads. The correlation coefficients for the multivariate concentration models ranged from -0.51 to 0.53, and the levels of significance were equal to or greater than 0.05. One-half of the multivariate concentration models had correlation coefficients less than zero. The negative correlation indicates an inverse relation (negative slope) between the calculated and estimated concentrations, or as the calculated data increase the estimated data decrease. A positive correlation coefficient indicates both data sets are increasing. Because of inverse relations, small correlation coefficients, and large

Table 6. Results of correlation analysis between calculated single-storm runoff loads and mean concentrations at Quarry Creek and Corral Creek sampling sites, Fort Leavenworth, Kansas, 1994–96, and corresponding loads and mean concentrations estimated from regional-regression models presented in Driver and Tasker (1990)

[<, less than]

Response variable	Number of samples	Correlation coefficient: Three variable load model[1]	Correlation coefficient: Multivariate load model[2]	Correlation coefficient: Multivariate concentration model[3]	Level of significance (p-value): Three variable load model[1]	Level of significance (p-value): Multivariate load model[2]	Level of significance (p-value): Multivariate concentration model[3]
Chemical oxygen demand	14	0.83	0.77	0.53	<0.05	<0.05	0.05
Dissolved solids	12	.63	.64	.27	<.05	<.05	.39
Suspended solids	14	.65	.58	-.28	<.05	<.05	.33
Total ammonia and organic nitrogen	14	.71	.70	.29	<.05	<.05	.32
Total nitrogen	14	.75	.75	.28	<.05	<.05	.34
Total phosphorus	14	.77	.76	.04	<.05	<.05	.90
Dissolved phosphorus	14	.86	.85	-.51	<.05	<.05	.51
Total recoverable copper	13	.90	.90	-.08	<.05	<.05	.19
Total recoverable lead	13	.91	.88	-.21	<.05	<.05	.49
Total recoverable zinc	13	.95	.95	-.04	<.05	<.05	.90

[1]Equations from table 3 in Driver and Tasker (1990).

[2]Equations from table 1 in Driver and Tasker (1990).

[3]Equations from table 5 in Driver and Tasker (1990).

p-values, the multivariate concentration models were considered unsatisfactory for use at Fort Leavenworth.

Most of the three-variable load model's correlation coefficients were slightly larger than the multivariate load model's correlation coefficients and, therefore, slightly better at estimating the storm-runoff loads for the storms that were sampled. Overall, the three-variable load models are the simplest method for estimating storm-runoff loads for the 10 constituents. Of the 10 constituents, the three-variable load model with the largest correlation coefficient was total recoverable zinc. Figure 9 shows the relation between calculated and estimated total recoverable zinc storm-runoff loads for the Quarry Creek and Corral Creek sampling sites for the storms sampled. The least-correlated, three-variable load model was for dissolved solids loads. The relation between calculated and estimated storm-runoff loads for dissolved solids at the Quarry Creek and Corral Creek sampling sites for the storms sampled is shown in figure 10.

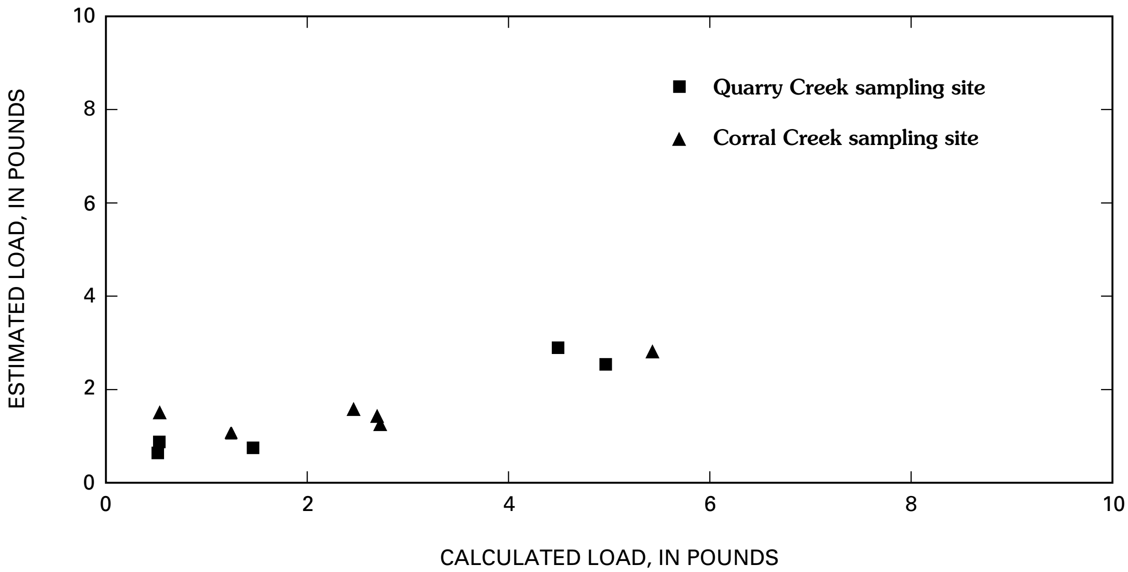

Figure 9. Relation of calculated to estimated total recoverable zinc loads at Quarry Creek and Corral Creek sampling sites, Fort Leavenworth, Kansas, 1994–96.

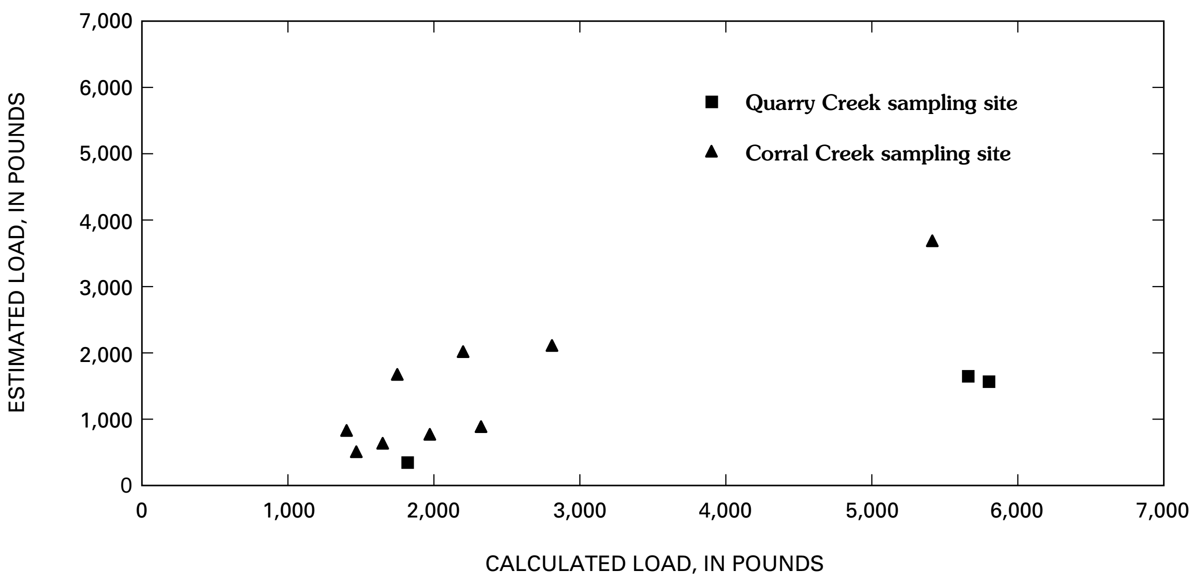

Figure 10. Relation of calculated to estimated dissolved solids loads at Quarry Creek and Corral Creek sampling sites, Fort Leavenworth, Kansas, 1994–96.

The three-variable models appear to be most suitable for estimating future storm-runoff loads. The three variables (DA, IA, and TRN) used in the model are easily obtained. DA (table 1) for each watershed will likely remain the same, IA (table 1) can be updated as necessary, and TRN for each storm can be measured or the data obtained from the National Weather Service.

SUMMARY

Storm runoff from urban areas may have concentrations and loads of contaminants that may degrade local water quality and downstream receiving water. The U.S. Geological Survey, in cooperation with the U.S. Army Environmental Office at Fort Leavenworth, Kansas, began a 2.5-year study in 1994 to characterize the quantity and quality of water in three selected streams during low-flow (12 samples) and storm-runoff (21 samples) conditions at three sampling sites on Fort Leavenworth. This characterization was used to determine if previously developed regional regression models could reasonably estimate loads and concentrations of selected water-quality constituents for urban watersheds in the Fort Leavenworth area. The purpose of this report is to present water-quality data collected during low flow and storm runoff to assess current (1994–96) conditions and possible methods for anticipating future water-quality effects from storm runoff and changes in land use.

Fort Leavenworth is located on the west bank of the Missouri River, about 10 mi upstream from Kansas City, Kansas. The study area consists of three watersheds that drain most of the urban area of the fort. The study area is about 4.0 mi^2 and includes about 38 percent of Fort Leavenworth's total area, about one-half of the adjacent Leavenworth Federal Penitentiary, and a small part of the city of Leavenworth. Land uses within the study area consist mostly of nonurban and urban open area with smaller commercial and residential areas.

Three sampling sites were established in May 1994 to monitor the streamflow and the water quality of Quarry Creek, an unnamed tributary to the Missouri River, and Corral Creek. Streamflow was monitored continuously, and water-quality samples were collected during low flow and storm runoff to determine mean annual constituent concentrations and loads.

Mean annual concentrations of selected water-quality constituents were calculated for each sampling site from samples collected during low-flow and storm-runoff conditions. Mean constituent concentrations for the most part were smallest during low flow with the exception of major ions, dissolved solids, and some nutrients. The largest mean chemical oxygen demands during low flow and in storm runoff were in water from Corral Creek. Storm-runoff samples generally had a larger chemical oxygen demand than low-flow samples. Major ion and dissolved solids concentrations generally were largest during low flow in water from all three sampling sites and were usually largest in water from Quarry Creek. Suspended solids concentrations in storm-runoff samples were typically an order of magnitude larger than concentrations in low-flow samples. Corral Creek, by far, had the largest concentrations of suspended solids of the three sites. Nutrient concentrations were most affected by storm runoff in the unnamed tributary watershed. Storm-runoff concentrations of total nitrogen and dissolved phosphorus were smaller than low-flow concentrations from the unnamed tributary watershed. Concentrations of total recoverable metals were much larger in storm-runoff samples than in low-flow samples. Of the three sampling sites, water from Corral Creek generally had the largest concentrations of metals during low flow and storm runoff. Total organic carbon concentrations were larger in storm-runoff samples than in low-flow samples. Water from Corral Creek had the largest total organic carbon concentrations of the three sampling sites.

Two volatile organic compounds where detected in low-flow water samples. Total chloroform was detected in water samples from all three sampling sites during March 1996; concentrations ranged from 0.2 to 0.5 μg/L. Total tetrachloroethylene was detected at 0.3 μg/L in the March 1996 sample from Quarry Creek. Three storm-runoff samples for analysis of volatile organic compounds were collected during three storms. Concentrations of volatile organic compounds in the samples were not above the analytical reporting levels.

Acid-base/neutral organic compounds were not detected in any of the low-flow or storm-runoff samples. Eight pesticides were detected in low-flow samples. Atrazine, prometon, and simazine were detected in low-flow samples from all three sampling sites. Fifteen pesticides were detected in storm-runoff samples collected from all three sampling sites. In water from Quarry Creek, p,p' DDD; DDE; p,p' DDE; p,p' DDT; malathion, and 2, 4–D were detected in more than one-half of the samples collected. More than one-half

of the samples collected from the unnamed tributary had detections of DDE; p,p’ DDT; malathion; and 2, 4–D. Chlordane, chlorpyrifos, Diazinon, malathion, and 2, 4–D were detected in more than one-half the samples collected from Corral Creek. A sample collected from Quarry Creek on August 22, 1996, was the only sample without a detection of 2, 4–D. None of the pesticide concentrations exceeded the Maximum Contaminant Level values established by U.S Environmental Protection Agency drinking-water regulations.

Mean annual loads of selected constituents were calculated for each watershed. The Corral Creek watershed contributed the largest amount of mass for 8 of the 10 selected constituents. Only the Quarry Creek watershed exceeded the mean annual load of the Corral Creek watershed for dissolved solids and dissolved phosphorus. The Quarry Creek and Corral Creek watersheds contributed more than 1.5 times the mass that the unnamed tributary watershed contributed for all 10 selected constituents. Overall, storm runoff contributed more than one-half of the mean annual load for most of the 10 selected constituents. In fact, more than 70 percent of the mean annual loads of suspended solids and total recoverable copper, lead, and zinc were contributed by storm runoff. Low-flow loads of dissolved solids at all three sampling sites, total nitrogen at the unnamed tributary site, and dissolved phosphorus at the Quarry Creek and the unnamed tributary sites contributed more than one-half the mean annual load.

Mean annual yields (mass per unit area) of selected constituents from each watershed indicated few differences between watersheds. The lack of variability of yields among the three watersheds indicates that differences in land uses are small enough that few distinctions can be made between watersheds. The Corral Creek watershed contributed the largest yields for 7 of the 10 selected water-quality constituents. Large yields of chemical oxygen demand, suspended solids, and total recoverable metals during storm runoff from the Corral Creek watershed are probably related to the erosion of exposed soils at construction sites within the watershed. The mean annual yield of dissolved solids was largest from the Quarry Creek watershed. The largest mean annual yields of total nitrogen and dissolved phosphorus were from the unnamed tributary watershed. Overall, storm runoff contributed more than one-half of the mean annual yields for chemical oxygen demand, suspended solids, most of the selected nutrient constituents, and all three of the selected total recoverable metals. In fact, more than 70 percent of the mean annual mean yields of suspended solids and total recoverable copper, lead, and zinc were contributed by storm runoff. Low-flow yields of dissolved solids in water from all three sampling sites, total nitrogen in water from the unnamed tributary, and dissolved phosphorus in water from Quarry Creek and the unnamed tributary contributed more than one-half the mean annual load. Low yields of suspended solids and total recoverable copper and zinc from the unnamed tributary watershed are probably related to retention-storage effects from lakes upstream from the sampling site.

Procedures for estimating single-storm runoff loads and mean concentrations developed by Driver and Tasker (1990) for each of 10 constituents were used in this study. Storm-runoff loads and mean concentrations were modeled using climatic, physical, and land-use characteristics. Load models estimated the calculated storm-runoff loads much better than the concentration models estimated the mean concentrations. The correlation coefficients for the three-variable load models ranged from 0.63 to 0.95. Eight of the 10 models had correlation factors greater than 0.70 and are considered, therefore, suitable for estimating storm-runoff loads, whereas none of the values of the correlation coefficients for multivariate concentration models were greater than 0.70.

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SUPPLEMENTAL INFORMATION

Table 7. Daily mean streamflow for three sampling sites at Fort Leavenworth, Kansas, for water years 1994–96

[All values are in cubic feet per second except as noted. e, estimated]

Day	Oct. 1993 to Sept. 1994											
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
	06820464 Quarry Creek at Missouri River, Fort Leavenworth, Kansas (fig. 2)											
1	---	---	---	---	---	---	---	3.5	0.80	0.45	0.51	0.38
2	---	---	---	---	---	---	---	2.7	.80	1.6	2.3	.35
3	---	---	---	---	---	---	---	2.5	.90	.51	.78	.35
4	---	---	---	---	---	---	---	2.7	.85	.49	1.0	.52
5	---	---	---	---	---	---	---	2.0	1.1	.45	.47	.39
6	---	---	---	---	---	---	---	5.1	2.9	.44	.44	.35
7	---	---	---	---	---	---	---	2.5	.95	.42	.44	.30
8	---	---	---	---	---	---	---	2.2	2.0	.40	.49	.34
9	---	---	---	---	---	---	---	2.0	.95	.37	.40	.22
10	---	---	---	---	---	---	---	1.8	.88	.37	.40	.22
11	---	---	---	---	---	---	---	2.0	.81	.33	.36	.21
12	---	---	---	---	---	---	1.0	1.6	.75	.40	.40	.20
13	---	---	---	---	---	---	.68	1.5	.72	.29	.37	.21
14	---	---	---	---	---	---	.53	1.8	.66	.27	.36	.20
15	---	---	---	---	---	---	.83	1.5	.61	.26	.35	.82
16	---	---	---	---	---	---	.50	1.3	.61	.30	.35	.29
17	---	---	---	---	---	---	.45	1.3	.58	.25	.33	.16
18	---	---	---	---	---	---	.42	1.2	.57	.23	.31	.15
19	---	---	---	---	---	---	.40	1.2	.52	.22	.45	.17
20	---	---	---	---	---	---	.39	1.1	.48	1.4	.35	.80
21	---	---	---	---	---	---	1.9	1.0	.50	.71	.29	.29
22	---	---	---	---	---	---	.90	.99	.50	.60	.26	1.5
23	---	---	---	---	---	---	.72	.95	.54	.57	.25	.53
24	---	---	---	---	---	---	.65	.90	.44	.57	.25	.37
25	---	---	---	---	---	---	.67	.85	.39	.51	.32	.95
26	---	---	---	---	---	---	.62	.81	.37	.57	.51	1.6
27	---	---	---	---	---	---	1.6	.75	.39	.47	.30	.51
28	---	---	---	---	---	---	16	.75	.37	.42	.28	.23
29	---	---	---	---	---	---	4.2	1.5	.34	.40	1.7	.19
30	---	---	---	---	---	---	5.4	.88	.34	.38	1.1	.20
31	---	---	---	---	---	---	---	.81	---	.33	.81	---
Total	---	---	---	---	---	---	---	**51.69**	**22.62**	**14.98**	**16.93**	**13.00**
Mean	---	---	---	---	---	---	---	**1.67**	**.75**	**.48**	**.55**	**.43**
Maximum	---	---	---	---	---	---	---	**5.1**	**2.9**	**1.6**	**2.3**	**1.6**
Minimum	---	---	---	---	---	---	---	**.75**	**.34**	**.22**	**.25**	**.15**
Acre-foot	---	---	---	---	---	---	---	**103**	**45**	**30**	**34**	**26**

Table 7. Daily mean streamflow for three sampling sites at Fort Leavenworth, Kansas, for water years 1994–96—Continued

Day	Oct. 1994 to Sept. 1995											
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
06820464 Quarry Creek at Missouri River, Fort Leavenworth, Kansas (fig. 2)—Continued												
1	0.22	0.40	0.33	0.28	0.60	0.25	0.24	1.1	e0.60	0.40	0.60	0.98
2	.25	.38	.30	.27	.47	.24	.29	e.30	e.58	.33	.84	.66
3	.71	.28	.30	.26	.41	.26	.37	1.2	e.50	.34	.78	.86
4	.34	.58	.28	.24	.35	.33	.44	e.60	e3.0	8.7	.59	.62
5	.29	.33	.30	.22	.32	.44	.54	e.50	e2.0	e2.0	.54	.50
6	.20	.22	4.6	.21	.33	.37	.56	e.50	e1.0	e1.2	.53	.50
7	.20	.28	1.5	.19	.31	.42	.45	2.0	e.70	e.80	.49	.79
8	.20	.33	.56	.22	.24	.43	.45	e2.5	e6.5	.63	e.44	.52
9	.25	.35	.42	.22	.25	.38	.27	e1.5	e3.0	.45	e.38	.46
10	.25	.36	.39	.28	.36	.42	.38	e.80	e2.0	.44	.32	.67
11	.25	.34	.30	.33	.23	.43	.67	e.70	e1.0	e.42	.39	.73
12	.25	.36	.36	.32	.26	.37	.39	e.65	e.70	e.38	.30	1.0
13	.25	.54	.35	.43	.20	.35	.35	e1.0	e.60	e.32	.29	.48
14	.24	.88	.34	.26	.22	.32	.43	e.70	e.55	e.28	.94	.68
15	.32	.35	.40	.22	.23	.30	.45	e.50	e.53	.25	3.5	.66
16	.38	.33	.45	.25	.38	.29	3.3	e3.8	e.50	.24	4.6	.43
17	.35	.24	.39	.49	.23	.25	1.4	e12	e.50	.77	.73	.66
18	.32	.35	.46	.31	.25	.25	2.3	e3.0	e.48	.90	e.70	.62
19	.29	.20	.36	.29	.23	.25	.51	e2.0	e.48	1.5	e.80	.78
20	.29	3.8	.30	.27	.23	.25	.83	e1.5	e.46	7.7	.96	.46
21	.45	1.4	.36	.27	.20	.25	.38	e.90	e.45	1.3	1.1	1.1
22	.29	1.5	.26	.28	.21	.25	.31	e.70	e.50	1.0	.83	.66
23	.45	.36	.33	.38	.20	.25	.29	e13	e.50	2.7	.73	.51
24	1.6	.35	.25	.36	.20	.23	.25	e3.0	e.45	e1.0	.92	.64
25	.36	.32	.25	.35	.20	1.2	.24	e1.0	e.40	.76	.73	.39
26	.39	.28	.25	.36	.88	.46	1.0	e2.0	e.70	.68	.84	.59
27	.34	2.0	.26	1.9	.42	.27	e.35	e4.0	e.50	.64	.59	.55
28	.32	.88	.29	2.4	.28	.24	e.28	e1.5	e5.0	.59	.71	.70
29	.20	.63	.30	.81	---	.21	e.24	e.90	.81	.57	.58	.55
30	.18	.98	.30	.65	---	.18	.21	e.70	.40	.54	.54	.97
31	.89	---	.33	.87	---	.80	---	e.70	---	.54	1.0	---
Total	**11.32**	**19.60**	**15.87**	**14.19**	**8.69**	**10.94**	**18.17**	**65.25**	**35.39**	**38.37**	**27.29**	**19.72**
Mean	**.37**	**.65**	**.51**	**.46**	**.31**	**.35**	**.61**	**2.10**	**1.18**	**1.24**	**.88**	**.66**
Maximum	**1.6**	**3.8**	**4.6**	**2.4**	**.88**	**1.2**	**3.3**	**13**	**6.5**	**8.7**	**4.6**	**1.1**
Minimum	**.18**	**.20**	**.25**	**.19**	**.20**	**.18**	**.21**	**.30**	**.40**	**.24**	**.29**	**.39**
Acre-foot	**22**	**39**	**31**	**28**	**17**	**22**	**36**	**129**	**70**	**76**	**54**	**39**

Table 7. Daily mean streamflow for three sampling sites at Fort Leavenworth, Kansas, for water years 1994–96—Continued

Day	Oct. 1995 to Sept. 1996											
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
	06820464 Quarry Creek at Missouri River, Fort Leavenworth, Kansas (fig. 2)—Continued											
1	0.50	6.3	0.44	0.22	e0.09	0.21	0.34	0.72	e8.9	e0.90	e5.0	0.68
2	.47	.67	.39	.24	e.08	.21	.31	.59	e2.0	e.80	2.7	.64
3	.71	.61	.38	e.22	e.10	.22	.28	.44	e1.0	e.70	1.7	.74
4	.49	.60	.39	e.20	e.20	.81	.16	1.9	e.70	e3.4	1.6	.78
5	.52	.79	.39	e.18	e.34	.47	.18	.64	e8.0	e2.2	1.3	.66
6	.52	.60	.48	e.15	.33	e.35	.18	.72	e1.5	e1.4	1.2	.57
7	.74	.49	.53	e.12	.58	e.27	.21	10	e1.0	e1.3	e1.1	.48
8	.51	.71	.41	e.10	.44	e.25	.23	e4.0	e.90	e1.5	e1.0	1.7
9	.74	.52	.25	e.20	.34	e.22	.25	e1.7	e.90	e1.3	e2.0	.98
10	.49	.53	.19	.27	.33	.22	.23	e1.2	e.88	e1.2	e1.5	.69
11	.48	.66	.20	.64	.29	.74	.21	e.80	e.80	e1.1	e1.2	.56
12	.74	.55	.20	.59	.89	.47	.27	e1.0	e.78	e1.0	1.1	.47
13	.49	.69	.22	.17	2.2	.36	.30	e.82	e15	1.1	1.1	.41
14	.55	.45	.24	.18	.97	.70	.38	e.72	e1.0	1.4	1.1	.77
15	.57	.83	.66	.20	.52	.42	.34	e.68	e1.0	1.2	1.0	.48
16	.57	.72	.20	.20	e.40	.20	.28	e.62	e11	1.0	e2.3	1.1
17	.73	.55	.20	e.20	.25	.88	.28	e.60	e1.5	.87	e2.0	.42
18	.59	.69	e.20	e.19	.25	.55	.28	e.58	e1.0	.81	e1.5	.41
19	.56	.45	e.20	e.18	.25	.67	.27	e.57	e.90	e.80	1.1	.83
20	.88	.58	e.20	.25	1.2	.41	.29	e.56	e.88	e16	e1.0	.49
21	.61	.41	e.20	.29	.65	.65	.67	e.57	e.82	e3.0	e1.1	.45
22	.85	.46	.20	.31	.41	.34	1.0	e.59	e.90	e2.0	e10	.36
23	.90	.69	.20	.26	.64	.57	.20	e1.2	e11	e1.5	e1.5	1.3
24	.67	.58	.20	.25	.21	1.1	2.1	e.60	e2.6	1.5	1.3	.54
25	.68	.41	.20	.27	.21	.44	.47	e.58	e1.5	1.5	.90	1.3
26	.72	.54	e.30	.25	.78	.47	.48	e13	e1.4	1.5	1.0	2.3
27	.86	.49	.19	.31	.62	.40	.62	e2.0	e1.3	1.1	.94	.91
28	.70	.54	e.18	.35	.45	.27	2.0	e.90	e1.2	e4.6	1.0	.46
29	.68	.43	e.20	.37	.42	.36	1.3	e.80	e1.1	e4.0	.83	.91
30	.89	.56	e.30	e.20	---	.75	.69	e.70	e1.0	e1.1	.65	.48
31	.87	---	.25	e.10	---	.43	---	e10	---	e1.1	.69	---
Total	**20.28**	**23.10**	**8.79**	**7.66**	**14.44**	**14.41**	**14.80**	**59.80**	**82.46**	**62.88**	**52.41**	**22.87**
Mean	**.65**	**.77**	**.28**	**.25**	**.50**	**.46**	**.49**	**1.93**	**2.75**	**2.03**	**1.69**	**.76**
Maximum	**.90**	**6.3**	**.66**	**.64**	**2.2**	**1.1**	**2.1**	**13**	**15**	**16**	**10**	**2.3**
Minimum	**.47**	**.41**	**.18**	**.10**	**.08**	**.20**	**.16**	**.44**	**.70**	**.70**	**.65**	**.36**
Acre-foot	**40**	**46**	**17**	**15**	**29**	**29**	**29**	**119**	**164**	**125**	**104**	**45**

Table 7. Daily mean streamflow for three sampling sites at Fort Leavenworth, Kansas, for water years 1994–96—Continued

Day	Oct. 1993 to Sept. 1994											
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
	06820468 Unnamed tributary at Stimson Avenue, Fort Leavenworth, Kansas (fig. 2)											
1	---	---	---	---	---	---	---	---	0.25	0.89	0.32	0.19
2	---	---	---	---	---	---	---	0.82	.30	1.5	2.0	.19
3	---	---	---	---	---	---	---	.76	.38	.12	.64	.19
4	---	---	---	---	---	---	---	.68	.22	.10	.51	.31
5	---	---	---	---	---	---	---	.58	.54	.08	.31	.14
6	---	---	---	---	---	---	---	3.6	3.3	.08	.29	.12
7	---	---	---	---	---	---	---	1.1	.96	.08	.29	.12
8	---	---	---	---	---	---	---	.81	1.6	.07	.34	.09
9	---	---	---	---	---	---	---	.72	.72	.05	.30	.10
10	---	---	---	---	---	---	---	.63	.55	.05	.26	.06
11	---	---	---	---	---	---	---	.48	.43	.06	.29	.08
12	---	---	---	---	---	---	---	.41	.37	.05	.30	.10
13	---	---	---	---	---	---	---	.46	.38	.05	.29	.11
14	---	---	---	---	---	---	---	1.3	.35	.13	.29	.13
15	---	---	---	---	---	---	---	.96	.29	.05	.29	.15
16	---	---	---	---	---	---	---	.59	.27	.10	.24	.17
17	---	---	---	---	---	---	---	.42	.25	.05	.24	.19
18	---	---	---	---	---	---	---	.34	.21	.05	.25	.19
19	---	---	---	---	---	---	---	.32	.19	.05	.49	.22
20	---	---	---	---	---	---	---	.30	.19	1.1	.19	.25
21	---	---	---	---	---	---	---	.30	.15	.20	.19	.81
22	---	---	---	---	---	---	---	.26	.15	.18	.19	.33
23	---	---	---	---	---	---	---	.27	.23	.16	.20	.50
24	---	---	---	---	---	---	---	.27	.14	.16	.24	.16
25	---	---	---	---	---	---	---	.35	.13	.16	.25	1.1
26	---	---	---	---	---	---	---	.24	.12	.26	.62	.30
27	---	---	---	---	---	---	---	.23	.10	.15	.34	.20
28	---	---	---	---	---	---	---	.24	.07	.15	.53	.19
29	---	---	---	---	---	---	---	1.7	.07	.15	2.2	.21
30	---	---	---	---	---	---	---	.62	.08	.15	1.2	.26
31	---	---	---	---	---	---	---	.37	---	.15	.23	---
Total	---	---	---	---	---	---	---	---	**12.99**	**6.58**	**14.32**	**7.16**
Mean	---	---	---	---	---	---	---	---	**.43**	**.21**	**.46**	**.24**
Maximum	---	---	---	---	---	---	---	---	**3.3**	**1.5**	**2.2**	**1.1**
Minimum	---	---	---	---	---	---	---	---	**.07**	**.05**	**.19**	**.06**
Acre-foot	---	---	---	---	---	---	---	---	**26**	**13**	**28**	**14**

Table 7. Daily mean streamflow for three sampling sites at Fort Leavenworth, Kansas, for water years 1994–96—Continued

Day	Oct. 1994 to Sept. 1995											
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
06820468 Unnamed tributary at Stimson Avenue, Fort Leavenworth, Kansas (fig. 2)—Continued												
1	0.29	0.20	0.37	0.36	0.33	0.14	0.04	0.90	e0.80	0.41	0.45	0.08
2	.43	.22	.32	.28	.26	.48	.04	.20	e.75	.39	.47	.08
3	.77	.20	.29	.24	.23	.35	.06	.96	e.70	.39	.55	.07
4	.23	.68	.31	.24	.16	.57	.03	.87	e2.0	3.6	.36	.08
5	.25	.39	.43	.24	.15	.42	.03	.27	e1.5	e1.5	.29	.09
6	.34	.22	3.4	.31	.14	.32	.04	.19	e.90	.93	.27	.08
7	.41	.27	1.4	.27	.17	.30	.04	1.3	e.80	.66	.23	.09
8	.31	.35	.50	.27	.15	.12	.04	e2.0	e4.1	.51	.20	.15
9	.23	.41	.33	.25	.15	.18	.20	e1.5	e2.0	.49	.20	.15
10	.19	.39	.30	.26	.15	.15	.54	e1.0	e2.0	.44	.20	.16
11	.24	.36	.29	.33	.15	.11	.52	e.80	e1.5	.44	.25	.16
12	.20	.24	.29	.32	.15	.25	.16	e.70	1.2	.40	.29	.38
13	.19	.50	.29	.29	.15	.28	.06	e.90	.94	.41	.30	.03
14	.19	.24	.29	.26	.15	.22	.05	e.70	.85	.57	.45	.07
15	.38	.20	.29	.24	.18	.13	.12	e.60	.82	.41	1.4	.08
16	.19	.22	.43	.25	.15	.11	1.9	e2.6	.81	.34	2.1	.10
17	.37	.45	.30	e.60	.15	.08	1.2	e7.2	.80	.38	.41	.12
18	.26	.27	.25	e.35	.14	.06	1.1	e2.5	.75	.41	.15	.12
19	.20	.40	.25	e.30	.13	.08	.27	e2.0	.73	1.7	.12	.32
20	.23	4.6	.27	.33	.15	.12	.71	e1.8	.65	3.0	.09	.04
21	.24	.97	.27	.26	.14	.05	.20	1.5	.60	1.3	.08	.23
22	.30	.42	.29	.24	.16	.05	.09	1.1	.59	.89	.09	e.02
23	.36	.42	.27	.24	.16	.05	.07	e7.8	.50	1.8	.10	.02
24	.18	.47	.24	.24	.15	.04	.08	e2.0	.44	.46	.09	.03
25	.18	.51	.24	.24	.18	1.1	.06	e1.0	.52	.32	.09	.03
26	.20	.62	.25	.24	.98	.23	.49	.83	.74	.27	.10	.04
27	.19	1.8	.28	2.0	.33	.15	.29	3.9	.62	.24	.11	.06
28	.24	.56	.24	2.1	.20	.09	.10	e1.0	2.7	.20	.09	.09
29	.29	.37	.24	.73	---	.06	.11	e.90	.84	.19	.10	.09
30	.32	.33	.24	.45	---	.04	.36	e.90	.50	.21	.12	.30
31	.56	---	.34	.42	---	.03	---	e.90	---	.29	.25	---
Total	**8.96**	**17.28**	**13.50**	**13.15**	**5.69**	**6.36**	**9.00**	**50.82**	**32.65**	**23.55**	**10.00**	**3.35**
Mean	**.29**	**.58**	**.44**	**.42**	**.20**	**.21**	**.30**	**1.64**	**1.09**	**.76**	**.32**	**.11**
Maximum	**.77**	**4.6**	**3.4**	**2.1**	**.98**	**1.1**	**1.9**	**7.8**	**4.1**	**3.6**	**2.1**	**.38**
Minimum	**.18**	**.20**	**.24**	**.24**	**.13**	**.03**	**.03**	**.19**	**.44**	**.19**	**.08**	**.01**
Acre-foot	**18**	**34**	**27**	**26**	**11**	**13**	**18**	**101**	**65**	**47**	**20**	**6.6**

Table 7. Daily mean streamflow for three sampling sites at Fort Leavenworth, Kansas, for water years 1994–96—Continued

Day	Oct. 1995 to Sept. 1996											
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
06820468 Unnamed tributary at Stimson Avenue, Fort Leavenworth, Kansas (fig. 2)—Continued												
1	0.14	2.4	0.26	0.23	e0.04	0.09	0.08	0.19	e5.5	0.41	1.8	0.15
2	.16	.35	.23	.22	e.03	.11	.07	.21	e1.1	.35	.95	.16
3	.20	.21	.23	.20	e.04	.10	.07	.18	e.70	.34	.64	.16
4	.25	.18	.24	e.15	e.08	.11	.07	.92	e.60	1.0	.51	.17
5	.30	.21	.40	e.12	.13	.15	e.07	.46	e4.9	.53	.51	.15
6	.38	.24	e.25	e.10	.20	.15	e.06	.65	e1.4	.40	.50	.15
7	.38	.22	e.27	e.08	.38	.16	e.06	3.6	e1.0	.34	.47	.19
8	.35	.19	e.20	e.08	.31	.13	e.06	e1.3	e.80	.56	.37	.50
9	.34	.16	e.14	e.10	.28	.11	.05	e.70	.69	.42	.64	.10
10	.34	.23	e.13	e.20	.28	.12	.04	e.60	.59	.32	.56	.07
11	.34	.27	e.12	.27	.26	.14	.04	e.55	.53	.29	.53	.11
12	.34	e.35	e.13	.22	.93	.13	.06	e.60	.52	.28	.43	.15
13	.37	e.26	e.14	.20	.67	.12	.05	.57	6.1	.34	.36	.15
14	.39	e.24	e.15	.19	.33	.18	.17	.51	e.80	.29	.29	.15
15	.39	e.40	e.30	.22	.27	.09	.03	.48	e.70	.24	.24	.38
16	.39	e.35	e.16	.20	.23	.09	.03	.45	e6.8	.22	.67	.65
17	.41	e.32	e.16	e.19	.20	.07	.06	.52	e3.4	.19	.65	.15
18	.41	e.30	e.16	e.17	.20	.05	.07	.50	e.80	.19	.49	.08
19	.43	e.30	e.16	e.11	.21	.10	.07	.48	e.70	.19	.64	.48
20	.46	e.30	e.16	e.10	.19	.19	.09	.43	e.60	10	.72	.20
21	.45	e.28	e.16	.15	.22	.15	.49	.42	e.60	e2.0	.50	.09
22	.48	e.30	e.16	.16	.20	.09	.28	.40	e.60	e1.2	2.1	.06
23	e.50	e.24	e.16	.13	.21	.23	.18	e1.0	5.4	1.0	2.9	.17
24	e.30	e.26	.16	e.12	.11	.65	.13	e.40	e2.0	.84	1.3	.11
25	e.30	e.24	.15	.10	.11	.19	.13	.27	e1.5	.73	.80	.55
26	e.30	e.26	.16	.12	.27	.06	.11	5.7	e1.0	.97	.59	1.2
27	e.40	.28	.15	.11	.28	.08	.28	e.80	e.80	.84	.58	.45
28	e.35	.24	.15	.12	.13	.10	1.1	e.60	e.70	2.4	.41	.12
29	e.35	.24	.16	.13	.10	.07	.69	e.55	e.60	2.6	.27	.06
30	e.60	.25	.26	e.06	---	.47	.24	e.50	e.50	1.1	.20	.07
31	e.38	---	.24	e.05	---	.11	---	e6.1	---	.69	.18	---
Total	**11.18**	**10.07**	**5.90**	**4.60**	**6.89**	**4.59**	**4.93**	**30.64**	**51.93**	**31.27**	**21.80**	**7.18**
Mean	**.36**	**.34**	**.19**	**.15**	**.24**	**.15**	**.16**	**.99**	**1.73**	**1.01**	**.70**	**.24**
Maximum	**.60**	**2.4**	**.40**	**.27**	**.93**	**.65**	**1.1**	**6.1**	**6.8**	**10**	**2.9**	**1.2**
Minimum	**.14**	**.16**	**.12**	**.05**	**.03**	**.05**	**.03**	**.18**	**.50**	**.19**	**.18**	**.06**
Acre-foot	**22**	**20**	**12**	**9.1**	**14**	**9.1**	**9.8**	**61**	**103**	**62**	**43**	**14**

Table 7. Daily mean streamflow for three sampling sites at Fort Leavenworth, Kansas, for water years 1994–96—Continued

	Oct. 1993 to Sept. 1994											
Day	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sept.**
06820472 Corral Creek at Missouri River, Fort Leavenworth, Kansas (fig. 2)												
1	---	---	---	---	---	---	---	2.6	0.27	1.0	0.74	0.26
2	---	---	---	---	---	---	---	1.9	.38	4.8	5.0	.24
3	---	---	---	---	---	---	---	1.5	.44	.46	1.1	.24
4	---	---	---	---	---	---	---	1.3	.31	.40	.53	.42
5	---	---	---	---	---	---	---	1.0	.51	.36	.31	.20
6	---	---	---	---	---	---	---	7.7	9.0	.40	.29	.16
7	---	---	---	---	---	---	---	1.8	.53	.35	.27	.14
8	---	---	---	---	---	---	---	1.4	2.5	.32	.25	.15
9	---	---	---	---	---	---	---	1.1	.44	.33	.29	.14
10	---	---	---	---	---	---	---	.92	.35	.30	.25	.13
11	---	---	---	---	---	---	---	.85	.29	.30	.24	.13
12	---	---	---	---	---	---	---	.72	.28	.31	.22	.15
13	---	---	---	---	---	---	---	.69	.27	.49	.16	.14
14	---	---	---	---	---	---	---	1.6	.20	.29	.17	.14
15	---	---	---	---	---	---	---	.72	.27	.17	.23	.13
16	---	---	---	---	---	---	---	.58	.20	.34	.18	.15
17	---	---	---	---	---	---	---	.49	.18	.27	.19	.18
18	---	---	---	---	---	---	0.36	.46	.18	.19	.18	.21
19	---	---	---	---	---	---	.31	.45	.18	.17	.82	.21
20	---	---	---	---	---	---	.35	.40	.19	2.3	.37	.22
21	---	---	---	---	---	---	5.2	.36	.15	.30	.19	.89
22	---	---	---	---	---	---	.75	.34	.16	.22	.20	1.1
23	---	---	---	---	---	---	.54	.33	.34	.21	.21	1.0
24	---	---	---	---	---	---	.45	.31	.13	.28	.19	.15
25	---	---	---	---	---	---	.77	.37	.12	.21	.16	3.1
26	---	---	---	---	---	---	.42	.33	.10	.36	1.2	.25
27	---	---	---	---	---	---	6.8	.30	.09	.14	.20	.11
28	---	---	---	---	---	---	25	.28	.08	.17	.21	.09
29	---	---	---	---	---	---	3.6	2.2	.15	.14	6.7	.10
30	---	---	---	---	---	---	7.6	.37	.26	.12	2.7	.15
31	---	---	---	---	---	---	---	.30	---	.09	.36	---
Total	---	---	---	---	---	---	---	**33.67**	**18.55**	**15.79**	**24.11**	**10.68**
Mean	---	---	---	---	---	---	---	**1.09**	**.62**	**.51**	**.78**	**.36**
Maximum	---	---	---	---	---	---	---	**7.7**	**9.0**	**4.8**	**6.7**	**3.1**
Minimum	---	---	---	---	---	---	---	**.28**	**.08**	**.09**	**.16**	**.09**
Acre-foot	---	---	---	---	---	---	---	**67**	**37**	**31**	**48**	**21**

Table 7. Daily mean streamflow for three sampling sites at Fort Leavenworth, Kansas, for water years 1994–96—Continued

Day	Oct. 1994 to Sept. 1995											
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
06820472 Corral Creek at Missouri River, Fort Leavenworth, Kansas (fig. 2)—Continued												
1	0.12	0.17	0.18	0.21	0.34	0.23	0.18	1.8	e1.0	0.53	0.32	0.29
2	.12	.17	.18	e.30	.39	.23	.15	.18	e1.5	.46	1.3	.27
3	.91	.39	.19	e.28	.33	.24	.15	2.4	e1.0	.45	.93	.16
4	.10	1.1	.17	e.28	.27	.81	.13	1.6	e5.0	e13	.42	.16
5	.35	.49	e.17	e.28	.24	.69	.16	.37	e3.6	e2.0	.37	.34
6	.19	.18	9.7	e.28	.25	.61	.17	.24	e1.5	.72	.36	.17
7	.31	.15	1.7	e.28	.18	.62	.17	3.9	e1.0	.58	.34	.16
8	.37	.17	.69	e.26	.23	.49	.15	e5.0	e10	.53	.33	.16
9	.18	.17	.47	e.25	.25	.81	.13	e3.0	e5.0	.43	.29	.18
10	.19	.18	.36	e.30	.22	.58	.79	e1.5	e2.5	.42	.26	.16
11	.19	.19	.33	e.40	.20	.44	.84	e1.2	e1.5	.39	.24	.17
12	.23	.15	.36	e.35	.24	.40	.19	e1.0	e1.3	.40	.22	1.1
13	.22	.64	.36	e.60	.25	.39	.20	e1.5	1.2	.36	.22	.19
14	.21	.15	.31	.41	.34	.40	.17	e.90	1.1	.31	1.5	.18
15	.71	.13	.32	.30	.33	.35	.17	e.70	.94	.29	5.2	.21
16	.28	.16	.61	.35	.26	.33	6.6	e6.6	.79	.27	6.9	.25
17	.35	.14	.30	.97	.27	.31	3.7	e19	.71	.26	.99	.24
18	.20	.20	.26	.28	.27	.30	2.2	e5.0	.63	.27	.50	.17
19	.15	.31	.27	.30	.24	.26	.45	e3.5	.59	16	.24	.91
20	.16	11	.27	.33	.21	.22	1.5	e2.0	.56	9.4	.19	.11
21	.18	.69	.27	.20	.20	.24	.26	1.8	.54	1.3	.22	1.1
22	.18	.31	.25	.21	.23	.23	.24	1.4	.57	.62	.23	.16
23	.27	.23	.24	.24	.22	.22	.17	e20	.55	12	.24	.13
24	.29	.20	.21	.25	.21	.21	.12	e5.0	.50	.99	.40	.10
25	.20	.16	.18	.26	.22	3.0	.10	e1.5	.69	.67	.27	.13
26	.22	.19	.20	.31	2.6	.48	1.0	3.7	1.0	.54	.15	.17
27	.23	3.7	.20	6.0	.51	.24	.17	e6.7	.59	.50	.14	.16
28	.25	.37	.21	4.3	.28	.21	.10	e3.0	6.6	.41	.17	.17
29	.22	.26	.22	.75	---	.20	.12	e1.5	.91	.33	.19	.42
30	.25	.21	.21	.59	---	.21	.34	e1.0	.63	.30	.27	.71
31	1.3	---	.37	.64	---	.21	---	e1.0	---	.29	.50	---
Total	**9.13**	**22.56**	**19.76**	**20.76**	**9.78**	**14.16**	**20.82**	**107.99**	**54.00**	**65.02**	**23.90**	**8.83**
Mean	**.29**	**.75**	**.64**	**.67**	**.35**	**.46**	**.69**	**3.48**	**1.80**	**2.10**	**.77**	**.29**
Maximum	**1.3**	**11**	**9.7**	**6.0**	**2.6**	**3.0**	**6.6**	**20**	**10**	**16**	**6.9**	**1.1**
Minimum	**.10**	**.13**	**.17**	**.20**	**.18**	**.20**	**.10**	**.18**	**.50**	**.26**	**.14**	**.10**
Acre-foot	**18**	**45**	**39**	**41**	**19**	**28**	**41**	**214**	**107**	**129**	**47**	**18**

Table 7. Daily mean streamflow for three sampling sites at Fort Leavenworth, Kansas, for water years 1994–96—Continued

Day	Oct. 1995 to Sept. 1996											
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
06820472 Corral Creek at Missouri River, Fort Leavenworth, Kansas (fig. 2)—Continued												
1	0.20	7.9	0.34	e0.24	e0.05	e0.16	0.32	0.84	e14	e0.78	e8.3	0.60
2	.22	.64	.31	e.25	e.05	e.17	.21	.47	e3.0	e.68	e1.5	.63
3	.28	.42	.29	e.21	e.05	.20	.22	.28	e.90	e.62	e1.0	.56
4	.27	.37	.30	e.18	e.10	.24	.19	3.5	e.70	5.4	.98	.53
5	.23	.45	.46	e.16	e.15	.27	.19	1.6	e13	1.1	1.1	.50
6	.27	.43	.26	e.11	e.18	.23	.19	2.3	e2.0	.94	.69	.52
7	.32	.44	.29	e.09	e.30	.21	.17	e10	e1.3	.81	.58	.50
8	.27	.40	.30	e.09	e.27	.20	.17	e4.5	e.92	1.9	.55	2.9
9	.23	.47	.14	e.14	e.25	.20	.16	e1.0	e.80	.66	1.1	.42
10	.24	.50	e.13	e.24	e.24	.20	.17	e.75	e.70	.60	1.0	.42
11	.22	.45	e.12	e.68	e.24	.20	.17	e.60	e.60	.59	.51	.44
12	.24	.83	e.13	e.60	e1.0	.17	.16	e1.4	e.60	.61	.49	.47
13	.26	.48	e.15	e.42	e.70	.17	.15	.68	e24	.59	.52	.48
14	.32	.46	e.20	.36	e.34	.34	.50	.64	e2.5	.67	.56	.44
15	.34	1.1	e.40	.27	e.28	.18	.39	.62	e1.0	.53	.53	1.4
16	.30	.51	e.18	.35	.68	.20	.15	.51	e18	.46	2.2	3.2
17	.36	.42	e.17	e.30	.35	.17	.13	.47	e2.0	.44	.91	.42
18	.33	.38	e.17	.22	.41	.17	.13	.43	e1.5	.48	.59	.37
19	.27	.39	e.17	.12	.32	.16	.13	.38	e1.0	.50	1.6	2.4
20	.23	.39	e.17	e.10	.34	.20	.13	.46	e.80	e25	1.1	.54
21	.24	.33	e.17	e.20	.33	.20	.25	.57	e.70	e4.0	.51	.43
22	.25	.35	e.17	e.19	.31	.19	1.4	.50	e.70	e2.0	25	.35
23	e.60	.27	e.17	e.17	.32	.39	.12	e2.6	e17	1.0	5.4	.69
24	e.40	.32	e.16	e.14	.29	1.9	1.1	e.50	e5.0	.89	1.0	.38
25	e.35	.27	e.15	e.13	.34	.26	.70	.43	e2.0	.98	.66	3.0
26	e.33	.31	e.20	e.13	.32	.27	.69	e20	e1.5	e1.3	.62	6.6
27	e.50	.28	e.18	e.13	.95	.19	.92	e1.0	e1.0	e1.2	.58	1.2
28	e.40	.27	e.16	e.20	.20	.23	2.7	e.75	e.92	e7.7	.58	.62
29	e.40	.31	e.16	e.15	e.18	.21	1.5	e.65	e.90	e6.7	.58	.48
30	e.70	.37	e.28	e.07	---	1.8	.74	e.60	e.86	e1.6	.59	.44
31	e.50	---	e.25	e.05	---	.42	---	e16	---	e1.0	.65	---
Total	**10.07**	**20.51**	**6.73**	**6.69**	**9.51**	**10.10**	**14.15**	**75.03**	**119.90**	**71.73**	**61.98**	**31.93**
Mean	**.32**	**.68**	**.22**	**.22**	**.33**	**.33**	**.47**	**2.42**	**4.00**	**2.31**	**2.00**	**1.06**
Maximum	**.70**	**7.9**	**.46**	**.68**	**1.0**	**1.9**	**2.7**	**20**	**24**	**25**	**25**	**6.6**
Minimum	**.20**	**.27**	**.12**	**.05**	**.03**	**.16**	**.12**	**.28**	**.60**	**.44**	**.49**	**.35**
Acre-foot	**20**	**41**	**13**	**13**	**19**	**20**	**28**	**149**	**238**	**142**	**123**	**63**

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; ^{o}C, degrees Celsius; mg/L, milligrams per liter; col/100 mL, colonies per 100 milliliters of water; µm-mf, micron-membrane filtration; µg/L, micrograms per liter; pci/L, picocuries per liter; PCB, polychlorinated biphenyls; PCN, polychlorinated napthalene; --, no data; <, less than; >, greater than; E, estimated; K, nonideal count]

Date	Time (24-hour)	Dis-charge, instan-taneous (cubic feet per second)	Specific conduct-ance (µS/cm)	Specific conduct-ance laboratory (µS/cm)	pH, water whole, field (standard units)	pH, water whole, laboratory (standard units)	Temper-ature, water (^{o}C)	Alkalinity, laboratory (mg/L as $CaCO_3$)	Oxygen demand, chemical, high level (mg/L)	Calcium, dissolved (mg/L as Ca)	Magne-sium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
06820464 Quarry Creek at Missouri River, Fort Leavenworth, Kansas (lat 39^{o}21'13" N, long 94^{o}54'44" W, fig. 2)												
Low flow												
SEPT. 1994												
14...	1100	0.21	1,070	--	7.8	--	22.0	274	12	140	26	52
AUG. 1995												
10...	1125	.35	1,040	1,020	7.6	7.7	26.0	276	10	130	25	43
MAR. 1996												
13...	1300	.21	952	962	8.3	8.2	14.0	265	25	120	24	46
AUG.												
26...	1040	.84	1,040	1,040	7.8	7.8	21.0	275	<10	150	24	39
Storm runoff												
NOV. 1995												
01...	0945	--	404	401	7.6	7.5	--	105	46	44	7.2	18
MAR. 1996												
24...	1700	--	830	796	7.4	7.2	--	178	90	81	18	55
APR.												
22...	0045	--	--	--	--	--	--	--	110	--	--	--
MAY												
23...	0440	--	836	833	7.8	7.1	--	--	69	86	16	48
AUG.												
19...	2315	--	--	943	--	7.7	--	247	23	120	21	42
22...	2215	--	--	410	--	7.3	--	117	56	44	8.7	16

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	Potassium, dissolved (mg/L as K)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, residue at 180 ^oC dissolved (mg/L)	Residue total at 105 ^oC, suspended (mg/L)	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia plus organic, total (mg/L as N)	Phosphorus, total (mg/L as P)
06820464 Quarry Creek at Missouri River, Fort Leavenworth, Kansas (lat 39°21'13" N, long 94°54'44" W, fig. 2)—Continued												
Low flow												
SEPT. 1994												
14...	3.5	150	99	0.2	26	702	11	0.04	1.9	0.13	0.30	0.11
AUG. 1995												
10...	3.5	150	79	.3	25	692	48	.07	1.9	.18	.70	.18
MAR. 1996												
13...	4.0	150	79	.4	13	622	6	.01	.61	<.015	.50	.32
AUG.												
26...	4.0	160	71	.3	27	658	21	.02	2.1	.05	.30	.13
Storm runoff												
NOV. 1995												
01...	5.0	42	29	.1	7.7	216	590	.02	.65	0.12	2.7	1.1
MAR. 1996												
24...	5.2	110	82	.4	11	480	536	.05	.61	.37	1.0	.32
APR.												
22...	--	--	--	--	--	--	864	.04	1.3	.92	4.5	1.3
MAY												
23...	5.5	--	--	--	--	--	390	.06	1.2	.08	2.1	.65
AUG.												
19...	4.8	130	79	.2	22	--	98	.06	1.8	.04	.50	.24
22...	6.7	52	22	.1	9.4	222	720	.03	.74	.04	1.0	.57

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	Phos-phorus, dissolved (mg/L as P)	Phos-phorus, ortho, dissolved (mg/L as P)	Coliform, fecal, 0.7 µm-mf (cols/ 100 mL)	Strepto-cocci, fecal, 0.45 µm-mf (cols/ 100 mL)	Antimony, total (µg/L as Sb)	Arsenic, total (µg/L as As)	Berylium, total recover-able (µg/L as Be)	Cadmium, water unfiltered, total (µg/L as Cd)	Chromium, total recover-able (µg/L as Cr)	Copper, total recover-able (µg/L as Cu)	Iron, total recover-able (µg/L as Fe)	Lead, total recover-able (µg/L as Pb)
06820464 Quarry Creek at Missouri River, Fort Leavenworth, Kansas (lat 39°21'13" N, long 94°54'44" W, fig. 2)—Continued												
Low flow												
SEPT. 1994												
14...	--	0.10	1,400	2,400	<1	2	<10	<1	<1	2	--	2
AUG. 1995												
10...	0.12	.12	K8,900	2,100	<1	2	<10	<1	1	3	1,000	4
MAR. 1996												
13...	.33	.23	89	135	<1	1	<10	<1	<1	2	110	<1
AUG.												
26...	.11	.13	14,000	12,000	2	2	<10	<1	1	1	540	2
Storm runoff												
NOV. 1995												
01...	.19	.20	--	--	1	4	<10	1	11	25	14,000	50
MAR. 1996												
24...	.27	.26	--	--	1	3	<10	<1	7	16	7,400	30
APR.												
22...	.06	.05	--	--	4	<1	<10	2	19	37	18,000	82
MAY												
23...	.18	.1	--	--	3	4	<10	<1	8	16	7,400	33
AUG.												
19...	.15	.17	--	--	<1	2	<10	<1	4	6	3,200	8
22...	.38	.43	--	--	2	4	<10	1	11	19	14,000	54

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	Manganese, total recoverable (µg/L as Mn)	Mercury, total recoverable (µg/L as Hg)	Nickel, total recoverable (µg/L as Ni)	Selenium, total (µg/L as Se)	Silver, total recoverable (µg/L as Ag)	Thallium, dissolved (µg/L as Tl)	Zinc, total recoverable (µg/L as Zn)	Gross alpha, dissolved (µg/L as U-nat)	Gross beta, dissolved (pCi/L as Sr/y-90)	Carbon, organic, total (µg/L as C)	Cyanide, total (mg/L as Cn)	Phenols, total (µg/L)
06820464 Quarry Creek at Missouri River, Fort Leavenworth, Kansas (lat 39°21'13" N, long 94°54'44" W, fig. 2)—Continued												
Low flow												
SEPT. 1994												
14...	--	<0.10	2	<1	<1	<0.5	20	--		3.2	<0.01	<1
AUG. 1995												
10...	230	<.10	3	1	<1	<.5	20	--	--	3.8	<.01	<1
MAR. 1996												
13...	380	<.10	4	<1	<1	<.5	<10	<3.0	<4.0	5.6	<.01	2
AUG.												
26...	180	<.10	4	<1	<1	<.5	20	--	--	3.6	<.01	2
Storm runoff												
NOV. 1995												
01...	840	.20	18	<1	<1	<.5	180	--	--	23	<.01	3
MAR. 1996												
24...	1,500	<.10	14	<1	<1	<.5	140	--	--	30	<.01	2
APR.												
22...	3,200	--	34	<1	<1	--	230	--	--	31	<.01	5
MAY												
23...	660	<.10	14	<1	<1	--	140	--	--	20	<.01	3
AUG.												
19...	160	.10	6	<1	<1	<.5	40	--	--	7.1	<.01	2
22...	910	<.10	19	<1	<1		190	--		25	<.01	<1

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	Oil and grease, total recover-able, gravi-metric (mg/L)	PCB, total (μg/L)	PCN unfiltered recover-able (μg/L)	Chloro-form, total (μg/L)	Aroclor, 1,2,5,4-PCB, total (μg/L)	Chlor--dane, total (μg/L)	Chlor-pyrifos, total, recover-able (μg/L)	Tetra-chloro-ethylene, total (μg/L)	*p,p'*-DDD, unfiltered, recover-able (μg/L)	*p,p'*-DDD, total (μg/L)	DDE, total (μg/L)	*p,p'*-DDE, total (μg/L)
06820464 Quarry Creek at Missouri River, Fort Leavenworth, Kansas (lat 39°21'13" N, long 94°54'44" W, fig. 2)—Continued												
Low flow												
SEPT. 1994												
14...	<1	<0.10	<0.10	<3.0	<0.1	<0.1	--	<3.0	--	<0.10	--	<0.04
AUG. 1995												
10...	<1	<.10	<.10	<3.0	<.1	<.1	<0.01	<3.0	<0.01	<.10	<0.01	<.04
MAR. 1996												
13...	<1	<.10	<.10	.20	<.1	<.1	<.01	.30	<.01	<.10	<.01	<.04
AUG.												
26...	<1	<.10	<.10	<.20	<.1	<.1	<.01	<.20	.02	<.10	<..01	<.04
Storm runoff												
NOV. 1995												
01...	<1	<.10	<.10	--	<.1	<.1	<.01	--	.03	<.10	.03	.05
MAR. 1996												
24...	<1	<.10	<.10	--	<.1	<.1	<.01	--	<.01	<.10	<.01	<.04
APR.												
22...	<1	<.10	<.10	--	--	--	--	--	--	--	--	--
MAY												
23...	<1	<.10	<.10	--	<.1	.1	--	--	--	<.10	--	.11
AUG.												
19...	<1	<.10	<.10	--	--	--	--	--	--	--	--	--
22...	3	<.10	<.10	--	<.1	<.1	<.01	--	.06	.10	.05	.11

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	*p,p'*-DDT, unfiltered, recover-able (µg/L)	*p,p'*-DDT, total (µg/L)	Diazinon total (µg/L)	Dieldrin, total (µg/L)	Heptachlor, total (µg/L)	Malathion, total (µg/L)	2,4–D, total (µg/L)	2,4–DP, total (µg/L)	Atrazine, water, dissolved, recover-able (µg/L)	Deethyl-atrazine, water, dissolved, recover-able (µg/L)	Prometon, water, dissolved, recover-able (µg/L)	Simazine, water, dissolved, recover-able (µg/L)
06820464 Quarry Creek at Missouri River, Fort Leavenworth, Kansas (lat 39°21'13" N, long 94°54'44" W, fig. 2)—Continued												
Low flow												
SEPT. 1994												
14...	--	<0.10	--	<0.02	<0.03	--	--	--	--	--	--	--
AUG. 1995												
10...	<0.01	<.10	<0.01	<.02	<.03	0.01	<0.01	<0.01	--	--	--	--
MAR 1996												
13...	<.01	<.10	<.01	<.02	<.03	<.01	<.01	<.01	--	--	--	--
AUG.												
26...	<.01	<.10	<.01	<.02	<.03	<.01	<.01	<.01	0.007	E0.003	0.35	0.20
Storm runoff												
NOV. 1995												
01...	.03	0.10	<.01	<0.02	<.03	.08	.05	<.01	--	--	--	--
MAR. 1996												
24...	<.01	<.01	<.01	<.02	<.03	<.01	.03	<.01	--	--	--	--
APR.												
22...	--	--	--	--	--	--	--	--	--	--	--	--
MAY												
23...	--	.30	<.01	.02	.03	--	--	--	--	--	--	--
AUG.												
19...	--	--	--	--	--	--	--	--	--	--	--	--
22...	.10	.40	<.01	<.02	<.03	.12	<.01	<.01	--	--	--	--

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	Time (24-hour)	Dis-charge, instan-taneous (cubic feet per second)	Specific conduct-ance (µS/cm)	Specific conduct-ance, laboratory (µS/cm)	pH, water whole, field (standard units)	pH, water whole, laboratory (standard units)	Temper-ature, water (°C)	Alkalinity, laboratory (mg/L as $CaCO_3$)	Oxygen demand, chemical, high level (mg/L)	Calcium, dissolved (mg/L as Ca)	Magne-sium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
06820468 Unnamed tributary at Stimson Avenue, Fort Leavenworth, Kansas (lat 39°20'50" N, long 94°54'42" W, fig. 2)												
Low flow												
SEPT. 1994												
14...	1430	0.10	846	--	7.7	--	22.0	208	33	99	26	42
AUG. 1995												
10...	1035	.18	650	648	6.9	7.3	22.5	151	15	71	18	30
MAR. 1996												
28...	1400	.14	853	873	7.4	7.1	11.5	210	100	68	21	66
AUG.												
26...	1315	.47	500	503	7.7	7.4	24.5	128	20	60	12	19
Storm runoff												
MAY 1995												
27...	0540	--	180	187	5.9	6.9	--	36	30	20	3.2	5.3
JUNE												
28...	0545	--	258	242	6.8	7.7	--	64	29	--	--	--
JULY												
19...	2305	--	142	168	7.0	7.6	--	50	27	15	3.0	4.8
MAY 1996												
04...	0500	--	--	--	--	--	--	--	52	--	--	--
JUNE												
13...	0310	--	--	94	--	7.0	--	32	38	8.7	.82	1.3
JULY												
28...	0505	--	--	92	--	7.0	--	37	51	7.8	.87	1.4
Duplicate												
AUG. 1996												
26...	1320	.47	500	504	7.7	7.4	24.5	128	17	59	12	18
Blanks												
QC–1	1130	--	--	2	--	6.5	--	1.2	--	.11	.01	<.20
QC–2	1235	--	--	3	--	7.7	--	1.8	<10	.04	<.01	<.20
QC–3	1130	--	--	4	--	8.4	--	1.6	<10	.03	<.01	<.20
QC–4	1230	--	--	2	--	6.9	--	1.5	<10	<.02	<.01	<.20

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	Potas-sium, dissolved (mg/L as K)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, residue at 180 °C dissolved (mg/L)	Residue total at 105 °C, suspended (mg/L)	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia plus organic, total (mg/L as N)	Phos-phorus, total (mg/L as P)
06820468 Unnamed tributary at Stimson Avenue, Fort Leavenworth, Kansas (lat 39°20'50" N, long 94°54'42" W, fig. 2)—Continued												
Low flow												
SEPT. 1994												
14...	4.6	130	72	0.4	28	564	6	0.13	3.1	0.06	0.50	0.20
AUG. 1995												
10...	3.8	88	52	.3	21	436	10	.19	2.5	.13	.60	.26
MAR. 1996												
28[1]...	7.7	130	72	.5	17	530	6	.14	.98	1.7	8.2	2.0
AUG.												
26...	3.9	63	37	.2	7.9	298	6	.05	1.3	.12	.60	.22
Storm runoff												
MAY 1995												
27...	2.8	13	20	<.1	5.5	115	76	.02	.27	.20	.80	.25
JUNE												
28...	--	23	16	<.1	7.8	142	108	.02	.30	.17	1.0	.19
JULY												
19...	3.3	11	10	<.1	4.9	102	385	.03	.30	.07	1.0	.40
MAY 1996												
04...	--	--	--	--	--	--	211	.02	.47	.65	2.7	.64
JUNE												
13...	2.0	4.0	1.9	<.1	1.6	50	450	.04	.63	.48	1.2	.30
JULY												
28...	1.6	3.8	2.1	<.1	1.2	46	594	.01	.54	.37	.80	.14
Duplicate												
AUG. 1996												
26...	4.0	63	37	.2	7.7	290	5	.05	1.3	.12	.60	.22
Blanks												
QC–1	<.10	<.10	<.10	<.10	.50	<1	3	<.01	<.05	<.01	<.20	<.01
QC–2	<.10	<.10	<.10	<.10	.30	<1	6	<.01	<.05	<.01	<.20	<.01
QC–3	<.10	<.10	<.10	<.10	.50	<1	<1	<.01	<.05	<.01	<.20	<.01
QC–4	<.10	<.10	<.10	<.10	.10	<1	<1	<.01	<.05	<.01	<.20	<.01

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	Phos-phorus, dissolved (mg/L as P)	Phos-phorus, ortho, dissolved (mg/L as P)	Coliform, fecal, 0.7 µm-mf (cols/ 100 mL)	Strepto-cocci, fecal, 0.45 µm-mf (cols/ 100 mL)	Antimony, total (µg/L as Sb)	Arsenic, total (µg/L as As)	Berylium, total recover-able (µg/L as Be)	Cadmium, water unfiltered, total (µg/L as Cd)	Chromium, total recover-able (µg/L as Cr)	Copper, total recover-able (µg/L as Cu)	Iron, total recover-able (µg/L as Fe)	Lead, total recover-able (µg/L as Pb)
06820468 Unnamed tributary at Stimson Avenue, Fort Leavenworth, Kansas (lat 39°20'50" N, long 94°54'42" W, fig. 2)—Continued												
Low flow												
SEPT. 1994												
14...	--	0.18	2,100	6,100	1	6	<1	<1	<1	4	--	<1
AUG. 1995												
10...	.23	.24	K8,100	5,400	<1	4	<1	<1	1	1	210	<1
MAR. 1996												
28...	.49	1.1	K2,500,000	42,000	1	3	<1	<1	<1	4	370	1
AUG.												
26...	.23	.23	15,000	7,400	1	4	<1	<1	<1	1	260	1
Storm runoff												
MAY 1995												
27...	.17	.18	--	--	--	--	<1	<1	--	--	--	--
JUNE												
28...	.12	.11	--	--	<1	3	<1	<1	2	5	2,700	17
JULY												
19...	.28	.29	>6,000	>10,000	<1	3	<1	<1	7	11	7,600	52
MAY 1996												
04...	.21	.13	--	--	--	2	<1	<1	5	11	3,500	35
JUNE												
13...	.12	.12	--	--	3	3	<1	<1	6	8	8,500	43
JULY												
28...	.09	.11	--	--	2	3	<1	<1	8	7	52,000	68
Duplicate												
AUG. 1996												
26...	.19	.22	--	--	1	4	<1	<1	<1	<1	270	<1
Blanks												
QC–1	<.01	<.01	--	--	<1	<1	<10	<1	<1	<1	20	<1
QC–2	<.01	<.01	--	--	<1	<1	<10	<1	<1	<1	30	<1
QC–3	<.01	<.01	--	--	<1	<1	<10	<1	<1	<1	30	<1
QC–4	<.01	<.01	--	--	<1	<1	<10	<1	<1	<1	<10	<1

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	Manganese, total recoverable (µg/L as Mn)	Mercury, total recoverable (µg/L as Hg)	Nickel, total recoverable (µg/L as Ni)	Selenium, total (µg/L as Se)	Silver, total recoverable (mg/L as Ag)	Thallium, dissolved (µg/L as Tl)	Zinc, total recoverable (µg/L as Zn)	Gross alpha, dissolved (µg/L as U-nat)	Gross beta, dissolved (pCi/L as SR/Y-90)	Carbon, organic, total (µg/L as C)	Cyanide, total (mg/L as Cn)	Phenols, total (µg/L)
06820468 Unnamed tributary on Stimson Avenue, Fort Leavenworth, Kansas (Lat 39°20'50" N Long 94°54"42" W)—Continued												
Low flow												
SEPT. 1994												
14...	--	<0.10	2	<1	<1	<0.5	<10	--	--	4.2	<0.01	<1
AUG. 1995												
10...	200	<.10	2	<1	<1	<.5	<10	--	--	--	<.01	<1
MAR. 1996												
28...	920	<.10	3	<1	<1	<.5	20	<3.0	7.9	29	<.01	5
AUG.												
26...	190	<.10	2	<1	<1	<.5	<10	--	--	6.3	<.01	<1
Storm runoff												
MAY 1995												
27...	--	--	--	<1	<1	<.5	--	--	--	7.9	<.01	1
JUNE												
28...	450	<.10	5	<1	<1	<.5	40	--	--	7.9	<.01	<1
JULY												
19...	810	.20	14	<1	<1	<.5	110	--	--	8.6	<.01	5
MAY 1996												
04...	310	<.10	6	<1	<1	--	100	--	--	14	.01	--
JUNE												
13...	380	<.10	9	<1	<1	<.5	90	--	--	10	<.01	<1
JULY												
28...	740	<.10	14	<1	<1	<.5	140	--	--	19	<.01	<1
Duplicate												
AUG. 1996												
26...	190	<.10	2	<1	<1	<.5	<.5	--	--	--	--	<1
Blanks												
QC–1	10	.30	<1	<1	<1	<.5	<10	--	--	.30	<.01	<1
QC–2	<10	<.10	<1	<1	<1	<.5	<10	--	--	.40	<.01	<1
QC–3	<10	<.10	<1	<1	<1	<.5	<10	--	--	.90	<.01	<1
QC–4	<10	<.10	<1	<1	<1	<.5	<10	--	--	.20	--	<1

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	Oil and grease, total recover-able, gravi-metric (mg/L)	PCB, total (µg/L)	PCN, unfiltered, recover-able (µg/L)	Chloro-form, total (µg/L)	Aroclor, 1,2,5,4-PCB, total (µg/L)	Chlor-dane, total (µg/L)	Chlor-pyrifos, total recover-able (µg/L)	Tetra-chloro-ethylene, total (µg/L)	*p,p'*-DDD, unfiltered, recover-able (µg/L)	*p,p'*-DDD, total (µg/L)	DDE, total (µg/L)	*p,p'*-DDE, total (µg/L)
06820468 Unnamed tributary on Stimson Avenue, Fort Leavenworth, Kansas (Lat 39°20'50" N Long 94°54'42" W)—Continued												
<u>Low flow</u>												
SEPT. 1994												
14...	<1	--	<0.10	<3.0	<0.1	<0.10	--	<3.0	--	<0.1	--	<0.1
AUG. 1995												
10...	<1	<0.10	<.10	<3.0	<.1	<.10	<0.01	<3.0	<0.01	<.1	<0.01	<.1
MAR. 1996												
28...	5	.20	<.10	<.50	<.1	<.10	.02	<.20	<.01	<.1	<.01	<.1
AUG.												
26...	3	<.10	<.10	<.20	<.1	<.10	<.01	<.20	<.01	<.1	<.01	<.1
<u>Storm runoff</u>												
MAY 1995												
27...	<1	--	<.10	--	<.2	<.20	<.01	--	--	<0.2	--	<.8
JUNE												
28...	<1	<.10	<.10	--	<.1	<.10	<.02	--	<.01	<.1	<.01	<.4
JULY												
19...	<1	<.10	<.10	<3.0	<.1	.10	.02	<3.0	.01	<.1	.01	<.4
MAY 1996												
04...	--	--	<.10	<.20	--	--	--	<.20	--	--	--	--
JUNE												
13...	11	<.10	<.10	--	<.1	<.10	<.01	--	<.01	<.1	.02	<.4
JULY												
28...	<1	<.10	<.10	<.20	--	<.10	.05	<.20	<.01	--	.04	--
<u>Duplicate</u>												
AUG. 1996												
26...	18	<.10	<.10	<.20	<.1	2.5	<.01	<.20	<.01	<.1	<.01	<.1
<u>Blanks</u>												
QC–1	<1	<.10	<.10	--	<.1	<.10	<.01	--	<.01	<.1	<.01	<.04
QC–2	<1	<.10	<.10	--	<.1	<.10	<.01	--	<.01	<.1	<.01	<.04
QC–3	<1	<.10	<.10	<3.0	<.1	<.10	<.01	<3.0	<.01	<.1	<.01	<.04
QC–4	2	<.10	<.10	--	<.1	<.10	<.01	--	<.01	<.1	<.01	<.04

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	*p,p'*-DDT, unfiltered, recover-able (µg/L)	*p,p'*-DDT, total (µg/L)	Diazinon, total (µg/L)	Dieldrin, total (µg/L)	Heptachlor, total (µg/L)	Malathion, total (µg/L)	2,4–D, total (µg/L)	2,4–DP, total (µg/L)	Atrazine, water, dissolved, recover-able (µg/L)	Deethyl-atrazine, water, dissolved, recover-able (µg/L)	Prometon, water, dissolved, recover-able (µg/L)	Simazine, water, dissolved, recover-able (µg/L)
06820468 Unnamed tributary at Stimson Avenue, Fort Leavenworth, Kansas (lat 39°20'50" N, long 94°54'42" W, fig. 2)—Continued												
Low flow												
SEPT. 1994												
14...	--	<0.1	--	<0.02	<0.02	--	--	--	--	--	--	--
AUG. 1995												
10...	<.01	<.1	<0.01	<.02	<.02	0.01	.06	<0.01	--	--	--	--
MAR. 1996												
28...	<.01	<.1	<.01	<.02	<.02	<.01	<.01	<.01	--	--	--	--
AUG.												
26...	<.01	<.1	<.01	<.02	<.02	<.01	.06	<.01	0.01	<0.002	9.18	2.98
Storm runoff												
MAY 1995												
27...	--	<.2	.04	<.02	<.03	<.01	.08	.04	--	--	--	--
JUNE												
28...	<.01	<.1	<.02	<.02	<.03	.75	.07	<.01	--	--	--	--
JULY												
19...	.01	<.1	<.01	<.02	<.03	2.6	.05	<.01	--	--	--	--
MAY 1996												
04...	--	--	--	--	--	--	--	--	--	--	--	--
JUNE												
13...	.02	<.1	<.01	<.02	<.03	1.5	.64	<.01	--	--	--	--
JULY												
28...	.02	--	<.01	<.01	<.01	.31	.12	<.01	--	--	--	--
Duplicate												
AUG. 1996												
26...	<.01	<.1	<.01	<.02	<.02	<.01	.04	<.01	.01	<.002	9.06	2.97
Blanks												
QC–1	<.10	--	<.01	<.01	<.03	<.01	<.01	<.01	--	--	--	--
QC–2	<.10	--	<.01	<.01	<.03	<.01	<.01	<.01	--	--	--	--
QC–3	<.10	<3.0	<.01	<.01	<.03	<.01	<.01	<.01	--	--	--	--
QC–4	<.10	--	<.01	<.01	<.03	<.01	<.01	<.01	--	--	--	--

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	Time (24-hour)	Discharge, instantaneous (cubic feet per second)	Specific conductance (µS/cm)	Specific conductance, laboratory (µS/cm)	pH, water whole, field (standard units)	pH, water whole, laboratory (standard units)	Temperature, water (°C)	Alkalinity, laboratory (mg/L as $CaCO_3$)	Oxygen demand, chemical, high level (mg/L)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
06820472 Corral Creek at Fort Leavenworth, Kansas (lat 39°20'09" N, long 94°55'01" W, fig. 2)												
<u>**Low flow**</u>												
SEPT. 1994												
15...	1110	0.15	710	--	7.6	--	24.0	163	44	63	17	46
AUG. 1995												
09...	1240	.33	733	724	7.4	7.2	28.5	184	27	76	16	41
MAR. 1996												
28...	1145	.24	750	761	7.7	7.8	5.5	157	15	67	18	60
AUG.												
26...	1455	.74	625	620	7.9	7.8	23.5	191	<10	30	15	23
<u>**Storm runoff**</u>												
JUNE 1995												
28...	0625	--	182	188	7.0	7.4	--	64	82	--	--	--
AUG.												
15...	2215	--	140	177	7.1	7.4	--	70	79	16	2.8	5.3
NOV.												
01...	0850	--	239	250	7.3	7.5	--	84	55	21	4.2	10
MAR. 1996												
24...	1600	--	412	438	7.6	7.5	--	107	140	31	6.9	31
APR.												
22...	0005	--	416	439	7.7	7.5	--	118	160	35	8.0	28
MAY												
04...	0515	--	--	306	--	7.4	--	89	98	25	5.6	17
23...	0345	--	365	413	7.7	7.1	--	--	110	36	7.5	18
JUNE												
13...	0330	--	--	296	--	7.3	--	102	120	29	4.7	8.2
AUG.												
16...	1545	--	--	372	--	7.3	--	111	59	42	7.9	15
<u>**Duplicate**</u>												
AUG. 1995												
09...	1245	.30	733	725	7.4	7.3	28.5	184	27	78	17	43

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	Potas-sium, dissolved (mg/L as K)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, residue at 180 °C dissolved (mg/L)	Residue total at 105 °C, suspended (mg/L)	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia plus organic, total (mg/L as N)	Phos-phorus, total (mg/L as P)
06820472 Corral Creek at Fort Leavenworth, Kansas (lat 39°20'09" N, long 94°55'01" W, fig. 2)—Continued												
Low flow												
SEPT. 1994												
15...	7.7	98	47	0.4	16	434	49	0.01	0.14	0.16	2.5	0.36
AUG. 1995												
09...	6.8	100	55	.4	17	438	92	.01	.28	.07	2.1	.24
MAR. 1996												
28...	4.0	110	79	.4	11	472	9	<.01	.14	.02	.30	.08
AUG.												
26...	4.6	72	39	.3	19	382	<1	<.01	.49	.02	.20	.14
Storm runoff												
JUNE 1995												
28...	--	15	7.9	<.1	4.6	100	652	.02	.58	.29	.80	.23
AUG.												
15...	3.4	12	6.2	.1	4.0	82	3,040	.01	.30	.07	2.3	1.2
NOV.												
01...	4.0	22	10	.2	4.5	142	1,380	.01	.23	.08	2.2	1.0
MAR. 1996												
24...	3.6	48	44	.4	5.7	234	1,860	.02	.52	.16	.80	.26
APR.												
22...	4.0	53	35	.3	5.4	236	2,600	.03	.70	.37	5.5	1.8
MAY												
04...	2.6	27	20	.2	4.3	170	924	.02	.49	.16	2.3	.78
23...	4.2	--	--	--	--	224	734	.03	.57	.03	1.8	.50
JUNE												
13...	3.1	25	13	.2	6.8	154	3,360	.04	.65	.17	.90	.32
AUG.												
16...	3.6	41	18	.2	9.5	210	258	.02	.52	.02	1.0	.40
Duplicate												
AUG. 1995												
09...	6.7	100	53	.3	17	460	92	.02	.30	.08	1.9	.26

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	Phos-phorus, dissolved (mg/L as P)	Phos-phorus, ortho, dissolved (mg/L as P)	Coliform, fecal, 0.7 μm-mf (cols/ 100 mL)	Strepto-cocci, fecal 0.45 μm-mf (cols/ 100 mL)	Antimony, total (μg/L as Sb)	Arsenic, total (μg/L as As)	Berylium, total recover-able (μg/L as Be)	Cadmium, water unfiltered, total (μg/L as Cd)	Chromium, total recover-able (μg/L as Cr)	Copper, total recover-able (μg/L as Cu)	Iron, total recover-able (μg/L as Fe)	Lead, total recover-able (μg/L as Pb)
06820472 Corral Creek at Fort Leavenworth, Kansas (lat 39°20'09" N, long 94°55'01" W, fig. 2)—Continued												
Low flow												
SEPT. 1994												
15...	--	0.09	24,000	6,700	1	6	<10	<1	3	5	--	8
AUG. 1995												
09...	0.17	.15	K14,000	K3,400	<1	3	<10	<1	2	4	3,400	5
MAR. 1996												
28...	.07	.06	K67	<1,500	1	1	<10	<1	<1	2	430	1
AUG.												
26...	.12	.15	1,900	1,500	<1	2	<10	<1	<1	<1	100	<1
Storm runoff												
JUNE 1995												
28...	.17	.16	--	--	<1	3	<10	1	13	20	17,000	40
AUG.												
15...	.18	.19	--	--	4	5	<10	--	--	--	--	--
NOV.												
01...	.25	.21	--	--	1	5	<10	2	20	22	27,000	79
MAR. 1996												
24...	.08	.08	--	--	5	4	<10	2	34	41	31,000	88
APR.												
22...	.11	.11	--	--	7	6	<10	3	34	42	35,000	100
MAY												
04...	.09	.08	--	--	3	4	<10	1	20	21	15,000	45
23...	.18	.07	--	--	--	2	<10	<1	14	16	12,000	35
JUNE												
13...	.10	.10	--	--	9	7	<10	3	39	58	69,000	110
AUG.												
16...	.12	.13	--	--	1	3	<10	<1	7	10	6,100	15
Duplicate												
AUG. 1995												
09...	.14	.15	K15,000	3,600	<1	3		<1	3	5	3,400	4

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	Manganese, total recoverable (µg/L as Mn)	Mercury, total recoverable (µg/L as Hg)	Nickel, total recoverable (µg/L as Ni)	Selenium, total (µg/L as Se)	Silver, total recoverable (µg/L as Ag)	Thallium, dissolved (µg/L as Tl)	Zinc, total recoverable (µg/L as Zn)	Gross alpha, dissolved (µg/L as U-Nat)	Gross beta, dissolved (pCi/L as SR/Y-90)	Carbon, organic, total (µg/L as C)	Cyanide, total (mg/L as Cn)	Phenols, total (µg/L)
06820472 Corral Creek at Fort Leavenworth, Kansas (lat 39°20'09" N, long 94°55'01" W, fig. 2)—Continued												
Low flow												
SEPT. 1994												
15...	--	<0.10	16	<1	<1	<0.5	40	--	--	10	<0.01	15
AUG. 1995												
09...	570	<.10	7	<1	<1	<.5	20	--	--	5.9	<.01	7
MAR. 1996												
28...	230	<.10	3	<1	<1	<.5	10	6.5	<4.0	3.7	<.01	<1
AUG.												
26...	60	<.10	3	<1	<1	<.5	<10	--	--	3.9	<.01	<1
Storm runoff												
JUNE 1995												
28...	1,600	<.10	31	<1	<1	<.5	160	--	--	16	<.01	<1
AUG.												
15...	--	.20	--	<5	<1	<.5	--	--	--	14	<.01	<1
NOV.												
01...	2,500	<.10	42	<1	<1	<.5	250	--	--	56	<.01	3
MAR. 1996												
24...	1,900	<.10	45	1	<1	<.5	320	--	--	56	<.01	--
APR.												
22...	2,500	<.10	66	<1	<1	<.5	390	6.8	4.2	54	<.01	4
MAY												
04...	2,600	<.10	26	<1	<1	<.5	180	<3.0	4.9	25	.01	3
23...	1,100	<.10	24	<1	<1	--	190	3.1	<4.0	35	<.01	2
JUNE												
13...	2,300	<.10	65	1	<1	<.5	380	--	--	32	<.01	<1
AUG.												
16...	410	.10	10	<1	<1	<.5	80	--	--	15	<.01	<1
Duplicate												
AUG. 1995												
09...	570	.20	8	<1	<1	<.5	20	--	--	5.6	<.01	7

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	Oil and grease, total recoverable, gravimetric (mg/L) (00556)	PCB, total (μg/L)	PCN, unfiltered, recoverable (μg/L)	Chloroform, total (μg/L)	Aroclor, 1,2,5,4-PCB, total (μg/L)	Chlordane, total (μg/L)	Chlorpyrifos, total recoverable (μg/L)	Tetrachloroethylene, total (μg/L)	*p, p'*-DDD, unfiltered, recoverable (μg/L)	*p, p'*-DDD, total (μg/L)	DDE, total (μg/L)	*p, p'*-DDE, total (μg/L)
06820472 Corral Creek at Fort Leavenworth, Kansas (lat 39°20'09" N, long 94°55'01" W, fig. 2)—Continued												
Low flow												
SEPT. 1994												
15...	<1	--	<0.10	<3.0	<0.10	<0.10	--	<3.0	--	<0.1	--	<0.04
AUG. 1995												
09...	<1	<0.10	<.10	<3.0	<.10	<.10	<0.01	<3.00	<0.01	<.1	<0.01	<.04
MAR. 1996												
28...	<1	<.10	<.10	.40	<.10	<.10	<.01	<.20	<.01	<.1	.01	<.04
AUG.												
26...	<1	<.10	<.10	<.20	<.10	<.10	<.01	<.20	<.01	<.1	.01	<.04
Storm runoff												
JUNE 1995												
28...	<1	<.10	<.10	--	<.10	<.10	<.02	--	.01	<.1	<.01	<.04
AUG.												
15...	<1	<.10	<.10	--	<.10	<.10	.09	--	<.01	<.1	<.01	<.04
NOV.												
01...	<1	<.10	<.10	--	<.10	.90	.01	--	.04	<.1	.01	<.04
MAR. 1996												
24...	--	<.10	<.10	--	<.10	.10	.02	--	.01	--	.01	--
APR.												
22...	2	<.10	<.10	--	<.10	.10	.01	--	<.01	<.1	<.01	<.04
MAY												
04...	<1	<.20	<.10	--	<.10	.20	E.01	<.20	<.02	<.1	<.02	<.04
23...	<1	<.10	<.10	--	<.10	.10	.01	--	<.01	<.1	<.01	<.04
JUNE												
13...	4	<.20	<.10	-	.10	.30	.01	--	<.02	<.1	.01	<.04
AUG.												
16...	<1	<.10	<.10	--	<.10	.20	<.01	--	<.01	<.1	<.01	<.04
Duplicate												
AUG. 1995												
09...	<1	<.10	<.10	<3.0	<.010	<.10	<.01	<.20	<.01	<.1	<.01	<.04

Table 8. Physical properties and selected water-quality constituent concentrations in samples collected during low flow and storm runoff at sampling sites at Fort Leavenworth, Kansas, 1994–96—Continued

Date	*p*, *p*'-DDT, unfiltered, recoverable (µg/L)	*p*, *p*'-DDT, total (µg/L)	Diazinon, total (µg/L)	Dieldrin, total (µg/L)	Heptachlor, total (µg/L)	Malathion, total (µg/L)	2,4–D, total (µg/L)	2,4–DP, total (µg/L)	Atrazine, water, dissolved, recoverable (µg/L)	Deethylatrazine, water, dissolved, recoverable (µg/L)	Prometon, water, dissolved, recoverable (µg/L)	Simazine, water, dissolved, recoverable (µg/L)
06820472 Corral Creek at Fort Leavenworth, Kansas (lat 39°20'09" N, long 94°55'01" W, fig. 2)—Continued												
Low flow												
SEPT. 1994												
15...	--	<0.1	--	<0.02	<0.03	--	--	--	--	--	--	--
AUG. 1995												
09...	<0.01	<.1	<0.01	<.02	<.03	<0.01	0.01	<.01	--	--	--	--
MAR. 1996												
28...	<.01	<.1	<.01	<.02	<.03	<.01	.02	<.01	--	--	--	--
AUG.												
26...	<.01	<.1	<.01	<.02	<.03	<.01	<.01	<.01	0.007	E0.003	0.05	0.01
Storm runoff												
JUNE 1995												
28...	<.01	<.1	.44	<.02	<.03	.69	.69	<0.01	--	--	--	--
AUG.												
15...	.02	<.1	.10	<.02	<.03	.06	.60	<.01	--	--	--	--
NOV.												
01...	.01	<.1	.01	<.02	.05	.01	.04	<.01	--	--	--	--
MAR. 1996												
24...	.01	--	<.01	<.02	<.01	.01	.15	<.01	--	--	--	--
APR.												
22...	<.01	<.1	.07	<.02	<.03	<.03	1.9	E.060	--	--	--	--
MAY												
04...	<.02	<.1	.02	<.02	<.03	<.02	1.2	.08	--	--	--	--
23...	<.01	<.1	E.17	<.02	<.03	<.01	9.8	.26	--	--	--	--
JUNE												
13...	.02	<.1	.01	<.02	<.03	.15	.78	<.01	--	--	--	--
AUG.												
16...	<.01	<.1	.02	<.02	<.03	.14	.06	<.01	--	--	--	--
Duplicate												
AUG. 1995												
09...	<.01	<.01	<.01	<.01	<.03	<.01	.03	<.01	--	--	--	--

[1]Sample was affected by broken sewer pipe.

Table 9. Analytical reporting levels of organic water-quality constituents analyzed for samples collected at Fort Leavenworth, Kansas, 1994–96

[--, not available]

Constituent	Minimum reporting level in micrograms per liter (μg/L)	Constituent	Minimum reporting level in micrograms per liter (μg/L)
Volatile organic compounds		**Volatile organic compounds—Continued**	
Acrolein	20	1,2-Dichloropropane	3, 0.2
Acrylonitrile	20	1,3-Dichloropropane	3, 0.2
Benzene	3, 0.2	2,2-Dichloropropane	3, 0.2
Bromobenzene	3, 0.2	1,1-Dichloropropene	3, 0.2
Bromochloromethane	3, 0.2	Ethylbenzene	3, 0.2
Bromodichloromethane	3	Hexachlorobutadiene	3, 0.2
Bromoform	3, 0.2	Isopropylbenzene	3, 0.2
Bromomethane	3, 0.2	4-Isopropyl-1-methylbenzene	3, 0.2
Butylbenzene	3, 0.2	Naphthalene	3, 0.2
Chlorobenzene	3, 0.2	Propylbenzene	3, 0.2
Chloroethane	3, 0.2	*sec*-Butylbenzene	3, 0.2
2-Chloroethylvinylether	3, 1	Styrene	3, 0.2
Chloroform	3, 0.2	*tert*-Butylbenzene	3, 0.2
Chloromethane	3, 0.2	*tert*-Butyl methyl ether	3, 0.2
2-Chlorotoluene	3, 0.2	1,1,1,2-Tetrachloroethane	3, 0.2
4-Chlorotoluene	3, 0.2	1,1,2,2-Tetrachloroethane	3, 0.2
cis-1,2-Dichloroethylene	3, 0.2	Tetrachloroethylene	3, 0.2
cis-1,3-Dichloropropene	3, 0.2	Tetrachloromethane	3, 0.2
Dibromochloromethane	3, 0.2	Toluene	3, 0.2
1,2-Dibromo-3-chloropropane	3, 1	*trans*-1,2-Dichloroethylene	3, 0.2
1,2-Dibromoethane	3, 0.2	*trans*-1,3-Dichloropropene	3, 0.2
Dibromomethane	3, 0.2	1,2,3-Trichlorobenzene	3, 0.2
1,2-Dichlorobenzene	3, 0.2	1,2,4-Trichlorobenzene	3, 0.2
1,3-Dichlorobenzene	3, 0.2	1,1,1-Trichloroethane	3, 0.2
1,4-Dichlorobenzene	3, 0.2	1,1,2-Trichloroethane	3, 0.2
Dichlorodifluoromethane	3, 0.2	Trichloroethylene	3, 0.2
1,1-Dichloroethane	3, 0.2	Trichlorofluoromethane	3, 0.2
1,2-Dichloroethane	3, 0.2	1,2,3-Trichloropropane	3, 0.2
1,1-Dichloroethylene	3, 0.2	1,1,2-Trichlorotrifluoroethane	3, 0.2
Dichloromethane	3, 0.2	1,2,4-Trimethylbenzene	3, 0.2

Table 9. Analytical reporting levels of organic water-quality constituents analyzed for samples collected at Fort Leavenworth, Kansas, 1994–96—Continued

Constituent	Minimum reporting level in micrograms per liter (μg/L)
Volatile organic compounds—Continued	
1,3,5-Trimethylbenzene	3, 0.2
Vinylchloride	1
Xylene	3, 0.2
Semivolatile acid-base/neutral organic compounds	
Acenaphthene	5
Acenaphthylene	5
Anthacene	5
Benz[*a*]anthracene	10
Benzidine	40
Benzo[*b*]fluoranthene	10
Benzo[*k*]fluoranthene	10
Benzo[*ghi*]perylene	10
Benzo[*a*]pyrene	10
bis(2-Chloroethoxy)methane	5
bis(2-Chloroethyl)ether	5
bis(2-Chloroisopropyl)ether	5
bis(2-ethylhexyl)phthalate	5
4-Bromophenylphenylether	5
Butylbenzyl phthalate	5
4-Chloro-3-methylphenol	30
2-Chloronaphthalene	5
2-Chlorophenol	5
4-Chlorophenyl phenyl ether	5
Chrysene	10
Dibenz[*a*,*h*]anthracene	10
1,2-Dichlorobenzene	5
1,3-Dichlorobenzene	5
1,4-Dichlorobenzene	5
3,3'-Dichlorobenzidine	20

Constituent	Minimum reporting level in micrograms per liter (μg/L)
Semivolatile acid-base/neutral organic compounds—Continued	
2,4-Dichlorophenol	5
Diethyl phthalate	5
2,4-Dimethylphenol	5
Dimethyl phthalate	5
Di-n-butyl phthalate	5
4,6-Dinitro-2-methylphenol	30
2,4-Dinitrophenol	20
2,4-Dinitrotoluene	5
2,6-Dinitrotoluene	5
Di-n-octyl phthalate	10
1,2-Diphenylhydrazine	5
Fluoranthene	5
Fluorene	5
Hexachlorobenzene	5
Hexachlorobutadiene	5
Hexachlorocyclopentadiene	5
Hexachloroethane	5
Indeno[1,2,3-cd]pyrene	10
Isophorone	5
Naphthalene	5
Nitrobenzene	5
2-Nitrophenol	5
4-Nitrophenol	30
N-Nitrosodimethylamine	5
N-Nitrosodi-n-propylamine	5
N-Nitrosodiphenylamine	5
Pentachlorophenol	30
Phenanthrene	5
Phenol	5
Phenol, 2,4,6-tribromo-	--

Table 9. Analytical reporting levels of organic water-quality constituents analyzed for samples collected at Fort Leavenworth, Kansas, 1994–96—Continued

Constituent	Minimum reporting level in micrograms per liter (μg/L)
Semivolatile acid-base/neutral organic compounds—Continued	
Pyrene	5
1,2,4-Trichlorobenzene	5
2,4,6-Trichlorophenol	20
Pesticides and aroclors	
Aldrin	.01
Carbophenothion	.01
Chlordane, (technical mix and metablolites)	.1
Chlorpyrifos	.01
2,4-D	.01
Diazinon	.01
Dichlorprop	.01
Dieldrin	.01
Disulfoton	.01
Endosulfan	.01
Endrin	.01
Ethion	.01
Fonofos	.01
Heptachlor	.01
Heptachlor epoxide	.01
Lindane	.01
Parathion-methyl	.01
Perthane	.1
Phorate	.01
Polychlorinated biphenyls	.1
Malathion	.01
Mirex	.01
Parathion	.01
Polychlorinated napthalenes	.1
p,p'-DDD	.01
Pesticides and aroclors—Continued	
p,p'-DDE	0.01
p,p'-DDT	.01
p,p'-Methoxychlor	.01
2,4,5-T	.01
Toxaphene	1
S,S,S-Tributylphosphorotrithioate	.01
2-(2,4,5-Trichlorophenoxy)propionic acid	.01
Aldrin	.04
alpha-Endosulfan	.1
alpha-HCH	.03
Aroclor 1016	.1
Aroclor 1221	1
Aroclor 1232	.1
Aroclor 1242	.1
Aroclor 1248	.1
Aroclor 1254	.1
Aroclor 1260	.1
beta-Endosulfan	.04
Endosulfan sulfate	.6
Endrin	.06
Endrin aldehyde	.2
Heptachlor	.03
Heptachlor epoxide	.8
beta-HCH	.03
Chlordane, (technical mix and metabolites)	.1
cis-Chlordane	.1
delta-HCH	.09
Dieldrin	.02
Isodrin	
Lindane	.03

Table 9. Analytical reporting levels of organic water-quality constituents analyzed for samples collected at Fort Leavenworth, Kansas, 1994–96—Continued

Constituent	Minimum reporting level in micrograms per liter (μg/L)	Constituent	Minimum reporting level in micrograms per liter (μg/L)
Pesticides and aroclors—Continued		**Pesticides and aroclors—Continued**	
p,p'-DDD	0.1	Diazinon	0.002
p,p'-DDE	.04	Dieldrin	.001
p,p'-DDT	.1	2,6-Diethylaniline	.003
Toxaphene	2	Disulfoton	.017
trans-Chlordane	.1	Metolachlor	.002
Acetochlor	.002	Metribuzin	.004
Alachlor	.002	Molinate	.004
alpha-HCH	.002	Napropamide	.003
Atrazine	.001	Parathion	.004
Azinphos-methyl	.001	Parathion-methyl	.006
Benfluralin	.002	Pebulate	.004
Butylate	.002	Pendimethalin	.004
Carbaryl	.003	Permethrin	.005
Carbofuran	.003	Phorate	.002
Chlorpyrifos	.004	*p,p*'-DDE	.006
Cyanazine	.004	Prometon	.018
EPTC	.002	Propachlor	.007
Ethalfluralin	.004	Propanil	.004
Ethoprophos	.003	Propargite	.013
Fonofos	.003	Propyzamide	.003
Lindane	.004	Simazine	.005
Linuron	.002	Tebuthiuron	.01
Malathion	.005	Terbacil	.007
Dacthal	.002	Terbufos	.013
Deethylatrazine	.002	Thiobencarb	.002
		Tri-allate	.001
		Trifluralin	.002