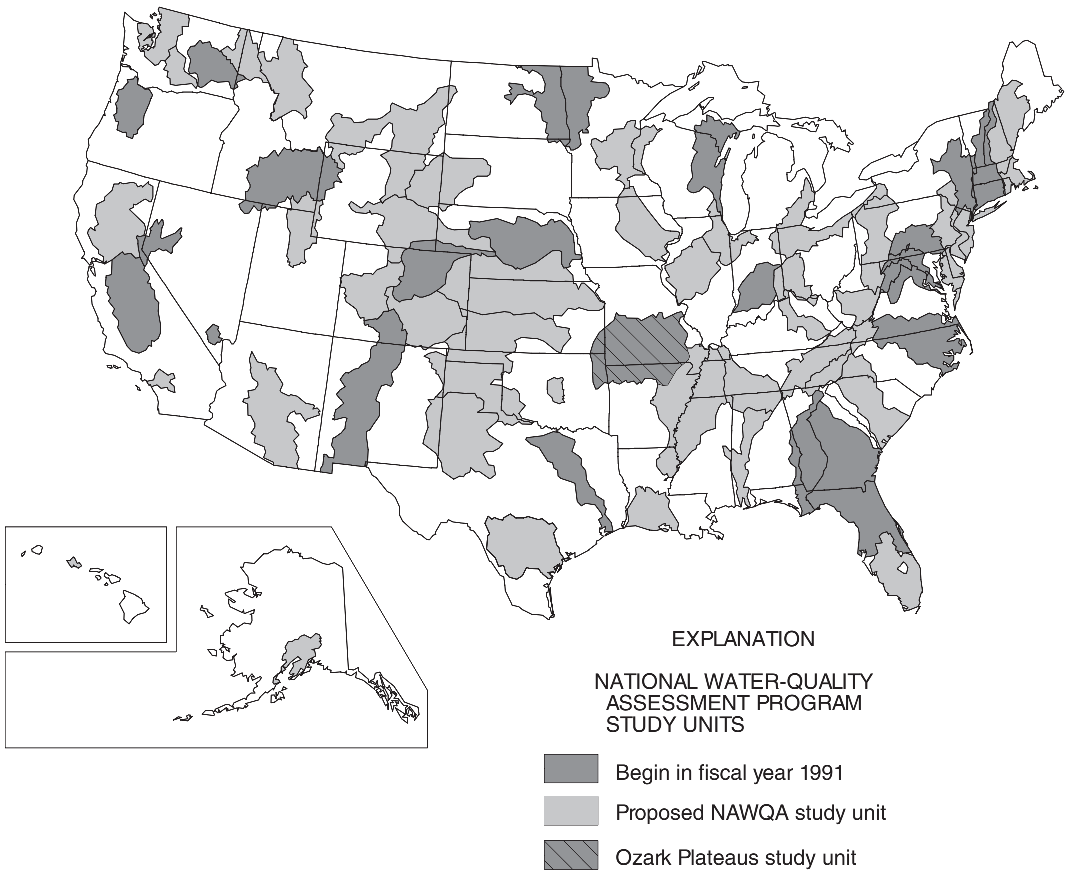
WATER-QUALITY ASSESSMENT OF THE OZARK PLATEAUS STUDY UNIT, ARKANSAS, KANSAS, MISSOURI, AND OKLAHOMA—SUMMARY OF INFORMATION ON PESTICIDES, 1970–90

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 96-4003



National Water-Quality Assessment Program

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By Richard W. Bell, Robert L. Joseph, and David A. Freiwald

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 96-4003

National Water-Quality Assessment Program

Little Rock, Arkansas
1996

U.S. DEPARTMENT OF THE INTERIOR
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<URL:http://wwwrvares.er.usgs.gov/nawqa_home.html>

FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for a specific contamination problem; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 60 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 60 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Chief Hydrologist

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WATER-QUALITY ASSESSMENT OF THE OZARK PLATEAUS STUDY UNIT, ARKANSAS, KANSAS, MISSOURI, AND OKLAHOMA—SUMMARY OF INFORMATION ON PESTICIDES, 1970-90

By Richard W. Bell, Robert L. Joseph, *and* David A. Freiwald

Abstract

Historical pesticide data from 1970-90 were compiled for 140 surface-water, 92 ground-water, 55 streambed- sediment, and 120 biological-tissue sampling sites within the Ozark Plateaus National Water Quality Assessment Program study unit. Surface-water, bed-sediment, and biological-tissue sites have drainage basins predominantly in the Springfield and Salem Plateaus; ground-water sites are predominantly located in the Osage Plains and Mississippi Alluvial Plain. Many sites were sampled only once or twice during this period. A large percentage of the samples was collected in the mid-1970's and early 1980's for surface-water, 1990 for ground water, the late 1980's for bed sediment, and the early 1980's for biological tissue.

Pesticide use was approximately 4.2 million pounds per year of active ingredients from 1982-85 in the study unit and was generally greatest in the Salem and Springfield Plateaus pasturelands and in the Osage Plains and Mississippi Alluvial Plain cropland areas. The most frequently applied pesticide in the study unit was 2,4-D. Alachlor was the second most applied pesticide. Corn, pasture, rice, sorghum, and soybeans received approximately 90 percent of the pesticides applied within the study unit. The highest pesticide application rate per acre occurred on these crops in the Mississippi Alluvial and Osage Plains. Pastureland was the predominant crop type in 50 of the 94 counties in the study unit.

Toxaphene, the pesticide having the most number of detections in surface water, was found in 17 of 866 samples from 5 of 112 sites. Concentrations ranged from 0.1 to 6.0 micrograms per liter. Six other pesticides or pesticide metabolites were detected in 12 or more surface-water samples: DDE, dieldrin, DDT, aldrin, 2,4-D, and lindane. The maximum concentration for these pesticides was less than 1.0 micrograms per liter.

Atrazine, the pesticide having the most number of detections in ground water, was found in 15 of 95 samples from 15 of 79 wells with concentrations ranging from 0.1 to 8.2 micrograms per liter. Metolachlor, alachlor, and prometon were detected more than once with maximum concentrations less than 1.0 micrograms per liter, except for prometon (2.4 micrograms per liter).

Chlordane was the pesticide having the most number of detections in bed sediment and biological tissue. Chlordane was detected in 12 of 73 samples from 10 of 45 bed-sediment sites with concentrations ranging from 2.0 to 240 micrograms per kilogram. In biological tissue, chlordane was found in 93 of 151 samples from 39 of 53 sites with concentrations ranging from 0.009 to 8.6 milligrams per kilogram. Other pesticides or pesticide metabolites detected more than once in bed sediment include DDT, DDD, p,p'-DDE, DDE,

and hexachlorobenzene and in biological tissue include DDT, p,p'-DDE, and hexachlorobenzene.

Quality criteria or standards have been established for 15 of the pesticides detected in the study unit. For surface-water samples, the drinking water maximum contaminant level for alachlor was exceeded in one sample from one site in 1982. For ground-water samples, the drinking water maximum contaminant level for atrazine was exceeded in four samples from four wells in 1990. For biological-tissue samples collected during the years 1982-89, the fish tissue action levels for chlordane (26 samples, 19 sites), heptachlor epoxide (3 sites; 3 samples), p,p'-DDE (2 sites; 2 samples), dieldrin (2 sites; 2 samples), and mirex (1 site; 1 sample) were exceeded. For bed-sediment samples, quality criteria or standards were not exceeded for any pesticide. Pesticides do not pose any widespread or persistent problems in the study unit, based on the limited number of samples that exceeded quality criteria and standards.

INTRODUCTION

In 1991, the U.S. Geological Survey (USGS) began full implementation of the National Water-Quality Assessment (NAWQA) Program to provide a nationally consistent description of water-quality conditions for a large part of the Nation's water resources. The long-term goals of the NAWQA Program are to describe the status and trends in the quality of the Nation's surface- and ground-water resources and to provide a better understanding of the natural and human factors that affect the quality of these resources. Investigations will be conducted on a rotational basis in 60 river basins or aquifer systems (referred to as study units) throughout the Nation.

Regional and national synthesis of information from the study units will be the foundation for the comprehensive assessment of the Nation's water quality. Information on water quality, and factors such as climate, geology, hydrology, land use, and agricultural practices, will be integrated to focus on specific water-quality issues that affect large contiguous hydrologic regions. For example, a concern addressed first in the program is the retrospective analysis of existing data on pesticides, nutrients, and suspended sediment as part of the national synthesis activities, which contribute to answering fundamental water-quality questions facing the Nation.

In 1991, the Ozark Plateaus NAWQA study unit was among the first 20 study units selected for assessment under the full implementation plan. The complex, mostly karst aquifer system of the Ozark Plateaus study unit, coupled with the influx of people and the probability of future population and agricultural growth, makes this area extremely susceptible to water-resources degradation. The study unit investigation will consist of 5 years (1991-95) of intensive assessment, followed by 5 years (1996-2000) of low-level monitoring, and then the cycle will be repeated. Each 5-year assessment period will include about 2 years of retrospective analysis and planning and 3 years of intensive-data collection.

The purpose of this report is to summarize several types of pesticide information for the study unit: pesticide- use data, spatial and temporal availability of pesticide data, and an assessment of recent (1970-90) conditions. This information will be used as a guide for additional data-collection activities. Also, information provided in this report will contribute to national synthesis activities that will compare and contrast water quality in similar and different environments throughout the Nation.

This report includes (1) a brief overview of the environmental setting of the study unit; (2) a summary of pesticide-use data for 1982-85; (3) a description of the sources of available pesticide data; (4) a description of the spatial and temporal distribution of pesticides and pesticide metabolites in surface-water, ground-water, streambed- sediment, and biological-tissue samples; and (5) an assessment of conditions using statistical summaries of pesticide and pesticide metabolite data collected during water years (October 1 through September 30) 1970-90.

DESCRIPTION OF THE OZARK PLATEAUS STUDY UNIT

This section of the report describes the environmental setting of the study unit. The environmental setting characteristics from Davis and others (1995) that are most important to the discussion of pesticides will be discussed here. For more detail, the reader is referred to the environmental setting report for the study unit (Adamski and others, 1995).

The Ozark Plateaus study unit area encompasses approximately 48,000 square miles (mi^2) and includes parts of northern Arkansas, southeastern Kansas, southern Missouri, and northeastern Oklahoma (fig. 1). The study unit includes most of the Ozark Plateaus Province as well as parts of the surrounding Central Lowland Province known as the Osage Plains section, and a small portion of the Mississippi Alluvial Plain section of the Coastal Plain Province (Fenneman, 1938).

The Ozark Plateaus Province consists of a structural dome of sedimentary and igneous rocks. Sedimentary rocks gently dip away from the igneous core of the St. Francois Mountains in southeastern Missouri to form three distinct physiographic sections (Fenneman, 1938)--the Salem Plateau (includes the St. Francois Mountains), the Springfield Plateau, and the Boston Mountains (fig. 1). Topography varies from mostly gently rolling hills in the Springfield Plateau, to rugged with relief up to 500 feet (ft) in the Salem Plateau, to extremely rugged with relief as much as 1,000 ft in the Boston Mountains. The Osage Plains of the Central Lowland Province in the west-northwestern part of the study unit has gently rolling topography with relief rarely exceeding 250 ft. The Mississippi Alluvial Plain of the Coastal Plain Province along the extreme southeastern boundary of the study unit has flat to gently rolling topography with little relief.

The St. Francois Mountains area is not a separate physiographic section as defined by Fenneman (1938), but will be discussed in this report separately because of its unique hydrogeologic features. For the purposes of this report, the physiographic sections described above and the St. Francois Mountains will hereinafter be referred to as physiographic areas.

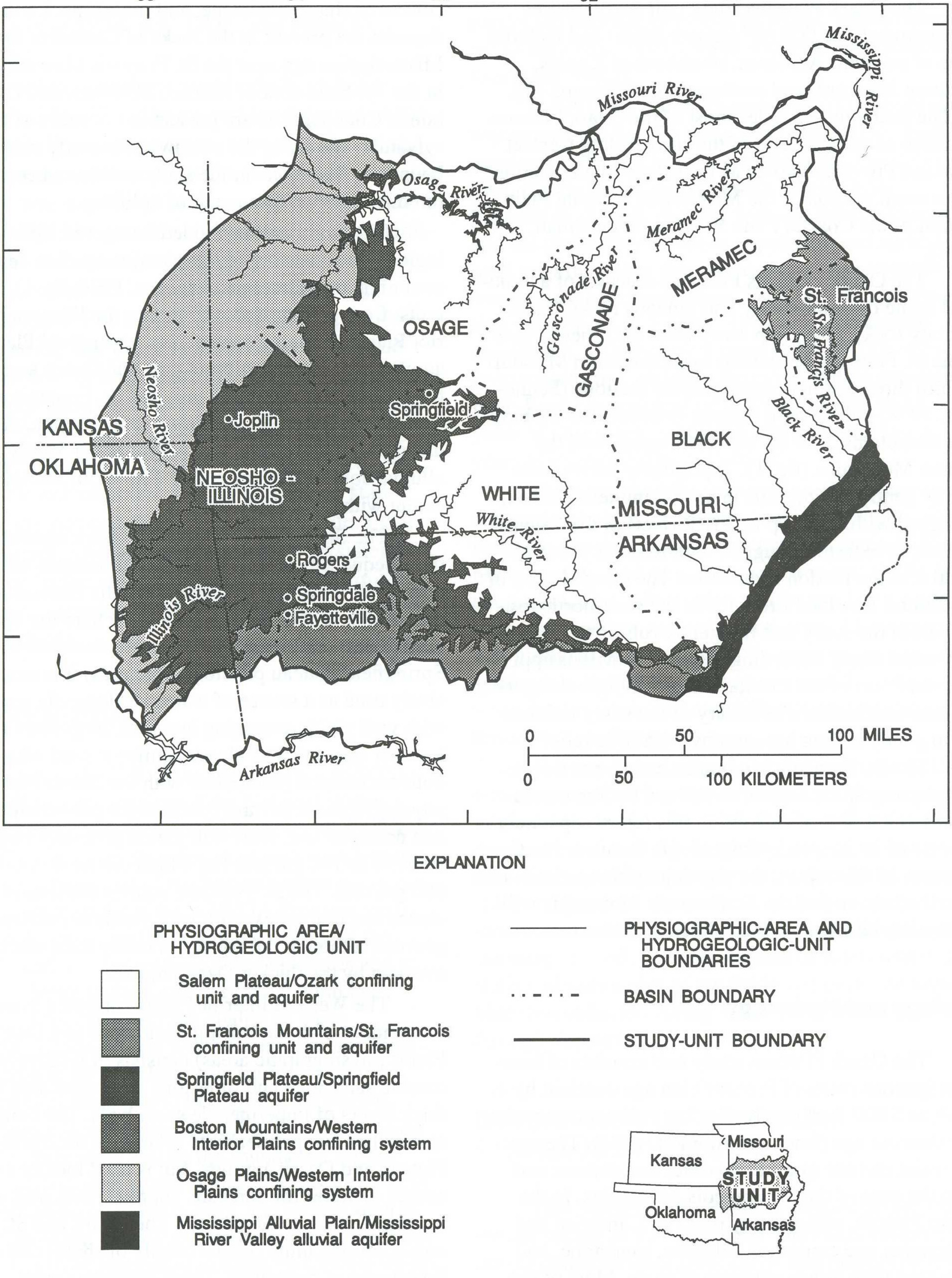
Geology and Hydrology

The Ozark Plateaus study unit consists of basement igneous rocks of Precambrian age overlain by as much as 5,000 ft of gently-dipping sedimentary rocks of Paleozoic age (Imes and Emmett, 1994). The igneous rocks include granite, rhyolite, and diabase and form the core of the St. Francois Mountains. In the Salem Plateau, sedimentary rocks of Cambrian and Ordovician age consist of dolomite, sandstone, and limestone with minor amounts of shale. Most of the rocks of Mississippian age in the Springfield Plateau are cherty limestones. Sedimentary rocks of Pennsylvanian age in the Osage Plains and Boston Mountains consist of shale, sandstone, and limestone. Lead-zinc deposits are present in the rocks of Cambrian through Mississippian age near the St. Francois Mountains and in the tri-State area of Kansas, Missouri, and Oklahoma. Coal deposits are present in the rocks of Pennsylvanian age along the northwestern study unit boundary. The rocks in the study unit have been fractured and faulted as a result of uplifting.

The study unit is divided into seven hydrogeologic units consisting of three major aquifers and four confining units (Imes and Emmett, 1994) (fig. 1). These units, from youngest to oldest, are: the Western Interior Plains confining system, the Springfield Plateau aquifer, the Ozark confining unit, the Ozark aquifer, the St. Francois confining unit, the St. Francois aquifer, and the Basement confining unit. The unconsolidated sediments of the Mississippi River Valley alluvial aquifer form an eighth aquifer, of limited areal extent within the study unit.

The Springfield Plateau and Ozark aquifers are thick sequences of limestones and dolomites with secondary permeability resulting from the fracture and dissolution of the carbonate rocks. Where the Springfield Plateau aquifer is unconfined (coincident with the Springfield Plateau physiographic area) it is extensively used as a source of water for domestic supplies, with well yields averaging less than 20 gallons per minute (gal/min). The Ozark aquifer is used where it is both unconfined (coincident with the Salem Plateau physiographic area) and confined for public supply and domestic use, with well yields generally ranging from 50 to 100 gal/min but which can be as much as 600 gal/min. The St. Francois aquifer consists of sandstones and dolomites, with well yields as much as 500 gal/min, although the aquifer is rarely used where overlain by the thicker Ozark aquifer.

The Western Interior Plains confining system (coincident with the Boston Mountains and Osage Plains physiographic areas) consists of relatively permeable sandstone and limestone beds separated by thick layers of impermeable shale beds. The confining system has low permeability relative to the Springfield Plateau and Ozark aquifers, but is used locally as a source of water for domestic supplies with well yields ranging from 1 to 40 gal/min. The Ozark and St. Francois confining units consist mostly of shales and dense limestones or dolomites. These confining units hydraulically separate the overlying and underlying aquifers. The Basement confining unit underlies the study unit and consists mostly of igneous rocks.


95°
94°
93°
92°
91°
90°
39°
38°
37°
36°
Mississippi River
Missouri River
Osage River
Meramec River
Gasconade River
MERAMEC
GASCONADE
OSAGE
St. Francois
St. Francis River
Black River
BLACK
Springfield
Joplin
KANSAS
OKLAHOMA
Neosho River
NEOSHO - ILLINOIS
WHITE
White River
MISSOURI
ARKANSAS
Rogers
Springdale
Fayetteville
Illinois River
Arkansas River
0 50 100 MILES
0 50 100 KILOMETERS
EXPLANATION
PHYSIOGRAPHIC AREA/ HYDROGEOLOGIC UNIT
Salem Plateau/Ozark confining unit and aquifer
St. Francois Mountains/St. Francois confining unit and aquifer
Springfield Plateau/Springfield Plateau aquifer
Boston Mountains/Western Interior Plains confining system
Osage Plains/Western Interior Plains confining system
Mississippi Alluvial Plain/Mississippi River Valley alluvial aquifer
PHYSIOGRAPHIC-AREA AND HYDROGEOLOGIC-UNIT BOUNDARIES
BASIN BOUNDARY
STUDY-UNIT BOUNDARY
Kansas
Missouri
STUDY UNIT
Oklahoma
Arkansas

The Ozark Plateaus study unit is drained by seven major rivers--the White, Neosho-Illinois, Osage, Gasconade, Meramec, Black, and St. Francis Rivers (fig. 1)--which flow directly or indirectly into the Mississippi River. Many large reservoirs have been constructed on the White, Osage, and Neosho Rivers.

Stream gradients are steepest in the Boston and St. Francois Mountains and flattest in the Osage Plains and Mississippi Alluvial Plain. Channel-bed material ranges from clay and silt in the Osage Plains to sand, gravel, boulders, and bedrock in most of the Ozark Plateaus Province. Streams in the Osage Plains are turbid, with long pools separated by poorly defined riffles. Streams in the Ozark Plateaus Province are mostly clear, with pools separated by riffles, and in places, cascading waterfalls.

Mean annual runoff generally increases from the north to the south (Gebert and others, 1985). Mean annual runoff is least in the northern Osage Plains, ranging from 9 to 10 inches (in.); increases in the Springfield and Salem Plateaus, ranging from 10 to 16 in.; and is greatest in the Boston Mountains, ranging from 14 to 20 in.

Minimum monthly streamflows generally occur in the summer and early fall and maximum monthly streamflows typically occur in the late winter and spring. Maximum monthly streamflows generally coincide with the period of maximum precipitation and minimum evapotranspiration.

Climate, Population, Land Use, and Water Use

The Ozark Plateaus study unit has a temperate climate with average annual precipitation ranging from about 38 inches per year (in/yr) in the north to about 48 in/yr near the southern edge of the study unit (Dugan and Peckenpaugh, 1985). Average monthly precipitation is greatest in the spring, about 3 to 5 inches per month (in/mo), and least in the late fall and winter, about 1 to 3 in/mo. Mean annual air temperature ranges from about 56 °F in the northeastern part of the study unit to about 60 °F in the southwestern part of the study unit (Dugan and Peckenpaugh, 1985). Estimated mean annual evapotranspiration in the study unit is 30 to 35 in. (Hanson, 1991).

Population within the study unit in 1990 was approximately 2.3 million people (U.S. Department of Commerce, Bureau of Census, 1990). Population increased by about 28 percent between 1970 and 1990 with the largest increases occurring in northwestern Arkansas and southwestern Missouri. Springfield, Mo., with a population of about 140,000 residents (1990), is the largest city in the study unit. Joplin, Mo., and Fayetteville, Rogers, and Springdale, Ark., are the only other cities within the study unit with populations exceeding 20,000 (1990).

Land use in the study unit (table 1) is predominantly forest and agriculture (includes pasture and cropland) (U.S. Geological Survey, 1990). Deciduous

Table 1. Land-use percentage by physiographic area

[<, less than; 1978-83 land-use data from U.S. Geological Survey (1990)]

Physiographic area	Percent land use				
	Urban	Agriculture[1]	Forest	Water	Barren[2]
Osage Plains	1	82	14	1	2
Springfield Plateau	3	58	38	1	<1
Salem Plateau	1	27	71	1	<1
Boston Mountains	1	29	70	<1	<1
Mississippi Alluvial Plain	1	83	8	[3]8	<1

[1]Includes pastures and cropland.
[2]Includes mining.
[3]Includes approximately 7 percent wetland.

forest is predominant in the Salem Plateau and Boston Mountains, although this is commonly mixed with evergreen forest. Some pasture also occurs in the Salem Plateau where livestock (beef and dairy cattle) are raised, mostly in the southern part. The Springfield Plateau is predominantly pasture, although this is mixed with cropland in the north and forest in the south. Intensive poultry farming occurs in pastures of the Springfield Plateau in northwestern Arkansas, southwestern Missouri, and northeastern Oklahoma. Cropland dominates in the Osage Plains and Mississippi Alluvial Plain. Major crops grown in the Osage Plains are soybeans and sorghum with some corn, wheat, grains, and field crops. Rice is the dominant crop grown in the Mississippi Alluvial Plain.

Total water use from both surface- and ground-water sources in the study unit was 1,053 million gallons per day (Mgal/d) in 1990 (Adamski and others, 1995). Of this, 614 Mgal/d was from ground-water sources and 439 Mgal/d was from surface-water sources. About 67 percent of the total ground-water use is for irrigation; however, most of this use is in counties along the extreme southeastern part of the study unit in the Mississippi Alluvial Plain. Domestic and public supply accounts for about 22 percent of the ground-water use. About 47 percent of the total surface-water use is for public supply and almost 30 percent is for commercial and industrial use. About 6 percent of the total water used in the study unit is for nonirrigation agricultural purposes.

PESTICIDE USE

Pesticide-use data are available for 24 pesticides and 20 crop types for the period 1982-85 (Gianessi and Puffer, 1988). Pesticide use (table 2) was estimated from county-level totals; for counties located along the study unit boundary, a correction factor was applied based on the percentage of the county within the study unit.

Approximately 4.2 million pounds per year of active ingredients from 24 pesticides were applied on 20 crop types within the study unit from 1982-85. Only 6 of the 24 pesticides were used extensively throughout the study unit and these account for approximately 88 percent of the total pesticides applied (table 2). Pesticide use generally was greatest in areas where the dominant land use was pastureland in the Springfield and Salem Plateaus and in cropland areas in the Osage Plains and Mississippi Alluvial Plain (fig. 2).

The most frequently applied pesticide in the study unit was 2,4-D (table 2, fig. 2). A selective herbicide, 2,4-D was most often applied to control weeds in pasture and cropland. Within the study unit, 2,4-D was applied most heavily in areas where pasture was the dominant crop type in the Springfield and Salem Plateaus. An estimated 912,583 pounds per year (lbs/yr) of 2,4-D were applied in all 94 counties in the study unit. Usage per county varied from a minimum of 54 lbs/yr in Johnson County, Ark. to a maximum of 40,286 lbs/yr in Craig County, Okla.; the median usage was 8,085 lbs/yr.

Alachlor, atrazine, propanil, trifluralin, and metolachlor were the other most frequently used pesticides in the study unit (table 2, fig. 2). All of these pesticides are herbicides used to control various weeds and grasses primarily in cropland areas. Usage for each of these pesticides ranges from 1 lb/yr to about 175,600 lbs/yr in individual counties, with median county application rates ranging from 834 lbs/yr to 48,300 lbs/yr. Propanil, a herbicide used on rice in a few counties in the extreme southeastern part of the study unit in the Mississippi Alluvial Plain, has the highest application rate per county.

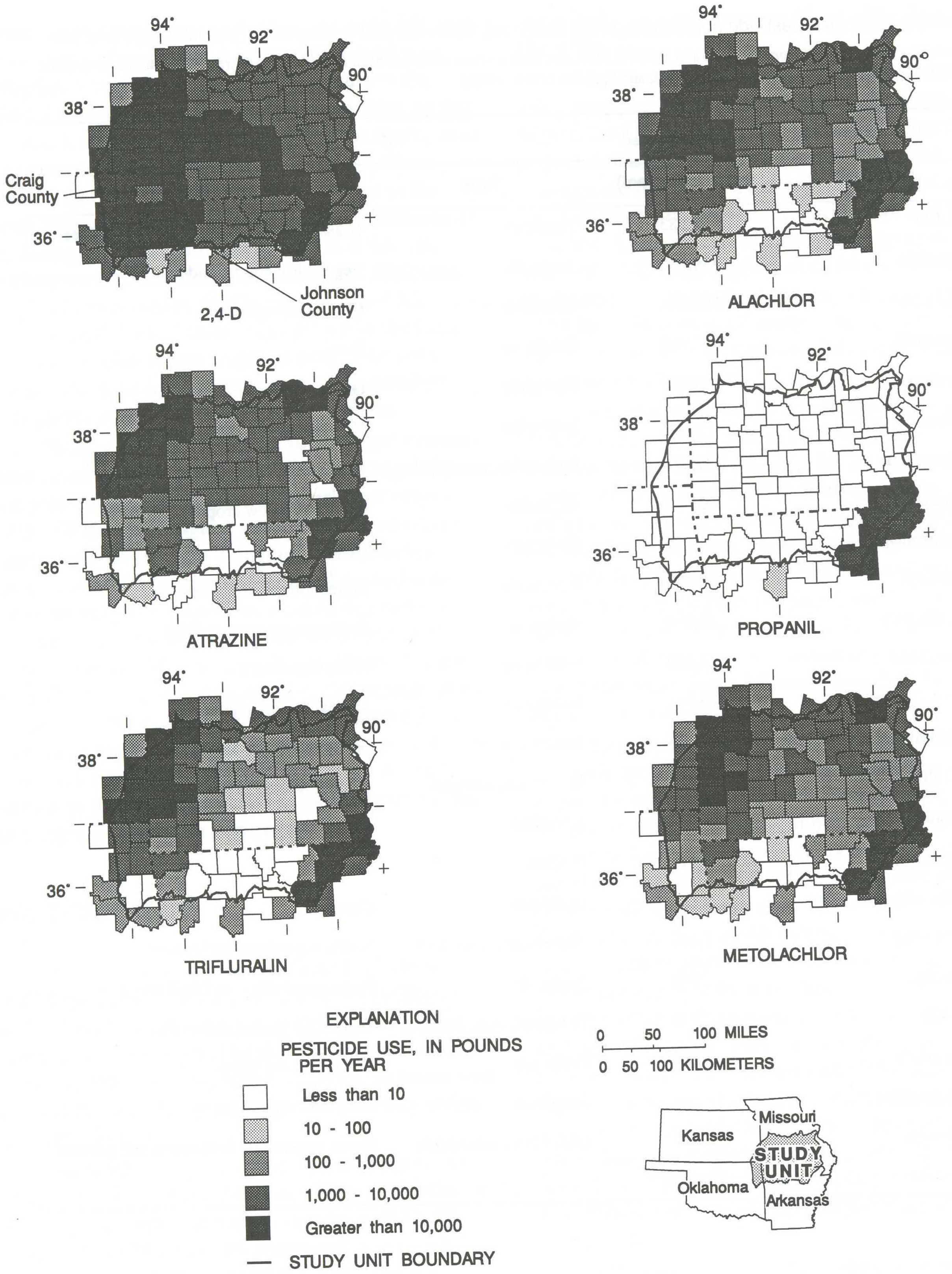
To gain another perspective on pesticide use in the study unit, the total pesticide application rates by county (pounds per year) were converted to pounds per acre (within the entire county) per year. For counties located along the study unit boundary, a correction factor was applied based on the percentage of the county within the study unit. The Mississippi Alluvial Plain, located in the southeastern part of the study unit, had the highest application rate per acre (fig. 3). Application rates ranged from 0.1 to greater than 1.0 pounds per acre per year (lbs/acre/yr) in counties in this part of the study unit. The Osage Plains, in the northwestern part of the study unit, also had relatively high application rates, ranging from 0.05 to 1.0 lbs/acre/yr. The application rates in the Springfield and Salem Plateaus ranged from less than 0.01 to 1.0 lbs/acre/yr. The application rates in the Boston and St. Francois Mountains ranged from less than 0.01 to 0.05 lbs/acre/yr.

Five crop types—corn, pasture, rice, sorghum, and soybeans—received approximately 90 percent of the pesticides applied within the study unit. Corn, sorghum, and soybeans were grown primarily in the Osage Plains; rice and soybeans were grown primarily

Table 2. Estimated pesticide applications in the study unit, 1982-85, and description of pesticide type and use

[Source: amount applied from Gianessi and Puffer (1988); description of use modified from Baldwin and others (1994), Becker and others (1992), Johnson and Jones (1994), Sine (1991), Spradley (1991; 1992)]

Pesticide	Amount applied (pounds per year of active ingredient)	Pesticide	
		Type	Use
2,4-D	912,583	Herbicide	Grasses, grains, pasture, and vegetables
Alachlor	739,730	Herbicide	Vegetables, cotton, and nuts
Atrazine	565,808	Herbicide	Corn and sorghum
Propanil	517,980	Herbicide	Rice
Trifluralin	494,921	Herbicide	Grains, vegetables, and nuts
Metolachlor	458,846	Herbicide	Vegetables, nuts, and cotton
Carbofuran	129,228	Insecticide, nematicide	Fruits, vegetables, grains, and cotton
Cyanazine	103,951	Herbicide	Corn and fallow cropland
Thiobencarb	61,285	Herbicide	Rice
Carbaryl	56,730	Insecticide	Fruits, forests, and field crops
Acifluorfen	43,859	Herbicide	Soybeans, peanuts, and rice
Parathion	32,522	Insecticide	Fruits and alfalfa
Methyl Parathion	26,946	Insecticide	Vegetables and alfalfa
Malathion	25,334	Insecticide	Fruits and vegetables
Disulfoton	9,232	Insecticide, acaricide	Grains and vegetables
Phorate	4,968	Insecticide	Grains and grasses
Vernolate	3,572	Herbicide	Turf
Fluometuron	2,883	Herbicide	Cotton
Enthoprop	1,443	Nematicide, insecticide	Fruits, vegetables, and grasses
Metiram	868	Fungicide	Fruits, vegetables, and field crops
PCNB	716	Fungicide, seed dressing	Vegetables, grains, and cotton
Bensulide	561	Herbicide	Vegetables and lawns
Chlorothalonil	498	Fungicide	Fruits and vegetables
Diazinon	408	Insecticide, nematicide	Fruits, vegetables, field crops, and pasture
TOTAL	4,194,872		



94°
92°
90°
38°
36°
Craig County
Johnson County
2,4-D
ALACHLOR
ATRAZINE
PROPANIL
TRIFLURALIN
METOLACHLOR
EXPLANATION
PESTICIDE USE, IN POUNDS PER YEAR
Less than 10
10 - 100
100 - 1,000
1,000 - 10,000
Greater than 10,000
STUDY UNIT BOUNDARY
0 50 100 MILES
0 50 100 KILOMETERS
Kansas
Missouri
STUDY UNIT
Oklahoma
Arkansas

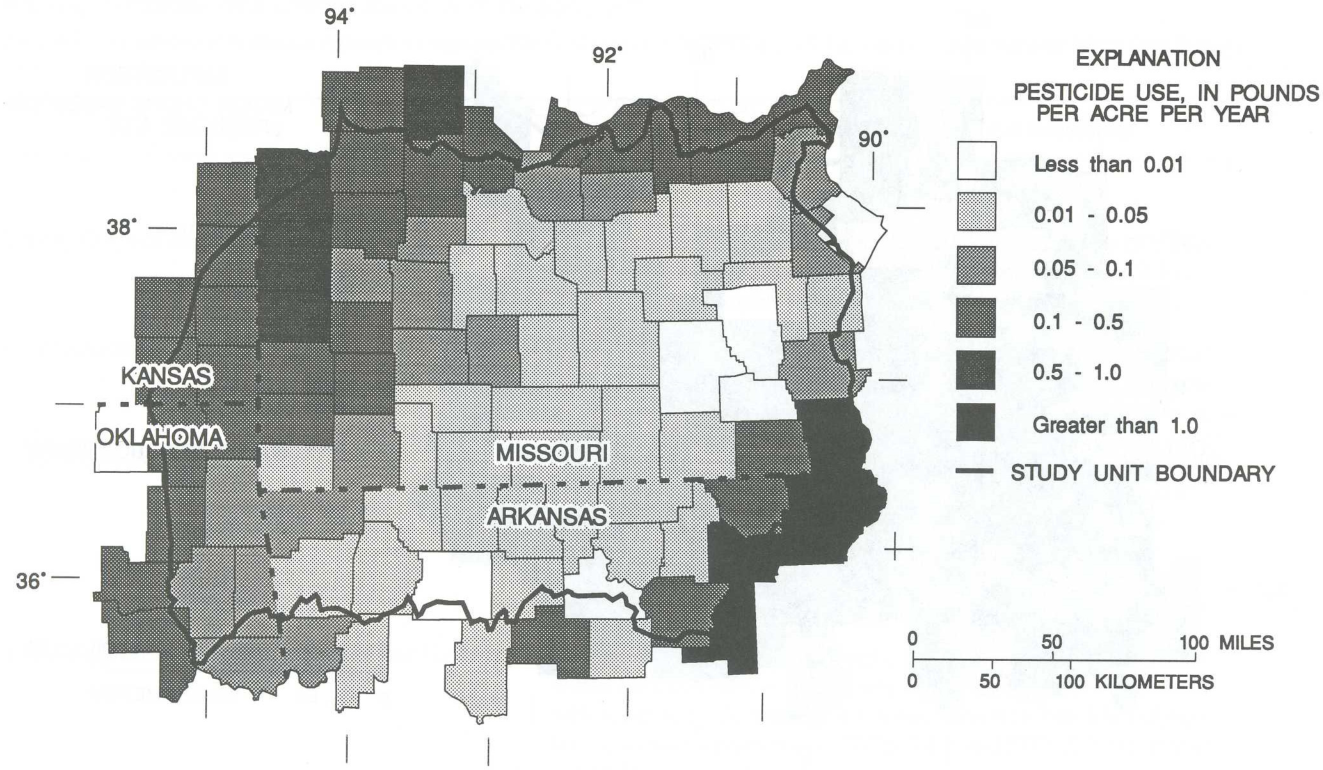


Figure 3. Pesticide application rate for counties within the study unit (calculated from data in Gianessi and Puffer, 1988).

in the Mississippi Alluvial Plain. Pastureland located in the Springfield and Salem Plateaus received moderate amounts of pesticides. Forestland and pastureland in the Boston and St. Francois Mountains received the least amounts of pesticides.

Pastureland was the predominate crop type in 50 of the 94 counties in the study unit based on crop estimates accompanying the pesticide-use data (fig.4). Pastureland dominated the Boston Mountains, St. Francois Mountains, and throughout most of the Springfield and Salem Plateaus. Corn, sorghum, and soybeans dominated the Osage Plains, and rice dominated the Mississippi Alluvial Plain.

SOURCES OF WATER-QUALITY, BED-SEDIMENT, AND BIOLOGICAL-TISSUE DATA

Pesticide-concentration data (the term "pesticide" hereinafter is used to refer to both pesticides and pesticide metabolites) and other water-quality data are collected by many Federal, State, and local governmental agencies for a variety of purposes. Industrial, wastewater, and water-supply facilities need water-quality information in order to make operational decisions. Regulatory agencies monitor water quality to determine compliance with permits and water-quality standards. Nonregulatory agencies monitor ambient water quality for the purposes of resource characterization and water-quality research. Depending on the purpose of data collection, samples may be collected employing various sample collection, processing, preservation, and analytical techniques and with various quality-assurance and quality-control requirements, resulting in different levels of detection and precision.

Numerous sources of pesticide data were available for the study unit, but only data collected by Federal or State governmental agencies and stored in computerized data bases were used in this report. Three Federal and three State agencies collected and maintained records of pesticide data for the majority of the surface-water, ground-water, bed-sediment, and biological-tissue sampling sites located within the study unit during the period of record (water year

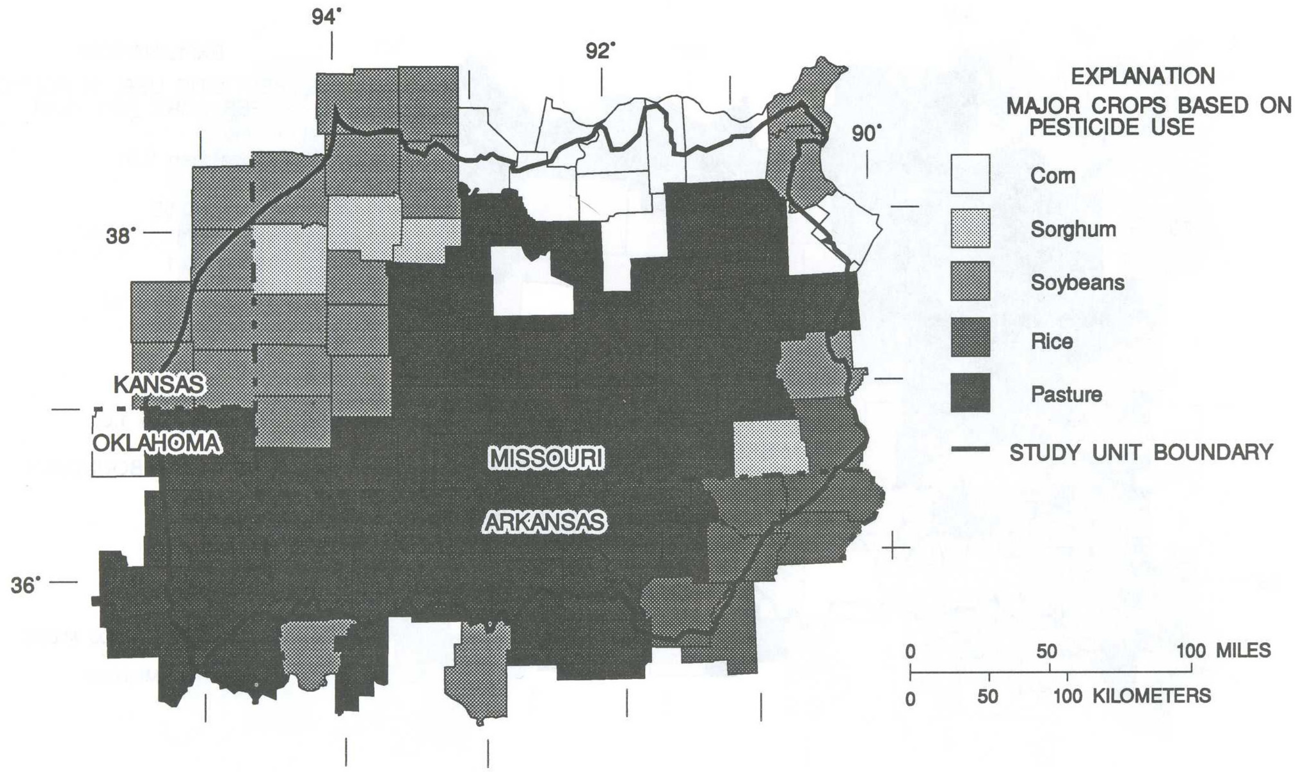


Figure 4. Crop types receiving the largest pesticide applications for counties within the study unit (calculated from data in Gianessi and Puffer, 1988).

1970-90) for this report (table 3). Each agency has different objectives for collecting pesticide data and these objectives affect the spatial, temporal, and hydrologic distribution of the data. No long-term pesticide monitoring networks were in operation in the study unit during the period of record.

Most of the computerized pesticide data available for the study unit resides in two national data bases: (1) USGS National Water Data Storage and Retrieval System (WATSTORE), and (2) U.S. Environmental Protection Agency's Storage and Retrieval system (STORET). WATSTORE was implemented in 1971 to provide processing, storage, and retrieval of water (and other media) data, and is capable of producing tables, graphs, and statistical analysis of these data (Hutchison, 1975). STORET is a data-management information system consisting of several software modules that allow the user to store and retrieve data, use analytical programs to access and analyze data, and pass data to user-written software or statistical packages (Hoelman, 1989).

The initial retrieval from WATSTORE and STORET located about 70,000 samples from 2,500 sample sites in the study unit for the period of record 1970-90. These 70,000 samples were searched for pesticide data, using more than 700 pesticide names. About 2,200 samples from about 450 sample sites had pesticide data to which several additional screening techniques were applied: (1) for cases in which more than one agency collected samples at sites that are in close proximity to each other, these sites were combined to represent a single site; (2) for cases in which more than one sample was collected at a particular site on a single day, only data from the first sample of the day was used so as not to cause a bias in the statistical analysis; and (3) an individual pesticide with fewer than five samples was excluded from the final data set. The final data set for this report contains 1,623 samples from 407 sites (140 surface water, 92 ground water, 55 bed sediment, and 120 biological tissue). The number of pesticide sampling sites and samples

Table 3. Major pesticide data sources available for the study unit

[STORET, U.S. Environmental Protection Agency's Storage and Retrieval system; WATSTORE, U.S. Geological Survey National Water Data Storage and Retrieval System]

Agency	Data collection purpose, type, and accessibility
Federal agencies	
U.S. Army Corps of Engineers	Resource assessment on Corps-developed projects; variety of water-quality data, sometimes collected in cooperation with other Federal agencies; data available from STORET and WATSTORE.
U.S. Environmental Protection Agency	Regulatory; wide variety of water-quality data, sometimes collected in cooperation with State agencies; all data in STORET; information on well construction and streamflow available.
U.S. Geological Survey	Water-resources assessment and research; limited monitoring network for ground- and surface-water quality; all data are computerized in WATSTORE including some State agency data; information on streamflow and well construction available.
State agencies	
Arkansas Department of Pollution Control and Ecology	Regulatory monitoring of 110 surface-water sites statewide, 46 sites within the study unit; samples analyzed for inorganic constituents, with some pesticide data and fish-tissue analysis for metals and organics; data are computerized in WATSTORE and STORET; information available on streamflow.
Kansas Department of Health and Environment	Monitoring network of surface- and ground-water quality originally in cooperation with the U.S. Geological Survey, but independently since 1990; 20 years of records, virtually all data in STORET; chemical and biological analyses for approximately 240 surface-water sites statewide, 15 sites within the study unit; about 30-40 percent have streamflow data.
Oklahoma Department of Environmental Quality	Monitoring ambient water quality and assessment of hazardous waste sites; most data in STORET or other computerized data base; some fish-tissue and bed-sediment data available, some pesticide data available; some streamflow information available.

collected for each sample type, by agency, is summarized in table 4.

SPATIAL AND TEMPORAL DISTRIBUTION OF PESTICIDE DATA

The spatial and temporal distribution of pesticide data is an important factor when evaluating the significance of that data. Spatial and temporal distribution, site and basin characteristics, land use, and ground-water site type and well depth are all important factors when assessing the representativeness and suitability of data for statistical analysis.

Surface Water

Pesticide data are available for 1,002 samples from 140 surface-water sampling sites within the study unit (fig. 5; table 5, at the back of this report). Spatial distribution of the surface-water sampling sites is not uniform. The density of sampling sites is greatest in the Springfield Plateau and Osage Plains and least for the St. Francois Mountains and western part of the Salem Plateau. Most surface-water sampling sites have drainage basins in the Springfield (45 sites) and Salem (43 sites) Plateaus; fewer have drainage basins in the Osage Plains (18 sites), and Boston Mountains (3 sites). Thirty-one surface-water sites

Table 4. Summary of number of pesticide sampling sites and samples collected for each sample type, by agency

Agency	Surface water		Ground water		Bed sediment		Biological tissue	
	Number of sampling sites	Number of samples	Number of sampling sites	Number of samples	Number of sampling sites	Number of samples	Number of sampling sites	Number of samples
U.S. Army Corps of Engineers	1	2	-	-	-	-	1	1
U.S. Environmental Protection Agency	39	70	-	-	31	31	78	179
U.S. Geological Survey	30	158	92	103	6	21	-	-
Arkansas Department of Pollution Control and Ecology	46	582	-	-	8	11	22	71
Kansas Department of Health and Environment	17	168	-	-	-	-	15	143
Oklahoma Department of Environmental Quality	8	22	-	-	10	24	4	37
TOTAL	[1]140	1,002	92	103	55	87	120	431

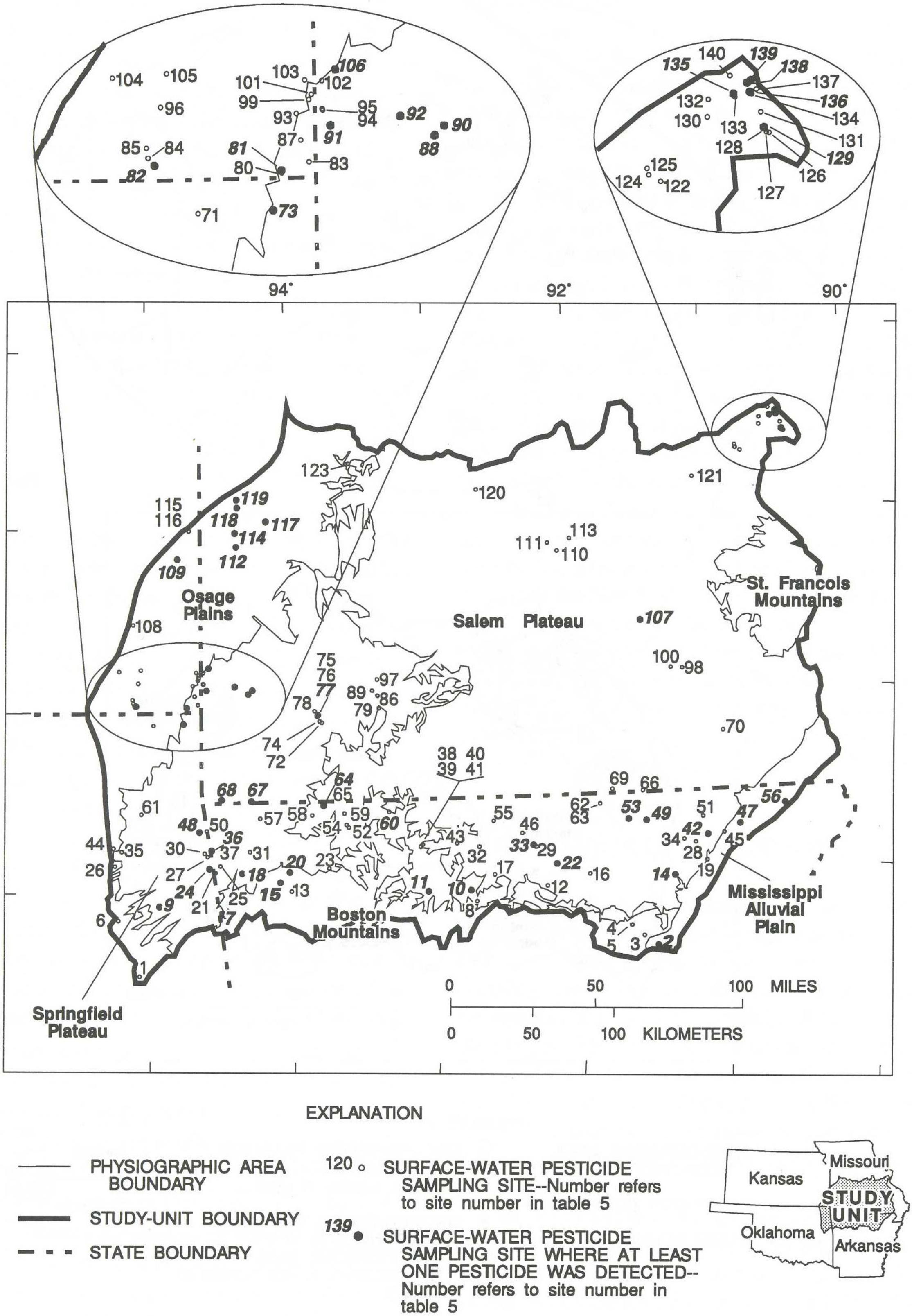
[1] Because the Illinois River near Tahlequah, Oklahoma is included with the number of sites for both the Oklahoma Department of Environmental Quality and the U.S. Geological Survey, the actual total for this column is 141.

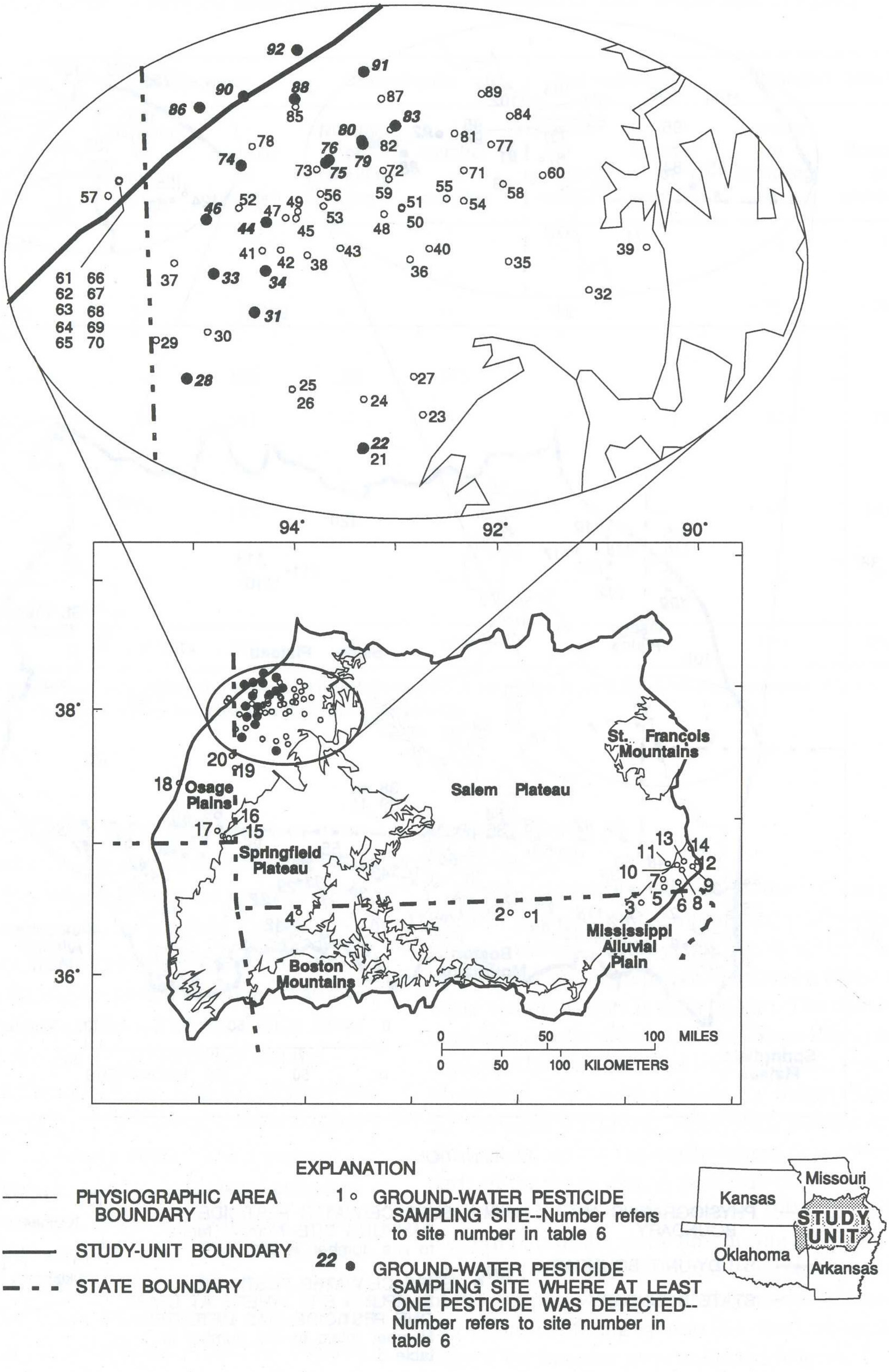
have drainage basins that cover parts of two or more physiographic areas. All or part of the drainage basins for 8 of the 11 sites where 20 or more samples were collected are located in the Springfield Plateau.

Many sites were sampled only once (42 sites) or twice (19 sites) during the period of record. The sites with the most samples collected are the White River near Norfork, Ark. (site 33, 39 samples) and the Neosho River at Chetopa, Kans. (site 82, 33 samples). About 50 percent of the 1,002 samples were collected in the mid-1970's and early-1980's. The 5 years in which the largest number of samples were collected are 1982 (124 samples), 1981 (117 samples), 1974 (97 samples), 1975 (83 samples), and 1973 (82 samples). Samples were collected in 16 or more years at the Spring River near Waco, Mo. (site 106, 17 years) and the Neosho River at Chetopa, Kans. (site 82, 16 years). The White River near Norfork, Ark. (site 33) had the most consecutive years (water years 1981-87) in which three or more samples were collected.

Ground Water

Pesticide data are available for 103 samples from 92 ground-water sampling sites (90 wells; 2 springs) within the study unit (fig. 6; table 6, at the back of this report). Spatial distribution of the ground-water sampling sites is not uniform. The density of sampling sites is greatest in the Osage Plains and Mississippi Alluvial Plain and least in the St. Francois Mountains, Boston Mountains, the Salem Plateau, and the Springfield Plateau. Ninety-four percent of the sites are located in the northwestern or southeastern parts of the study unit. A pesticide-occurrence survey conducted by Ziegler and others (1994) in the northwestern part of the study unit during 1990-91 accounts for 66 percent of the sites. Nearly 70 percent of the samples were collected from the Western Interior Plains confining system (64 sites); about 21 percent of the samples were collected from the Mississippi River Valley alluvial aquifer (13 sites). Only four sites obtaining water from the Springfield Plateau aquifer and only three sites obtaining water from


94°
92°
90°
38°
36°
Osage Plains
Salem Plateau
St. Francois Mountains
Springfield Plateau
Boston Mountains
Mississippi Alluvial Plain
0 50 100 MILES
0 50 100 KILOMETERS
EXPLANATION
PHYSIOGRAPHIC AREA BOUNDARY
STUDY-UNIT BOUNDARY
STATE BOUNDARY
120 SURFACE-WATER PESTICIDE SAMPLING SITE--Number refers to site number in table 5
139 SURFACE-WATER PESTICIDE SAMPLING SITE WHERE AT LEAST ONE PESTICIDE WAS DETECTED--Number refers to site number in table 5
Kansas
Missouri
STUDY UNIT
Oklahoma
Arkansas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Osage Plains
Springfield Plateau
Salem Plateau
St. Francois Mountains
Boston Mountains
Mississippi Alluvial Plain
0 50 100 MILES
0 50 100 KILOMETERS
EXPLANATION
PHYSIOGRAPHIC AREA BOUNDARY
STUDY-UNIT BOUNDARY
STATE BOUNDARY
1 GROUND-WATER PESTICIDE SAMPLING SITE--Number refers to site number in table 6
22 GROUND-WATER PESTICIDE SAMPLING SITE WHERE AT LEAST ONE PESTICIDE WAS DETECTED--Number refers to site number in table 6
Kansas
Missouri
Oklahoma
Arkansas
STUDY UNIT

the Ozark aquifer were sampled. Depths of the wells included in the data set ranges from 8 to 1,769 ft. Most of the wells (84) are less than 320 ft deep. Sixty-two of the 92 wells are private wells used for domestic purposes. Uses for the other wells include public supply, stock, and irrigation.

Most ground-water sites were sampled only once (85 sites) or twice (3 sites) during the period of record. Four sites (sites 6,7,13, and 14) were sampled three times. Sixty percent of the samples were collected in 1990 in a study by Ziegler and others (1994). The years with the largest number of samples collected were 1990 (62 samples), 1989 (11 samples), 1987 (10 samples), and 1986 (8 samples).

Bed Sediment

Pesticide data are available for 87 samples from 55 bed-sediment sampling sites, which were located in streams within the study unit (fig. 7; table 7, at the back of this report). Spatial distribution of the bed-sediment sampling sites is not uniform. The density of sampling sites is greatest in the northeastern Salem Plateau and the central and southwestern parts of the Springfield Plateau, and least in the St. Francois Mountains and large areas of the Osage Plains and the Salem Plateau. Most bed-sediment sites are located in the southern and extreme northeastern Salem Plateau (16 sites), and the Springfield Plateau (14 sites). Substantially fewer sites are located in the Osage Plains (2 sites) and Boston Mountains (1 site). Twenty-two sites have drainage basins that cover parts of two or more physiographic areas. Six or more samples were collected at three sites located in the Springfield Plateau.

Most bed-sediment sites were sampled only once (42 sites) or twice (8 sites) during the period of record. Most sites at which more than one sample was collected are located in the southern part of the study unit. The sites with the greatest number of samples are North Sylamore Creek near Fifty Six, Ark. (site 3, 9 samples), the Illinois River at Highway 64 Bridge, Okla. (site 7, 7 samples), and the Illinois River near Tahlequah, Okla. (site 6, 6 samples). About 40 percent of the 87 samples were collected during the late 1980's. The years in which the largest number of samples were collected were: 1990 (16 samples), 1981 (12 samples), and 1988 (11 samples).

Biological Tissue

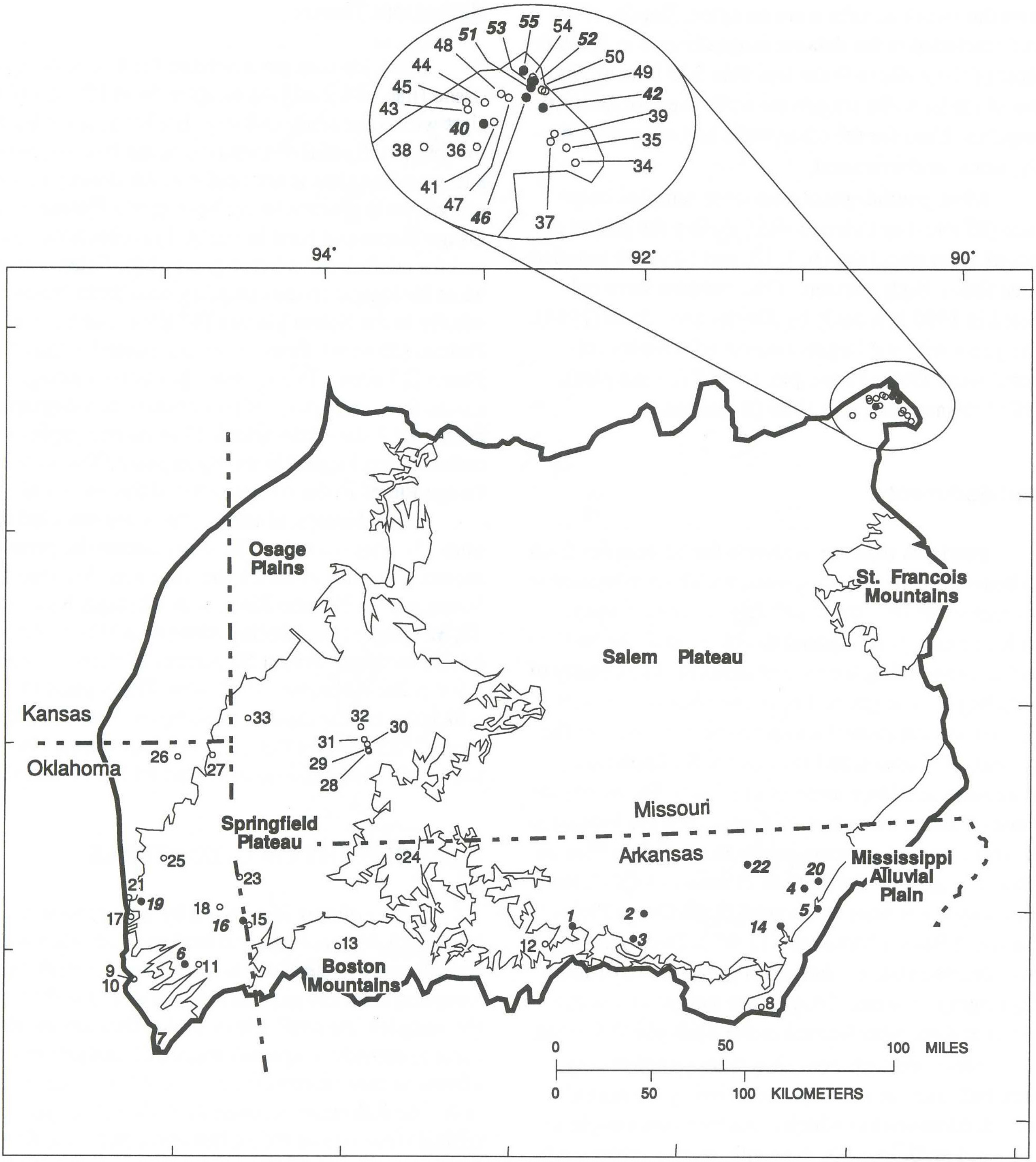
Pesticide data are available for 431 biological-tissue (fish and shellfish) samples from 120 sampling sites within the study unit (fig. 8; table 8, at the back of this report). Spatial distribution of the biological-tissue sampling sites is not uniform; the density of sampling sites is greatest in the Springfield Plateau and Osage Plains and least in the St. Francois Mountains and the central and western parts of the Salem Plateau. Most biological-tissue sampling sites drain basins wholly in the Salem Plateau (47 sites) and Springfield Plateau (35 sites). Fewer sites are located in the Osage Plains (17 sites). Twenty-one sites have drainage basins that cover parts of two or more physiographic areas. All 7 sites from which 17 or more samples were collected are located in the Springfield Plateau or Osage Plains in the western part of the study unit.

Many biological-tissue sites were sampled only once (51 sites) or twice (20 sites) during the period of record. The sites at which the most samples were collected are the Neosho River near Chetopa, Kans. (site 47, 32 samples) and Spring River near Waco, Mo. (site 69, 26 samples). About 50 percent of the 431 samples were collected between 1981-86. The 5 years in which the largest number of samples were collected were: 1983 (68 samples), 1984 (34 samples), 1981 (33 samples), 1986 (32 samples), and 1973 (30 samples).

ASSESSMENT OF CONDITIONS

Water quality is affected by factors related to physiography, geology, and land use and other human activities. Because of the limited spatial distribution of sampling sites and gaps in the temporal distribution of the samples, the available pesticide data are insufficient to provide a rigorous statistical analysis of the effects of these factors on water quality in the study unit. The following sections provide a descriptive statistical summary of recent historical pesticide data for surface water, ground water, bed sediment, and biological tissue.

Limitations in laboratory analytical techniques and equipment determine the lower limit below which constituent concentrations cannot be accurately determined. When the actual concentration is less than this lower limit, the concentration is reported as less than the detection limit of the analytical method. A particular constituent may have concentrations with several



EXPLANATION

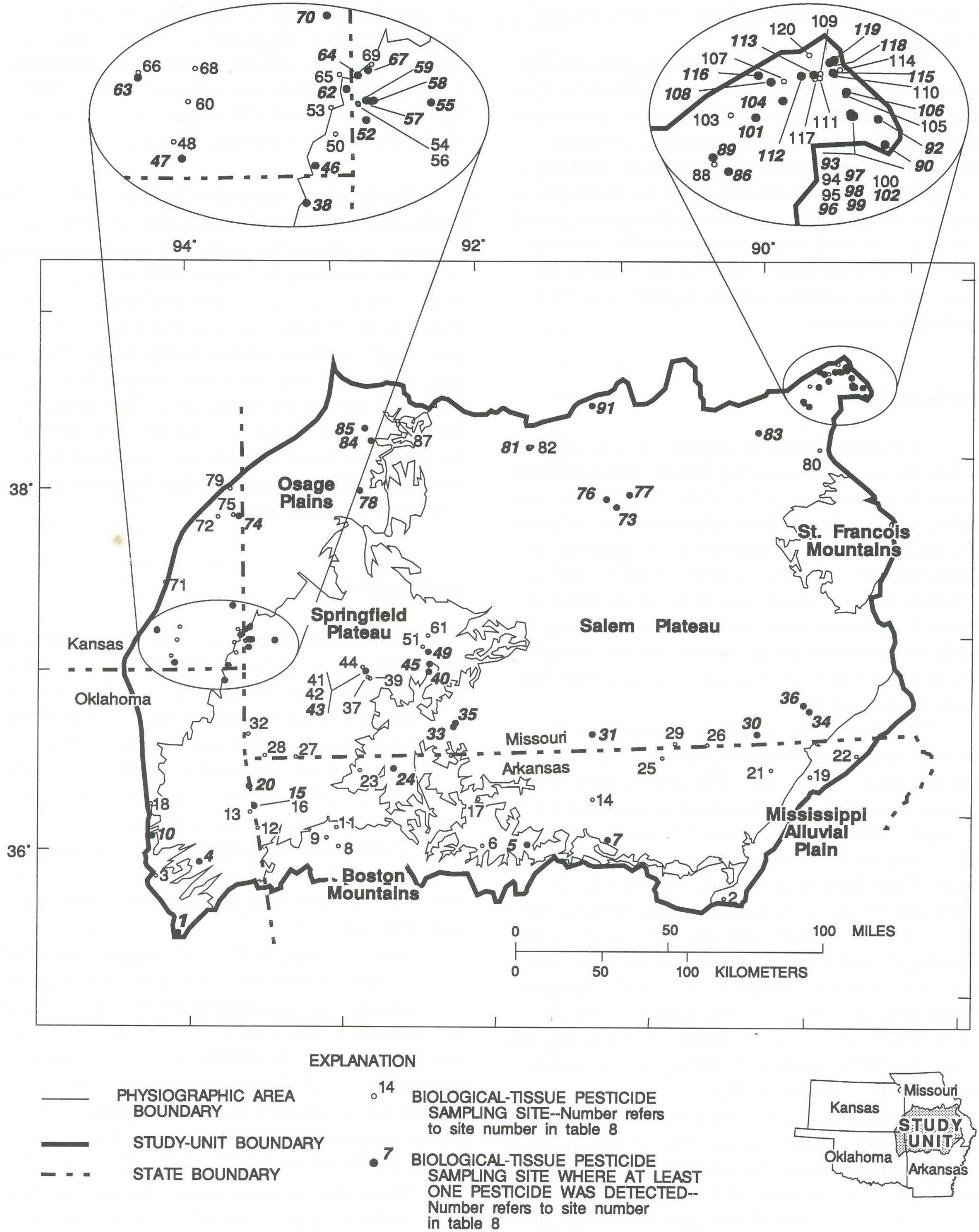
—— PHYSIOGRAPHIC AREA BOUNDARY

▬▬ STUDY-UNIT BOUNDARY

- - - STATE BOUNDARY

○ 13 BOTTOM-MATERIAL PESTICIDE SAMPLING SITE--Number refers to site number in table 7

● *3* BOTTOM-MATERIAL PESTICIDE SAMPLING SITE WHERE AT LEAST ONE PESTICIDE WAS DETECTED--Number refers to site number in table 7



94°
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Osage Plains
Springfield Plateau
Salem Plateau
St. Francois Mountains
Boston Mountains
Mississippi Alluvial Plain
Kansas
Oklahoma
Missouri
Arkansas
0 50 100 MILES
0 50 100 KILOMETERS
EXPLANATION
PHYSIOGRAPHIC AREA BOUNDARY
STUDY-UNIT BOUNDARY
STATE BOUNDARY
14 BIOLOGICAL-TISSUE PESTICIDE SAMPLING SITE--Number refers to site number in table 8
7 BIOLOGICAL-TISSUE PESTICIDE SAMPLING SITE WHERE AT LEAST ONE PESTICIDE WAS DETECTED--Number refers to site number in table 8
Kansas
Missouri
Oklahoma
Arkansas
STUDY UNIT

different detection limits because analytical techniques vary between laboratories and have changed over time.

Descriptive statistics are used to show the central tendency and variation in the pesticide data. The minimum, maximum, and 50th percentile (median) of samples with detected concentrations are presented; the median is used to represent the central tendency of the data instead of the mean because it is insensitive to extreme values in the data. The median is not reported unless five or more observations exceeded the detection limit. The maximum detection limit shows the censored concentration with the highest value for a particular parameter.

Surface Water

A statistical summary of pesticide data collected at 140 surface-water sampling sites for 51 pesticides is shown in table 9. Thirty-five of the 51 pesticides were below the detection limit for all the samples collected. Sixteen pesticides were detected in 132 samples collected from 43 sites. The locations of the 43 sites at which at least 1 pesticide was detected are shown in figure 5. Pesticides were detected in most areas of the study unit where sampling sites are located, but primarily in the southern, western, and extreme northeastern parts of the study unit.

The insecticide toxaphene, the pesticide having the most number of detections, was found in 17 of 866 samples from 5 of 112 sites. The concentration of toxaphene in samples with detections ranged from 0.1 to 6.0 µg/L (micrograms per liter). The toxaphene sample having the maximum concentration was collected at the White River near Norfork, Ark. (site 33) in 1982. Site 33 had 12 toxaphene detects between 1981-85. Other sites that had toxaphene samples above the detection limit include: Strawberry River near Smithville, Ark. (site 14; 2 samples, 1975, 1982); Spavinaw Creek north of Sycamore, Okla. (site 36; 1 sample, 1975); Spavinaw Creek near Sycamore, Okla. (site 48; 1 sample, 1975); South Fork Spring River at Saddle, Ark. (site 53; 1 sample, 1985).

Six other pesticides were detected in 12 or more samples: DDE was detected in 16 of 718 samples from 15 sites of 75 sites; dieldrin was detected in 15 of 990 samples from 15 of 132 sites; DDT was detected in 15 of 794 samples from 14 of 88 sites; aldrin was detected in 14 of 977 samples from 13 of 122 sites; 2,4-D was detected in 13 of 514 samples from 9 of 76 sites; lindane (parameter code 39340) was detected in 12 of 194 samples from 6 of 59 sites. The maximum concentration for these six pesticides was less than 1.0 µg/L. The samples with the maximum concentration of these six pesticides were collected prior to 1983, with the exception of DDE, which was collected in 1990 at the Illinois River near Tahlequah, Okla. (site 9).

The highest percentage of samples with concentrations above the detection limit were for samples analyzed for triazine herbicides and metabolites using an enzyme screening technique. All five samples, which were collected in the northwestern part of the study unit in 1990, had concentrations above the detection limit. These concentrations ranged from 1.0 µg/L at the Marmaton River near Nevada, Mo. (site 112) to 5.0 µg/L at the Marais des Cygnes drainage ditch, Mo. (site 118). Of the other 15 pesticides that had detectable concentrations, only lindane (6.2 percent) and alachlor (5.2 percent) had detections in more than 4 percent of the samples.

Ground Water

A statistical summary of pesticide data collected at 92 ground-water sampling sites for 44 pesticides is shown in table 10. All samples for 37 of the 44 pesticides were below the detection limit. Seven pesticides were detected in 31 samples collected from 18 sites. The locations of the 18 sites at which at least 1 pesticide was detected are shown in figure 6. These pesticides were found exclusively in ground water in the Osage Plains in the northwestern part of the study unit; however, spatial coverage of sampling sites was limited. All 31 samples with detectable concentrations were collected in 1990.

Atrazine, found in 15 of 95 samples from 15 of 79 wells, was the pesticide that had the most number of detections. The concentration of atrazine in samples with detections ranged from 0.1 to 8.2 µg/L. The atrazine sample having the maximum concentration was collected at site 88. Fourteen other sites in the northwestern part of the study unit had samples with atrazine concentrations above the detection limit: sites 22, 28, 31, 33, 34, 44, 46, 74, 79, 80, 83, 90, 91, 92.

Three other pesticides were detected more than once: metolachlor was detected in 5 of 93 samples from 5 of 73 wells; alachlor was detected in 5 of 96 samples from 5 of 76 wells; prometon was detected in 3 of 15 samples from 3 of 15 wells. The maximum

Table 9. Statistical summary of pesticide data from surface-water sampling sites for water years 1970-90

[STORET parameter code, U.S. Environmental Protection Agency's Storage and Retrieval code assigned to a parameter based on factors including the medium type and the analytical method used for the analysis; µg/L, micrograms per liter; --, data unavailable; ww, whole water]

		Detected concentration (µg/L)			Number of				
STORET parameter code	**Parameter name**	**Minimum**	**Median**	**Maximum**	**samples**	**sites**	**sites with a detectable concentration**	**samples with a detectable concentration**	**Maximum detection limit (µg/L)**
34541	1,2-dichloropropane, total	--	--	--	54	26	0	0	10.
39730	2,4-D, total	0.02	0.03	0.61	514	76	9	13	0.8
34601	2,4-dichlorophenol, total	--	--	--	55	27	0	0	52.
39360	DDD, total	--	--	0.01	312	54	1	1	1.0
39365	DDE, total	0.001	0.001	0.01	718	75	15	16	1.0
39370	DDT, total	0.001	0.002	0.023	794	88	14	15	10.
39305	o,p'-DDT, total	--	--	--	90	11	0	0	10.
39300	p,p'-DDT, total	--	--	--	169	48	0	0	1.1
39040	DEF, total	--	--	--	17	2	0	0	0.01
39250	PCN, total	--	--	--	59	16	0	0	5.0
34200	Acenaphthylene, total	--	--	--	55	27	0	0	10.
77825	Alachlor, total recoverable	0.015	0.66	4.2	115	23	5	6	0.5
39330	Aldrin, total	0.001	0.001	0.001	977	122	13	14	1.0
39337	Alpha benzene hexachloride, total	0.02	--	0.02	93	44	3	3	0.19
39338	Beta benzene hexachloride, total	--	--	--	72	30	0	0	0.38
39062	Chlordane, cis isomer, ww, total	--	--	--	10	3	0	0	0.1
39350	Chlordane, total	0.2	0.3	0.5	353	76	3	7	3.8
39065	Chlordane, trans isomer, ww, total	--	--	--	10	3	0	0	0.1
39071	Chlordane-nonachlor, trans isomer, ww, total	--	--	--	10	3	0	0	0.1
81403	Chloropyrifos, total	--	--	--	62	28	0	0	10.
34704	Cis-1,3-dichloropropene, total	--	--	--	51	23	0	0	1.0
34699	Trans-1,3-dichloropropene, total	--	--	--	52	24	0	0	1.0
39570	Diazinon, total	--	--	0.01	60	14	1	1	0.1
39380	Dieldrin, total	0.001	0.001	0.01	990	132	15	15	2.0
39011	Disyston, total	--	--	--	17	2	0	0	0.01
39388	Endosulfan I, total	--	--	--	188	50	0	0	1.0
34361	Endosulfan I, ww, recoverable	--	--	--	70	29	0	0	0.38
34356	Endosulfan beta, total	--	--	--	70	29	0	0	0.63
34351	Endosulfan sulfate, total	--	--	--	70	29	0	0	1.3

Table 9. Statistical summary of pesticide data from surface-water sampling sites for water years 1970-90--Continued

[STORET parameter code, U.S. Environmental Protection Agency's Storage and Retrieval code assigned to a parameter based on factors including the medium type and the analytical method used for the analysis; µg/L, micrograms per liter; --, data unavailable; ww, whole water]

STORET parameter code	Parameter name	Detected concentration (µg/L) Minimum	Median	Maximum	Number of samples	sites	sites with a detectable concentration	samples with a detectable concentration	Maximum detection limit (µg/L)
39398	Ethion, total	--	--	--	46	10	0	0	0.01
39421	Heptachlor epoxide, dissolved	--	--	--	7	7	0	0	1.0
39420	Heptachlor epoxide, total	--	--	--	438	97	0	0	1.0
39410	Heptachlor, total	0.014	--	0.23	439	97	1	3	1.0
39700	Hexachlorobenzene, total	--	--	--	71	32	0	0	10.
39340	Lindane, total	0.012	0.052	0.29	194	59	6	12	0.2
39782	Lindane, total	0.03	--	0.07	810	81	1	3	10.
39530	Malathion, total	--	--	--	235	60	0	0	1.0
39480	Methoxychlor, total	--	--	--	365	69	0	0	50.
39600	Methyl parathion, total	--	--	--	510	59	0	0	7.0
39356	Metolachlor, ww	--	--	--	80	17	0	0	0.25
81408	Metribuzin, ww	--	--	0.57	101	17	1	1	0.1
39755	Mirex, total	--	--	--	60	14	0	0	0.01
39540	Parathion, total	--	--	--	51	11	0	0	0.01
39034	Perthane, total	--	--	--	34	10	0	0	0.1
39023	Phorate, total	--	--	--	17	2	0	0	0.01
39760	Silvex, total	--	--	--	99	17	0	0	0.01
39055	Simazine, total	--	--	--	843	100	0	0	0.5
39402	Toxaphene, suspended, total	--	--	--	20	14	0	0	2.5
39400	Toxaphene, total	0.1	0.7	6.0	866	112	5	17	7.0
34757	Triazine screen by enzyme ww, recoverable	1.0	4.0	5.0	5	5	5	5	- -
39786	Trithion, total	--	--	--	46	10	0	0	0.01

concentration of these three pesticides was less than 1.0 µg/L, with the exception of prometon (2.4 µg/L).

The pesticide having the highest percentage of samples above the detection limit was prometon (20 percent). The concentrations ranged from 0.1 at site 83 to 2.4 µg/L at site 86. Of the other six pesticides that had detectable concentrations, only atrazine (15.8 percent) was found in more than 10 percent of the samples. Four other pesticides were detected in more than 5 percent of the samples: propazine (6.7), simazine (6.7), metolachlor (5.4), and alachlor (5.2).

Bed Sediment

A statistical summary of pesticide data collected at 55 bed-sediment sampling sites for 41 pesticides is shown in table 11. Twenty-six of the 41 pesticides

Table 10. Statistical summary of pesticide data from ground-water sampling sites for water years 1970-90

[STORET parameter code, U.S. Environmental Protection Agency's Storage and Retrieval code assigned to a parameter based on factors including the medium type and the analytical method used for the analysis; µg/L, micrograms per liter; --, data unavailable; ww, whole water]

STORET parameter code	Parameter name	Detected concentration (µg/L)			Number of				Maximum detection limit (µg/L)
		Minimum	Median	Maximum	samples	sites	sites with a detectable concentration	samples with a detectable concentration	
39740	2,4,5-T, total	--	--	--	21	15	0	0	0.2
39730	2,4-D, total	--	--	--	22	16	0	0	0.4
39770	DCPA, unfiltered, recoverable	--	--	--	6	6	0	0	0.05
39360	DDD, total	--	--	--	6	5	0	0	0.05
39365	DDE, total	--	--	--	6	5	0	0	0.05
39370	DDT, total	--	--	--	6	5	0	0	0.05
39305	o,p'-DDT, total	--	--	--	6	6	0	0	0.1
39310	p,p'-DDD, total	--	--	--	10	10	0	0	0.04
39320	p,p'-DDE, total	--	--	--	10	10	0	0	0.02
39300	p,p'-DDT, total	--	--	--	16	16	0	0	0.1
34200	Acenaphthylene, total	--	--	--	11	11	0	0	2.0
77825	Alachlor, total, recoverable	0.1	0.51	0.93	96	76	5	5	0.25
39330	Aldrin, total	--	--	--	22	21	0	0	0.13
39337	Alpha BHC	--	--	--	10	10	0	0	0.13
82184	Ametryne, total	--	--	--	15	15	0	0	0.1
39630	Atrazine, total	0.1	0.3	8.2	95	79	15	15	1.2
39338	Beta benzene hexachloride, total	--	--	--	10	10	0	0	0.25
39350	Chlordane, total	--	--	--	30	24	0	0	0.3
81757	Cyanazine, total	--	--	--	93	73	0	0	0.5
39570	Diazinon, total	--	--	--	21	14	0	0	0.2
39380	Dieldrin, total	--	--	--	22	21	0	0	0.1
82624	Endosulfan II, ww, total recoverable	--	--	--	10	10	0	0	0.00
34351	Endosulfan sulfate, total	--	--	--	10	10	0	0	0.1
39390	Endrin, unfiltered, recoverable	--	--	--	23	22	0	0	0.1
39420	Heptachlor epoxide, total	--	--	--	15	14	0	0	0.1
39410	Heptachlor, total	--	--	--	16	15	0	0	0.1
39700	Hexachlorobenzene, total	--	--	--	11	10	0	0	2.0
39340	Lindane, total	--	--	--	13	12	0	0	0.1
39530	Malathion, total	--	--	--	13	8	0	0	0.5

Table 10. Statistical summary of pesticide data from ground-water sampling sites for water years 1970-90--Continued

[STORET parameter code, U.S. Environmental Protection Agency's Storage and Retrieval code assigned to a parameter based on factors including the medium type and the analytical method used for the analysis; µg/L, micrograms per liter; --, data unavailable; ww, whole water]

		Detected concentration (µg/L)			Number of				
STORET parameter code	Parameter name	Minimum	Median	Maximum	samples	sites	sites with a detectable concentration	samples with a detectable concentration	Maximum detection limit (µg/L)
39051	Methomyl, total	--	--	--	9	5	0	0	5.0
39480	Methoxychlor, total	--	--	--	10	10	0	0	0.5
39600	Methyl parathion, total	--	--	--	12	8	0	0	0.2
82612	Metolachlor ww, total recoverable	0.06	0.12	0.19	93	73	5	5	5.0
82611	Metribuzin ww, recoverable	--	--	0.1	93	73	1	1	0.5
39023	Phorate, total	--	--	--	10	10	0	0	0.1
39056	Prometon, total	0.1	--	2.4	15	15	3	3	0.1
39057	Prometryne, total	--	--	--	15	15	0	0	0.1
39024	Propazine, total	--	--	0.43	15	15	1	1	0.1
39750	Sevin, total	--	--	--	18	11	0	0	1.0
39760	Silvex, total	--	--	--	14	13	0	0	0.2
39055	Simazine, total	--	--	0.18	15	15	1	1	0.1
38887	Terbutryn, ww, recoverable	--	--	--	14	14	0	0	0.05
39400	Toxaphene, total	--	--	--	29	25	0	0	2.0
39030	Trifluralin, total	--	--	--	79	72	0	0	0.1

were below the detection limit for all the samples analyzed. Fifteen pesticides were detected in 39 samples collected from 19 sites. The locations of the 19 sites at which at least 1 pesticide was detected are shown in figure 7. Pesticides were detected in bed sediment in the Springfield and Salem Plateaus in the southern and extreme northeastern part of the study unit; however, spatial coverage of the sampling sites was limited.

Chlordane, found in 12 of 73 samples from 10 of 45 sites, was the pesticide that had the most number of detections. The concentration for chlordane in samples with detections ranged from 2.0 to 240 µg/kg (micrograms per kilogram). The chlordane sample having the maximum concentration was collected at Sugar Creek above the confluence with Romaine Creek, Mo. (site 52) in 1990. No other chlordane samples were collected at site 52 during the period of record. Other sites that had chlordane samples above the detection limit were: Buffalo River near Harriet, Ark. (site 1; 1 of 4 samples, 1982); North Sylamore Creek near Fifty Six, Ark. (site 3; 1 of 8 samples, 1975); Illinois River near Tahlequah, Okla. (site 6; 3 of 6 samples, 1981-85); Illinois River near Watts, Okla. (site 16; 1 of 2 samples, 1986); Unnamed tributary of the Meramec River, Mo. (site 42; 1 of 1 sample, 1990); Meramec River below Fishpot Creek, Mo. (site 46; 1 of 1 sample, 1988); Grand Glaize Creek at Big Bend Road, Mo. (site 51; 1 of 1 sample, 1988); Grand Glaize Creek at Doughtery Ferry Road, Mo. (site 53; 1 of 1 sample, 1990); Grand Glaize Creek at Deitrich Road, Mo. (site 55; 1 of 1 sample, 1990).

Five other pesticides were detected more than once: DDT was detected in 5 of 48 samples from 5 of 19 sites; DDD was detected in 5 of 20 samples from 4 of 5 sites; p,p’-DDE was detected in 3 of 50 samples from 2 of 37 sites; DDE was detected in 3 of 20 samples from 2 of 5 sites; hexachlorobenzene was detected in 2 of 43 samples from 2 of 29 sites. The maximum concentration of these five pesticides was

Table 11. Statistical summary of pesticide data from bed-sediment sampling sites for water years 1970-90

[STORET parameter code, U.S. Environmental Protection Agency's Storage and Retrieval code assigned to a parameter based on factors including the medium type and the analytical method used for the analysis; µg/kg, micrograms per kilogram; --, data unavailable]

STORET parameter code	Parameter name	Detected concentration (µg/kg) Minimum	Median	Maximum	Number of samples	sites	sites with a detectable concentration	samples with a detectable concentration	Maximum detection limit (µg/kg)
39741	2,4,5-T	--	--	0.6	8	4	1	1	0.4
39731	2,4-D	--	--	--	8	4	0	0	0.8
34609	2,4-DP	--	--	--	12	12	0	0	1,000
34604	2,4-dichlorophenol	--	--	--	12	12	0	0	2,100
39363	DDD	0.3	1.2	4.2	20	5	4	5	0.2
39368	DDE	0.1	--	1.5	20	5	2	3	0.2
39373	DDT	0.1	0.6	2.0	48	19	5	5	14.0
39306	o,p'-DDT	--	--	--	34	19	0	0	8.0
39311	p,p'-DDD	--	--	3.0	53	37	1	1	20.
39321	p,p'-DDE	5.0	--	7.3	50	37	2	3	20.
39301	p,p'-DDT	--	--	6.1	55	35	1	1	40.
39251	PCN, total	--	--	--	4	2	0	0	1.0
34203	Acenaphthylene	--	--	--	10	10	0	0	500
39333	Aldrin	--	--	--	74	44	0	0	40.
39076	Alpha benzene hexachloride, total	--	--	16.0	52	36	1	1	29.
34257	Beta benzene hexachloride	--	--	--	10	10	0	0	500
34262	Delta benzene hexachloride	--	--	--	20	20	0	0	10.
39351	Chlordane	2.0	33.5	240	73	45	10	12	120
34702	Cis 1,3-dichloropropene	--	--	--	7	7	0	0	50.
34697	Trans-1,3-dichloropropene	--	--	--	7	7	0	0	50.
39571	Diazinon	--	--	--	9	5	0	0	0.2
34544	Dichloropropane	--	--	--	7	7	0	0	50.
39383	Dieldrin	--	--	1.4	75	44	1	1	30.
34364	Endosulfan alpha	--	--	--	20	20	0	0	12.
34359	Endosulfan beta	--	--	--	20	20	0	0	20.
34354	Endosulfan sulfate	--	--	--	20	20	0	0	40.
39393	Endrin	--	--	0.4	78	45	1	1	20.
39399	Ethion	--	--	--	6	3	0	0	0.1
39413	Heptachlor	--	--	5.0	48	46	1	1	10.
39423	Heptachlor epoxide	--	--	0.6	49	35	1	1	30.

Table 11. Statistical summary of pesticide data from bed-sediment sampling sites for water years 1970-90--Continued

[STORET parameter code, U.S. Environmental Protection Agency's Storage and Retrieval code assigned to a parameter based on factors including the medium type and the analytical method used for the analysis; µg/kg, micrograms per kilogram; --, data unavailable]

		Detected concentration (µg/kg)			Number of				
STORET parameter code	**Parameter name**	Minimum	Median	Maximum	samples	sites	sites with a detectable concentration	samples with a detectable concentration	Maximum detection limit (µg/kg)
39701	Hexachlorobenzene	1.0	--	600	43	29	2	2	600
39343	Lindane	--	--	--	41	26	0	0	10.
39531	Malathion	--	--	--	10	5	0	0	0.2
39481	Methoxychlor	--	--	0.3	44	25	1	1	91.
39601	Methyl parathion	--	--	--	12	6	0	0	0.2
39791	Methyl trithion	--	--	--	6	3	0	0	0.1
39758	Mirex	--	--	--	4	2	0	0	0.1
39541	Parathion	--	--	--	12	5	0	0	0.2
81886	Perthane	--	--	--	4	2	0	0	1.0
39761	Silvex	--	--	--	8	4	0	0	0.3
39403	Toxaphene	--	--	--	55	38	0	0	1,300

less than 10 µg/kg, with the exception of hexachlorobenzene (600 µg/kg).

The pesticide having the highest percentage of samples above the detection limit was DDD (25 percent). Four other pesticides had more than 10 percent of the samples above the detection limit: chlordane (16 percent), DDE (15 percent), 2,4,5-T (12.5 percent), and DDT (10.4 percent). Of the other 10 pesticides, which had detectable concentrations, only p,p'-DDE (6 percent) and hexachlorobenzene (4.7 percent) were detected in more than 3 percent of the samples.

Biological Tissue

A statistical summary of pesticide data collected at 120 biological-tissue sampling sites for 43 pesticides is shown in table 12. It is likely that a variety of species, ages, sizes, and tissue types (whole organisms, fillets, and specific organs) is represented in these data; all of these factors affect data comparability. Twenty of the 43 pesticides were below the detection limit for all the samples analyzed. Twenty-three pesticides were detected in 798 samples collected from 61 sites. The locations of the 61 sites at which at least 1 pesticide was detected are shown in figure 8. Pesticides were detected in most areas of the study unit where sampling sites are located; the extreme northeastern part of the study unit had the greatest density of sites with detectable concentrations.

Chlordane, found in 93 of 151 samples at 39 of 53 sites, was the pesticide that had the most number of detections. The concentration of chlordane in samples with detections ranged from 0.009 to 8.6 milligrams per kilogram (mg/kg). The chlordane sample having the maximum concentration was collected at the Meramec River at Fenton, Mo. (site 106) in 1984. Site 106 had one other detection of chlordane in 1985. Other sites that had tissue samples with chlordane concentrations equal to or greater than 1 mg/kg were: Cow Creek 1 mile east of Langdon, Kans. (site 70; 1 of 2 samples, 1988); Meramec River 1 mile upstream of Mississippi River confluence, Mo. (site 90; 1 of 1 sample, 1984); and Romaine Creek upstream of Highway 141 Bridge, Mo. (site 96; 1 of 1 sample, 1984).

Four other pesticides were detected in 75 or more samples: p,p'-DDE was detected in 92 of 151 samples from 37 of 49 sites; chlordane-cis isomer was detected in 88 of 157 samples from 38 of 58 sites;

Table 12. Statistical summary of pesticide data from biological-tissue sampling sites for water years 1970-90

[STORET parameter code, U.S. Environmental Protection Agency's Storage and Retrieval code assigned to a parameter based on factors including the medium type and the analytical method used for the analysis; mg/kg, milligrams per kilogram; --, data unavailable]

		Detected concentration (mg/kg)			Number of				
STORET parameter code	**Parameter name**	Minimum	Median	Maximum	samples	sites	sites with a detectable concentration	samples with a detectable concentration	Maximum detection limit (mg/kg)
34545	1,2-dichloropropane	--	--	--	48	17	0	0	0.01
34605	2,4-dichlorophenol	--	--	--	50	19	0	0	2.0
34204	Acenaphthylene	--	--	--	21	11	0	0	2.0
82571	Alachlor	--	--	--	46	16	0	0	0.08
34680	Aldrin, fish	--	--	0.04	57	23	1	1	0.08
39334	Aldrin, shellfish or animal	--	--	--	18	3	0	0	6.0
82404	Atrazine, fish	--	--	--	69	29	0	0	0.38
39074	Alpha benzene hexachloride	0.004	0.009	4.51	147	47	10	11	0.04
34258	Beta benzene hexachloride	--	--	--	50	18	0	0	0.04
34263	Delta benzene hexachloride	--	--	--	50	18	0	0	0.08
34682	Chlordane	0.009	0.16	8.6	151	53	39	93	0.8
39063	Chlordane-cis isomer	0.003	0.021	21.0	157	58	38	88	0.13
39072	Chlordane-nonachlor, trans isomer	0.003	0.021	0.82	143	47	35	85	0.2
39066	Chlordane-trans isomer	0.002	0.019	18.2	146	49	35	75	0.13
34703	Cis-1,3-dichloropropene, fish	--	--	--	20	9	0	0	0.02
34698	Trans-1,3-dichloropropene, fish	--	--	--	20	9	0	0	0.02
39358	DDT, total, aquatic organisms	0.1	0.835	330	21	3	3	10	40.
39307	o,p'-DDT	--	--	--	123	35	0	0	0.1
39312	p,p'-DDD	0.01	0.045	0.24	140	44	15	22	0.24
39302	p,p'-DDT	0.01	0.05	0.2	149	46	12	14	0.4
39322	p,p'-DDE	0.01	0.03	52.7	151	49	37	92	0.16
39404	Dieldrin	0.01	0.02	125	150	49	19	41	0.12
34355	Endosulfan sulfate	--	--	--	91	29	0	0	0.8
34365	Endosulfan, alpha	--	--	--	96	29	0	0	0.12
34360	Endosulfan, beta	--	--	0.05	91	29	1	1	0.24
34685	Endrin	0.275	--	0.275	117	37	3	3	0.2
39397	Endrin, shellfish or animal	--	--	--	18	3	0	0	6.0
34687	Heptachlor	0.002	0.005	0.11	102	31	5	5	8.0
34686	Heptachlor epoxide	0.002	0.008	9.34	105	33	18	29	0.15

Table 12. Statistical summary of pesticide data from biological-tissue sampling sites for water years 1970-90--Continued

[STORET parameter code, U.S. Environmental Protection Agency's Storage and Retrieval code assigned to a parameter based on factors including the medium type and the analytical method used for the analysis; mg/kg, milligrams per kilogram; --, data unavailable]

		Detected concentration (mg/kg)			Number of				
STORET parameter code	Parameter name	Minimum	Median	Maximum	samples	sites	sites with a detectable concentration	samples with a detectable concentration	Maximum detection limit (mg/kg)
34688	Hexachlorobenzene	0.001	0.002	1.37	78	30	4	6	2.0
39785	Lindane	0.01	0.025	3.19	99	31	6	8	0.02
39534	Malathion	--	--	--	10	3	0	0	0.1
39482	Methoxychlor, fish	--	--	--	27	10	0	0	100
81644	Methoxychlor, fish	--	--	--	39	14	0	0	0.2
39346	Metolachlor	--	--	--	41	16	0	0	0.5
82405	Metribuzin	0.019	0.054	0.29	87	39	5	11	0.2
81645	Mirex, fish	--	--	0.57	15	9	1	1	0.25
82029	Oxychlordane	0.003	0.014	6.75	57	20	10	18	0.02
81810	Parathion, fish	--	--	--	6	3	0	0	0.1
82533	Propazine, fish	--	--	--	36	17	0	0	0.05
82406	Simazine, fish	0.2	0.32	0.45	211	51	3	7	3.8
34691	Toxaphene	--	--	1.5	72	25	1	1	6.5
39407	Toxaphene, fish	--	--	424.	9	2	1	1	60.

chlordane-nonachlor-trans isomer was detected in 85 of 143 samples from 35 of 47 sites; and chlordane-trans isomer was detected in 75 of 146 samples from 35 of 49 sites. The maximum concentrations of these four pesticides were 52.7, 21.0, 0.82, and 18.2 mg/kg, respectively. The samples having the maximum concentration of these four pesticides were collected prior to 1987. Twelve other pesticides were detected in 5 or more samples.

The pesticide having the highest percentage of samples above the detection limit was chlordane (61.6 percent). Four other pesticides were detected in 50 percent or more of the samples: p,p'-DDE, chlordane-nonachlor (trans isomer), chlordane-cis isomer, chlordane-trans isomer.

Comparison of Pesticide Data with Selected Quality Criteria and Standards

Fifteen pesticides detected at sites in the study unit have quality criteria (nonenforceable suggested values) or standards (legally enforceable values) established for one or more sample types. The maximum concentrations of these pesticides in surface-water, ground-water, bed-sediment, and biological-tissue samples summarized in this report are compared with selected quality criteria and standards established by the U.S. Environmental Protection Agency (USEPA) and U.S. Food and Drug Administration (USFDA) in table 13.

For surface water, the Acute Aquatic Life Criteria (AALC) established by the USEPA (Nowell and Resek, 1994) provide a basis of comparison with the maximum concentration of the detected pesticides having an AALC value. None of the four detected pesticides having an AALC value (chlordane, DDT, dieldrin, or heptachlor) exceeded their respective AALC.

The drinking water Maximum Contaminant Level (MCL) established by the USEPA (Nowell and Resek, 1994) provides a basis of comparison with the maximum concentration of detected pesticides having

Table 13. Comparison of selected quality criteria and standards with maximum detected concentrations in surface-water, ground-water, bed-sediment, and biological-tissue samples

[Maximum concentration, maximum concentration of samples given in this report; AALC, Acute Aquatic Life Criteria; MCL, Maximum Contaminant Level; SQC, Sediment Quality Criteria; FTAL, Fish Tissue Action Level; µg/L, micrograms per liter; µg/kg, micrograms per kilogram; mg/kg, milligrams per kilogram; --, data unavailable; nsg, no standard or guideline established]

	Surface water		Ground water		Bed sediment		Biological Tissue	
Parameter name	Maximum concentration (µg/L)	AALC[1] (µg/L)	Maximum concentration (µg/L)	Drinking water standard MCL[1,2] (µg/L)	Maximum concentration (µg/kg)	SQC[1] (µg/kg)	Maximum concentration (mg/kg)	FTAL[1,3] (mg/kg)
Alachlor	4.2	nsg	0.93	2.0	--	nsg	--	nsg
Aldrin	0.001	nsg	--	nsg	--	nsg	0.04	0.3
Atrazine	--	nsg	8.2	3.0	--	nsg	--	nsg
Chlordane	0.5	2.4	--	2.0	240	309	8.6	0.3
DDT total	0.023	1.1	--	--	--	nsg	330	nsg
Dieldrin	0.01	2.5	--	nsg	1.4	11,000	125	0.3
Endrin	--	0.18	--	2.0	0.4	4,200	0.275	0.3
Heptachlor	0.23	0.52	--	0.4	5	110	0.11	0.3
Heptachlor epoxide	--	0.52	--	0.2	0.6	nsg	9.34	0.3
Mirex	--	nsg	--	nsg	--	nsg	0.57	0.1
p,p'-DDD	--	nsg	--	nsg	3	nsg	0.24	5
p,p'-DDT	--	nsg	--	nsg	6.1	828	0.2	5
p,p'-DDE	--	nsg	--	nsg	7.3	nsg	52.7	5
Simazine	--	nsg	0.18	4.0	--	nsg	0.45	nsg
Toxaphene	6.0	nsg	--	3.0	--	64.7	424	5,000

[1] Criteria and standards established by the U. S. Environmental Protection Agency (AALC, MCL, SQC) and the U.S. Food and Drug Administration (FTAL) listed in Nowell and Resek (1994).
[2] Applies to pesticide concentrations in both surface water and ground water.
[3] Edible portion of fish tissue.

a MCL value. Because the MCL applies to finished drinking water, the comparison of concentrations of detected pesticides in this report with the MCL is merely for informational purposes. Alachlor, the only pesticide detected in surface water that exceeded its MCL, was detected in one sample in 1982 collected at site 109 (figure 5 and table 5), which is located in the Osage Plains in the northwestern part of the study unit. Of the three pesticides detected in ground water that have an established MCL, only atrazine exceeded the MCL value of 3.0 µg/L. The sites where atrazine concentrations exceeded the drinking water MCL were: sites 79, 80, 88, 91 (fig. 6 and table 6). All four samples (one from each site) were collected in 1990 at sites located in the Osage Plains in the northwestern part of the study unit.

For bed sediment, the Sediment Quality Criteria (SQC) developed by the USEPA (Nowell and Resek, 1994) provides a basis of comparison with the maximum concentration of detected pesticides having a SQC value. None of the five detected pesticides having a SQC value (chlordane, dieldrin, endrin, heptachlor, p,p'-DDT) exceeded their respective SQC.

For biological tissue, the Fish Tissue Action Level (FTAL) established by the USFDA (Nowell and Resek, 1994) provides a basis of comparison with the maximum concentration of detected pesticides having a FTAL value. Five pesticides exceeded their respective FTAL. Chlordane concentrations in 26 samples from 19 sites (40, 45, 46, 47, 59, 63, 70, 74, 81, 85, 90, 91, 92, 93, 96, 104, 106, 108, 112; fig. 8, table 8) exceeded the FTAL value of 0.3 mg/kg. Heptachlor epoxide concentrations in three samples (sites 10, 78, 101) exceeded the FTAL value of 0.3 mg/kg. Concentrations of p,p'-DDE in two samples (sites 10, 78) exceeded the FTAL value of 5 mg/kg. Dieldrin concentrations in two samples (sites 10, 78) exceeded the FTAL value of 0.3 mg/kg. The concentration of mirex in one sample (site 10) exceeded the FTAL value of 0.1 mg/kg. The samples with chlordane concentrations exceeding the FTAL were from primarily the Salem Plateau in the extreme northeastern part of the study unit. The samples with heptachlor epoxide, p,p'-DDE, dieldrin, and mirex concentrations exceeding the FTAL were from the southwestern, northwestern, and northeastern parts of the study unit. All the samples with concentrations exceeding their respective FTAL were collected in 1986-87, except for samples with chlordane, which were collected during the years 1982-89.

The comparison of detected pesticides with selected quality criteria and standards indicates that pesticides do not pose any widespread or persistent problems in the study unit, although a complete evaluation is not possible because of the limited spatial and temporal distribution of samples. Two criteria, the AALC (for surface water) and the SQC (for bed sediment) were not exceeded by any samples and the MCL (for surface and ground water) was exceeded in only five samples, all from sites in the northwestern part of the study unit. The FTAL value (for biological tissue) was exceeded by five pesticides, but only chlordane exceeded its FTAL in more than three samples, all from sites in the extreme northeastern part of the study unit.

SUMMARY

Approximately 4.2 million pounds per year of active ingredients from 24 pesticides were applied on 20 crop types within the study unit from 1982-85. Only 6 of the 24 pesticides were used extensively throughout the study unit and these account for approximately 88 percent of the total pesticides applied. Pesticide use generally was greatest in areas where the dominant land use was pastureland in the Springfield and Salem Plateaus and in cropland areas in the Osage Plains and Mississippi Alluvial Plain. The most frequently applied pesticide in the study unit was 2,4-D. Alachlor was the second most applied pesticide.

Five crop types received approximately 90 percent of the pesticides applied within the study unit: corn, pasture, rice, sorghum, and soybeans. The highest use occurred on these crops in the Mississippi Alluvial Plain and Osage Plains. Pastureland located in the Springfield and Salem Plateaus received moderate amounts of pesticides. Forestland and pastureland in the Boston and St. Francois Mountains received the least amounts of pesticides. Pastureland was the predominant crop type in 50 of the 94 counties in the study unit based on crop estimates accompanying the pesticide-use data.

Pesticide data are available for 1,002 samples from 140 surface-water sites within the study unit. Surface-water sites have drainage basins primarily in the Springfield (45 sites) and Salem (43 sites) Plateaus. Many surface-water sites were sampled only once (42 sites) or twice (19 sites) during the 1970-90 period of record. About 50 percent of the 1,002 samples were collected in the mid-1970's and early 1980's.

Pesticide data are available for 103 samples from 92 ground-water sites (90 wells; 2 springs) within the study unit. Most of the sites (94 percent) are located in the northwestern or southeastern parts of the study unit. Most ground-water sites were sampled only once (85 sites) or twice (3 sites) during the 1970-90 period of record. Sixty percent of the samples were collected in 1990 in a study by Ziegler and others (1994) in the northwestern part of the study unit.

Pesticide data are available for 87 samples from 55 bed-sediment sites within the study unit. Bed-sediment sites have drainage basins predominately in the southern and extreme northeastern Salem Plateau (16 sites), and the Springfield Plateau (14 sites). Most bed-sediment sites were sampled only once (42 sites) or twice (8 sites) during the 1970-90 period of record. About 40 percent of the 87 samples were collected during the late 1980's.

Pesticide data are available for 431 biological-tissue (fish and shellfish) samples from 120 sites within the study unit. Most biological-tissue sampling sites have drainage basins in the Salem Plateau (47 sites) and Springfield Plateau (35 sites). Many biological-tissue sites were sampled only once (51 sites) or twice (20 sites) during the period of record. About 50 percent of the 431 samples were collected between 1981-86.

Pesticide data collected at 140 surface-water sites for 51 pesticides are summarized in this report. Thirty-five pesticides were below the detection limit in all the samples analyzed. One or more of 16 pesticides were detected in 132 samples collected from 43 sites. Toxaphene, found in 17 of 866 samples from 5 of 112 sites, was the pesticide that had the most number of detections. The concentration of toxaphene in samples with detections ranged from 0.1 to 6.0 µg/L. Six other pesticides were detected in 12 or more samples: DDE, dieldrin, DDT, aldrin, 2,4-D, and lindane. The maximum concentration for these six pesticides was less than 1.0 µg/L.

Pesticide data collected at 92 ground-water sites for 44 pesticides are summarized in this report. The concentrations of 37 pesticides were below the detection limit in all the samples analyzed. One or more of 7 pesticides were detected in 31 samples collected from 18 sites. All 31 samples with detectable concentrations were collected in 1990. Atrazine, found in 15 of 95 samples from 15 of 79 wells, was the pesticide that had the most number of detections. The concentration of atrazine in samples with detections ranged from 0.1 to 8.2 µg/L. Three other pesticides were detected more than once: metolachlor, alachlor, and prometon. The maximum concentration for these three pesticides was less than 1.0 µg/L, with the exception of prometon (2.4 µg/L).

Pesticide data collected at 55 bed-sediment sites for 41 pesticides are summarized in this report. The concentrations of 26 pesticides were below the detection limit in all the samples analyzed. One or more of 15 pesticides were detected in 39 samples collected from 19 sites. Chlordane, found in 12 of 73 samples from 10 of 45 sites, was the pesticide that had the most number of detections. The concentration of chlordane in samples with detections ranged from 2.0 to 240 µg/kg. Five other pesticides were detected more than once: DDT, DDD, p,p'-DDE, DDE, and hexachlorobenzene. The maximum concentration for these five pesticides was less than 10 µg/kg, with the exception of hexachlorobenzene (600 µg/kg).

Pesticide data collected at 120 biological-tissue sites for 43 pesticides are summarized in this report. The concentrations of 20 pesticides were below the detection limit in all the samples analyzed. One or more of 23 pesticides were detected in 798 samples collected from 61 sites. Chlordane, found in 93 of 151 samples from 39 of 53 sites, was the pesticide that had the most number of detections. The concentration of chlordane in samples with detections ranged from 0.009 to 8.6 mg/kg. Four other pesticides were detected in 75 or more samples: p,p'-DDE, chlordane-cis isomer, chlordane-nonachlor-trans isomer, and chlordane-trans isomer. The maximum concentrations for these four pesticides were 52.7, 21.0, 0.82, and 18.2 mg/kg, respectively. Twelve other pesticides were detected in 5 or more samples.

Quality criteria or standards have been established for 15 of the pesticides detected at sites in the study unit. For surface-water samples, the drinking water maximum contaminant level for alachlor was exceeded in one sample in 1982 from one site located in the northwestern part of the study unit in the Osage Plains. For ground-water samples, the drinking water maximum contaminant level for atrazine was exceeded in four samples from four wells in 1990. The four wells are located in the northwestern part of the study unit in the Osage Plains. For biological-tissue samples, the fish tissue action levels for chlordane (26 samples; 19 sites), heptachlor epoxide (3 sites; 3 samples), p,p'-DDE (2 sites; 2 samples), dieldrin (2 sites; 2 samples), and mirex (1 site; 1 sample) were exceeded. These sites are located primarily in the northeastern part of the study unit. All the samples exceeding the fish tissue action levels were collected in 1982-89. For bed-sediment samples, quality criteria or standards were not exceeded for any pesticide. Pesticides do not pose any widespread or persistent problems in the study unit, based on the limited number of samples that exceeded quality criteria and standards.

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TABLES

Table 5. Site and basin characteristics of surface-water sampling sites

[mi^2, square mile; WY70-90, water years 1970-1990; --, data unavailable; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; KDHE, Kansas Department of Health and Environment; USCOE, U.S. Army Corps of Engineers]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physiographic area[1]	Period of record (WY70-90)	Number of samples
1	Illinois River at Highway 64 Bridge, Okla.	353100	950528	--	ODEQ	Springfield	1979-90	6
2	White River at Oil Trough, Ark.	353836	912742	--	ADPCE	Mississippi Alluvial Plain, Boston, Salem, Springfield	1974-87	30
3	White River near Salado, Ark.	354203	913319	--	ADPCE	Boston, Salem, Springfield	1984	1
4	White River at Batesville, Ark.	354535	913828	11,070	USGS	Boston, Salem, Springfield	1984	1
5	White River above Batesville, Ark.	354537	913813	--	ADPCE	Boston, Salem, Springfield	1984	1
6	Grand Neosho River near Fort Gibson Dam, Okla.	355115	951345	--	USEPA	Springfield, Osage Plains	1980-81	2
7	Baron Fork at Dutch Mills, Ark.	355248	942911	41	ADPCE	Springfield	1972-85	20
8	Bear Creek west of Marshall, Ark.	355520	924220	--	ADPCE	Boston	1985	1
9	Illinois River near Tahlequah, Okla.	355522	945524	959	ODEQ, USGS	Springfield	1978-90	16
10	Buffalo River near St. Joe, Ark.	355902	924444	829	ADPCE	Boston, Springfield	1974-85	18
11	Buffalo River near Hasty, Ark.	355903	930230	--	ADPCE	Boston, Springfield	1974-77	6
12	North Sylamore Creek near Fifty Six, Ark.	355943	921245	58	USGS	Springfield	1970-81	13
13	White River below Fayetteville, Ark.	360000	940000	--	USEPA	Boston, Springfield	1981	1
14	Strawberry River near Smithville, Ark.	360140	911931	--	ADPCE	Salem	1974-84	15
15	West Fork White River east of Fayetteville, Ark.	360300	940442	--	ADPCE	Boston, Springfield	1974-85	18
16	Mill Creek near Melbourne, Ark.	360313	915458	--	ADPCE	Salem	1984,85	2
17	Buffalo River near Harriet, Ark.	360403	923438	--	USGS	Boston	1979-82	4
18	Illinois River at Savoy, Ark.	360611	942039	167	ADPCE	Springfield	1974-84	13
19	Black River at Black Rock, Ark.	360615	910550	7,369	USGS	Mississippi Alluvial Plain, Salem, St. Francois	1970-79	7
20	White River near Goshen, Ark.	360622	940041	--	ADPCE	Boston, Springfield	1974-85	19
21	Illinois River south of Siloam Springs, Ark.	360631	943200	--	ADPCE	Springfield	1972-81	15
22	White River at Calico Rock, Ark.	360658	920835	9,978	USGS	Salem, Boston, Springfield	1974-79	6

Table 5. Site and basin characteristics of surface-water sampling sites--Continued

[mi^2, square mile; WY70-90, water years 1970-1990; --, data unavailable; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; KDHE, Kansas Department of Health and Environment; USCOE, U.S. Army Corps of Engineers]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physiographic area[1]	Period of record (WY70-90)	Number of samples
23	Holman Creek near Huntsville, Ark.	360725	934402	--	ADPCE	Boston	1984,85	2
24	Illinois River near Watts, Okla.	360748	943419	635	USGS	Springfield	1989-90	9
25	Illinois River near Siloam Springs, Ark.	360841	942941	509	ADPCE	Springfield	1982-85	7
26	Grand Neosho River above Industrial Park, Okla.	361051	951625	--	ODEQ	Springfield, Osage Plains	1980,90	2
27	Sager Creek near Siloam Springs, Ark.	361150	943500	--	ADPCE	Springfield	1972-82	20
28	Spring River at Imboden, Ark.	361219	911019	1,183	USGS	Salem	1970,71	2
29	North Fork River at Norfork, Ark.	361248	921654	--	ADPCE	Salem	1974-82	17
30	Flint Creek near West Siloam Springs, Okla.	361258	943615	--	ADPCE	Springfield	1982-85	6
31	Osage Creek near Elm Springs, Ark.	361319	941718	130	ADPCE	Springfield	1974-85	16
32	Crooked Creek at Yellville, Ark.	361323	924047	406	ADPCE	Salem, Springfield	1979-85	11
33	White River near Norfork, Ark.	361324	921806	--	ADPCE	Salem, Boston, Spring-field	1974-87	39
34	Spring River at Ravenden, Ark.	361330	911503	--	ADPCE	Salem	1974-84	15
35	Neosho River at State Highway 33 Bridge, Okla.	361345	951059	--	ODEQ	Springfield, Osage Plains	1990	1
36	Spavinaw Creek north of Sycamore, Okla.	361351	943320	--	ADPCE	Springfield	1972-76	10
37	Flint Creek north of Siloam Springs, Ark.	361353	943320	--	ADPCE	Springfield	1972-81	15
38	Crooked Creek at Harrison, Ark.	361357	930528	--	USGS	Springfield	1984	1
39	Crooked Creek above Harrison, Ark.	361404	930527	--	ADPCE	Salem	1984	1
40	Crooked Creek near Harrison, Ark.	361438	930438	--	USGS	Springfield	1984,85	2
41	Crooked Creek below Harrison, Ark.	361439	930439	--	ADPCE	Salem	1984,85	2
42	Eleven Point River near Pocahontas, Ark.	361443	910505	1,192	ADPCE	Salem	1974-84	19
43	Crooked Creek at Pyatt, Ark.	361445	925004	207	ADPCE	Springfield	1974-78	10
44	Pryor Creek at Highway 69a Bridge, Okla.	361455	951530	--	ODEQ	Osage Plains	1980,90	2

Table 5. Site and basin characteristics of surface-water sampling sites--Continued

[mi^2, square mile; WY70-90, water years 1970-1990; --, data unavailable; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; KDHE, Kansas Department of Health and Environment; USCOE, U.S. Army Corps of Engineers]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physiographic area[1]	Period of record (WY70-90)	Number of samples
45	Black River at Pocahontas, Ark.	361514	905812	4,845	ADPCE	Mississippi Alluvial Plain, Salem, St. Francois	1977-84	11
46	Hicks Creek near Mountain Home, Ark.	361732	922234	--	ADPCE	Salem	1983-85	5
47	Current River near Pocahontas, Ark.	361755	905130	2,606	ADPCE	Mississippi Alluvial Plain, Salem	1972-84	27
48	Spavinaw Creek near Sycamore, Okla.	362007	943824	133	USGS	Springfield	1974-75	4
49	Spring River near Hardy, Ark.	362017	913030	--	ADPCE	Salem	1974-82	17
50	Spavinaw Creek near Cherokee City, Ark.	362031	943515	--	ADPCE	Springfield	1977-85	13
51	Eleven Point River near Ravenden Springs, Ark.	362048	910648	1,134	ADPCE	Salem	1972-73	5
52	Osage Creek above Berryville, Ark.	362056	933525	--	ADPCE	Salem, Springfield, Boston	1984,85	2
53	South Fork Spring River at Saddle, Ark.	362100	913800	--	ADPCE	Salem	1974-85	19
54	Osage Creek below Berryville, Ark.	362151	933626	--	ADPCE	Salem, Springfield, Boston	1984,85	4
55	White River at Bull Shoals Dam near Flippin, Ark.	362154	923430	6,051	USGS	Salem, Boston, Springfield	1974-82	26
56	Black River near Corning, Ark.	362407	903229	1,749	ADPCE	Mississippi Alluvial Plain, Salem, St. Francois	1972-86	29
57	Mckisic Creek tributary near Bentonville, Ark.	362426	941246	--	USGS	Springfield	1984,85	2
58	White River at Beaver Dam near Eureka Springs, Ark.	362515	935050	1,192	ADPCE	Salem, Boston, Springfield	1973-74	4
59	Kings River near Berryville, Ark.	362536	933715	527	ADPCE	Salem, Boston, Springfield	1973-85	20
60	Long Creek near Denver, Ark.	362546	931822	--	ADPCE	Springfield	1984,85	2
61	Neosho River near Langley, Okla.	362615	950244	--	ODEQ	Springfield, Osage Plains	1990	1
62	South Fork of Spring River near Moko, Ark.	362623	914944	--	USGS	Salem	1972-73	3
63	South Fork of Spring River near Salem, Ark.	362623	914944	--	ADPCE	Salem	1973	3
64	White River at Beaver, Ark.	362820	934555	1,238	USGS	Salem, Boston, Springfield	1974-82	10
65	White River near Beaver, Ark.	362828	934554	--	ADPCE	Salem, Boston, Springfield	1974-82	12
66	Spring River near Thayer, Mo.	363010	913131	--	ADPCE	Salem	1972-85	19
67	Little Sugar Creek at Caverna, Mo.	363010	941630	--	ADPCE	Springfield	1973-82	17

Table 5. Site and basin characteristics of surface-water sampling sites--Continued

[mi^2, square mile; WY70-90, water years 1970-1990; --, data unavailable; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; KDHE, Kansas Department of Health and Environment; USCOE, U.S. Army Corps of Engineers]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physiographic area[1]	Period of record (WY70-90)	Number of samples
68	Butler Creek near Sulphur Springs, Ark.	363044	942854	--	ADPCE	Springfield	1973-85	24
69	Myatt Creek near Lanton, Mo.	363104	914418	--	USGS	Salem	1972-73	5
70	Current River below Hawes Campground, Mo.	364908	905648	--	USGS	Salem	1973-80	6
71	Neosho River near Commerce, Okla.	365543	945726	--	ODEQ	Osage Plains	1990	1
72	Spring River near Verona, Mo.	365600	934600	--	USEPA	Springfield	1978	1
73	Spring River at Devil's Prominade Bridge, Okla.	365604	944445	--	ODEQ	Osage, Springfield	1981-90	3
74	Spring River 0.6 mi upstream from U.S. 60 Bridge, Mo.	365628	934656	--	USEPA	Springfield	1981	1
75	Unnamed Creek between Syntex and Spring, Mo.	365808	934757	--	USEPA	Springfield	1981	1
76	Spring River west of Verona, Mo.	365808	934803	--	USEPA	Springfield	1981	1
77	Douger Brook at State Route P Bridge, Mo.	365830	934741	--	USEPA	Springfield	1981	1
78	Spring River 2.4 mi down stream of Douger Bridge, Mo.	365951	934859	--	USEPA	Springfield	1981	1
79	James River near Boaz below Wilson Creek, Mo.	370025	932150	462	USEPA	Springfield	1978	1
80	Spring River at Baxter Springs, Kans.	370105	944314	--	USEPA	Springfield	1982	1
81	Spring River near Baxter Springs, Kans.	370125	944315	2,510	USGS	Springfield	1972-73	4
82	Neosho River at Chetopa, Kans.	370210	950450	--	KDHE	Osage Plains	1972-89	33
83	Shoal Creek near Galena, Kans.	370231	943834	--	KDHE	Springfield	1975-90	18
84	Neosho River near Chetopa, Kans.	370309	950551	--	KDHE	Osage Plains	1976	1
85	Labette Creek near Chetopa, Kans.	370428	950611	--	KDHE	Osage Plains	1990	2
86	James River 2 mi above Wilson Creek, Mo.	370435	932215	--	USEPA	Springfield	1978	1
87	Short Creek near Galena, Kans.	370523	943958	--	KDHE	Springfield	1990	1
88	Jones Creek near Fidelity, Mo.	370549	941711	--	USGS	Springfield	1977-78	4
89	Wilson Creek downstream of South Creek, Mo.[2]	370624	932430	--	USEPA	Springfield	1985	1
90	Center Creek above Fidelity, Mo.	370707	941528	--	USGS	Springfield	1978	6

Table 5. Site and basin characteristics of surface-water sampling sites--Continued

[mi^2, square mile; WY70-90, water years 1970-1990; --, data unavailable; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; KDHE, Kansas Department of Health and Environment; USCOE, U.S. Army Corps of Engineers]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physiographic area[1]	Period of record (WY70-90)	Number of samples
91	Turkey Creek near Joplin, Mo.	370715	943455	42	KDHE	Springfield	1975-90	18
92	Center Creek near Carterville, Mo.	370826	942257	232	USGS	Springfield	1977-78	7
93	Shawnee Creek near Crestline, Kans.	370855	944038	--	KDHE	Springfield, Osage Plains	1990	1
94	Center Creek near Smithfield, Mo.	370921	943610	--	KDHE	Springfield	1975-90	17
95	Center Creek south of Smithfield, Mo.	370930	943615	--	USEPA	Springfield	1977	1
96	Neosho River near Oswego, Kans.	370954	950346	--	KDHE	Osage Plains	1990	2
97	Wilson Creek upstream of South Creek, Mo.[3]	371006	932212	--	USEPA	Springfield	1985	1
98	Current River above Powder Mill, Mo.	371032	911248	--	USGS	Salem	1973-80	6
99	Spring River near Crestline, Kans.	371044	943830	--	KDHE	Springfield	1990	1
100	Jacks Fork above Two Rivers, Mo.	371053	911736	--	USGS	Salem	1973-80	6
101	Spring River near Galena, Kans.	371125	943805	--	USEPA	Springfield	1977	1
102	Spring River south of Waco, Mo.	371315	943615	--	USEPA	Springfield	1977	1
103	Cow Creek near Lawton, Kans.	371321	943914	--	KDHE	Osage Plains	1990	1
104	Labette Creek near Labette, Kans.	371348	951152	--	KDHE	Osage Plains	1990	2
105	Lightning Creek near Oswego, Kans.	371418	950238	--	KDHE	Osage Plains	1990	2
106	Spring River near Waco, Mo.	371444	943358	1,164	KDHE	Springfield, Osage Plains	1973-89	32
107	Current River below Montauk State Park, Mo.	372701	912941	--	USGS	Salem	1973-80	7
108	Neosho River water station no. 1, Kans.	372918	950830	--	KDHE	Osage Plains	1990	1
109	Marmaton River near Fort Scott, Kans.	375113	944649	--	KDHE	Osage Plains	1975-90	18
110	Devil's Elbow on Big Piney, Mo.	375115	920400	--	USEPA	Salem	1977	1
111	Gasconade at Highway Y, Mo.	375400	920800	--	USEPA	Salem	1977	1
112	Marmaton River near Nevada, Mo.	375507	942139	--	USGS	Osage Plains	1990	1

Table 5. Site and basin characteristics of surface-water sampling sites--Continued

[mi^2, square mile; WY70-90, water years 1970-1990; --, data unavailable; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; KDHE, Kansas Department of Health and Environment; USCOE, U.S. Army Corps of Engineers]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physiographic area[1]	Period of record (WY70-90)	Number of samples
113	Gasconade River near Jerome, Mo.	375512	915833	--	USEPA	Salem	1977	1
114	Little Osage River near Horton, Mo.	375938	942207	--	USGS	Osage Plains	1990	1
115	Little Osage River near Fulton, Kans.	380029	944142	--	KDHE	Osage Plains	1975-90	18
116	Little Osage River at Fulton, Kans.	380109	944248	295	USGS	Osage Plains	1980,81	2
117	Osage River above Schell City, Mo.	380320	940844	5,410	USGS	Osage Plains	1990	1
118	Marais des Cygnes drainage ditch, Mo.	380802	942102	--	USGS	Osage Plains	1990	1
119	Miami Creek near Butler, Mo.	381039	942112	--	USGS	Osage Plains	1990	1
120	Osage Gasconade, Bagnell Dam, Mo.	381220	923745	--	USEPA	Salem	1970-71	3
121	Meramec River at Meramec Park, Mo.	381400	910500	--	USEPA	Salem	1977	1
122	Calvey Creek no. 1, Mo.	382200	904400	--	USEPA	Salem	1977	1
123	Tebo Creek, Henry Co. Highway PP, Mo.	382204	933240	--	USCOE	Springfield, Osage Plains	1988	2
124	Calvey Creek no. 2, Mo.	382300	904600	--	USEPA	Salem	1977	1
125	Calvey Creek no. 3, Mo.	382350	904610	--	USEPA	Salem	1977	1
126	Meramec River at Highway 21 Bridge, Mo.	382745	902500	--	USEPA	Salem	1983	2
127	Romaine Creek near mouth, Mo.	382748	902527	--	USEPA	Salem	1983	3
128	Sugar Creek near mouth, Mo.	382813	902543	--	USEPA	Salem	1983	3
129	Saline Creek before confluence of Sugar Creek, Mo.	382825	902549	--	USEPA	Salem	1983	3
130	Meramec River upstream I44 Bridge at Times Beach, Mo.	383013	903525	--	USEPA	Salem	1983	3
131	Meramec River below Fenton upstream of Marina, Mo.	383030	902610	--	USEPA	Salem	1983	3
132	Meramec River downstream of Glencoe, Mo.	383232	903507	--	USEPA	Salem	1983	3
133	Meramec River upstream of Valley Park Bridge, Mo.	383240	903030	--	USEPA	Salem	1983	3
134	Chrysler car plant-industrial waste, Mo.	383300	902735	--	USEPA	Salem	1983	2
135	Fishpot Creek at Hanna Road Bridge, St. Louis, Mo.	383308	903041	--	USEPA	Salem	1983	3

Table 5. Site and basin characteristics of surface-water sampling sites--Continued

[mi^2, square mile; WY70-90, water years 1970-1990; --, data unavailable; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; KDHE, Kansas Department of Health and Environment; USCOE, U.S. Army Corps of Engineers]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physiographic area[1]	Period of record (WY70-90)	Number of samples
136	Grand Glaize Creek at Marshall Road Bridge, Mo.	383316	902751	--	USEPA	Salem	1983	3
137	Meramec River near Kirkwood wastewater-treatment intake, Mo.	383334	902645	--	USEPA	Salem	1983	3
138	Grand Glaize Creek at Carmen Road Bridge, Mo.	383430	902814	--	USEPA	Salem	1983	3
139	Sugar Creek near Ozark View Subdivision, St. Louis, Mo.	383447	902732	--	USEPA	Salem	1983	3
140	Grand Glaize Creek Below Sulphur Springs Road, Mo.	383533	903108	--	USEPA	Salem	1983	3

[1] Springfield, Springfield Plateau; Boston, Boston Mountains; Salem, Salem Plateau; St. Francois, St. Francois Mountains.
[2] Original site name is “Wilson Creek downstream”; reference to South Creek added for clarification.
[3] Original site name is “Wilson Creek upstream”; reference to South Creek added for clarification.

Table 6. Site characteristics of ground-water sampling sites

[WY70-90, water years 1970-90; USGS, U.S. Geological Survey; Coop, cooperative program; MODOH, Missouri Department of Health; OZAQ, Ozark aquifer; ALVM, Post Paleozoic sediments; SPAQ, Springfield Plateau aquifer; WIPC, Western Interior Plains confining system; --, data unavailable]

Site number	Local number/ name	Latitude	Longitude	Collecting agency	Hydro-geologic unit	Well depth (feet)	Period of record (WY70-90)	Number of samples
1	T20N R08W 27AAB1	362219	0914921	USGS	OZAQ	1,280	1975	1
2	T20N R09W 18CAD1	362338	0915904	USGS	OZAQ	1,250	1975	1
3	T21N R03E 35BCC2	362515	0904347	USGS	ALVM	55	1990	1
4	T21N R29W 35DDB2	362636	0940126	USGS	OZAQ	1,769	1972,1977	2
5	T22N R05E 26BBC	363151	0903010	USGS	ALVM	26	1987	1
6	T22N R06E 12DCC	363344	0902157	USGS	ALVM	30	1986-87	3
7	T23N R05E 34DCC	363529	0903035	USGS	ALVM	25	1986-87	3
8	T23N R07E 08DBB	363916	0901924	USGS	ALVM	80	1987	1
9	T24N R08E 32CDC	364032	0901311	USGS	ALVM	40	1987	2
10	T24N R06E 25CDD	364137	0902156	USGS	ALVM	60	1987	1
11	T24N R06E 30BBA	364228	0902722	USGS	ALVM	65	1987	1
12	T24N R08E 23BCC	364240	0901019	USGS	ALVM	50	1987	1
13	T24N R07E 22BBB1	364311	0901754	USGS	ALVM	--	1986-87	3
14	T25N R08E 18ADD1	364848	0901338	USGS	ALVM	48	1986-87	3
15	T35S R25E 04CCC01	370105	0944121	USGS	SPAQ	202	1978	1
16	T34S R24E 35DAB01	370218	0944453	USGS	SPAQ	--	1988	1
17	T34S R24E 17DDC01	370437	0944755	USGS	WIPC	40	1988	1
18	T30S R20E 12DCC01	372634	0951002	USGS	WIPC	30	1981	1
19	T29S R25E 01ACB01	373308	0943720	USGS	WIPC	--	1988	1
20	T28S R25E 03AAA01	373836	0943906	USGS	WIPC	11	1979	1
21	Well 4085	374036	0941314	USGS, (Coop-MODOH)	WIPC	22	1990	1
22	Well 4084	374046	0941256	USGS, (Coop-MODOH)	WIPC	24.9	1990	1
23	Spring 4604	374338	0940600	USGS, (Coop-MODOH)	WIPC	--	1990	1
24	Well 4090	374508	0941249	USGS, (Coop-MODOH)	WIPC	25	1990	1
25	Spring 4069a	374606	0942102	USGS, (Coop-MODOH)	WIPC	--	1990	1
26	Well 4069	374609	0942102	USGS, (Coop-MODOH)	WIPC	33	1990	1
27	Well 4603	374704	0940659	USGS, (Coop-MODOH)	WIPC	29.6	1990	1
28	Well 4082	374713	0943304	USGS, (Coop-MODOH)	WIPC	22	1990	1

Table 6. Site characteristics of ground-water sampling sites--Continued

[WY70-90, water years 1970-90; USGS, U.S. Geological Survey; Coop, cooperative program; MODOH, Missouri Department of Health; OZAQ, Ozark aquifer; ALVM, Post Paleozoic sediments; SPAQ, Springfield Plateau aquifer; WIPC, Western Interior Plains confining system; --, data unavailable]

Site number	Local number/ name	Latitude	Longitude	Collecting agency	Hydro-geologic unit	Well depth (feet)	Period of record (WY70-90)	Number of samples
29	Well 4075	375044	0943633	USGS, (Coop-MODOH)	WIPC	22	1990	1
30	Well 4060	375123	0943038	USGS, (Coop-MODOH)	WIPC	38.5	1990	1
31	Well 4071	375305	0942506	USGS, (Coop-MODOH)	WIPC	65	1990	1
32	Well 2060	375429	0934638	USGS, (Coop-MODOH)	WIPC	10.8	1990	1
33	Well 4001	375633	0942949	USGS, (Coop-MODOH)	WIPC	34.	1990	1
34	Well 4063	375645	0942347	USGS, (Coop-MODOH)	WIPC	28.1	1990	1
35	Well 2117	375711	0935552	USGS, (Coop-MODOH)	SPAQ	60	1990	1
36	Well 4087	375732	0940710	USGS, (Coop-MODOH)	WIPC	18	1990	1
37	Well 4002	375733	0943419	USGS, (Coop-MODOH)	WIPC	21.41	1990	1
38	Well 4504	375804	0941901	USGS, (Coop-MODOH)	WIPC	23	1990	1
39	Well 2045	375809	0933957	USGS, (Coop-MODOH)	WIPC	50	1990	1
40	Well 4501	375828	0940454	USGS, (Coop-MODOH)	WIPC	26	1990	1
41	Well 4061	375832	0942410	USGS, (Coop-MODOH)	WIPC	40.9	1990	1
42	Well 4506	375834	0942203	USGS, (Coop-MODOH)	WIPC	90	1990	1
43	Well 4503	375838	0941514	USGS, (Coop-MODOH)	WIPC	15	1990	1
44	Well 4056	380104	0942335	USGS, (Coop-MODOH)	WIPC	33.6	1990	1
45	Well 4507	380120	0942015	USGS, (Coop-MODOH)	WIPC	20	1990	1
46	Well 4062	380122	0943033	USGS, (Coop-MODOH)	WIPC	20	1990	1
47	Well 4505	380125	0942123	USGS, (Coop-MODOH)	WIPC	20.75	1990	1
48	Well 4502	380136	0941006	USGS, (Coop-MODOH)	WIPC	43	1990	1
49	Well 4508	380158	0941958	USGS, (Coop-MODOH)	WIPC	60.35	1990	1

Table 6. Site characteristics of ground-water sampling sites--Continued

[WY70-90, water years 1970-90; USGS, U.S. Geological Survey; Coop, cooperative program; MODOH, Missouri Department of Health; OZAQ, Ozark aquifer; ALVM, Post Paleozoic sediments; SPAQ, Springfield Plateau aquifer; WIPC, Western Interior Plains confining system; --, data unavailable]

Site number	Local number/ name	Latitude	Longitude	Collecting agency	Hydro-geologic unit	Well depth (feet)	Period of record (WY70-90)	Number of samples
50	Well 4510	380203	0940800	USGS, (Coop-MODOH)	WIPC	240	1990	1
51	Well 4511	380210	0940759	USGS, (Coop-MODOH)	WIPC	55	1990	1
52	Well 4055	380222	0942649	USGS, (Coop-MODOH)	WIPC	--	1990	1
53	Well 4509	380224	0941704	USGS, (Coop-MODOH)	WIPC	53.17	1990	1
54	Well 2023	380237	0940052	USGS, (Coop-MODOH)	WIPC	69.5	1990	1
55	Well 2002	380253	0940251	USGS, (Coop-MODOH)	WIPC	16.45	1990	1
56	Well 1181	380330	0941722	USGS, (Coop-MODOH)	WIPC	32	1990	1
57	23S 25E 07DAA 01	380335	0944147	USGS	WIPC	19.4	1979	1
58	Well 2075	380404	0935616	USGS, (Coop-MODOH)	WIPC	165	1990	1
59	Well 1906	380442	0940929	USGS, (Coop-MODOH)	WIPC	28.4	1990	1
60	Well 2805	380445	0935142	USGS, (Coop-MODOH)	WIPC	128	1990	1
61	23S 25E 04BBC 01	380448	0944033	USGS	--	38.4	1989	1
62	23S 25E 04BBC 02	380448	0944033	USGS	WIPC	28.7	1989	1
63	23S 25E 04BBB 01	380454	0944034	USGS	--	32.7	1989	1
64	23S 25E 04BBB 02	380454	0944034	USGS	--	40.4	1989	1
65	23S 25E 04BBB 03	380454	0944034	USGS	--	32.7	1989	1
66	22S 25E 33CCD 01	380501	0944025	USGS	--	49.5	1989	1
67	22S 25E 33CCD 02	380501	0944025	USGS	--	40.6	1989	1
68	22S 25E 33CCD 03	380501	0944025	USGS	WIPC	8.7	1989	2
69	22S 25E 33CCC 01	380501	0944034	USGS	--	42.2	1989	1
70	22S 25E 33CCC 02	380501	0944034	USGS	--	30.4	1989	1
71	Well 2802	380521	0940046	USGS, (Coop-MODOH)	WIPC	225	1990	1
72	Well 1907	380528	0941007	USGS, (Coop-MODOH)	WIPC	16.9	1990	1
73	Well 1902	380540	0941749	USGS, (Coop-MODOH)	ALVM	88	1990	1
74	Well 1133	380609	0942625	USGS, (Coop-MODOH)	WIPC	200	1990	1

Table 6. Site characteristics of ground-water sampling sites--Continued

[WY70-90, water years 1970-90; USGS, U.S. Geological Survey; Coop, cooperative program; MODOH, Missouri Department of Health; OZAQ, Ozark aquifer; ALVM, Post Paleozoic sediments; SPAQ, Springfield Plateau aquifer; WIPC, Western Interior Plains confining system; --, data unavailable]

Site number	Local number/ name	Latitude	Longitude	Collecting agency	Hydro-geologic unit	Well depth (feet)	Period of record (WY70-90)	Number of samples
75	Well 1179	380615	0941640	USGS, (Coop-MODOH)	WIPC	43	1990	1
76	Well 1187	380630	0941616	USGS, (Coop-MODOH)	WIPC	34.8	1990	1
77	Well 2110	380736	0935735	USGS, (Coop-MODOH)	WIPC	170	1990	1
78	Well 1003	380748	0942512	USGS, (Coop-MODOH)	WIPC	120	1990	1
79	Well 1905a (field)	380752	0941222	USGS, (Coop-MODOH)	WIPC	29.1	1990	1
80	Well 1905	380809	0941231	USGS, (Coop-MODOH)	WIPC	15.8	1990	1
81	Well 2801	380838	0940144	USGS, (Coop-MODOH)	WIPC	260	1990	1
82	Well 1910	380905	0940910	USGS, (Coop-MODOH)	WIPC	17.2	1990	1
83	Well 1191	380924	0940835	USGS, (Coop-MODOH)	ALVM	18.4	1990	1
84	Well 2803	381004	0935521	USGS, (Coop-MODOH)	SPAQ	310	1990	1
85	Well 1172	381115	0942003	USGS, (Coop-MODOH)	WIPC	22	1990	1
86	Well 1028	381119	0943110	USGS, (Coop-MODOH)	WIPC	200	1990	1
87	Well 1188	381150	0941009	USGS, (Coop-MODOH)	WIPC	16.75	1990	1
88	Well 1175	381157	0942008	USGS, (Coop-MODOH)	WIPC	8	1990	1
89	Well 2909	381204	0935832	USGS, (Coop-MODOH)	WIPC	180	1990	1
90	Well 1174	381213	0942600	USGS, (Coop-MODOH)	WIPC	--	1990	1
91	Well 1170	381418	0941207	USGS, (Coop-MODOH)	WIPC	51.5	1990	1
92	Well 1017	381620	0941943	USGS, (Coop-MODOH)	WIPC	46.4	1990	1

Table 7. Site and basin characteristics of bed-sediment sampling sites

[mi^2, square mile; WY70-90, water years 1970-1990; --, data unavailable; USGS, U.S. Geological Survey; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USEPA, U.S. Environmental Protection Agency]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physio-graphic area[1]	Period of record (WY70-90)	Number of samples
1	Buffalo River near Harriet, Ark.	360403	923438	--	USGS	Boston	1979-82	4
2	White River at Calico Rock, Ark.	360658	920835	9,978	USGS	Salem, Boston, Springfield	1975	2
3	North Sylamore Creek near Fifty Six, Ark.	355943	921245	58	USGS	Springfield	1970-81	9
4	Spring River at Imboden, Ark.	361219	911019	1,183	USGS	Salem	1970, 1971	2
5	Black River at Black Rock, Ark.	360615	910550	7,369	USGS	Mississippi Alluvial Plain, Salem, St. Francois	1970-73	3
6	Illinois River near Tahlequah, Okla.	355522	945524	959	USGS, ODEQ	Springfield	1980-89	6
7	Illinois River at Highway 64 Bridge, Okla.	353100	950528	--	ODEQ	Springfield	1981-90	7
8	White River at Oil Trough, Ark.	353836	912742	--	ADPCE	Mississippi Alluvial Plain, Boston, Salem, Springfield	1983	1
9	Fort Gibson near Dam (Neosho River), Okla.	355115	951345	--	USEPA	Springfield, Osage Plains	1980	1
10	Grand River below Fort Gibson Reservoir, Okla.	355115	951345	--	USEPA	Springfield, Osage Plains	1981	1
11	Baron Fork at Eldon, Okla.	355516	945018	--	ODEQ	Springfield	1989	1
12	Buffalo River near St. Joe, Ark.	355902	924444	829	ADPCE	Boston, Springfield	1983	1
13	White River below Fayetteville, Ark.	360000	940000	--	USEPA	Boston, Springfield	1981	1
14	Strawberry River near Smithville, Ark.	360140	911931	--	ADPCE	Salem	1976	2
15	Illinois River south of Siloam Springs, Ark.	360631	943200	--	ADPCE	Springfield	1977	1
16	Illinois River near Watts, Okla.	360748	943412	635	ODEQ	Springfield	1986, 1989	2
17	Grand Neosho River above Industrial Park, Okla.	361051	951625	--	ODEQ	Springfield, Osage Plains	1990	1
18	Flint Creek near Kansas, Okla.	361154	944230	--	ODEQ	Springfield	1986, 1989	2
19	Neosho River at State Highway 33 Bridge, Okla.	361345	951059	--	ODEQ	Springfield, Osage Plains	1990	1
20	Eleven Point River near Pocahontas, Ark.	361413	910505	--	ADPCE	Salem	1976	1
21	Pryor Creek at Highway 69a Bridge, Okla.	361455	951530	--	ODEQ	Osage Plains	1990	1
22	Spring River near Hardy, Ark.	362000	913030	--	ADPCE	Salem	1976	2

Table 7. Site and basin characteristics of bed-sediment sampling sites--Continued

[mi^2, square mile; WY70-90, water years 1970-1990; --, data unavailable; USGS, U.S. Geological Survey; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USEPA, U.S. Environmental Protection Agency]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physio-graphic area[1]	Period of record (WY70-90)	Number of samples
23	Spavinaw Creek north of Cherokee City, Ark.	362031	943515	--	ADPCE	Springfield	1983	1
24	Kings River near Berryville, Ark.	362536	933715	527	ADPCE	Salem, Boston, Springfield	1983, 1984	2
25	Neosho River near Langley, Okla.	362615	950244	--	ODEQ	Springfield, Osage Plains	1990	1
26	Neosho River near Commerce, Okla.	365543	945726	--	ODEQ	Osage Plains	1990	1
27	Spring River at Devil’s Prominade Bridge, Okla.	365604	944445	--	ODEQ	Osage Plains, Springfield	1981, 1990	2
28	Celia’s Spring River trout farm pond, Mo.	365630	934720	--	USEPA	Springfield	1981	1
29	Spring River at Business Route 60 Bridge, Mo.	365655	934737	--	USEPA	Springfield	1981	1
30	Spring River 315 ft upstream of Douger Bridge, Mo.	365826	934754	--	USEPA	Springfield	1981	1
31	Spring River 2.4 mi down-stream of Douger Bridge, Mo.	365951	934859	--	USEPA	Springfield	1981	1
32	Spring River 5.9 mi down-stream of Douger Bridge, Mo.	370330	935008	--	USEPA	Springfield	1981	1
33	Eagle-Picher Industries Inc., Joplin, Mo.	370635	943138	--	USEPA	Springfield	1988	1
34	Pomme Creek near Highway 61 bridge, Mo. [2]	382522	902235	--	USEPA	Salem	1990	1
35	Meramec River below Saline Creek, Mo.	382705	902345	--	USEPA	Salem, St. Francois	1988	1
36	Big River 2 miles above mouth, Mo.	382743	903636	--	USEPA	Salem, St. Francois	1988	1
37	Romaine Creek near Paulina Hills, Mo. [3]	382750	902600	--	USEPA	Salem	1990	1
38	Meramec River at Pacific, Mo.	382800	904410	--	USEPA	Salem	1988	1
39	Meramec River below Fenton Creek, Mo.	382840	902520	--	USEPA	Salem, St. Francois	1988	1
40	Meramec River upstream I44 bridge at Times Beach, Mo.	383013	903525	--	USEPA	Salem, St. Francois	1983	1
41	Antire Creek near confluence with the Meramec River, Mo.[4]	383022	903355	--	USEPA	Salem	1990	1
42	Unnamed tributary of the Meramec River, Mo.	383137	902647	--	USEPA	Salem	1990	1
43	Meramec River below Flat Creek, Mo.	383155	903735	--	USEPA	Salem, St. Francois	1988	1
44	Meramec River downstream of Glencoe, Mo.	383232	903507	--	USEPA	Salem, St. Francois	1983	1
45	Carr Creek near Glencoe, Mo. [5]	383240	903748	--	USEPA	Salem	1990	1

Table 7. Site and basin characteristics of bed-sediment sampling sites--Continued

[mi^2, square mile; WY70-90, water years 1970-1990; --, data unavailable; USGS, U.S. Geological Survey; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USEPA, U.S. Environmental Protection Agency]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physio-graphic area[1]	Period of record (WY70-90)	Number of samples
46	Meramec River below Fishpot Creek, Mo.	383252	902905	--	USEPA	Salem, St. Francois	1988	1
47	Meramec River below Kiefer Creek, Mo.	383255	903138	--	USEPA	Salem, St. Francois	1988	1
48	Kiefer Creek near confluence with the Meramec River, Mo. [6]	383324	903240	--	USEPA	Salem	1990	1
49	Meramec River below Grand Glaize Creek, Mo.	383325	902618	--	USEPA	Salem, St. Francois	1988	1
50	Meramec River near Kirkwood wastewater treatment intake, Mo.	383334	902645	--	USEPA	Salem, St. Francois	1983	1
51	Grand Glaize Creek at Big Bend Road, Mo.	383355	902820	--	USEPA	Salem	1988	1
52	Sugar Creek above confluence with Romaine Creek, Mo. [7]	383435	902750	--	USEPA	Salem	1990	1
53	Grand Glaize Creek at Doughtery Ferry Road, Mo.	383435	902815	--	USEPA	Salem	1990	1
54	Grand Glaize Creek at Barrett Station Road, Mo.	383457	902800	--	USEPA	Salem	1988	1
55	Grand Glaize Creek at Deitrich Road, Mo.	383548	902915	--	USEPA	Salem	1990	1

[1] Boston, Boston Mountains; Salem, Salem Plateau; Springfield, Springfield Plateau; St. Francois, St. Francois Mountains.
[2] Original site name is “Pomme Creek”; reference to location added for clarification.
[3] Original site name is “Romaine Creek”; reference to location added for clarification.
[4] Original site name is “Antire Creek”; reference to location added for clarification.
[5] Original site name is “Carr Creek”; reference to location added for clarification.
[6] Original site name is “Kiefer Creek”; reference to location added for clarification.
[7] Original site name is “Sugar Creek”; reference to location added for clarification.

Table 8. Site and basin characteristics of biological-tissue sampling sites

[mi^2, square miles; WY70-90, water years 1970-1990; --, data unavailable; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USEPA, U.S. Environmental Protection Agency; KDHE, Kansas Department of Health and Environment; USCOE, U.S. Army Corps of Engineers]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physio-graphic area[1]	Period of record (WY70-90)	Number of samples
1	Illinois River at Highway 64 Bridge, Okla.	353100	950528	--	ODEQ	Springfield	1979-90	13
2	White River at Oil Trough, Ark.	353836	912742	--	ADPCE	Mississippi Alluvial Plain, Boston, Salem, Springfield	1985-87	8
3	Grand Neosho River near Fort Gibson Dam, Okla.	355115	951345	--	USEPA	Springfield, Osage Plains	1981	1
4	Illinois River near Tahlequah, Okla.	355522	945524	959	ODEQ	Springfield	1978-90	19
5	Buffalo River near St. Joe, Ark.	355902	924444	829	ADPCE	Boston, Springfield	1978-81	4
6	Buffalo River near Hasty, Ark.	355903	930230	--	ADPCE	Boston, Springfield	1984	1
7	North Sylamore Creek near Fifty Six, Ark.	355943	921245	58	USEPA	Springfield	1985	1
8	White River below Fayetteville, Ark.	360000	940000	--	USEPA	Boston, Springfield	1981	1
9	West Fork White River east of Fayetteville, Ark.	360300	940442	--	ADPCE	Boston, Springfield	1974	1
10	Fort Gibson Lake at Pryer Creek, Okla.	360400	951600	--	USEPA	Osage Plains, Springfield	1986, 87	2
11	White River near Goshen, Ark.	360621	940041	--	ADPCE	Boston, Springfield	1974-86	3
12	Illinois River south of Siloam Springs, Ark.	360631	943200	--	ADPCE	Springfield	1977	1
13	Sager Creek near Siloam Springs, Ark.	361150	943500	--	ADPCE	Springfield	1973	2
14	White River near Norfork, Ark.	361324	921806	--	ADPCE	Salem, Boston, Springfield	1985-87	8
15	Spavinaw Creek north of Sycamore, Okla.	361351	943320	--	ADPCE	Springfield	1973-79	4
16	Flint Creek north of Siloam Springs, Ark.	361353	943320	--	ADPCE	Springfield	1972	1
17	Crooked Creek below Harrison, Ark.	361439	930339	--	ADPCE	Springfield	1986	1
18	Pryor Creek at Highway 69a Bridge, Okla.	361455	951530	--	ODEQ	Osage Plains	1980	1
19	Current River near Pocahontas, Ark.	361755	905130	2,606	ADPCE	Mississippi Alluvial Plain, Salem	1973	2
20	Spavinaw Creek near Cherokee City, Ark.	362031	943515	--	ADPCE	Springfield	1978-83	4
21	Eleven Point River near Ravenden Springs, Ark.	362048	910648	1,134	ADPCE	Salem	1972-73	3

Table 8. Site and basin characteristics of biological-tissue sampling sites--Continued

[mi^2, square miles; WY70-90, water years 1970-1990; --, data unavailable; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USEPA, U.S. Environmental Protection Agency; KDHE, Kansas Department of Health and Environment; USCOE, U.S. Army Corps of Engineers]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physio-graphic area[1]	Period of record (WY70-90)	Number of samples
22	Black River near Corning, Ark.	362407	903229	1,749	ADPCE	Mississippi Alluvial Plain, Salem, St. Francois	1973-74	3
23	White River near Eureka Springs, Ark.	362515	935050	1,192	ADPCE	Salem, Boston, Springfield	1973	3
24	Kings River near Berryville, Ark.	362536	933715	527	ADPCE	Salem, Boston, Springfield	1973-84	8
25	South Fork of Spring River near Salem, Ark.	362623	914944	--	ADPCE	Salem	1973	2
26	Spring River near Thayer, Mo.	363010	913131	--	ADPCE	Salem	1972-73	3
27	Little Sugar Creek at Caverna, Mo.	363010	941630	--	ADPCE	Springfield	1973	3
28	Butler Creek near Sulphur Springs, Ark.	363044	942854	--	ADPCE	Springfield	1973	3
29	Myatt Creek near Thayer, Mo.	363104	914418	--	ADPCE	Salem	1972-73	3
30	Eleven Point River west of Calm, Mo.	363300	911136	--	USEPA	Salem	1986-88	3
31	North Fork River west of Tecumseh, Mo.	363515	921720	--	USEPA	Salem	1980	1
32	Elk River at Cowskin access south of Tiff City, Kans.	363800	943524	--	USEPA	Springfield	1982	1
33	Lake Taneycomo and Roark Creek Confluence, Mo.	363903	931254	--	USEPA	Salem, Springfield, Boston Mountains	1981	2
34	Current River west of Doniphan, Mo.	363952	905024	--	USEPA	Salem	1980-84	4
35	Lake Taneycomo 3.1 miles below Branson, Mo.	364021	931200	--	USEPA	Salem, Springfield, Boston Mountains	1980-86	5
36	Current River NNW. of Doniphan, Mo.	364157	905236	--	USEPA	Salem	1985-88	4
37	Spring River near Verona, Mo.	365600	934600	--	USEPA	Springfield	1978	1
38	Spring River at Devil’s Prominade Bridge, Okla.	365604	944445	--	ODEQ	Osage Plains, Springfield	1981	4
39	Spring River 0.6 mi upstream from U.S. 60 Bridge, Mo.	365628	934656	--	USEPA	Springfield	1981	1
40	James River at Shelvin Rock access, southeast of Nixa, Mo.	365747	932211	--	USEPA	Springfield	1985-86	2
41	Unnamed Creek between Syntex and Spring, Mo.	365808	934757	--	USEPA	Springfield	1981	1

Table 8. Site and basin characteristics of biological-tissue sampling sites--Continued

[mi^2, square miles; WY70-90, water years 1970-1990; --, data unavailable; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USEPA, U.S. Environmental Protection Agency; KDHE, Kansas Department of Health and Environment; USCOE, U.S. Army Corps of Engineers]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physio-graphic area[1]	Period of record (WY70-90)	Number of samples
42	Spring River west of Verona, Mo.	365808	934803	--	USEPA	Springfield	1981	1
43	Douger Bridge at State Route P in Lawrence County, Mo.	365830	934741	--	USEPA	Springfield	1981	1
44	Spring River 2.4 mi downstream of Douger Bridge, Mo.	365951	934859	--	USEPA	Springfield	1981	1
45	James River near Boaz below Wilson Creek, Mo.	370025	932150	462	USEPA	Springfield	1980-84	5
46	Spring River at Baxter Springs, Kans.	370105	944314	--	USEPA	Springfield	1980-86	6
47	Neosho River near Chetopa, Kans.	370210	950450	--	KDHE	Osage Plains	1974-89	32
48	Labette Creek near Chetopa, Kans.	370428	950611	--	KDHE	Osage Plains	1990	2
49	James River 2 mi above Wilson Creek, Mo.	370435	932215	--	USEPA	Springfield	1978, 80	2
50	Short Creek near Galena, Kans.	370523	943958	--	KDHE	Springfield	1990	1
51	Wilson Creek downstream of South Creek, Mo. [2]	370624	932430	--	USEPA	Springfield	1985	1
52	Turkey Creek near Joplin, Mo.	370715	943455	42	KDHE	Springfield	1975-90	18
53	Shawnee Creek near Crestline, Kans.	370855	944038	--	KDHE	Springfield, Osage Plains	1990	1
54	Center Creek near Smithfield, Mo.	370921	943610	--	KDHE	Springfield	1975-90	17
55	Center Creek east of Carterville, Mo.	370930	942420	--	USEPA	Springfield	1980	1
56	Center Creek south of Smithfield, Mo.	370930	943615	--	USEPA	Springfield	1977	1
57	Spring River east of Waco, Mo.	370948	943406	--	USEPA	Springfield	1986-89	4
58	Center Creek 1 mi south of Carl Junction, Mo.	370951	943339	--	USEPA	Springfield	1985-86	2
59	Center Creek at Highway JJ Bridge near Smithfield, Mo.	370953	943454	--	USEPA	Springfield	1981-84	4
60	Neosho River near Oswego, Kans.	370954	950346	--	KDHE	Osage Plains	1990	2
61	Wilson Creek upstream of South Creek, Mo. [3]	371006	932212	--	USEPA	Springfield	1985	1
62	Spring River near Galena, Kans.	371125	943805	--	USEPA	Springfield	1977	1

Table 8. Site and basin characteristics of biological-tissue sampling sites--Continued

[mi^2, square miles; WY70-90, water years 1970-1990; --, data unavailable; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USEPA, U.S. Environmental Protection Agency; KDHE, Kansas Department of Health and Environment; USCOE, U.S. Army Corps of Engineers]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physio-graphic area[1]	Period of record (WY70-90)	Number of samples
63	Labette Creek southwest of Labette, Kans.	371310	951155	--	USEPA	Osage Plains	1988-89	2
64	Spring River south of Waco, Mo.	371315	943615	--	USEPA	Springfield	1977-84	4
65	Cow Creek near Lawton, Kans.	371321	943914	--	KDHE	Osage Plains	1990	1
66	Labette Creek near Labette, Kans.	371348	951152	--	KDHE	Osage Plains	1990	2
67	Spring River at State 171 Bridge, southeast of Waco, Mo.	371356	943433	--	USEPA	Springfield	1985	1
68	Lightning Creek near Oswego, Kans.	371418	950238	--	KDHE	Osage Plains	1990	2
69	Spring River near Waco, Mo.	371444	943358	1,164	KDHE	Springfield, Osage Plains	1973-89	26
70	Cow Creek 1 mile east of Langdon, Kans.	372120	944110	--	USEPA	Osage Plains	1988-89	2
71	Neosho River water station no. 1, Kans.	372918	950830	--	KDHE	Osage Plains	1990	1
72	Marmaton River near Fort Scott, Kans.	375113	944649	--	KDHE	Osage Plains	1990	2
73	Devil’s Elbow on Big Piney, Mo.	375115	920400	--	USEPA	Salem	1977	1
74	Marmaton River east of Fort Scott, Kans.	375120	943822	--	USEPA	Osage Plains	1988-89	2
75	Marmaton River near Fort Scott, Kans.	375147	944036	--	KDHE	Osage Plains	1975-90	18
76	Gasconade at Highway Y, Mo.	375400	920800	--	USEPA	Salem	1977	1
77	Gasconade River near Jerome, Mo.	375512	915833	--	USEPA	Salem	1977-89	11
78	Osage River at Roscoe, Mo.	375915	934845	--	USEPA	Osage Plains	1987	1
79	Little Osage River near Fulton, Kans.	380029	944142	--	KDHE	Osage Plains	1975-90	18
80	Big River at Mammouth access west of Desoto, Mo.	380720	904036	--	USEPA	Salem, St. Francois	1980	1
81	Lake of the Ozarks at Jennings Branch Cove, Mo.	381202	923851	--	USEPA	Salem	1985-86	2
82	Osage Gasconade, Bagnell Dam, Mo.	381220	923745	--	USEPA	Salem	1971	2
83	Meramec River at Meramec Park, Mo.	381400	910500	--	USEPA	Salem	1977	1

Table 8. Site and basin characteristics of biological-tissue sampling sites--Continued

[mi^2, square miles; WY70-90, water years 1970-1990; --, data unavailable; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USEPA, U.S. Environmental Protection Agency; KDHE, Kansas Department of Health and Environment; USCOE, U.S. Army Corps of Engineers]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physio-graphic area[1]	Period of record (WY70-90)	Number of samples
84	Truman Lake near Brownington, Mo.	381538	934342	--	USEPA	Osage Plains	1987	1
85	Truman Lake south-south east of Clinton, Mo.	381952	934610	--	USEPA	Osage Plains	1987-88	3
86	Calvey Creek no. 1, Mo.	382200	904400	--	USEPA	Salem	1977	1
87	Tebo Creek, Henry Co. Highway PP, Mo.	382204	933240	--	USCOE	Springfield, Osage Plains	1988	1
88	Calvey Creek no. 2, Mo.	382300	904600	--	USEPA	Salem	1977	1
89	Calvey Creek no. 3, Mo.	382350	904610	--	USEPA	Salem	1977	1
90	Meramec River 1 mi upstream of Mississippi River confluence, Mo.	382418	902053	--	USEPA	Salem	1984	1
91	Osage River north of St. Thomas, Mo.	382518	921231	--	USEPA	Salem, Springfield, Osage Plains	1981-89	9
92	Meramec River northeast of Arnold, Mo.	382723	902139	--	USEPA	Salem	1984	1
93	Meramec River east of Paulina Hills, Mo.	382745	902459	--	USEPA	Salem	1984	1
94	Meramec River at Highway 21 Bridge, Mo.	382745	902500	--	USEPA	Salem	1983	2
95	Romaine Creek near mouth, Mo.	382748	902527	--	USEPA	Salem	1983	3
96	Romaine Creek upstream of Highway 141 Bridge, Mo.	382748	902543	--	USEPA	Salem	1984	1
97	Romaine Creek 0.5 miles above the Meramec River, Mo.	382750	902524	--	USEPA	Salem	1985	1
98	Romaine Creek upstream of the Saline Creek confluence, Mo.	382753	902514	--	USEPA	Salem	1985	1
99	Saline Creek upstream of Meramec confluence, Mo.	382756	902501	--	USEPA	Salem	1985	1
100	Sugar Creek near mouth, Mo.	382813	902543	--	USEPA	Salem	1983	3
101	Meramec River south of Eureka, Mo.	382821	903933	--	USEPA	Salem	1980-88	11
102	Saline Creek before confluence of Sugar Creek, Mo.	382825	902549	--	USEPA	Salem	1983	3
103	Meramec River 2 miles below Pacific, Mo.	382848	904312	--	USEPA	Salem	1984	1

Table 8. Site and basin characteristics of biological-tissue sampling sites--Continued

[mi^2, square miles; WY70-90, water years 1970-1990; --, data unavailable; ODEQ, Oklahoma Department of Environmental Quality; ADPCE, Arkansas Department of Pollution Control and Ecology; USEPA, U.S. Environmental Protection Agency; KDHE, Kansas Department of Health and Environment; USCOE, U.S. Army Corps of Engineers]

Site number	Site name	Latitude	Longitude	Drainage area (mi^2)	Collecting agency	Physiographic area[1]	Period of record (WY70-90)	Number of samples
104	Meramec River upstream I44 Bridge at Times Beach, Mo.	383013	903525	--	USEPA	Salem	1983	4
105	Meramec River below Fenton upstream of Marina, Mo.	383030	902610	--	USEPA	Salem	1983	3
106	Meramec River at Fenton, Mo.	383051	902603	--	USEPA	Salem	1984-85	2
107	Meramec River down stream of Glencoe, Mo.	383232	903507	--	USEPA	Salem	1983	4
108	Meramec River just below Glencoe, Mo.	383232	903703	--	USEPA	Salem	1984	1
109	Meramec River upstream of Valley Park Bridge, Mo.	383240	903030	--	USEPA	Salem	1983	3
110	Meramec River at Fishpot Creek, Mo.	383241	902948	--	USEPA	Salem	1984	1
111	Chrysler car plant industrial waste, Mo.	383300	902735	--	USEPA	Salem	1983	1
112	Kiefer Creek near Castlewood, Mo.	383305	903233	--	USEPA	Salem	1984	1
113	Fishpot Creek at Hanna Road Bridge, St. Louis, Mo.	383308	903041	--	USEPA	Salem	1983	3
114	Grand Glaize Creek between Marshall Road Bridge & Meramec River, Mo.	383314	902941	--	USEPA	Salem	1984	1
115	Grand Glaize Creek at Marshall Road Bridge, St. Louis, Mo.	383316	902751	--	USEPA	Salem	1983	3
116	Hamilton Creek near Glencoe, Mo.	383325	903851	--	USEPA	Salem	1984	1
117	Meramec River near Kirkwood wastewater treatment intake, Mo	383334	902645	--	USEPA	Salem	1983	4
118	Grand Glaize at Carmen Road Bridge, Mo.	383430	902814	--	USEPA	Salem	1983	3
119	Sugar Creek near Ozark View subdivision, St. Louis, Mo.	383447	902732	--	USEPA	Salem	1983	3
120	Grand Glaize Creek below Sulphur Springs Road, Mo.	383533	903108	--	USEPA	Salem	1983	3

[1] Springfield, Springfield Plateau; Boston, Boston Mountains; Salem, Salem Plateau; St. Francois, St. Francois Mountains.
[2] Original site name is “Wilson Creek downstream”; reference to South Creek added for clarification.
[3] Original site name is “Wilson Creek upstream”; reference to South Creek added for clarification.