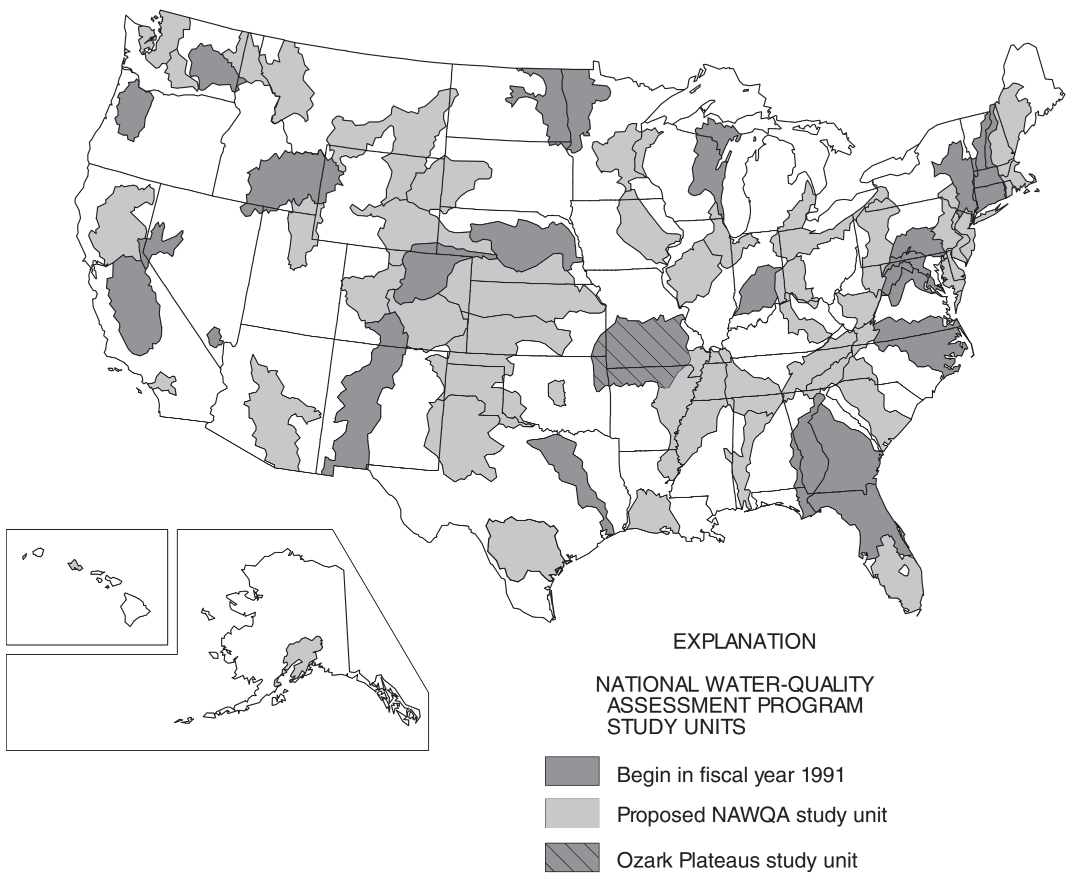
WATER-QUALITY ASSESSMENT OF THE OZARK PLATEAUS STUDY UNIT, ARKANSAS, KANSAS, MISSOURI, AND OKLAHOMA—ANALYSIS OF INFORMATION ON NUTRIENTS, SUSPENDED SEDIMENT, AND SUSPENDED SOLIDS, 1970-92

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 95-4042



National Water-Quality Assessment Program

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By Jerri V. Davis, James C. Petersen, James C. Adamski, and David A. Freiwald

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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 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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CONVERSION FACTORS

Multiply	By	To obtain
inch (in.)	25.4	millimeter
inch per year (in/yr)	25.4	millimeter per year
inch per month (in/mo)	25.4	millimeter per month
foot (ft)	0.3048	meter
mile (mi)	1.609	Kilometer
acre	4,047	square meter
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
gallon per minute (gal/min)	0.06309	liter per second
million gallons per day (Mgal/d)	0.04381	cubic meter per second
ton	0.9072	megagram
tons per square mile (ton/mi^2)		
ton per year (ton/yr)		

Degrees Celsius (° C) can be converted to degrees Fahrenheit (° F) by using the following equation:

$$°F = (1.8 \times °C) + 32$$

Water year: In this report "water year" refers to October 1 through September 30, numbered for the calendar year starting January 1. For example, water year 1991 is defined as October 1, 1990 through September 30, 1991.

Water-Quality Assessment of the Ozark Plateaus Study Unit, Arkansas, Kansas, Missouri, and Oklahoma—Analysis of Information on Nutrients, Suspended Sediment, and Suspended Solids, 1970–92

By Jerri V. Davis, James C. Petersen, James C. Adamski, *and* David A. Freiwald

Abstract

Water-quality data collected during water years 1970–90 (October 1 to September 30) for 83 surface-water sites and during 1970–92 for 395 ground-water sites in the 48,000 square mile Ozark Plateaus study unit of the National Water-Quality Assessment Program were analyzed using selected descriptive and statistical methods. The water-quality data include nutrient (nitrogen and phosphorus), suspended-sediment, and suspended-solids data; and ancillary information on fertilizer use, animal waste, sewage-treatment plants, and land use.

Statistically significant differences existed in surface-water quality that can be attributed to physiography, land use, and other effects. The sites that were considered to be substantially affected by sewage-treatment plants had the largest concentrations of nutrients. Nutrient concentrations generally were larger at sites associated with agricultural basins than at sites associated with forested basins.

Statistically significant differences existed in the quality of ground water that can be attributed to hydrogeologic and land-use effects. Nutrient concentrations generally were largest where the water source is indicated to be shallow in origin and where parts of the hydrogeologic units are in agricultural land-use areas.

Water quality has changed at several surface-water sites since 1970. Nutrient concentrations appear to have increased at some sites and decreased at other sites. Causes of these apparent trends are not known, but many of the sites with apparent trends are in agricultural areas.

Surface-water loads of nutrients and suspended sediment were affected by several factors including streamflow, climate, drainage area, reservoir operation, and inputs from point and nonpoint sources. Annual loads were largest in large basins, with large inputs of nutrients or sediment during periods of high streamflows at locations where reservoir operation effects are not substantial.

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. Nationally consistent 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 that will be 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 will 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-scale implementation plan. The complex, mostly karst aquifer system of the Ozark Plateaus study unit, coupled with the influx of people and 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 activity 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 describe the spatial and temporal availability of nutrient and suspended-sediment and suspended-solids data and to develop an improved conceptual model of the spatial and temporal patterns of concentrations and loads of nutrients and suspended sediment and suspended solids within the study unit. The synthesis of existing nutrient and suspended-sediment and suspended-solids data will document what is currently known prior to the intensive-data collection phase of NAWQA and improve our understanding of the hydrologic system. This information will be used as a guide for additional data-collection activities. The information in this report also will contribute to the national synthesis activity that will compare and contrast water quality in similar and different environments throughout the Nation.

The scope of this report includes (1) a brief overview of the environmental setting of the study unit; (2) an assessment of methods used to analyze available data; (3) the spatial and temporal distribution characteristics of nutrient data for surface and ground water and suspended-sediment and suspended-solids data for surface water; (4) a description of water-quality conditions in selected physiographic, hydrogeologic, and land-use settings using statistical summaries of nutrient and suspended-sediment and suspended-solids data; and (5) a limited trend analysis and surface-water load calculations for selected constituents and basins. The water-quality data analyzed were collected during water years 1970–92.

DESCRIPTION OF THE OZARK PLATEAUS STUDY UNIT

This section describes the environmental setting of the study unit. The environmental setting characteristics that are most important to the discussion of nutrients and suspended-sediment and suspended-solids patterns will be discussed here. For more detail, the reader is referred to the environmental setting report for the study unit by Adamski and others (1995).

The Ozark Plateaus study unit area is approximately 48,000 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.

The Ozark Plateaus Province consists of a structural dome of igneous rocks that form the St. Francois Mountains in southeastern Missouri. Sedimentary rocks gently dip away from this core of igneous rocks 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 ranges from mostly gently rolling hills in the Springfield Plateau, rugged with relief as much as 500 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 minimal relief.

The St. Francois Mountains area is not a separate physiographic section as defined by Fenneman (1938), but will often 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 hereafter be referred to as physiographic areas.

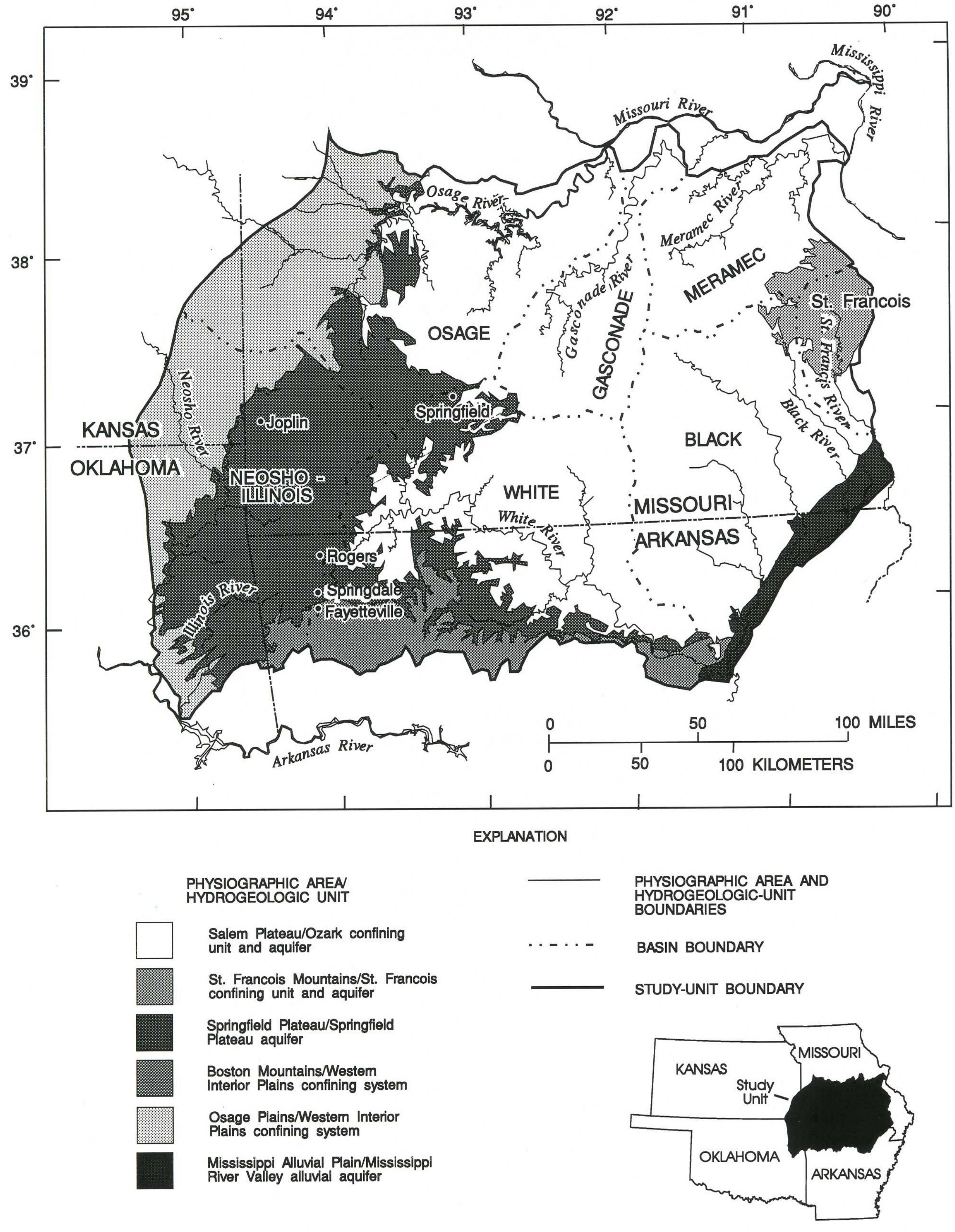

Figure 1. Location of Ozark Plateaus study unit, major river basins, physiographic areas, and hydrogeologic units.

Geology and Hydrology

The geology (Imes and Emmett, 1994) of 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. The igneous rocks include granite, rhyolite, and diabase and are located in the St. Francois Mountains. In the Salem Plateau, sedimentary rocks of Cambrian through 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 extensively fractured and faulted as a result of uplifting.

The study unit is divided into seven hydrogeologic units consisting of three major aquifers interbedded within 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, but minor aquifer, of limited areal extent within the study unit.

Aquifers in the study unit are in different rock types and have varying yields of water. The Springfield Plateau and Ozark aquifers are thick sequences of limestones and dolomites with secondary permeability resulting from fracturing and dissolutioning of the dense rocks. Where the Springfield Plateau aquifer is unconfined (coincident with the Springfield Plateau physiographic area), it is extensively used as a source of domestic water, with well yields averaging less than 20 gal/min. The Ozark aquifer is used where it is both unconfined (coincident with the Salem Plateau physiographic area) and confined as public supply and domestic use, with well yields 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 except where it crops out.

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 and 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 mostly consist 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 mostly consists of igneous rocks.

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 either directly or indirectly flow 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 (ranging from 9 to 10 in.) in the northern Osage Plains, increases to the south (ranging from 10 to 16 in.) in the Springfield and Salem Plateaus, and is greatest (ranging from 14 to 20 in.) in the Boston Mountains.

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 increasing from about 38 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 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). The estimated mean annual evapotranspiration rate in the study unit is 30 to 35 in. (Hanson, 1991).

Atmospheric deposition is recognized as an important source of nutrients from a mass balance standpoint, although sufficient monitoring information is not yet available for rigorous quantification. The removal of atmospheric gases and particles by wet (precipitation) and dry deposition are major mechanisms for nutrient inputs to basins. Wet precipitation chemistry data for ammonia and nitrate from four National Trends Network monitoring sites in or near the study unit for 1980–90 were used to calculate nitrogen deposition (National Atmospheric Deposition Program, 1981–91). These calculated values were then corrected for dry deposition inputs (Sisterson, 1990). The total mean annual nitrogen deposition calculated for the study unit is 1.89 tons/mi^2. Mean annual wet ammonia (as nitrogen) deposition is 0.65 ton/mi^2 and wet plus dry nitrate (as nitrogen) deposition is 1.24 tons/mi^2. Droplet and urban deposition corrections were not used in these calculations because they are not considered a factor in the study unit.

Population within the study unit in 1990 was approximately 2.3 million people (U.S. Department of Commerce, Bureau of the 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 (1990), is the largest city in the study unit. Joplin, Mo., and Fayetteville, Rogers, and Springdale, Ark., are the only cities within the study unit with populations exceeding 20,000 residents (1990).

Land use in the study unit predominantly is forest and agriculture (includes pasture and cropland; table 1; U.S. Geological Survey, 1990). Deciduous forest is predominant in the Salem Plateau and Boston Mountains, although this is often mixed with evergreen forest. Some pasture also occurs in the Salem Plateau where livestock (beef and dairy cattle) are raised. The Springfield Plateau predominantly is pasture, although this is mixed with cropland in the north and forest in the south. Intensive poultry farming is associated with the Springfield Plateau pastures 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. The two major lead and zinc mining areas are the Southeastern District (Old Lead Belt, Viburnum Trend, and the Fredericktown subdistricts) in and around the St. Francois Mountains and the Tri-State Mining District of Kansas, Missouri, and Oklahoma.

Table 1. Land-use percentage by physiographic area

[1978–83 land-use data from U.S. Geological Survey (1990)]

	Percentage of land use				
Physiographic area	**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 pasture and cropland.
[2] Includes mining.
[3] Includes approximately 7 percent wetland.

Total water use from both surface- and ground-water sources in the study unit was 1,053 Mgal/d in 1990. 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 from counties along the extreme southeastern part of the study unit in the Mississippi Alluvial Plain. Domestic and public supply accounts for about 21 percent of the ground-water use. About 47 percent of the total surface-water use is used for public supply and almost 30 percent for commercial and industrial use. Less than 6 percent of total water use in the study unit is for agricultural purposes other than irrigation.

Nitrogen and Phosphorus Fertilizer Use

Fertilizer use in the Ozark Plateaus study unit has increased substantially since 1960. Fertilizer-use estimates (Alexander and Smith, 1990) indicate that nitrogen and phosphorus fertilizer use has increased 152 percent and 55 percent, respectively, from 1965 to 1985.

The application rates for nitrogen and phosphorus fertilizer in the Ozark Plateaus study unit are less than the national median. Estimates of nitrogen and phosphorus fertilizer application rates for 1982 were computed as a ratio of fertilizer use to fertilized acreage. The national median of nitrogen fertilizer application rate is 28 tons/mi^2, with median application rates by State ranging from 14 to 64 tons/mi^2. Nitrogen fertilizer application rates (1982) for the counties within the study unit ranged from an estimated 0 to 35 tons/mi^2. Application rates generally were larger in counties in Arkansas and Kansas. The national median of phosphorus fertilizer application rate is 6 tons/mi^2, with median application rates by State ranging from 3 to 17 tons/mi^2. Phosphorus fertilizer application rates (1982) for the counties within the study unit ranged from an estimated 0 to 5 tons/mi^2 (Alexander and Smith, 1990).

Fertilizer use differed substantially among major river basins (table 2) in the study unit. Annual nitrogen fertilizer use in 1965 ranged from 0.53 ton/mi^2 in the St. Francis River Basin to 2.41 tons/mi^2 in the Osage River Basin. In 1985, annual nitrogen fertilizer use ranged from 1.30 tons/mi^2 in the St. Francis River Basin to 5.09 tons/mi^2 in the Osage and Neosho-Illinois River Basins. Nitrogen fertilizer use in the Osage and the Neosho-Illinois River Basins nearly equals the combined total nitrogen fertilizer use in the rest of the study unit. Annual phosphorus fertilizer use in 1965 ranged from 0.14 ton/mi^2 in the St. Francis River Basin to 0.64 ton/mi^2 in the Osage River Basin. In 1985, annual phosphorus fertilizer use ranged from 0.23 ton/mi^2 in the St. Francis River Basin to 0.87 ton/mi^2 in the Osage River Basin. As with nitrogen fertilizer use, approximately one-half of the total phosphorus fertilizer used was applied in the Osage and Neosho-Illinois River Basins.

The physiographic area with the largest nitrogen fertilizer use within the study unit in 1985 was the Mississippi Alluvial Plain (8.0 tons/mi^2) followed by the Osage Plains (7.1 tons/mi^2), Salem Plateau (3.0

Table 2. Annual nitrogen and phosphorus fertilizer use by major river basins, 1965 and 1985

[Fertilizer use data from U.S. Department of Agriculture *in* Alexander and Smith, 1990]

River basin	Area (acres)	Nitrogen fertilizer (tons per square mile per year)		Percent difference	Phosphorus fertilizer (tons per square mile per year)		Percent difference
		1965	1985		1965	1985	
Black	5,435,238	1.33	3.17	139	0.34	0.49	42
Gasconade	2,180,647	1.28	3.22	152	.34	.56	65
Meramec	2,553,402	.77	1.85	141	.20	.32	58
Neosho-Illinois	5,948,454	1.67	5.09	206	.45	.78	73
Osage	6,332,800	2.41	5.09	111	.64	.87	36
St. Francis	849,216	.53	1.30	144	.14	.23	59
White	7,170,362	.81	2.43	200	.21	.37	77

tons/mi^2), Springfield Plateau (2.8 tons/mi^2), and the Boston Mountains (1.8 tons/mi^2). The largest phosphorus fertilizer use in 1985 occurred in the Mississippi Alluvial Plain and the Osage Plains (each 0.99 ton/mi^2) followed by the Springfield Plateau (0.52 ton/mi^2), Salem Plateau (0.49 ton/mi^2), and the Boston Mountains (0.23 ton/mi^2).

Animal and Municipal Sources of Nutrients

Livestock and poultry waste is a major source of nutrient loading in parts of the study unit. The nutrient composition of animal waste varies widely with respect to animal species, feed consumption and content, and age (Fulhage, 1989a). Animal waste contains three major nutrients (nitrogen, phosphorus, and potassium) essential for plant production and is, therefore, used as a source of fertilizer for pasture.

The quantity of nutrients available for use from livestock and poultry waste changes substantially from the amount initially excreted. The type of housing and waste-handling system used and different storage times greatly affect the nitrogen and phosphorus concentration of animal waste. The longer time that animal waste lies in the soil before plant uptake, the more nutrients can be lost through mineralization, volatilization, denitrification, leaching, and erosion.

Fulhage (1989a) indicates that more than one-half of the nitrogen content of manure will be either used by plants or volatilized to the atmosphere. Phosphorus in manure is primarily in the organic form but is not readily available to plants until it is broken down by bacteria (a slow process). Also, phosphorus tends to remain attached to soil that can erode into receiving waters causing excessive plant and algae growth (Fulhage, 1989a).

Estimated livestock and poultry populations within the study unit were used to calculate total nutrient contribution to the study unit by animal waste (table 3). An estimated 154,600 tons of wet weight manure is produced daily in the study unit that annually produces about 358,300 tons of nitrogen and 123,400 tons of phosphorus initially available for use.

Data on municipal sewage-treatment plant (STP) point-source discharges were retrieved from the U.S. Environmental Protection Agency's (USEPA) Permit Compliance System data base for 1985–91. The STP's that have effluents of 0.5 Mgal/d or more are shown in figure 2. Municipalities are frequently upgrading and changing their STP's, and, therefore, in some instances, these data have been superseded.

Table 3. Animal waste nutrient contribution to the Ozark Plateaus study unit

Animal species	Annual population[1]	Manure production (tons per day)[2]	Pounds nitrogen per 1,000 pounds of animal per year[3]	Nitrogen (tons per year)	Pounds phosphorus per 1,000 pounds of animal per year[2]	Phosphorus (tons per year)
Beef cattle	4,264,000	127,900	124	264,400	40	85,300
Dairy cattle	231,000	9,500	150	17,300	27	3,100
Swine	1,087,000	8,800	165	22,400	55	7,500
Chickens	[4]498,325,000	4,400	352	29,200	149	12,400
Turkeys	[4]25,178,000	[5]4,000	372	25,000	[4]225	15,100
Total		154,600		358,300		123,400

[1] Arkansas Agricultural Statistics Service, 1992; Kansas State Board of Agriculture, 1991; Missouri Agriculture Statistics Office, 1991; Oklahoma Department of Agriculture, 1992; Ken Arnold, Missouri Department of Natural Resources, oral commun., 1993; Jerry Barker, Oklahoma Department of Agriculture, oral commun., 1992.

[2] University of Missouri-Columbia Extension Division and Missouri Department of Natural Resources, 1979 (animal waste production based on wet weight pounds of manure per day per 1,000 pounds of animal).

[3] Missouri Department of Natural Resources (1989).

[4] Chicken and turkey populations are totals produced during a year. Manure production and nutrient contribution (tons per year) values have been adjusted based on the average number of chickens and turkeys being produced on a single day. Multiple flocks of chickens (6) and turkeys (2.25) are produced per year (Fulhage, 1989b).

[5] Van Dyne and Gilbertson, 1978.

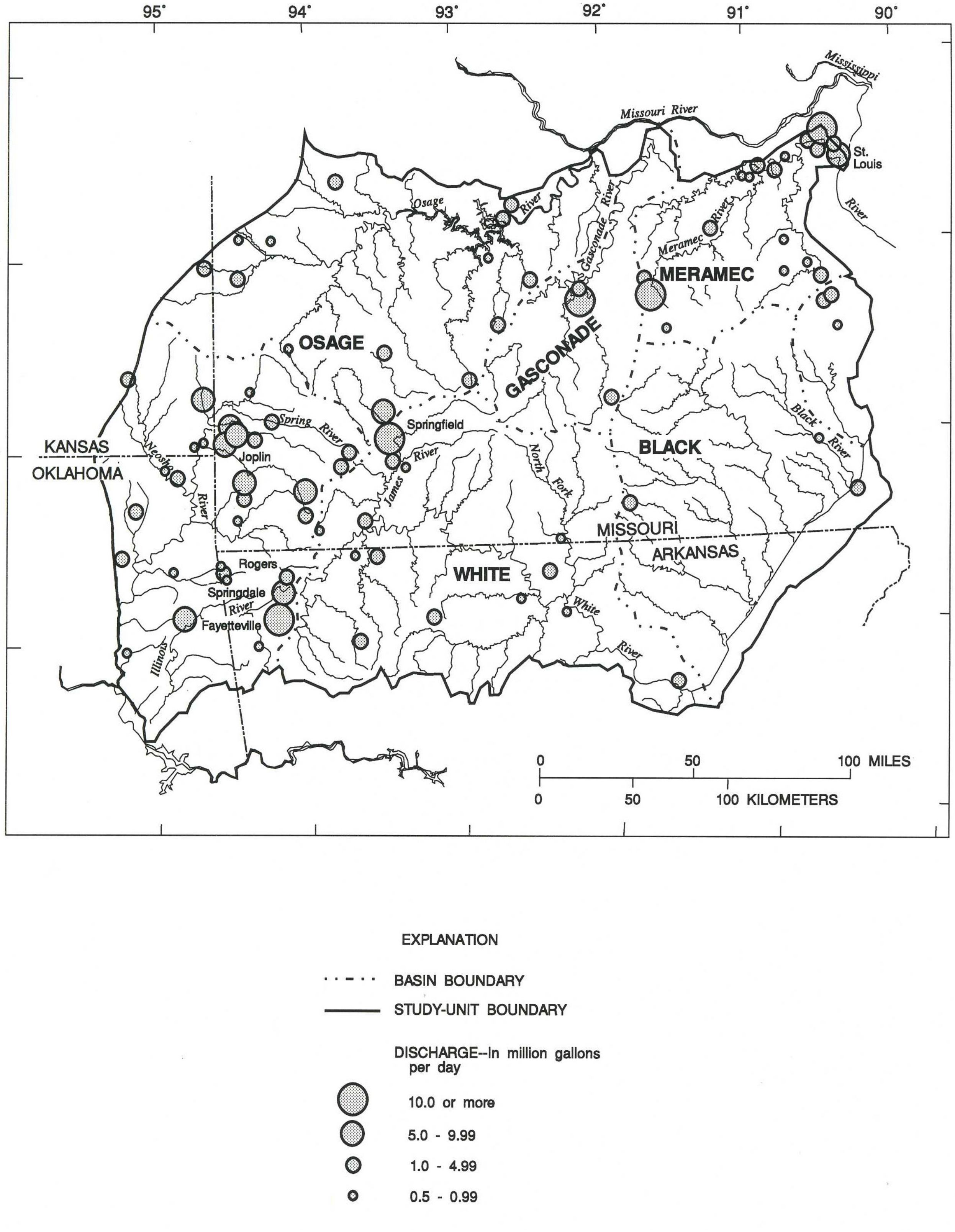

Figure 2. Municipal sewage-treatment plant point-source discharges greater than 0.5 million gallons per day.

Many additional sources of 0.49 Mgal/d or less from municipalities, private homes, recreational areas, businesses, and public offices were excluded from this analysis.

The upper White, lower Meramec, Illinois, and Spring River Basins have the highest number of municipal STP's (fig. 2). The Southwest plant in Springfield, Mo., discharges effluent into a tributary of the White River and has the largest single discharge capability (42.5 Mgal/d) in the study unit. The Metropolitan Sewer District of St. Louis has five STP's that discharge to the lower Meramec River. These five plants have the capability of collectively discharging as much as 36 Mgal/d. The cities of Springdale, Fayetteville, and Rogers, Ark., discharge their effluent into tributaries of the Illinois River, although Fayetteville also discharges some effluent into a tributary of the White River. These three cities have the ability to collectively discharge as much as 34 Mgal/d. Joplin, Mo., discharges about 21 Mgal/d into tributaries of the Spring River.

Most municipalities in the study unit treat their raw sewage with a combination of two or more treatment methods. The most common method of sewage treatment seems to be the use of oxidation ditches or ponds. Trickling filters, aerated lagoons, extended aeration, and lagoons in series also are common methods of treatment. Sewage water that has undergone tertiary treatment will contain nitrogen mostly as nitrate, whereas the nitrogen in secondary treated wastewater is mostly in the form of ammonia, which will rapidly oxidize in most stream environments. Chlorination is frequently used in the disinfectant process. In general, the average STP has a daily discharge of 0.479 Mgal of effluent with an average total nitrogen concentration of 8.4 mg/L (milligrams per liter) and an average total phosphorus concentration of 5.2 mg/L (National Oceanic and Atmospheric Administration, 1993).

ASSESSMENT APPROACH

The following section describes the method of selecting the constituents and their importance. It also describes the evaluation and sources of data and the methods of analysis.

Selection of Properties and Constituents for Analysis

For purposes of this report, nutrients are defined as the nitrogen and phosphorus species. The fixation of atmospheric nitrogen by plants and animals, the dissolution of phosphorus-bearing rocks or minerals in the soil, and organic matter, including soil organic matter and decaying plants and animals, are natural sources for nitrogen and phosphorus in streams. Anthropogenic sources include sewage discharges, fertilizers, animal waste, and septic tanks. Atmospheric deposition is another source of nitrogen in natural waters (Hem, 1985). Background concentrations in streams generally are small, because the dissolved forms of the two elements are assimilated rapidly by plants and bacteria. Aquatic vegetation, particularly algae, depend on nitrogen and phosphorus for their food supply. Nitrogen or phosphorus concentrations greater than normal, ambient levels can contribute to the dense growth of algae (algal blooms). Bacterial decomposition of dead algal cells after an algal bloom can cause the depletion of dissolved oxygen, causing fish kills and other negative effects on aquatic life.

Nitrogen occurs in surface and ground water as nitrite (NO_2^{-1}), nitrate (NO_3^{-1}), and ammonium (NH_4^{+1}) ions and at intermediate oxidation states in organic solutes (Hem, 1985). The ammonium ion is in chemical equilibrium with unionized ammonia, a nitrogen species that is toxic to aquatic life under certain conditions. Ammonium ions predominate at pH values of less than 9.2, which is larger than the pH of most natural water (Hem, 1985). Nitrite and organic species are unstable in aerated water, nitrate is readily transported in water and is stable over a wide range of conditions, and ammonium cations tend to adsorb on mineral surfaces. The reduced forms of nitrogen (nitrite, ammonium, and organic species) are oxidized to nitrate in most aerobic environments, but in contaminated streams and aquifers, a substantial part of the total nitrogen concentration may be these reduced species. Large nitrate concentrations are undesirable in a domestic or public water supply because of potential health hazards, particularly for infants. Because of the potential health risks associated with nitrate, the USEPA has established a Maximum Contaminant Level (MCL) of 10 mg/L of nitrate as nitrogen in public-drinking water supplies (U.S. Environmental Protection Agency, 1986).

The most common phosphorus species in water is the fully oxidized orthophosphate ion (PO_4^{-3}), but organic phosphate species synthesized by plants and animals also constitute a substantial part of the phosphorus in natural waters (Hem, 1985). The orthophosphate ion is the phosphorus species most readily available for use by aquatic plants. Most phosphorus-containing compounds are relatively insoluble, and thus the chemistry of the element favors precipitation or adsorption onto sediments.

For surface-water data, the nitrogen and phosphorus species considered in this report were nitrite plus nitrate, ammonia (includes both ammonium ions and unionized ammonia), total ammonia plus organic nitrogen, total nitrogen, total phosphorus, and orthophosphate. Because nitrite rapidly oxidizes to nitrate in most surface water, the assumption was made that nitrite concentrations were negligible, and nitrite plus nitrate was considered instead of the individual species. Nitrate is soluble in water and so first consideration was given to dissolved nitrite plus nitrate (filtered samples). Total nitrite plus nitrate (whole-water samples) was substituted if dissolved data were unavailable. Ammonia is less soluble than nitrate, but the same substitution was made when dissolved data were unavailable, because samples for ammonia analyses do not undergo rigorous digestion prior to analysis. Total nitrogen is the sum of the nitrogen species and, for surface water, generally is calculated using total nitrite plus nitrate and total ammonia plus organic nitrogen. For this analysis, dissolved ammonia plus organic nitrogen data were not substituted for missing total ammonia plus organic nitrogen data because the Kjeldahl method used involves rigorous sample digestion. Dissolved nitrite plus nitrate concentrations were substituted in the total nitrogen calculation when total nitrite plus nitrate data were unavailable. The orthophosphate ion, like nitrate, is soluble. In cases where dissolved orthophosphate data were unavailable, total orthophosphate data were substituted.

For ground-water data, the nitrogen and phosphorus species considered for this report were nitrite plus nitrate, ammonia, ammonia plus organic nitrogen, total nitrogen, total phosphorus, and orthophosphate. Similar methods were used for substituting the various measurements of nitrogen and phosphorus concentrations in ground water. For example, nitrate concentrations in ground water were reported in four ways: nitrate, total (whole water), as nitrogen; nitrate, dissolved (filtered), as nitrogen; nitrate, total, as nitrate; and nitrate, dissolved, as nitrate. First, filtered and whole-water analyses were grouped together because colloidal material in ground water in the Ozark Plateaus generally is negligible. Second, concentrations reported as nitrate were converted to concentrations as nitrogen by dividing the former by 4.43. The result was a single constituent for nitrate. Similar groupings and data conversions were used for other species of nitrogen and phosphorus.

Because of the substitution and combination of certain water-quality measurements for other measurements (for example, total nitrite plus nitrate for dissolved nitrite plus nitrate), the resulting data for a constituent (nitrite plus nitrate, for example) often included results of analyses performed on filtered and whole-water samples. For these constituents, the "total" and "dissolved" adjectives are not included in the following discussions. Data for total ammonia plus organic nitrogen and total phosphorus in surface-water samples were not combined with data for filtered samples, and the "total" adjective is, therefore, retained. However, the "total" in "total nitrogen" refers to a summation of nitrogen species values, some of which may be from analyses of filtered samples.

Suspended sediment in water is the particulate matter that consists of soil and rock particles eroded from land. Sediment can be transported in the water column or can settle to the streambed. The movement of suspended sediment in streams is an important factor in the transport and fate of chemicals in the environment, because the particles can sorb nutrients, trace elements, and organic compounds. Fecal bacteria also can be associated with suspended sediment. The sediment available for transport by a stream is controlled by a combination of factors, including the intensity or frequency of precipitation, soil type, vegetative cover, topography, and land use. Overland runoff of precipitation primarily is responsible for delivering sediment to streams. Large suspended-sediment concentrations often are associated with intense storms that increase stream discharge, erosion, and resuspension of bed sediments. Row-crop agriculture, animal grazing, timber harvesting, mining, highway construction and maintenance, and urbanization can cause increased erosion and thus increase stream sediment concentrations. Surface-water quality can be adversely affected by suspended sediment. Turbid streams are aesthetically unsatisfactory for swimming and other recreation and are biologically less productive than clear streams because of decreased light penetration. Elevated suspended-sediment concentrations can affect fish populations, either directly or indirectly, by preventing the successful development of fish eggs and larvae or by decreasing the available food supply. Deposits of sediment in reservoirs decrease the storage capacity for water supply or flood control, and removal of sediment from water supplies is expensive.

Two measures of stream suspended-sediment concentrations were considered for this report—suspended sediment and suspended solids. These two measures are not considered to be comparable because of differences in collection and analytical techniques. Suspended-sediment samples are a composite of individual samples collected at multiple verticals in a stream cross section. The suspended-solids sample is usually a subsample of a composite or a sample collected at a single vertical in the stream. Protocols for the analysis of suspended-sediment samples specify that the entire sample is analyzed; whereas suspended-solids analysis is done on a 100-mL aliquot of the sample. When sand is a component of the suspended sediment, it is impossible to remove a 100-mL aliquot from the sample that contains a representative amount of the sand, therefore biasing the results of the suspended-solids analysis to the low side of the actual suspended-sediment concentration. Organic particles are removed from suspended-sediment samples prior to analysis, while the suspended-solids concentrations can include some organic particles. Suspended-sediment concentrations are considered the most accurate indicator of the actual stream-sediment concentrations because of the representative sampling and analytical techniques that are used. Suspended-sediment data were used in this report when available. When suspended-solids data were used, the data were not compared directly to suspended-sediment data.

Evaluation of Water-Quality Data

Water-quality data are collected by many Federal, State, and local governmental agencies and others for a variety of regulatory and nonregulatory purposes. Regulatory agencies monitor water quality to determine compliance with permits and water-quality standards. Industrial, wastewater, and water-supply facilities need water-quality information to make operational decisions. Nonregulatory agencies monitor ambient water quality for resource characterization, and research-oriented groups study water-quality processes. Depending on the purpose for data collection, samples may be collected with varying frequency in specific locations employing different sample collection, processing, preservation, and analytical techniques and with different quality-assurance and quality-control requirements. Careful screening is necessary before using data for a regional-scale water-quality assessment, because data collected for some purposes may be unsuitable for a regional-type assessment.

Surface-Water Quality Data

The initial surface-water data set contained approximately 71,500 water-quality samples for 2,222 sites for water years 1970–90. Some of these 2,222 sites were duplicates sampled by more than one agency, so the data that were selected have the best temporal, seasonal, or hydrologic distribution or were collected, processed, preserved, or analyzed using preferred techniques. Screening criteria (described below) were applied to the data set decreasing the number of samples to about 20,000 for 83 sites.

Screening criteria were used for all surface-water quality data considered for inclusion in the final data set used in this analysis. Those data not meeting the specified criteria were removed from the data set. Data were acceptable if:

1. Site-specific information regarding location, type, number of samples, and seasonal and hydrologic distribution of samples was available. Sites with inadequate existing location information were deleted. Wastewater discharge and contaminant monitoring data were automatically excluded. Only instream, ambient water-quality data were used. Instream data collected to monitor stream water quality downstream of a STP were included, but this specific purpose was noted. Sites with less than 6 years of either quarterly, bimonthly, or monthly data were not used unless the data were needed for areal coverage, and then only those sites with 10 or more samples were used. Sites with poor seasonal or hydrologic sample distribution also were excluded. Samples had to be collected relatively evenly in each season and throughout the range of streamflows; this was a subjective determination. Examples of distributions are shown in the “Characteristics of Water-Quality Data” section of this report.
2. Sample collection, processing, preservation, and analytical techniques were appropriate. A variety of sample collection methods are used, but the use of the data will determine the best collection method. The USGS collects depth-integrated samples from multiple verticals in the stream cross section using techniques described

by Guy and Norman (1970) for the collection of suspended-sediment samples. The objective of using this method is to obtain a sample that is representative of the stream cross section. This is especially important for constituents associated with suspended sediment or where complete stream mixing is in question. Agencies collecting samples for permit compliance or water-quality standards generally collect a single vertical at the centroid of flow, which may not represent the stream cross section. Samples collected from a single vertical were used for describing water-quality conditions but were not used for load estimations. Data collected using questionable techniques, such as a dip sample from the edge of the stream, were deleted from the data set.

Sample processing and preservation techniques are used to stabilize the sample so that it retains its original character as nearly as possible. These procedures involve filtering or addition of reagents to stop biological action. Nutrient samples generally are preserved with mercuric chloride (USGS) or sulfuric acid (USEPA-approved method) and then chilled, or by chilling alone. The data used for this report were derived from samples preserved by one of these methods.

The analytical methods used for sample analysis are another important consideration. For approximately the past decade, most laboratories have used autoanalyzers to determine nitrite, nitrate, ammonia, phosphorus, and orthophosphate, and the Kjeldahl method to determine ammonia plus organic nitrogen (for example, Fishman and Friedman, 1989, or American Public Health Association and others, 1989). Only the period including water years 1980–90 was used for the discussion of water-quality conditions. Prior to 1980, other methods may have been used that potentially resulted in a positive or negative analytical bias. Data collected before water year 1980 are shown as part of the discussion of long-term trends.

3. Quality assurance and quality control (QA/QC) practices were used by the collecting and analyzing agencies. The QA/QC practices employed by a laboratory are another indicator of data quality. Participation in an external reference sample program (the USGS Standard Reference Water Sample or USEPA Water Protection and Water Supply sample programs, for example) and internal QA/QC measures such as field duplicates, laboratory duplicates, spikes, blanks, standards, and reference samples all may be part of a laboratory QA/QC program. For this analysis, only data analyzed at the USGS National Water-Quality Laboratory, USEPA-approved laboratories, or laboratories with adequate QA/QC programs were used. Chemical logic programs, such as those that calculate cation-anion balances or that compare total and dissolved constituent concentrations, were not used. The cation-anion balance is not an appropriate indicator of the quality of a laboratory's nutrient or sediment data, and, in many cases, either a total or dissolved concentration was available, but not both.

Ground-Water Quality Data

Approximately 2,000 water-quality samples were available from 719 ground-water sites for water years 1970–92; of these, 223 sites had more than 1 water-quality sample. Only the latest, most analytically complete water-quality sample for each ground-water site was included in the data set for statistical analysis, because multiple samples from a specific site would weight the data set unevenly. Therefore, the number of water-quality samples in the data set was decreased to 719.

The number of ground-water sites in the data base was further decreased to arrive at a final data set for analysis based on the amount of available information and spatial distribution. Ground-water sites lacking data on geologic unit and well depth were deleted. Wells that are completed in the Ozark and St. Francois confining units were deleted because these units are rarely used for water supply; hence, available data are few and insufficient. Ground-water sites with water-quality data were not evenly spatially distributed throughout the study unit because data were gathered for numerous studies in relatively small parts of the Ozark Plateaus Province. For example, numerous ground-water samples were collected as part of a study in Boone County, Arkansas (Leidy and Morris, 1990). In comparison, few ground-water samples have been collected from many other parts of the study unit. To obtain an even spatial distribution of data from wells and springs, some ground-water sites with water-quality data were deleted from areas of the study unit with large sample sizes. The deletion process was subjectively random with regard only to site location. A total of 395 ground-water sites with water-quality data for water years 1970–92 was included in the final data set for ground-water analysis.

Sources of Available Water-Quality Data

Numerous sources of surface- and ground-water quality data were available for this analysis. Because of the large volume of data, only data collected by Federal or State governmental agencies stored in computerized data bases were used in the final data analysis.

Each agency has different objectives for collecting water-quality data. The specific collection objectives affect the spatial, temporal, and, in the case of surface water, hydrologic distribution of the data and potentially the usefulness of some data. Synoptic-type data collection activities generally involve infrequent sampling at numerous sites in a large area for a limited number of constituents. Project-specific data collection may involve sampling numerous sites in a relatively small geographic area for a few, specific constituents. Synoptic- and project-type data may have limited use because of the poor spatial, temporal, or hydrologic distribution of the data and the number of constituents analyzed. Data collected for ambient water-quality monitoring networks generally are collected with regular frequency and for many constituents. Many ambient water-quality monitoring networks have been in existence for 10 or more consecutive years and are most useful for regional-type water-quality assessments.

The USGS began collecting water-quality data for selected streams of the Ozark Plateaus in the early 1920's. Presently (1994), 6 Federal and 15 State agencies from Arkansas, Kansas, Missouri, and Oklahoma collect and maintain records for most of the surface- and ground-water quality information in the study unit. The major water-quality data sources available for this investigation have been tabulated by agency (table 4). Many other local agencies and private organizations collect water-quality data, but much of these data are in paper files rather than in computerized data bases, making much of these data impractical for use in this report.

Most of the computerized water-quality data available for the study unit are in three national data bases: (1) USGS National Water Data Storage and Retrieval system (WATSTORE), (2) USEPA Storage and Retrieval system (STORET), and (3) U.S. Department of Energy National Uranium Resources Evaluation Program system (NURE).

The Water Resources Division of USGS implemented WATSTORE in 1971. In addition to data processing, storage, and retrieval, WATSTORE is capable of producing tables, graphs, and statistical analysis of water data (Hutchison, 1975). WATSTORE is administered by and accessed through the National Water Information System (NWIS). NWIS is a distributed water data base in which data can be processed over a network of minicomputers at USGS offices throughout the United States (Maddy and others, 1991). All data used for analysis in this report now are stored in WATSTORE.

STORET is a computerized data-management information system maintained by the USEPA. STORET consists of several software modules that allow the user to store and retrieve data, use analytical programs to access and analyze data, and to transfer data to user written software or statistical packages. STORET contains information for more than 700,000 sampling sites throughout the United States with more than 130 million observations (Hoelman, 1989).

From 1974 to 1980, the U.S. Department of Energy NURE Program systematically evaluated the uranium resources of the conterminous United States and Alaska. In 1984, the USGS assumed the responsibility for archiving and distribution of NURE data. Seven major types of NURE data are now available: (1) geological maps; (2) aerial radiometric data; (3) aeromagnetic data; (4) data from hydrogeochemical and stream-sediment sample analyses; (5) geochemical data from rock sample analyses; (6) radiometric data from borehole logging; and (7) evaluation data for resource estimates.

Water-quality data from four Federal and four State agencies were used for this retrospective analysis, representing a total of 83 surface-water sampling sites and 395 ground-water sampling sites. The data used in this report are summarized in table 5 by agency, the number of surface- and ground-water sampling sites, and the collection method and frequency of sampling.

Methods of Data Analysis

This section describes the methods of data analysis that were used in this report. These methods include treatment of censored data, descriptive statis-

Table 4. Major water-quality data sources available for the Ozark Plateaus study unit

Agency	Data collection purpose, type, and accessibility
	Federal agencies
National Park Service	Resources assessment in National Park Service lands; data are collected seasonally, in cooperation with the U.S. Geological Survey and universities; data include organic and coliform bacteria; data are computerized, some in WATSTORE; some streamflow data available.
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/or WATSTORE.
U.S. Department of Energy	NURE Program; assess uranium resources of the Nation; data are computerized, all data are inorganic; some data available on well location, depth, and casing length.
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. Forest Service	Resource assessment in National Forest lands; some data are computerized, some are paper files only; data include inorganic and biological analyses and results of dye-tracing tests; some information available on streamflow.
U.S. Geological Survey	Water-resources assessment and research; limited monitoring network for surface- and ground-water quality; inorganic and some organic data; all data are computerized in WATSTORE including some State agency data; information on streamflow and well construction available.
	Arkansas agencies
Arkansas Department of Health	Monitoring of public water-supply system; most samples collected after treatment, although some raw water sampled; samples analyzed for inorganic, organic, radiochemical, and biological constituents; most data in paper files, although will soon be computerized; no streamflow data.
Arkansas Department of Pollution Control and Ecology	Regulatory monitoring of 110 surface-water sites statewide; samples analyzed for inorganic compounds with some pesticide data and fish-tissue analysis for trace elements and organic compounds; data are computerized in WATSTORE and STORET; information available on streamflow.
Arkansas Geological Commission	Geologic mapping and mineral assessment with some water-resources research; data are collected in cooperation with the U.S. Geological Survey and are computerized; information available on well construction.
	Kansas agencies
Kansas Department of Health and Environment	Monitoring network of surface- and ground-water quality originally in cooperation with the U.S. Geological Survey, but in-house since 1990; 20 years of records, virtually all data in STORET; chemical and biological analyses for approximately 240 surface-water sites statewide, about 30 to 40 percent have streamflow data.
Kansas Department of Wildlife and Parks	Monitoring of surface-water quality; data include inorganic analyses; data are published, but not computerized.
Kansas Geological Survey	Geological investigations and limited ground-water resources research; data are computerized; information available on well construction, particularly for wells drilled after 1975.

Table 4. Major water-quality data sources available for the Ozark Plateaus study unit—Continued

Agency	Data collection purpose, type, and accessibility
	Missouri agencies
Missouri Department of Conservation	Monitoring contaminants in fish; analysis of fish tissue for organic compounds, lead, cadmium, and mercury; samples collected at between 75 to 125 sites statewide; large volume of data, only some are computerized.
Missouri Department of Health	Regulatory monitoring of ground-water quality; data include coliform bacteria analyses on private wells statewide and nitrate and pesticide analyses in west-central Missouri; also some tritium analyses; data are collected in cooperation with the U.S. Geological Survey and are computerized; information available on well construction.
Missouri Department of Natural Resources - Division of Environmental Quality	Regulatory and some ambient monitoring; data include chemical, radiochemical, and microbiological analyses of community and non-community water-supply wells; analyses of stream water quality done in cooperation with the U.S. Geological Survey; surface-water and microbiological data are computerized, ground-water data are being computerized; information on well construction available mostly for wells drilled after 1975.
Missouri Department of Natural Resources - Division of Geology and Land Survey	Geologic and water-resources research generally site specific; inorganic and some pesticide analyses; some data are computerized, some only in paper files; information on well construction includes drillers' logs for about 30,000 wells statewide, some are computerized.
	Oklahoma agencies
Oklahoma Conservation Commission	Regulatory and ambient monitoring, as well as prioritization of basins for cost-share assistance; data include nutrients, specific conductance, pH, and dissolved oxygen, with some biological data on fish, periphyton, and algae; data are computerized in STORET and WATSTORE.
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 sites are water-supply systems with samples collected after treatment; ground-water samples generally are raw; analyses include inorganic, and some fish tissue, sediment, and pesticide; some streamflow information is available; well construction information is available from the Oklahoma Water Resources Board.
Oklahoma Geological Survey	All water-quality work done in cooperation with the U.S. Geological Survey; all data are computerized; information on well-site characteristics and construction available on most sampling sites.
Oklahoma Scenic River Commission	Monitoring ambient water quality of the Illinois, Flint, and Baron Fork Rivers; analyses include nutrients, suspended solids, chloride, sulfate, hardness, turbidity, and chemical oxygen demand; all data in STORET.
Oklahoma Water Resources Board	Monitoring network to establish trends and set water-quality standards; 300 wells statewide; all data in STORET; analyses primarily include inorganic compounds; well construction information available as supplied from drillers' logs.

tics (illustrated by boxplots), hypothesis tests, time-series plots, and load estimation.

Treatment of Censored Data

Limitations in laboratory analytical techniques and equipment determine the lower limit below which constituent concentrations cannot be accurately determined or reported. When the actual concentration is less than this lower limit, the concentration is reported as less than the detection limit or minimum reporting level of the analytical method. Some of the data reported in this analysis as less than a certain concen-

Table 5. Summary by agency of the number of sites, collection methods, and frequency of water-quality samples used for analysis in this report

[GB, grab; M, monthly; D, daily; NA, not applicable; U, untreated water samples; EWI, equal width increment; PD, project dependent frequency; T, treated water samples; B-M, bimonthly; W, weekly]

Agency	Surface-water samples			Ground-water samples		
	Number of sites	Collection method	Collection frequency	Number of sites	Collection method	Collection frequency
National Park Service	1	GB	M	0	NA	NA
U.S. Army Corps of Engineers	1	GB	M, D	0	NA	NA
U.S. Forest Service	0	NA	NA	Spring—3 Well—1	U	3-4 per year
U.S. Geological Survey	42	EWI	PD	Spring—61 Well—300	U	PD
Arkansas Department of Pollution Control and Ecology	30	GB	PD	Spring—11 Well—4	T	once every 5-6 years
Kansas Department of Health and Environment	2	GB	B-M, M	0	NA	NA
Missouri Department of Natural Resources	[1]0	NA	NA	Spring—6 Well—0	T, U	PD
Oklahoma Department of Environmental Quality	7	GB	M, W	Spring—8 Well—1	T	PD
Total number of sites analyzed	83			Spring—89 Well—306		

[1] Several of the U.S. Geological Survey sites were sampled in cooperation with the Missouri Department of Natural Resources.

tration may actually represent method detection limits rather than minimum reporting levels. In the following discussions, "detection limit" will be used to describe the lower limit of an analytical method. Data are considered censored if greater than 5 percent of the total number of data values are flagged as being less than a certain detection limit or as not detected. A particular constituent may have censored values with several different detection limits because analytical techniques differ among laboratories or have changed over time. How these censored data are handled in statistical analysis varies with each method. When dealing with censored values, the objective is to maximize information without losing statistical integrity. The specific treatment of censored data will be discussed in the descriptions of the individual statistical methods.

Assessment of Water-Quality Conditions

A relatively short and recent period from water years 1980–90 was chosen to assess current surface-water quality conditions because of potential time trends and to minimize the number of changes in detection limits through time. The 11-year period is short enough so that only in extreme cases would long-term time trends affect the overall description of current conditions. Nutrient concentrations are frequently at or less than detection limits, and in general, detection limits have been fairly consistent through the selected 11-year period. For ground water, a longer period (water years 1970–92) was used so that sufficient data would be available for analysis and interpretation. Water-quality conditions for surface and ground water were assessed using descriptive statistics and hypothesis tests.

Descriptive Statistics

Descriptive statistics were used to show the central tendency and variation in the water-quality data. The minimum, maximum, and the 10th, 25th, 50th (median), 75th, and 90th percentiles were calculated. The median was chosen to represent the central tendency of the data instead of the mean because the median is less sensitive to extreme values. The 25th and 75th percentiles provide more information on the central tendency and also variation of the data. The 10th and 90th percentiles provide information on the typical variation in the data because they exclude the extreme values in the lower and upper 10 percent of the data set. When summary statistics for individual surface-water sites were calculated, the percentiles for censored data were estimated using a log-probability regression procedure described by Gilliom and Helsel (1986) and Helsel and Cohn (1988). The estimated percentiles were not reported if there were fewer than five observations larger than the detection limit.

The distribution of selected nutrient concentrations for surface- and ground-water data was graphically displayed using side-by-side boxplots. A boxplot is a useful tool for visually examining the central tendency and variation of a group of data or for comparing two or more groups of data (Tukey, 1977). A boxplot is constructed by drawing a box from the 25th percentile to the 75th percentile. A horizontal line in the box depicts the median (50th percentile). In the truncated version of the boxplot used for this report, vertical lines (whiskers) are drawn from the box to the 10th and 90th percentiles. The top and bottom 10 percent of the data are excluded to avoid scale compression of the data by the extremes. Boxplots constructed for sites with censored data were modified by making the lower limit of the box equal to the detection limit. For sites with multiple-detection limits, the lower limit was set equal to the largest detection limit. If this detection limit was unusually large, the lower limit was set to the next largest detection limit to avoid losing important data.

Hypothesis Tests

The nonparametric Kruskal-Wallis analysis-of-variance test (Helsel and Hirsch, 1992) was used to test for differences in the distributions of two or more groups of data. The distributions of the groups are considered significantly different from one another if the probability (p-value) is less than 5 percent (<0.05) that the observed difference occurs by chance.

Analysis of Long-Term Trends

Data from selected sites were plotted as time series with a line of central tendency, or smooth, added. The smoothing technique used is called the LOWESS (LOcally WEighted Scatterplot Smoothing) procedure (Cleveland, 1979). The purpose of smoothing is to highlight trends or patterns in the data that are difficult to see when only data are plotted as scatterplots. The smoothed line is determined by the pattern of the data and may not be linear. Scatterplots and LOWESS allow a visual examination of trend patterns for sites with data available for different periods and illustrate patterns of similarity or variation in constituent concentrations between two or more surface- or ground-water sites. No statistical trend tests were performed for this report.

Estimation of Loads

Loads (the product of concentration times discharge) were estimated for total nitrogen, total phosphorus, and suspended sediment at selected surface-water sites in the study unit. Site selection criteria for load determinations were based on the sample collection method used and availability of continuous-streamflow data. All sites with continuous-streamflow data and water-quality samples collected using the depth- and width-integrated methods (described previously in the "Evaluation of Water-Quality Data" section) were identified. A subset (about 35 percent) of these sites was selected to represent a variety of basins of interest in the study unit. Because the loads of many constituents increase as streamflow increases, a large part of the annual load can be associated with the highest flows; therefore, it is important to estimate high-flow concentrations accurately. Loads were estimated only if four or more of the samples for a given constituent were collected at streamflows in the upper decile; that is, at flows that corresponded to daily mean flows that would be expected to be exceeded 10 percent or less of the time.

A load estimation method using the Minimum Variance Unbiased Estimator (described in Cohn and others, 1992) and log linear regression models was used to estimate annual mean loads. One of several log linear regression models based on concentration and streamflow data for water years 1980–90 was chosen for estimating loads during the same period. The model selected was chosen based on significance of variables, correlation coefficients, and residual analysis. Independent variables in the models include time, sine and cosine of time, and functions of streamflow.

CHARACTERISTICS OF WATER-QUALITY DATA

The distribution of water-quality data through space and time is an important factor when evaluating the significance of that data. Spatial and temporal distribution, site and basin characteristics, land use, ground-water site type (well or spring), and well depth are all important in assessing the representativeness and suitability of data for statistical summaries.

Spatial and Temporal Distribution of Surface-Water Quality Data

Nutrient and suspended-sediment data were available for more than 2,000 surface-water sites in the study unit. The location of the 83 sites selected to evaluate the water-quality conditions of the study unit for this report is shown in figure 3. Spatial distribution of the sites is not uniform; long-term water-quality sampling programs have not been conducted in the headwaters of streams draining several physiographic areas, such as the Salem Plateau, the St. Francois Mountains, and the Boston Mountains. However, the sites selected collectively represent a wide range of the physiography and major land uses present in the study unit.

Site and basin characteristic information for the 83 surface-water sites is shown in table 6, at the back of this report. Drainage areas of the streams for these sites range from 35 mi^2 (Butler Creek near Sulphur Springs, Ark., site 62) to 14,500 mi^2 (Osage River below St. Thomas, Mo., site 9). The frequency of sample collection generally was monthly or bimonthly for most of the sites.

A site type was assigned to each site based on physiography and land use, or proximity to a STP. Integrator sites have basins that have heterogeneous physiography or land use or both and integrate the effects of a variety of natural or anthropogenic factors affecting water-quality conditions. All other site types represent indicator sites, which have basins that have relatively homogeneous physiography and land use. The factors affecting water-quality conditions in these basins are more readily identifiable. Geographic Information Retrieval and Analysis System (GIRAS) land-use coverage data (U.S. Geological Survey, 1990) were used to determine the major land uses in each basin. Forest and agricultural land-use settings predominate throughout the study unit. Agricultural land use can be further subdivided into cropland, pasture, and forest/pasture mix (greater than one-third but less than two-thirds pasture), to reflect the different agricultural practices in the Ozark Plateaus study unit. Poultry, cattle, and swine commonly are raised on these pastures. Other sites have been categorized as “STP sites” because of the close proximity of STP discharges.

The monthly distribution of sampling differs somewhat among agencies and sampling programs. For example, nitrite plus nitrate samples were collected at most sites on a somewhat uniform monthly or bimonthly schedule (fig. 4). The selected sites represent sampling programs conducted by Federal and State agencies and are generally characteristic of the 83 surface-water sites used in this analysis. A seasonal component to sampling at some locations is indicated by an increased frequency of sample collection. The increased sampling frequency at some sites during summer and early fall months is related to collection of samples during low-flow conditions. The larger number of samples collected during May, August, and December at the White River at Beaver Dam near Eureka Springs, Ark. (site 22), is related to the triannual frequency of sample collection.

Streamflow conditions frequently affect the concentration of constituents in rivers and streams. To accurately represent water-quality conditions at a particular location, water-quality samples should be collected during a variety of streamflow conditions. The number of samples of a representative constituent, total phosphorus, collected under different discharge conditions at selected surface-water sites in the study unit during water years 1980–90 is shown in figure 5. The sites for which data are shown in figure 5, all of which had continuous record streamflow information, represent several Federal and State agencies and generally are characteristic of other sites for which continuous discharge information is available. Discharge conditions are grouped in categories of deciles of daily mean discharge. For example, discharges in the first decile (10 percent) category represent low flows; these discharges were exceeded 90 percent of the time during water years 1980–90. The sites shown in figure 5 generally were sampled throughout the complete range of discharge conditions, although specific deciles for some sites might have fewer samples than expected for an ideal statistical distribution. For example, 79 total phosphorus samples were collected from the Osage River below St. Thomas, Mo. (site 9), dur-

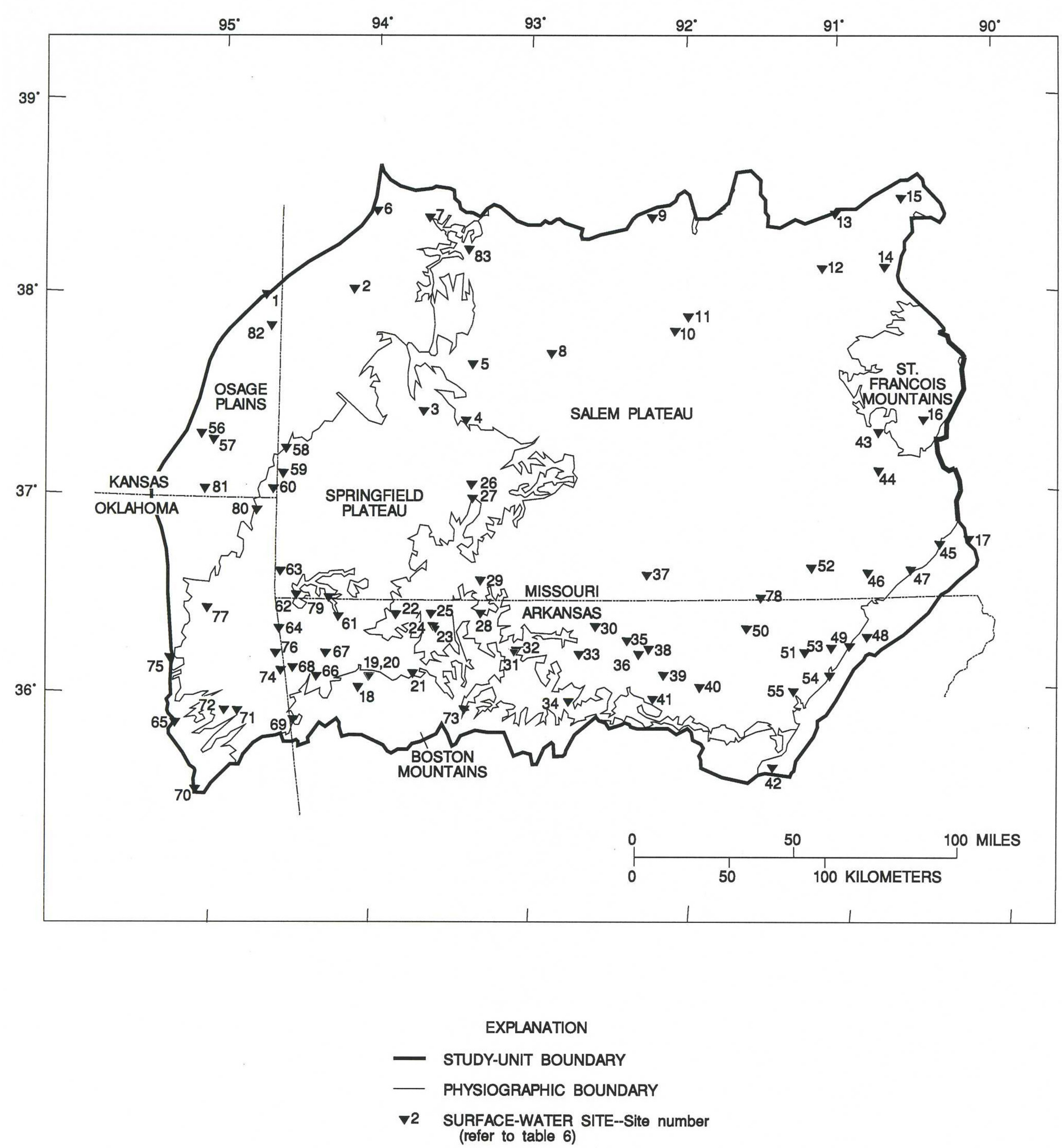

Figure 3. Location of selected surface-water sites with nutrient and suspended-sediment data.

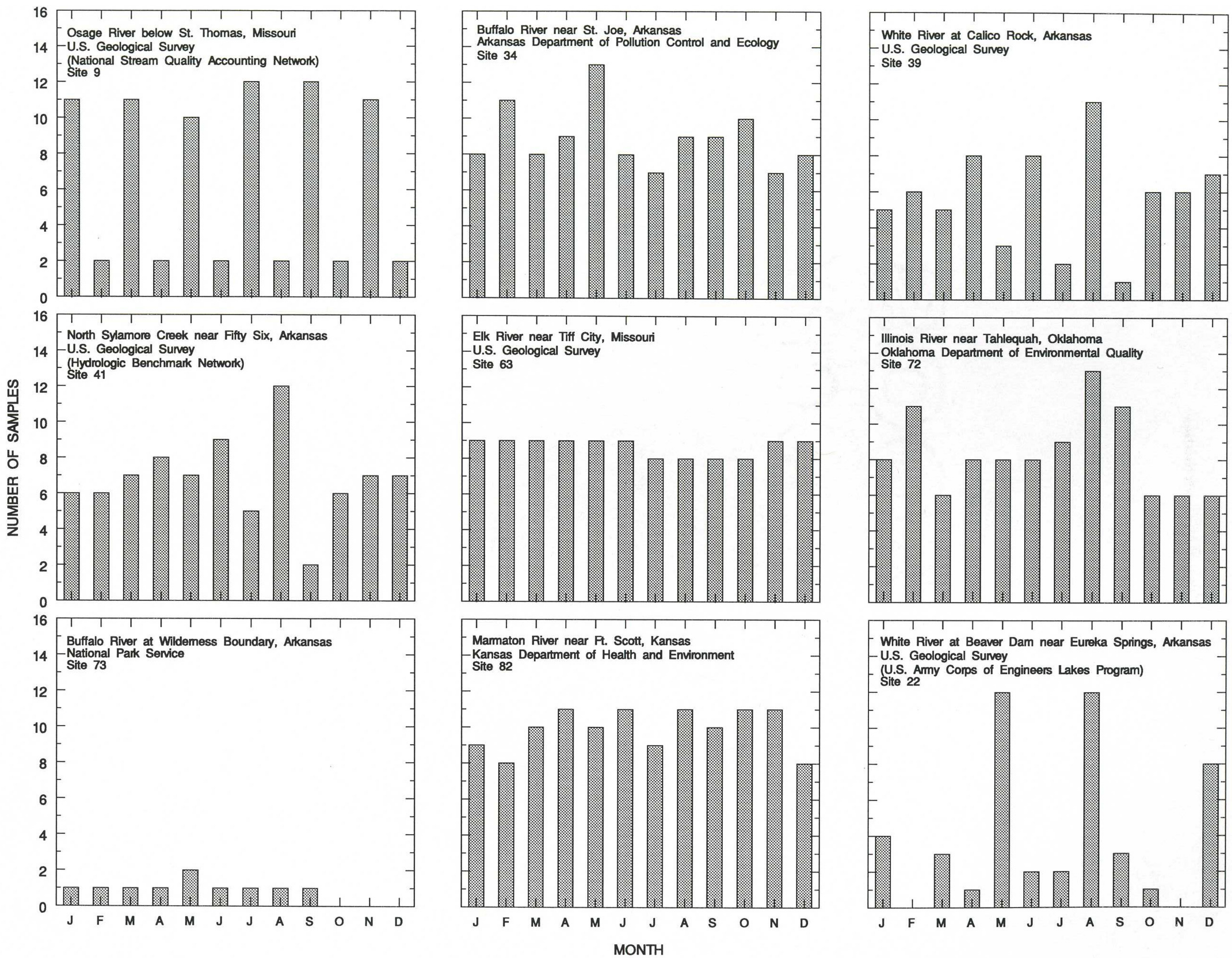

Figure 4. Monthly distribution of samples collected and analyzed for nitrite plus nitrate at selected surface-water sites for water years 1980-90.

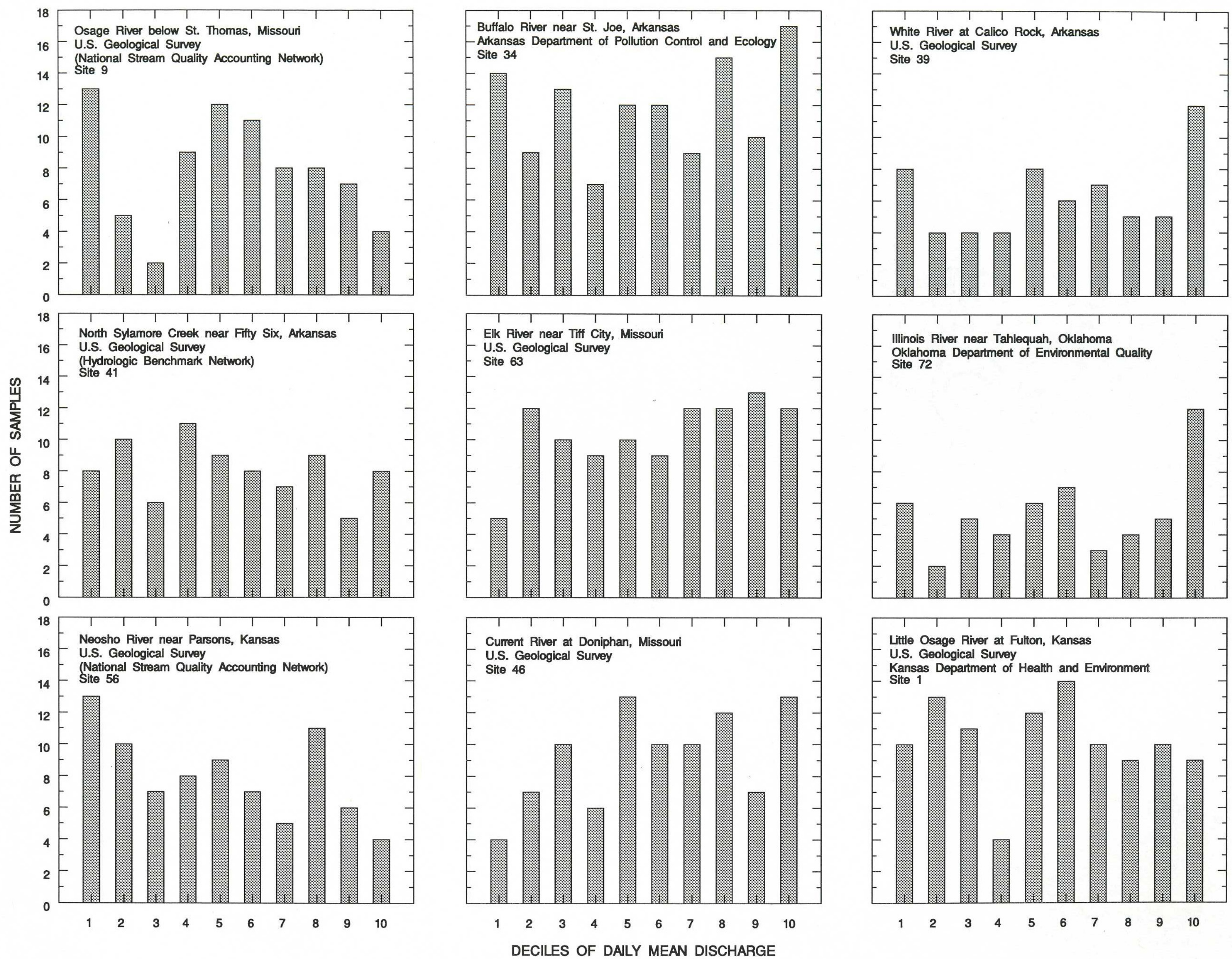

Figure 5. Number of samples for total phosphorus within deciles of daily mean discharge for water years 1980-90.

ing water years 1980–90. Ideally, the 79 samples would have been distributed evenly in each decile category, but the third decile (20–30 percent) category was sampled only two times.

Spatial and Temporal Distribution of Ground-Water Quality Data

The number of ground-water samples from each hydrogeologic unit used in the data set for this report is related to the unit's relative size and importance as a source of water (table 7; figs. 6 and 7). For example, ground-water samples were collected most frequently from the Ozark aquifer. The Ozark aquifer is areally extensive and used across the study unit, even in places where the aquifer is confined by a thick sequence of overlying rocks.

In general, the land use (agriculture, forest, and urban) for each ground-water sampling site was determined from the GIRAS land-use coverage (U.S. Geological Survey, 1990). Most of the sites were identified in areas of agricultural and forested land use. The number of ground-water sites in each land use (fig. 8) is approximately proportional to the amount of a particular land-use setting in each hydrogeologic unit. For example, the predominant land-use setting in the Western Interior Plains confining system is agricultural; therefore, most of the ground-water sites from this hydrogeologic unit are located in areas of agricultural land use. Most water samples from within the Ozark aquifer are from deep (mostly greater than 500 ft) public-supply wells. Although the land use adjacent to these public-supply wells has been identified as urban, the aquifer probably is recharged in forested or agricultural land that surrounds most of these communities.

The number of water samples collected from spring and well site types in each aquifer is related to hydrogeology and use (fig. 8). For example, the data set contains no water samples collected from springs in the Mississippi River Valley alluvial aquifer because few springs issue from the unconsolidated sediments that constitute that aquifer. By contrast, in the Springfield Plateau aquifer, the number of water samples collected from springs is greater than the number from wells because springs are abundant, are readily available to sample, and are locally an important source of water.

The number of ground-water samples collected from the confined and unconfined hydrogeologic types is related to geology and use (fig. 9). For example, a large number of wells are completed in the confined parts of the Springfield Plateau and Ozark aquifers because those units are overlain in places by a thick sequence of rock. In contrast, few wells are completed in confined parts of the St. Francois aquifer. The Western Interior Plains confining system and the Mississippi River Valley alluvial aquifer are not confined in the study unit.

The ground-water samples are not evenly distributed throughout the period of record from 1970–92 (fig. 9). The largest number of samples were collected in 1970 and the smallest in 1984. Similar to the spatial distribution of ground-water sites, the uneven temporal distribution of ground-water quality data is a consequence of numerous local-scale hydrologic investigations for which data were collected during a relatively short, 2- to 3-year, period.

The depths of wells used here ranged from 5 to 3,420 ft below land surface. Median well depth is 436 ft below land surface. Well depth generally is not a reliable indicator of the depth of the source of water in a well. Most wells in the study unit have a short section of surface casing (less than 50 ft) and an open borehole (no screened interval) that allows the well to obtain water from nearly the entire open section. Therefore, water samples collected from deep wells generally were a composite of water from the entire hydrogeologic unit or even from several units.

Statistical analyses indicate median well depths differ significantly among the five major hydrogeologic units (fig. 10). Median well depths are related to the depth and thickness of each hydrogeologic unit. For example, median well depths are greater in the Ozark and St. Francois aquifers than in the other hydrogeologic units because the Ozark and St. Francois aquifers are relatively thick in the study unit and are used in areas where they are overlain by a thick sequence of confining rock. In contrast, the Western Interior Plains confining system and Mississippi River Valley alluvial aquifer are present in relatively thin surficial deposits in the study unit; therefore, median depths of wells completed in these two units are less than in the other hydrogeologic units.

Median depth of wells is greatest in the urban land-use setting compared to forest and agricultural land-use settings (fig. 10). The wells in the urban land-use setting primarily are for public supply and are drilled relatively deep and often penetrate several geologic units to provide an adequate water supply.

Table 7. Number of ground-water samples, by hydrogeologic unit, used in data analysis

Hydrogeologic unit	Abbreviation	Number of samples	Percent
Mississippi River Valley alluvial aquifer	ALVM	20	5.1
Ozark aquifer	OZAQ		
Confined		81	20.5
Unconfined		131	33.2
St. Francois aquifer	SFAQ	11	2.8
Springfield Plateau aquifer	SPAQ		
Confined		29	7.3
Unconfined		74	18.7
Western Interior Plains confining system	WIPC	49	12.4
Total		395	100.0

Median well depths are greater in the confined parts of the Springfield Plateau and Ozark aquifers as compared to those in the unconfined parts of the same hydrogeologic unit (fig. 10). Wells completed in the confined parts of the Springfield Plateau and Ozark aquifers are drilled deep to penetrate a thick sequence of overlying confining rocks to reach the more productive confined aquifer.

WATER-QUALITY CONDITIONS

Water quality is affected by physiography, geology, land use, and other natural and human factors. The relation between water quality and selected factors is discussed in the following sections.

Surface Water

The factors affecting nutrient and suspended-solids concentrations in surface water were determined by analyzing the relation of water quality with various basin characteristics using the techniques described in the section "Methods of Data Analysis." Data for water years 1980–90 for individual stream sites were combined based on physiography and land-use setting or site type (table 6). Water-quality differences within a physiographic area with multiple land-use settings and between physiographic areas with forested or agricultural land-use settings were considered. Because of the availability of data for only a small group of sites in the Boston and St. Francois Mountains, the results of these analyses may not always be representative of these physiographic areas. For selected nutrients, concentrations for indicator basins were compared to concentrations for integrator basins later in this section.The relation between selected nutrient concentration and stream discharge also was determined. Summary statistics for each of the 83 surface-water sites are listed in table 8, at the back of this report.

Nutrients

The nutrient species analyzed included nitrite plus nitrate, ammonia, total ammonia plus organic nitrogen, total nitrogen, total phosphorus, and orthophosphate. Summary statistics of the nutrient data for all indicator basins (table 6) grouped by physiography and land-use setting are listed in table 9, at the back of this report, and figures 11 to 16.

Nitrite Plus Nitrate

Nitrite plus nitrate concentrations differed significantly among samples for streams draining basins with different land-use settings within the five physiographic areas (fig. 11 and table 9). In all cases, concentrations at STP sites were significantly larger than at any other type of site. Within the Boston Mountains and Springfield and Salem Plateaus, nitrite plus nitrate concentrations increased significantly with more intense land-use activities (from forest to forest/pas-

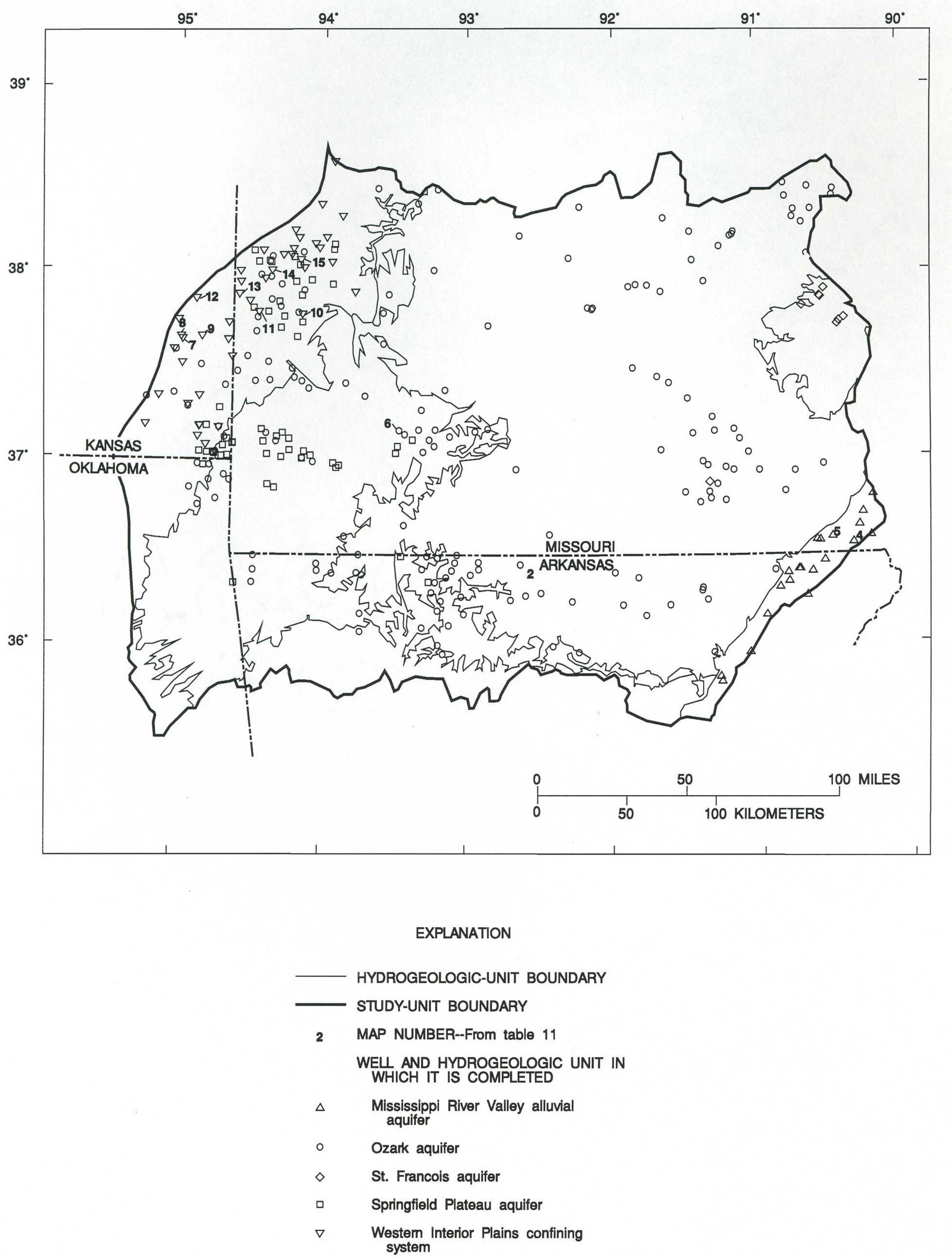

Figure 6. Location of wells used in data analysis.

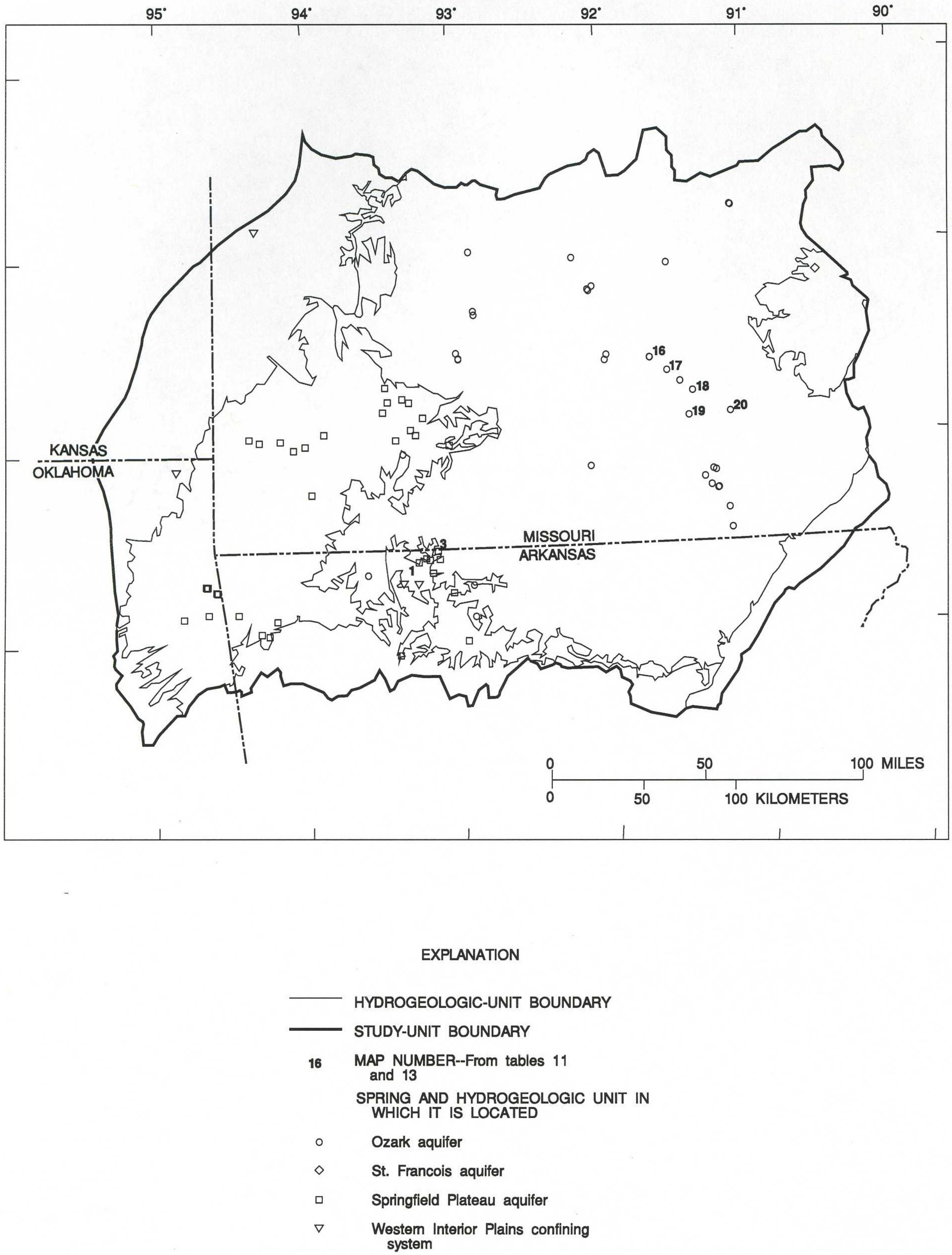

Figure 7. Location of springs used in data analysis.

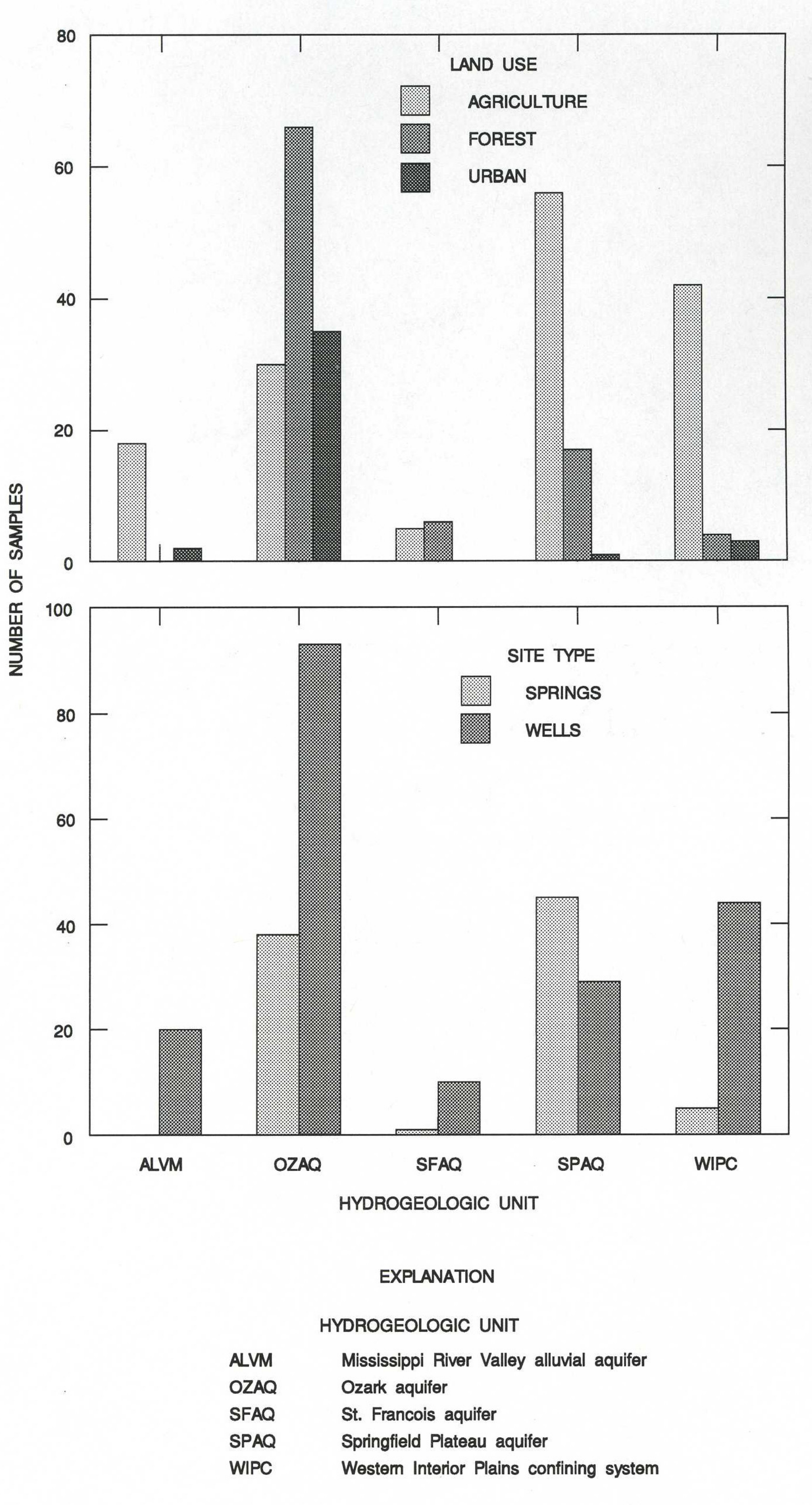

Figure 8. Number of ground-water samples, by land use and site type, used in data analysis.

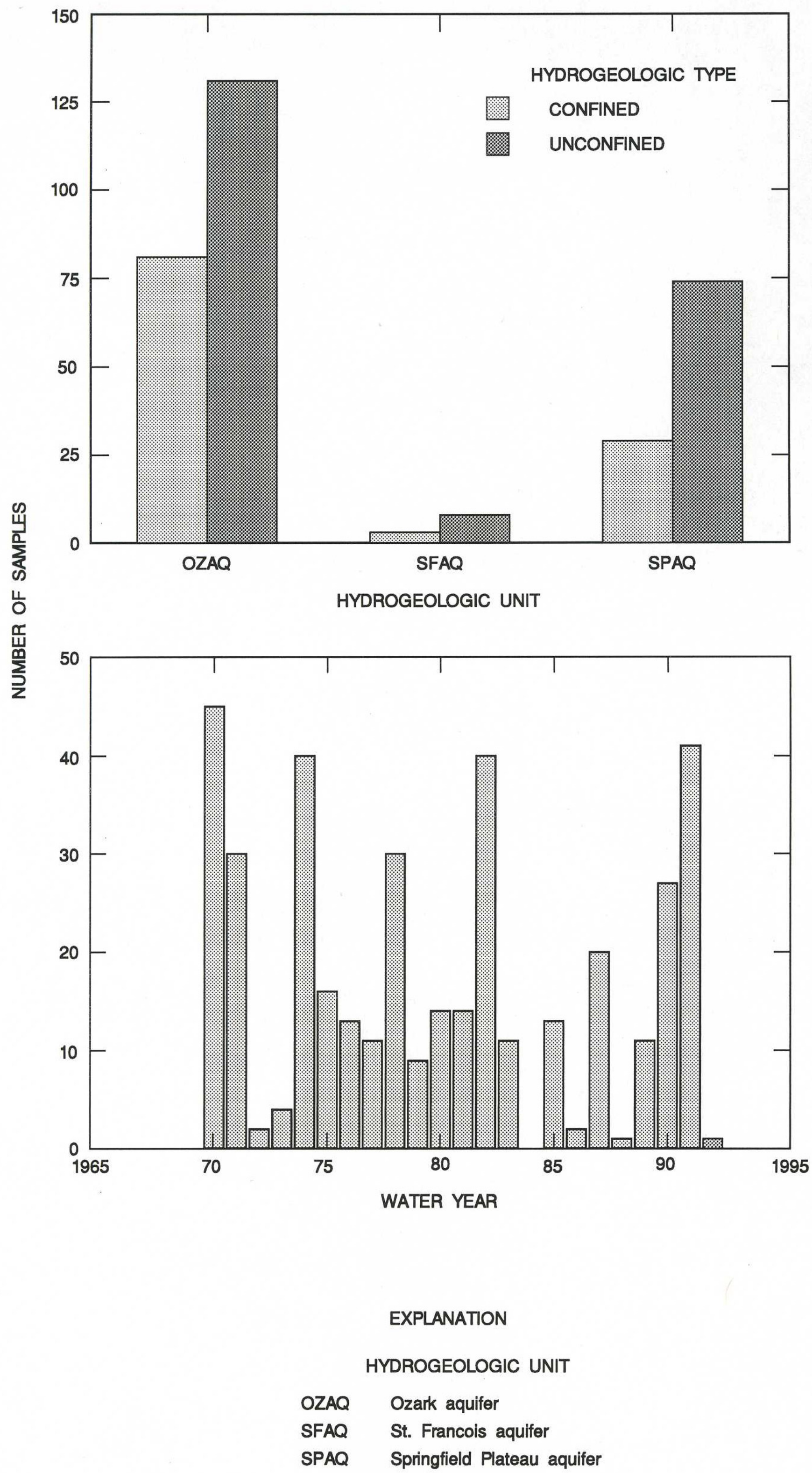

Figure 9. Number of ground-water samples by confined and unconfined aquifers and temporal distribution.

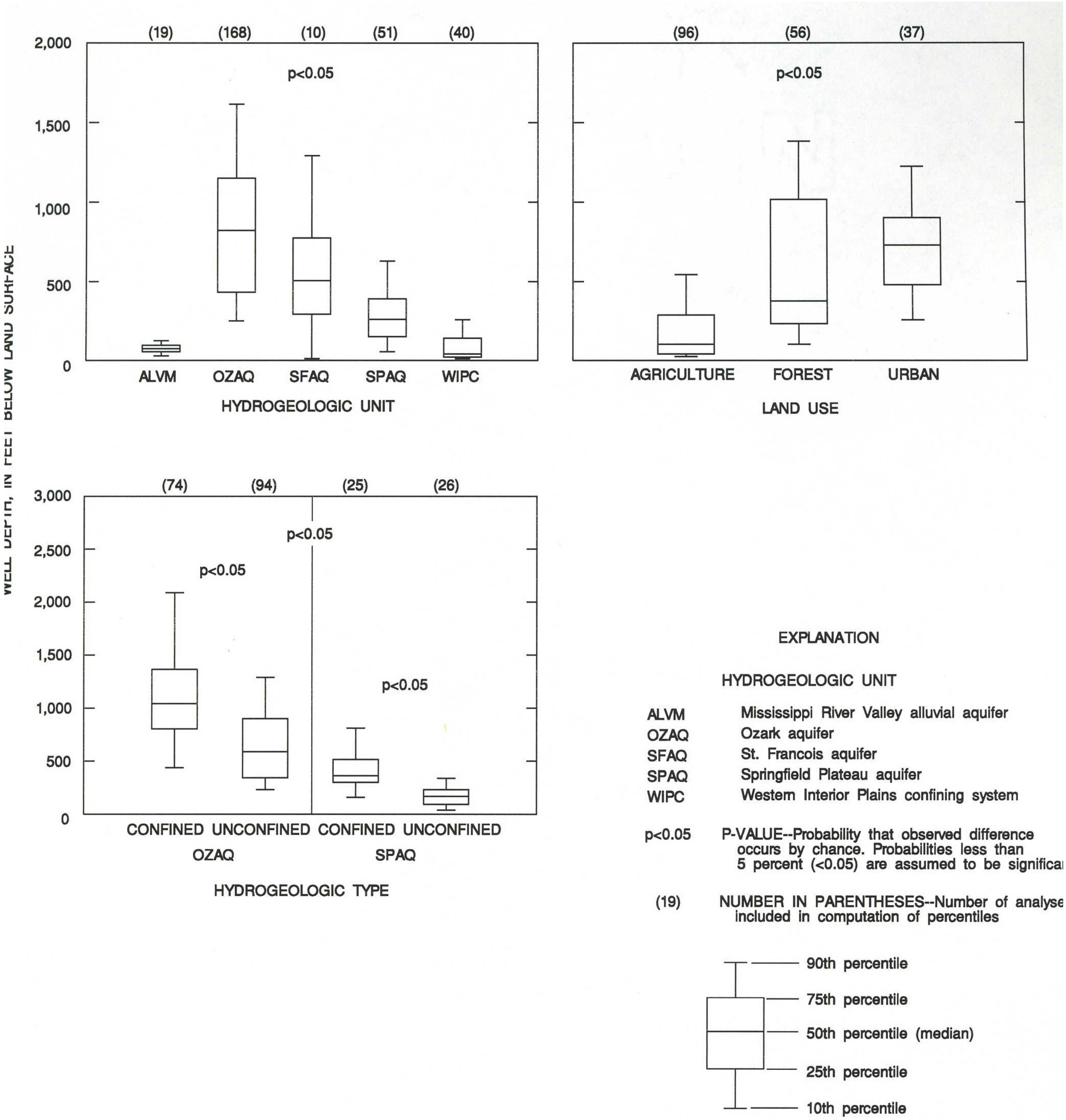

Figure 10. Statistical distribution of well depth.

ture mix to pasture), indicating a strong association between percent pasture and nitrite plus nitrate concentrations. With the exception of the STP sites, the largest concentrations were in samples from streams draining Springfield Plateau forest/pasture mix and pasture sites, where some of the largest densities of poultry, cattle, and swine in the study unit are located.

Significant differences in nitrite plus nitrate concentrations also occurred between samples from forested and agricultural basins in different physiographic areas (fig. 11). Concentrations were smallest at forested sites in the Springfield Plateau. Differences between the Springfield and Salem Plateaus forested sites would not be expected, but in this case, the 2 basins representing Springfield Plateau forested land use are 85 percent or more forested as compared with the 11 Salem Plateau sites, which may be as much as 33 percent pasture. Wasteloads can be expected to increase as forest lands are converted to pasture. Concentrations from the forested Boston Mountains sites were elevated relative to the other physiographic areas. The Salem Plateau forest/pasture mix sites had smaller nitrite plus nitrate concentrations than Osage Plains cropland sites, and both had concentrations significantly smaller than either of the Springfield Plateau agricultural land-use settings.

Ammonia

Ammonia concentrations, like nitrite plus nitrate concentrations, were significantly larger in samples from STP sites in all of the physiographic areas (fig. 12 and table 9). Ammonia concentrations for sites in the Springfield and Salem Plateaus generally increased significantly with more intense land-use activities, with the exception of samples from sites in the Springfield Plateau forest/pasture mix. Ammonia concentrations were significantly larger than those from basins where pasture is the dominant land use.

When comparing forested land use among four of the physiographic areas, only samples from the Boston Mountains forested sites had significantly larger ammonia concentrations (fig. 12). Most of the samples representing the Boston Mountains forested site type were collected at one site on the West Fork White River east of Fayetteville, Ark. (site 18; table 9). The land use in this basin is primarily forested. However, a substantial amount of pasture occurs adjacent to the stream for 15 to 20 mi upstream of the site. An STP about 15 river miles upstream and urban nonpoint sources also probably contributed to the larger ammonia concentrations. Samples from the Salem Plateau forest/pasture mix agricultural land-use sites generally had the smallest ammonia concentrations, and samples from the Osage Plains cropland sites had the largest.

Total Ammonia Plus Organic Nitrogen

Fewer total ammonia plus organic nitrogen data were available for all physiographic areas; therefore, fewer comparisons could be made. The patterns for total ammonia plus organic nitrogen were not as definite as those for nitrite plus nitrate and ammonia (fig. 13 and table 9). Samples from STP sites had significantly larger concentrations than samples from other land-use settings within the same physiographic area as with other species. Also, total ammonia plus organic nitrogen concentrations at sites in forested basins within the Springfield and Salem Plateaus were equal to or significantly smaller than concentrations at sites in basins with agricultural land use.

When comparing total ammonia plus organic nitrogen samples from basins with forested land use in different physiographic areas, the Springfield Plateau again had the smallest concentrations and the Boston Mountains the largest (fig. 13). Total ammonia plus organic nitrogen concentrations did not differ significantly among samples from basins with agricultural land uses in the Springfield and Salem Plateaus, but all of these concentrations were significantly smaller than concentrations in samples collected from streams in the Osage Plains cropland.

Total Nitrogen

The best indicator of nitrogen loads in a stream is the total nitrogen concentration because total nitrogen is the sum of all nitrogen species (nitrite, nitrate, ammonia, and organic nitrogen). Total nitrogen also is the preferred constituent to use for comparisons between land uses and physiographic areas; however, as with total ammonia and organic nitrogen, fewer total nitrogen analyses were available (table 9). Fewer analyses were available because total nitrogen generally is a calculated value and thus requires values for all species that contribute to total nitrogen concentrations. Because total ammonia plus organic nitrogen was not determined for many of the samples, total nitrogen values could not be calculated for these samples.

Samples collected from STP sites had the largest total nitrogen concentrations in the Boston Moun-

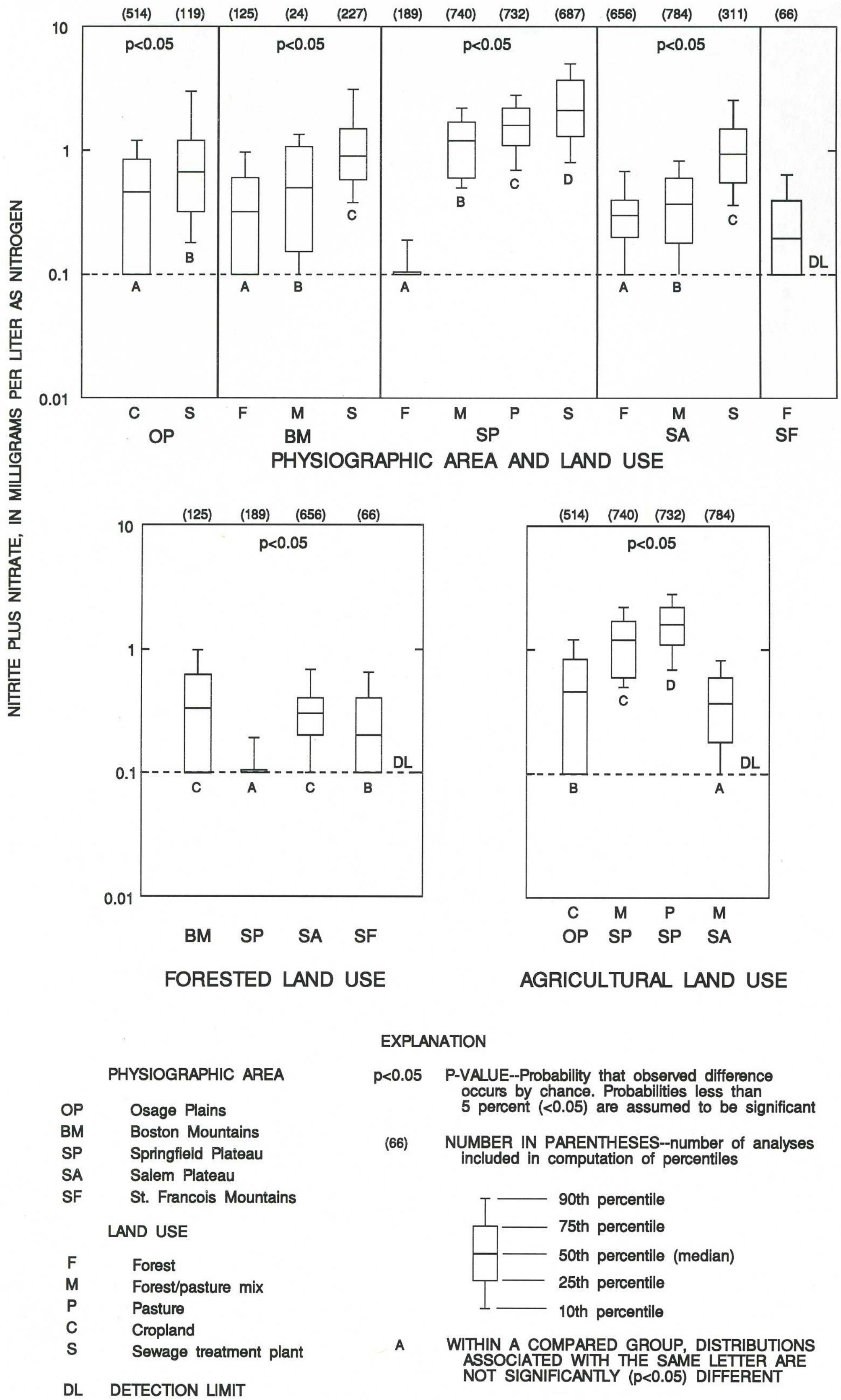

Figure 11. Statistical distribution of nitrite plus nitrate concentrations at surface-water sites for water years 1980-90.

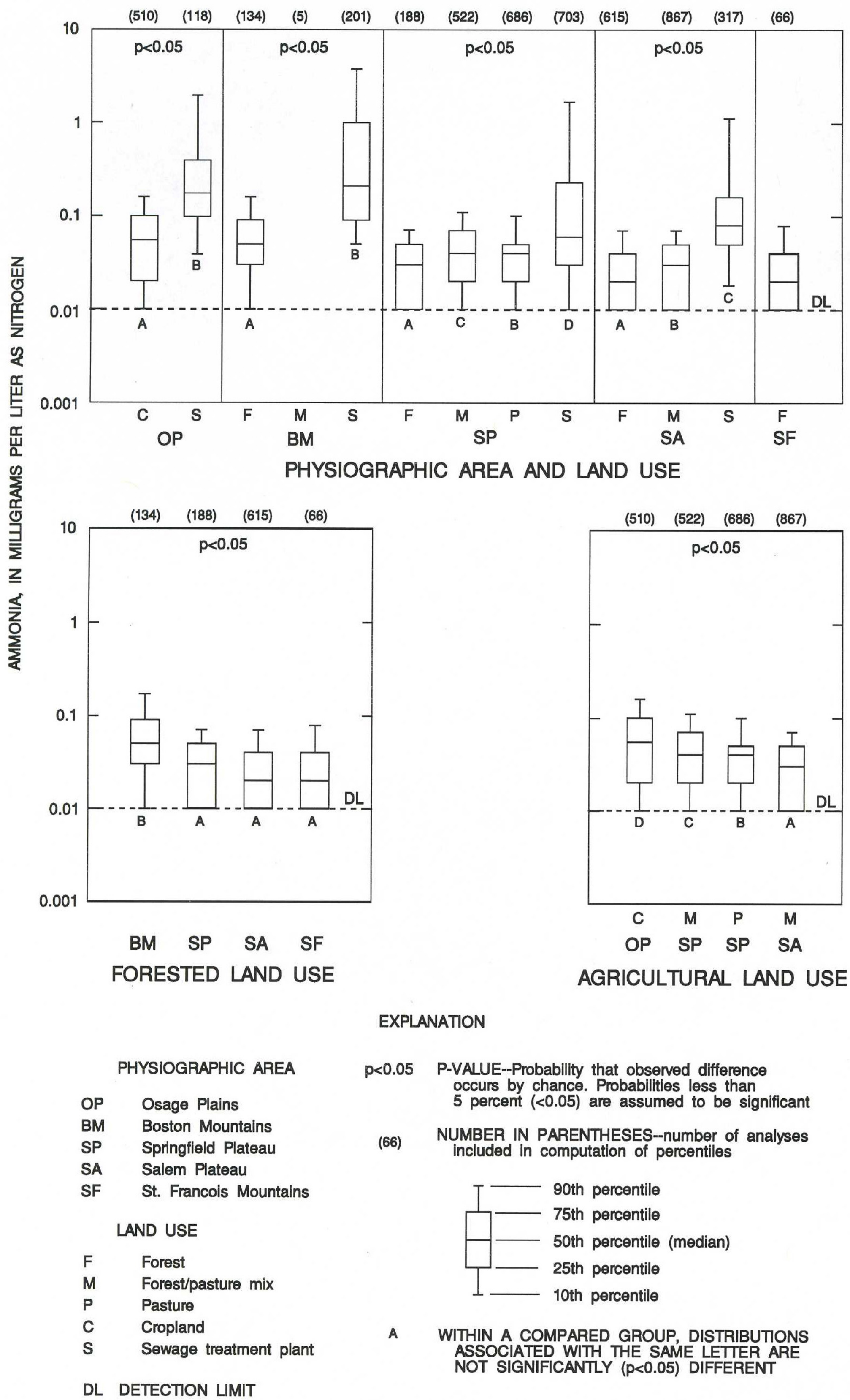

Figure 12. Statistical distribution of ammonia concentrations at surface-water sites for water years 1980-90.

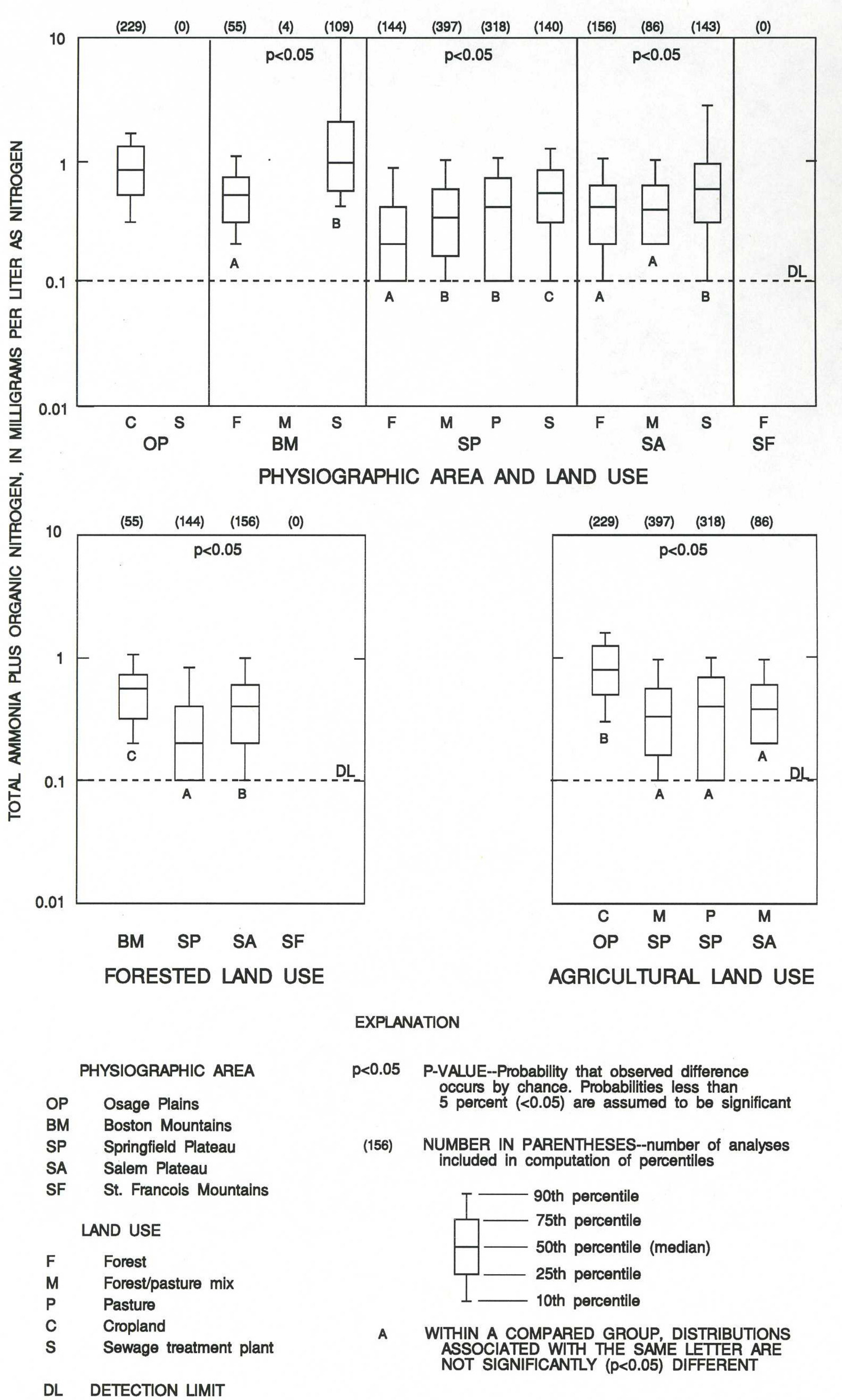

Figure 13. Statistical distribution of total ammonia plus organic nitrogen concentrations at surface-water sites for water years 1980-90.

tains and Springfield and Salem Plateaus (fig. 14). Within the Springfield Plateau, total nitrogen concentrations increased significantly with more intense land-use activities (from forest to forest/pasture mix to pasture). For samples from forested basins, the pattern seen with nitrite plus nitrate and total ammonia plus organic nitrogen was repeated.

Within agricultural basins, streams in the Salem Plateau forest/pasture mix land-use setting had the smallest total nitrogen concentrations, whereas streams in the Springfield Plateau pasture had the largest (fig. 14). In previous comparisons between samples collected from streams in agricultural areas in the Osage Plains and Springfield Plateau, samples from the Osage Plains cropland had the smallest nitrite plus nitrate concentrations and the largest ammonia and total ammonia plus organic nitrogen concentrations. Total nitrogen concentrations in the Osage Plains were significantly larger than the Salem Plateau forest/pasture mix but smaller than either of the Springfield Plateau agricultural land uses.

Total Phosphorus

Total phosphorus concentrations include phosphorus in solution and adsorbed to sediment particles. Total phosphorus concentrations differed significantly between streams in different land-use settings in the five physiographic areas (fig. 15 and table 9). As with the various nitrogen species, concentrations at STP sites were significantly larger than at sites from the other land-use settings. Within the Springfield Plateau, total phosphorus concentrations at sites in forested basins were significantly smaller than concentrations at sites in basins with agricultural land use. This difference did not occur in the Salem Plateau.

Significant differences in total phosphorus concentrations also occurred in samples from forested and agricultural land-use settings between the five physiographic areas (fig. 15). Concentrations were smallest for streams in forested parts of the Springfield Plateau. Total phosphorus concentrations in samples from the forested Boston Mountains probably were elevated relative to the other physiographic areas because of the adjacent pasture and the STP located upstream of one of the sites. Within agricultural basins, the Salem Plateau forest/pasture mix sites had the smallest total phosphorus concentrations, and the Osage Plains cropland and Springfield Plateau pasture sites had the largest. The larger concentrations in the Osage Plains could be related not only to agricultural land use but also to the substantially larger suspended-sediment concentrations in streams in the area.

Orthophosphate

Orthophosphate is the most common phosphorus ion detected in solution in natural waters. Orthophosphate analysis was not routinely done, and less data were available than for total phosphorus. Orthophosphate concentrations had virtually the same pattern as concentrations for total phosphorus for various land-use settings within the physiographic areas (fig. 16 and table 9), except that concentrations from Springfield Plateau pasture streams were significantly larger than those from the forest/pasture mix streams in the Springfield Plateau.

Patterns similar to those for total phosphorus also were seen for orthophosphate concentrations from forested and agricultural land-use settings between the five physiographic areas (fig. 16). An exception is that concentrations for Osage Plains cropland streams were significantly smaller than those from either of the agricultural land-use settings in the Springfield Plateau. These results support the idea that much of the phosphorus in the Osage Plains cropland streams was associated with sediment particles, whereas much of the phosphorus in the Springfield Plateau forest/pasture mix and pasture streams was in solution as orthophosphate.

Suspended Sediment and Suspended Solids

Because of differences in collection and analytical methods, suspended-sediment data are considered to be more accurate than suspended-solids data as an indicator of actual stream concentrations of inorganic material. Only 14 of the 83 sites had suspended-sediment data, so suspended-solids data were used here.

Suspended-solids concentrations were largest in the Osage Plains because of easily erodible soils and intensive field- and row-crop agriculture (fig. 17 and table 9). The slightly larger concentrations in the Boston Mountains, as compared to the Springfield and Salem Plateaus and St. Francois Mountains, may be the result of the availability of data for only a small group of possibly unrepresentative sites in the Boston Mountains. Suspended-solids concentrations differed significantly among samples from different land-use settings in the Springfield and Salem Plateaus; concentrations increased with more intense land-use activities (from forest to forest/pasture mix to pasture). Concen-

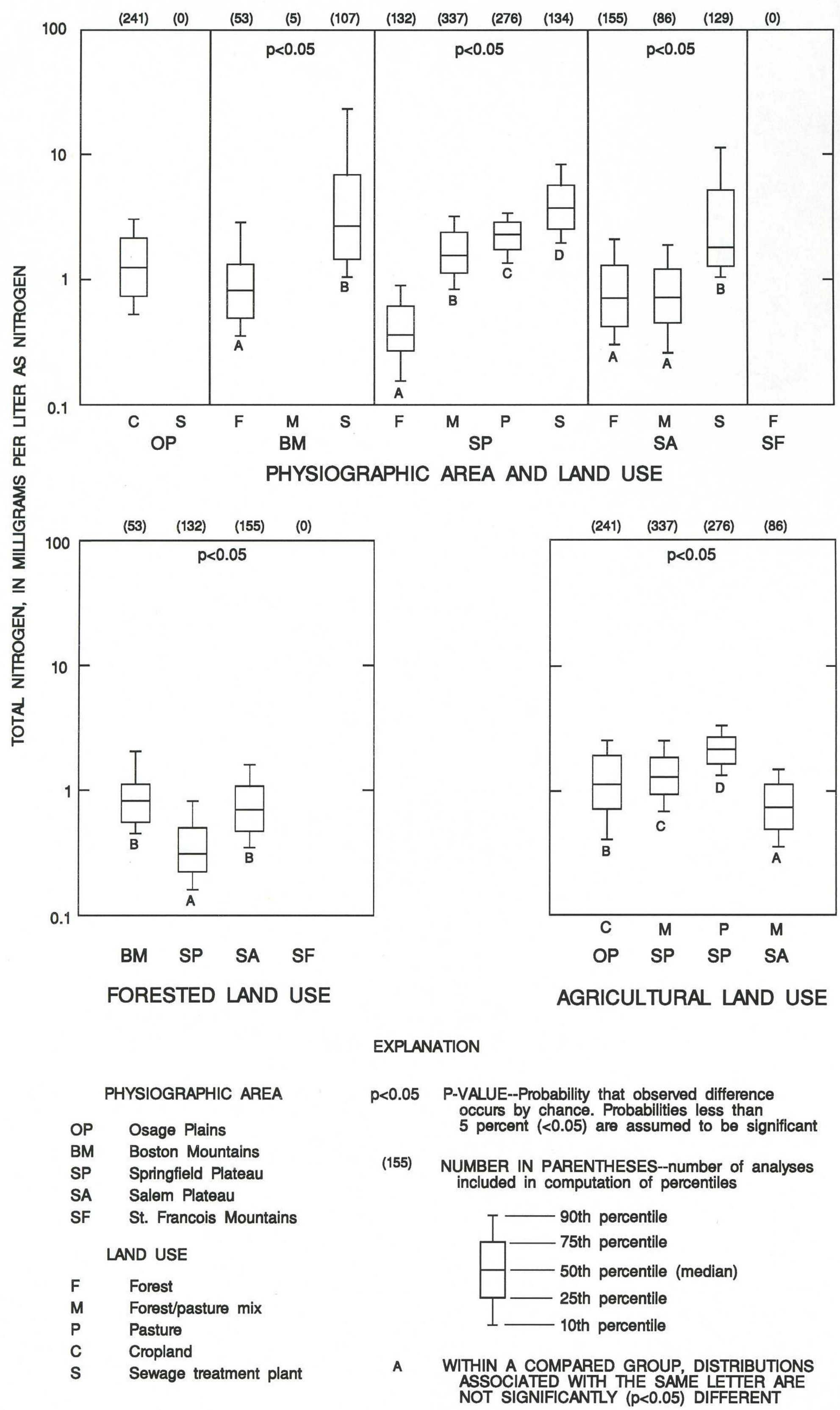

Figure 14. Statistical distribution of total nitrogen concentrations at surface-water sites for water years 1980-90.

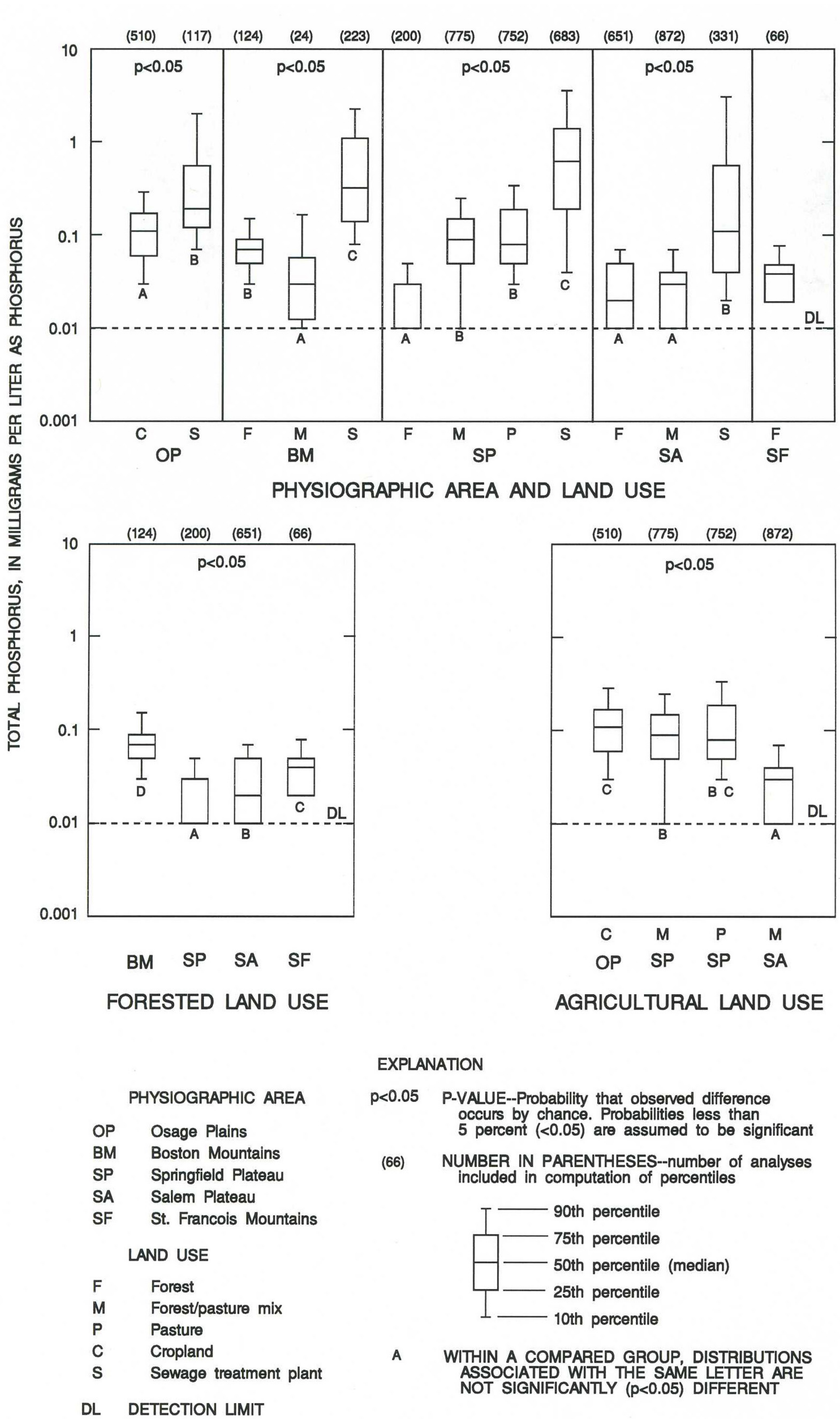

Figure 15. Statistical distribution of total phosphorus concentrations at surface-water sites for water years 1980-90.

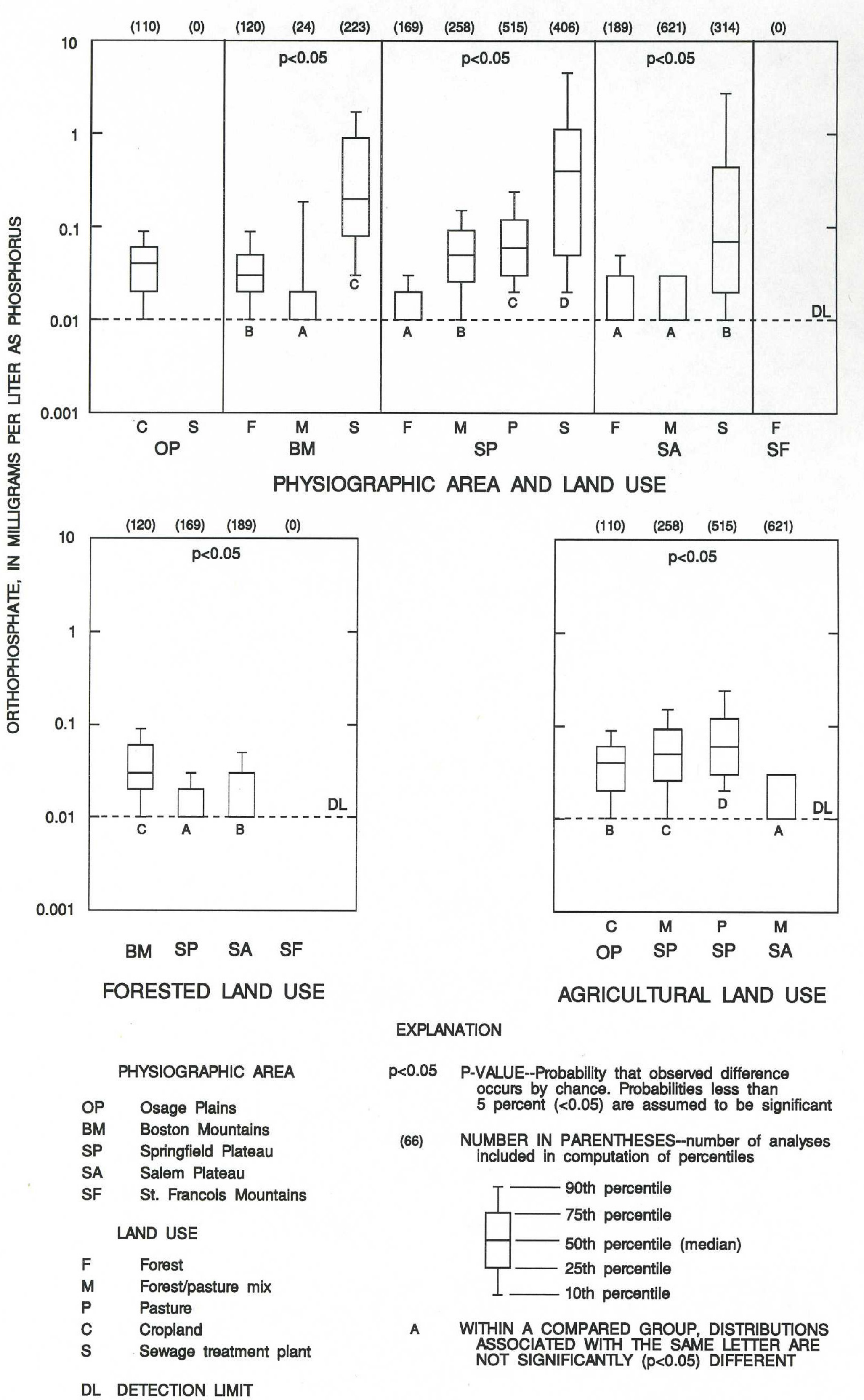

Figure 16. Statistical distribution of orthophosphate concentrations at surface-water sites for water years 1980-90.

trations in the samples from STP sites are most likely related to land-use activities in the basin and not from STP effluents.

Significant differences in suspended-solids concentrations also occurred among samples from forested and agricultural basins in the five physiographic areas (fig. 17). Concentrations were significantly larger in the Salem Plateau and St. Francois Mountains than in the Springfield Plateau probably because of the larger percentage of pasture in the basins of available sites in these two forested regions. Suspended-solids concentrations in samples collected at Springfield Plateau pasture sites and at Salem Plateau forest/pasture mix sites did not differ, but they were both significantly larger than the concentrations in samples collected at Springfield Plateau forest/pasture mix sites. The reason for the difference within the Springfield Plateau can be attributed to increased land disturbance from forest/pasture mix to pasture.

Comparison of Indicator and Integrator Sites

Indicator sites were chosen to represent specific land-use settings, such as forested, forest/pasture mix, pasture, and STP, within a specific physiographic area. To be designated an indicator site, a basin had to have relatively homogeneous land use and physiography. Integrator sites had more heterogeneous land use and physiography. Median nutrient concentrations at integrator sites in general were intermediate between the observed median concentrations at upstream indicator sites (tables 8 and 9), because the water quality at integrator sites was partially determined by the mixing of water coming from these basins. Three basins—the Meramec River, the Osage River, and the White River—were chosen for comparison of nitrite plus nitrate and total phosphorus concentrations at indicator and integrator sites (figs. 18 and 19) because these basins represent a wide variety of conditions. The hydrologic, chemical, and biological processes occurring in these three basins represent processes in the other major basins of the study unit.

Meramec River

The Meramec River is not regulated by reservoirs and lies within the St. Francois Mountains and Salem Plateau (fig. 1). The upper Meramec River Basin (site 12) is primarily forested and lies within the Salem Plateau. Major basins within the Meramec River Basin include the Bourbeuse River Basin (site 13), which lies in the Salem Plateau and has a forest/pasture mix land-use setting, and the Big River Basin (site 14), which lies in the St. Francois Mountains and Salem Plateau and is primarily forested (table 6, fig. 3). Historically, lead and zinc mining occurred in the basin. Median nitrite plus nitrate concentrations were largest at the site in the Bourbeuse River Basin, which probably has the most agricultural activity in the Meramec River Basin, and smallest at the downstream integrator site (site 15), which indicates a dilution effect (fig. 18). Median total phosphorus concentrations at the integrator site (site 15) were intermediate between concentrations for samples from the two forested sites (sites 12 and 14) and the forest/pasture mix site (site 13, fig. 19). Variations in water quality at these sites within the Meramec River Basin can be attributed mostly to land-use differences rather than physiography or stream regulation.

Osage River

The Osage River Basin lies within the Osage Plains and Springfield and Salem Plateaus physiographic areas (fig. 1). The Osage River and its major tributaries are regulated by several dams on the main stem, including two dams on the Osage River in Missouri, one dam on the Pomme de Terre River, and one dam on the Sac River. The indicator sites in the basin represent multiple land-use settings within different physiographic areas including: Osage Plains cropland (sites 1, 2, and 6), Springfield Plateau pasture (site 3), and Salem Plateau pasture, forest/pasture mix, and forest (sites 5, 8, and 10; table 6, fig. 3). Although site 10 (Big Piney River at Devil's Elbow) is not actually in the Osage River Basin, the quality of water for the Big Piney River, a tributary of the Gasconade River, was representative of the water quality for similar streams in the Osage River Basin.

Median concentrations of nitrite plus nitrate were largest at stream sites in the basins with agricultural land use (sites 1, 2, 3, 5, 6, and 8) and decreased at the Salem Plateau forested and integrator sites (sites 9, 10, and 83; fig. 18). The smaller median concentration at site 83 (Osage River below Truman Dam at Warsaw, Mo.), the first integrator site, probably was related to the location of the site below a major reservoir and the storage of relatively dilute water within the reservoir. The median nitrite plus nitrate concentration at the second integrator site (site 9, Osage River below St. Thomas, Mo.) was equal to the median concentration at site 83 but smaller than the

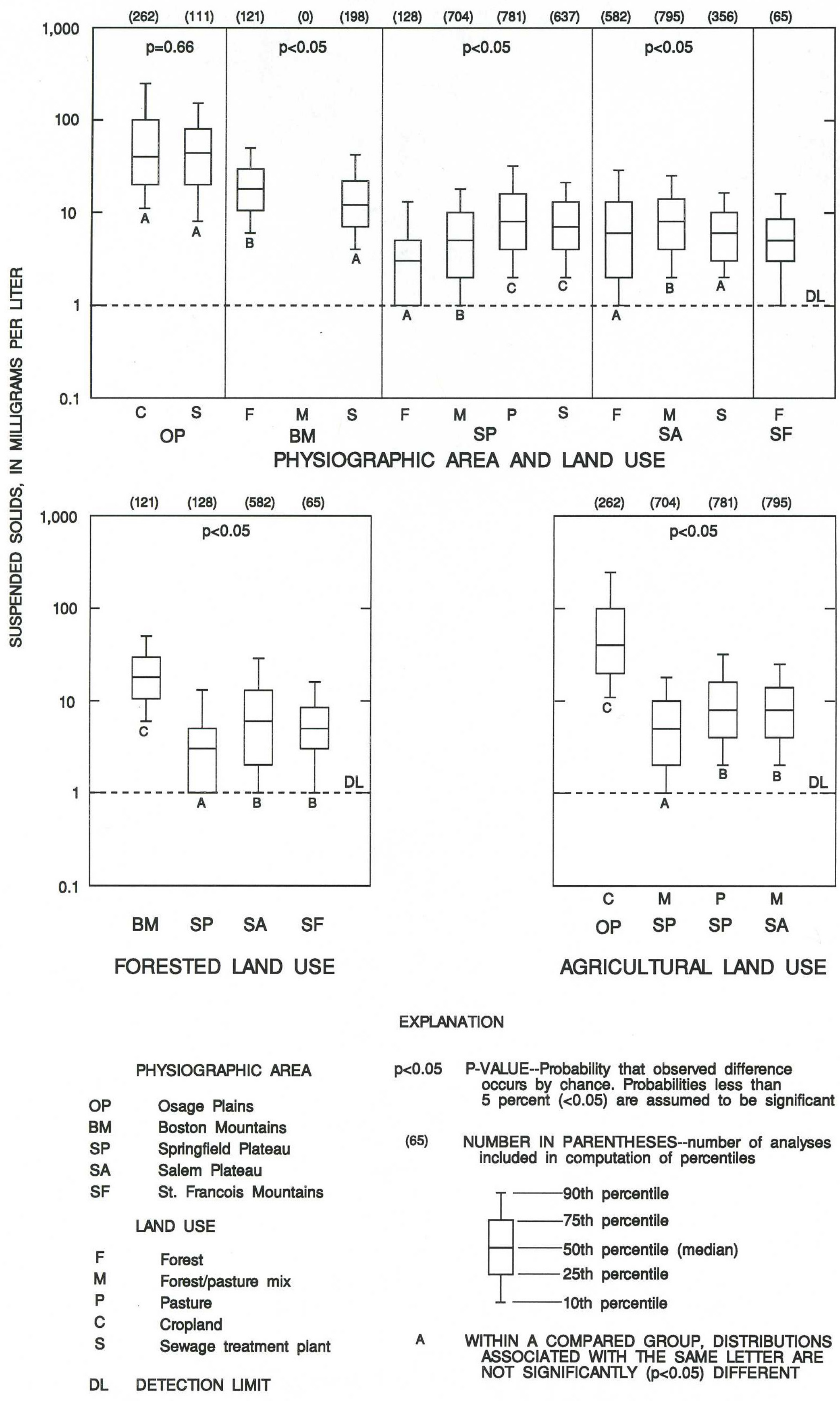

Figure 17. Statistical distribution of suspended-solids concentrations at surface-water sites for water years 1980-90.

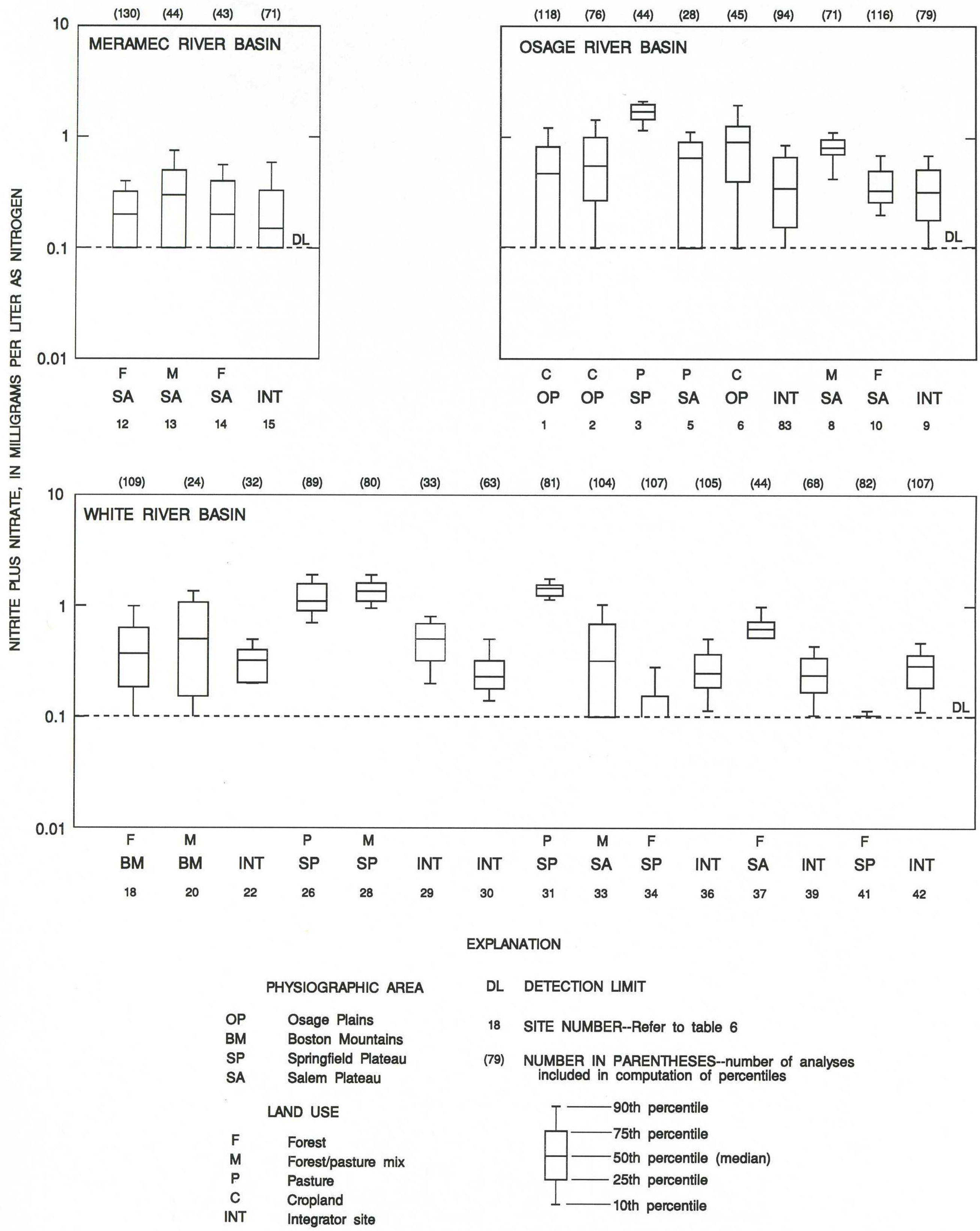

Figure 18. Statistical distribution of nitrite plus nitrate concentrations at surface-water indicator and integrator sites in the Meramec, Osage, and White

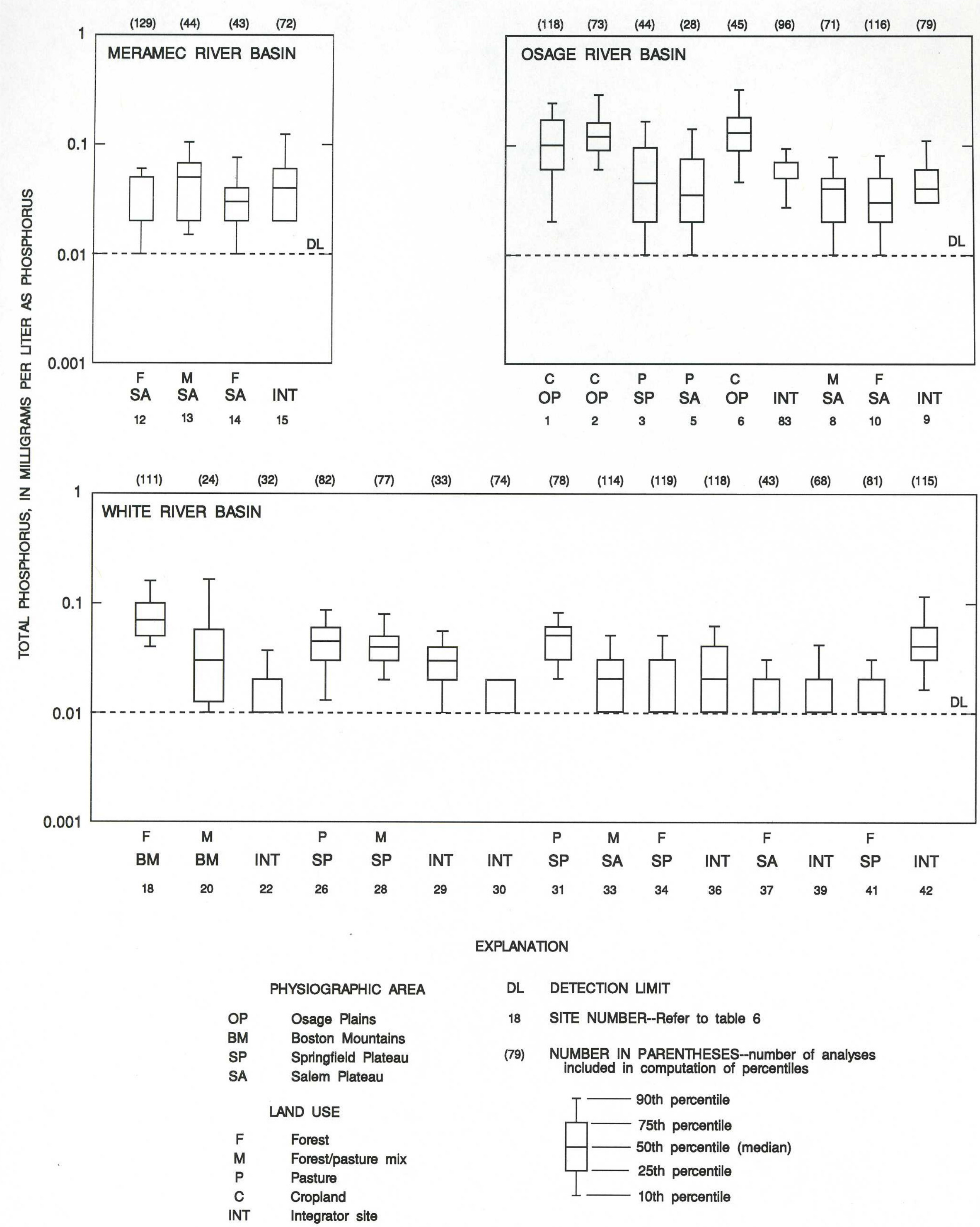

Figure 19. Statistical distribution of total phosphorus concentrations at surface-water indicator and integrator sites in the Meramec, Osage, and White River Basins for water years 1980-90.

median concentration at site 8, indicating that the water quality at site 9 was determined partially by the mixing of water of different quality from other basins.

Total phosphorus concentrations were largest in samples from the Osage Plains cropland as shown previously (fig. 19). Median concentrations at the two integrator site (sites 9 and 83) were intermediate between the upstream indicator sites, again indicating that the water quality at these sites was determined partially by the mixing of water of different quality from other basins.

White River

The White River Basin drains parts of the Boston Mountains, Springfield and Salem Plateaus, and Mississippi Alluvial Plain physiographic areas (fig. 1). The White River and major tributaries are regulated by four dams on the mainstem and one dam on the North Fork River. The indicator sites in the basin represent multiple land-use settings within different physiographic areas including: Boston Mountains forest and forest/pasture mix (sites 18 and 20), Springfield Plateau forest, forest/pasture mix, and pasture (sites 26, 28, 31, 34, and 41), and Salem Plateau forest and forest/pasture mix (sites 33 and 37; table 6, fig. 3).

Concentrations of nitrite plus nitrate generally were largest in the basins with agricultural land use and were smallest in the two Springfield Plateau forested basins (sites 34 and 41; fig. 18). Site 18 (West Fork White River east of Fayetteville, Ark.), representing Boston Mountains forested land use, had relatively large nitrite plus nitrate concentrations. As discussed previously, although the land use in this basin is primarily forested, pasture adjacent to the stream, a STP upstream, and the urban nonpoint sources probably contributed to nutrient concentrations. Site 37 (North Fork River near Tecumseh, Mo.), representing Salem Plateau forested land use, also had relatively large nitrite plus nitrate concentrations. Dye-trace studies indicate that two springs discharging into the river upstream of site 37 are recharged partly by effluent from a STP (J.E. Vandike, Missouri Department of Natural Resources, oral commun., 1994). The median values and ranges in concentrations at five of the integrator sites (sites 22, 30, 36, 39, and 42) were similar and were intermediate between the indicator sites in the White River Basin. The larger concentrations at integrator site 29, which is located below Table Rock Dam, probably reflect the larger concentrations expected with the agricultural and urban development that has occurred in the basin.

Total phosphorus concentrations also generally were largest in the basins with agricultural land use and were smallest in the two Springfield Plateau forested basins (sites 34 and 41), the Salem Plateau forested basin (site 37), and three of the integrator basins (sites 22, 30, and 39; fig. 19). The larger concentrations at integrator site 29 most likely were related to development in the basin. Integrator site 42 on the White River is located in the Mississippi Alluvial Plain. Streams in this region generally have larger sediment concentrations than streams in other regions in the study unit, which probably accounts for the larger total phosphorus concentrations at this site.

Relation of Selected Nutrient Concentrations and Discharge

The relation between nutrient concentration and discharge is a function of which phase the nutrient prefers (dissolved or particulate phase), point or nonpoint source origin of the nutrient, the overall magnitude and availability of the constituent in the basin, and the degree of streamflow regulation by reservoirs. Two constituents, nitrite plus nitrate and total phosphorus, were considered in this discussion. Representative plots of concentration and discharge with a line of central tendency (LOWESS) for selected sites with various land uses and from different physiographic areas are shown in figures 20 and 21. Plots for selected integrator sites also are shown.

Nitrite Plus Nitrate

Nitrite and nitrate primarily exist in the dissolved phase. Increases in discharge caused by precipitation runoff in unregulated basins with primarily nonpoint sources of nitrite and nitrate generally result in an initial increase in nitrite plus nitrate concentrations caused by washoff of available material followed by decreasing concentrations as dilution occurs. The magnitude of the concentrations will depend on the availability of nitrite and nitrate in the basin, which is directly related to land use. The sites representing forested land use (sites 12, 16, 34, and 41) had little to no increases in nitrite plus nitrate concentrations with increasing discharge and virtually no dilution effect. In contrast, the sites representing agricultural land use (sites 2, 53, 63, and 66) had definite increases in concentration with increasing discharge followed by dilution (fig. 20).

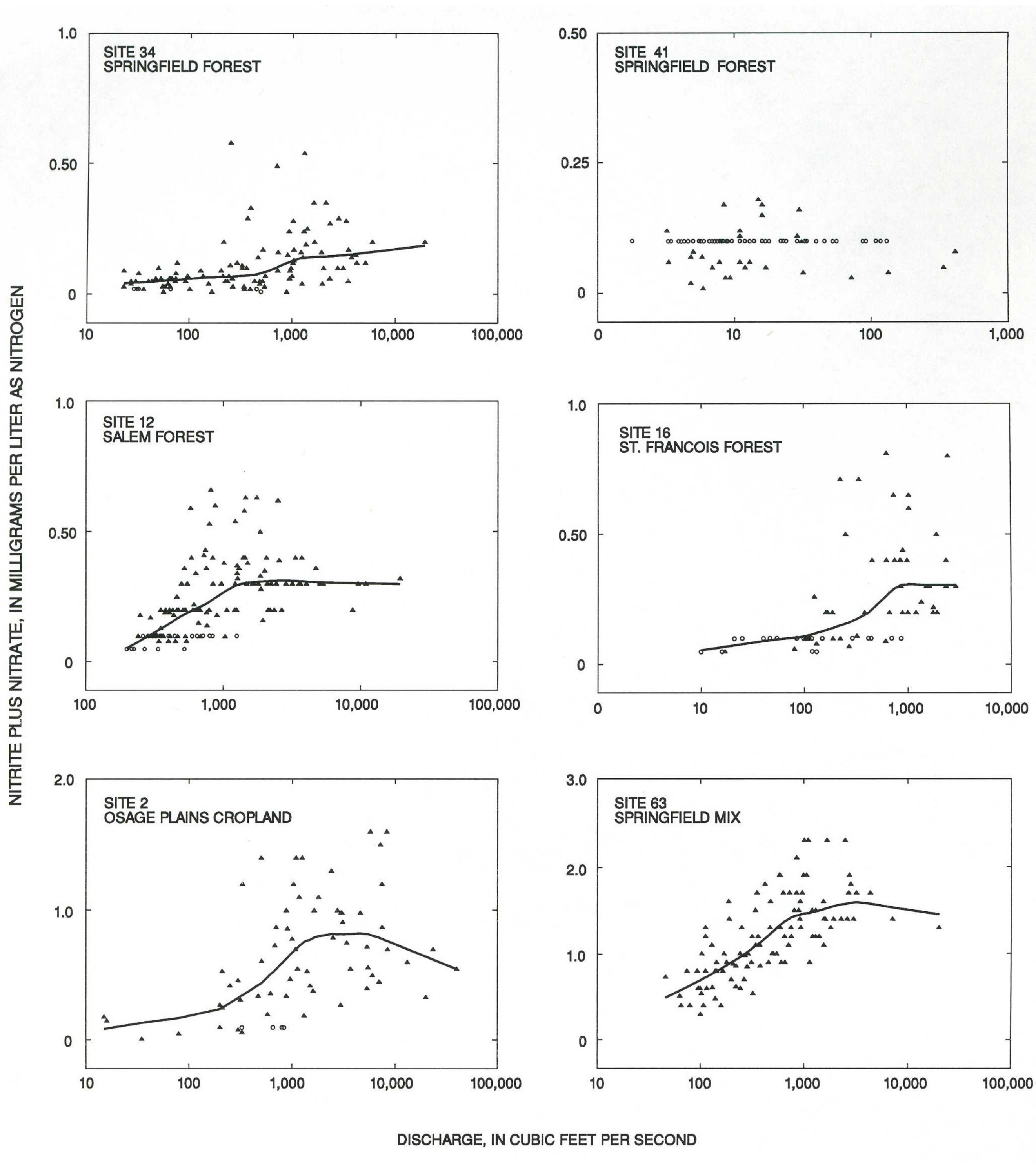

Figure 20. Relation of nitrite plus nitrate concentration to discharge at selected sites for water years 1980-90.

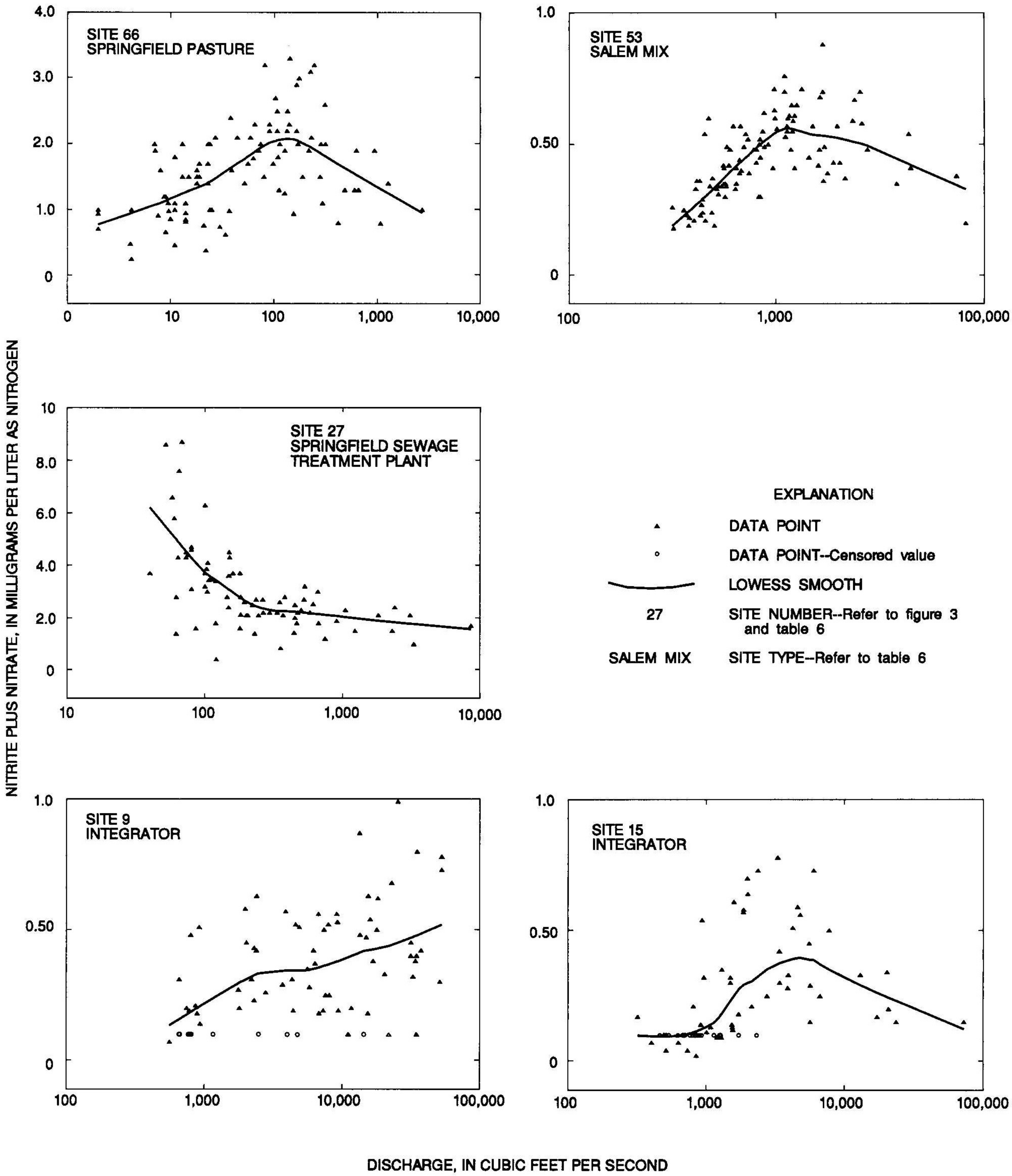

Figure 20. Relation of nitrite plus nitrate concentration to discharge at selected sites for water yars 1980-90—Continued.

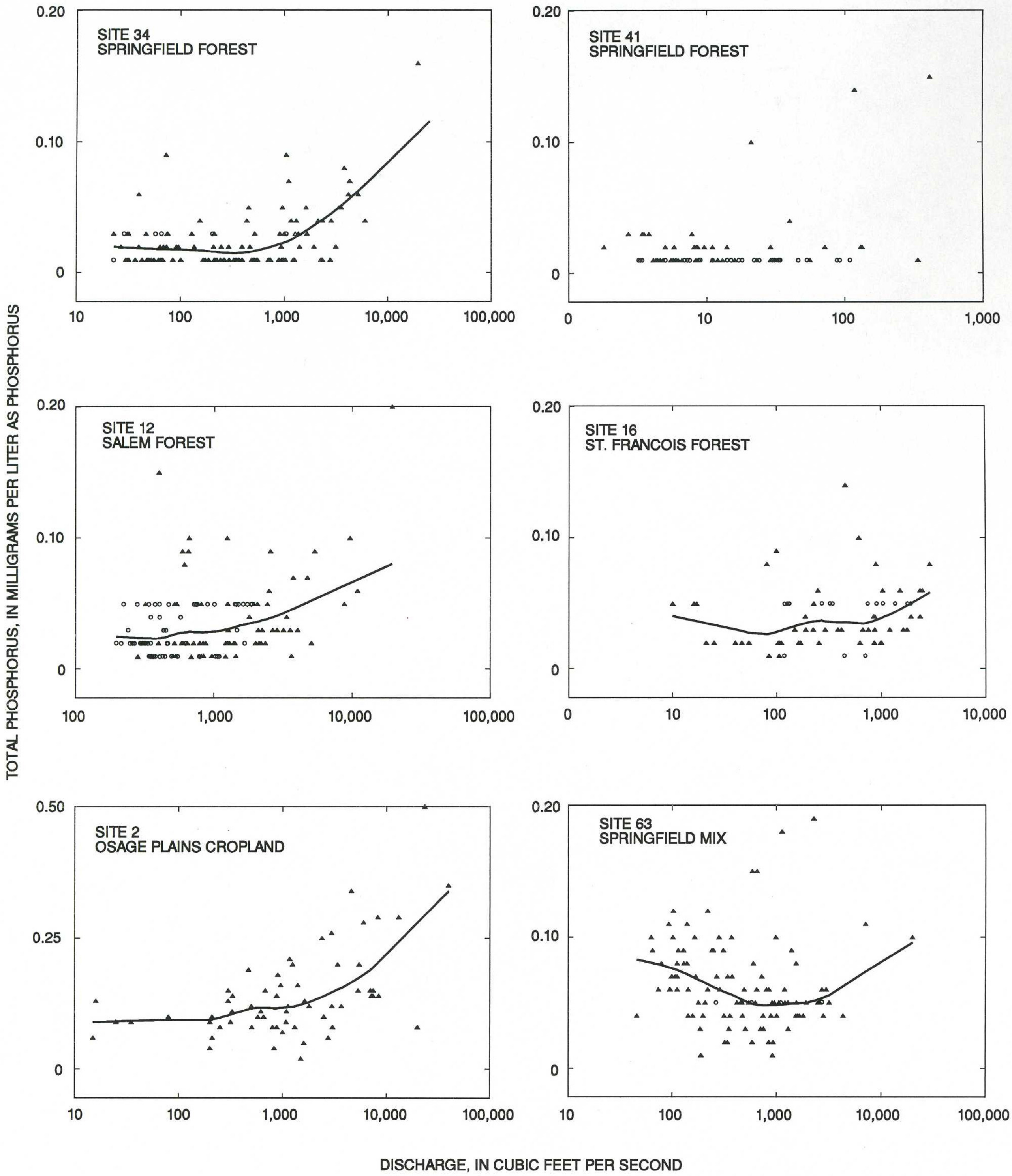

Figure 21. Relation of total phosphorus concentration to discharge at selected sites for water years 1980-90.

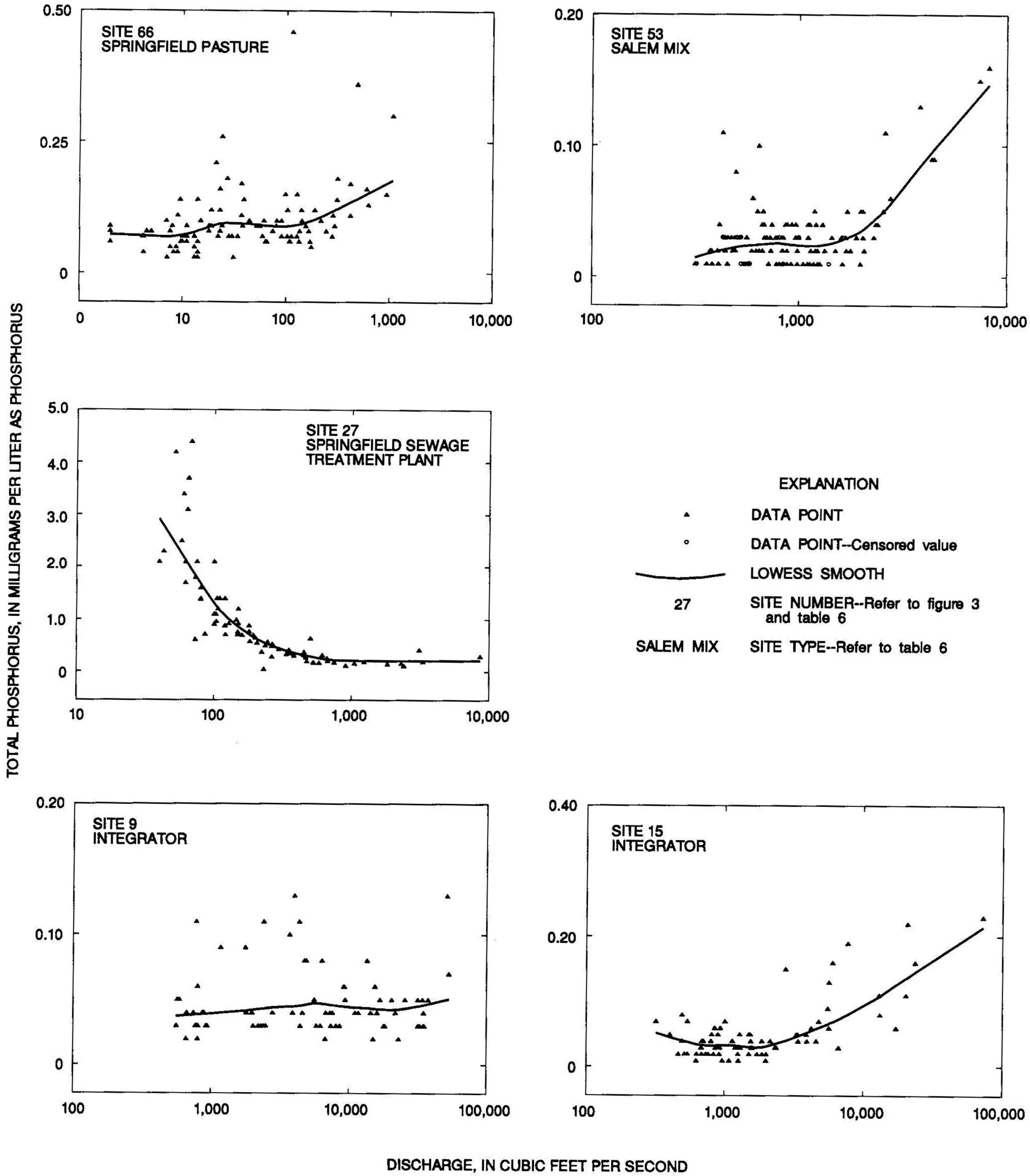

Figure 21. Relation of total phosphorus concentration to discharge at selected sites for water years 1980-90—Continued.

At sites primarily affected by point sources of nitrite and nitrate, concentrations generally were largest at low flows. Increases in discharge caused by precipitation runoff dilute the point source of nitrite plus nitrate causing a decrease in concentration as detected at site 27, which is a Springfield Plateau STP site.

Streamflow regulation by reservoirs can affect the concentration-discharge relation. Increases in discharge caused by dam releases upstream will not significantly change constituent concentrations in the stream. Integrator site 9 is located downstream of a major reservoir and had a rather indefinite relation between nitrite plus nitrate and discharge. Integrator Site 15 is unregulated and had a similar concentration-discharge relation to that of the agricultural basins.

Total Phosphorus

Because phosphorus species tend to adsorb to sediments, increases in discharge caused by precipitation runoff in unregulated basins with mostly nonpoint sources of phosphorus generally result in an increase in phosphorus concentrations. Sites 2, 53, and 66, representing agricultural land use, had increasing total phosphorus concentrations with increasing discharge. No definite concentration-discharge relation was observed at site 63, which also represents agricultural land use. Total phosphorus concentrations either increased or did not change as discharge increased in samples from the four forested basins (sites 12, 16, 34, and 41; fig. 21).

As with nitrite and nitrate, total phosphorus concentrations at sites primarily affected by point sources of phosphorus were largest at low flows. Increases in discharge caused by precipitation runoff dilute the point source of phosphorus causing a decrease in concentration as detected at site 27.

Streamflow regulation by reservoirs may affect the concentration-discharge relation even more for total phosphorus than for nitrite plus nitrate because of sediment trapping by the reservoir. Total phosphorus concentrations had no change with discharge at a site downstream of a reservoir (site 9), whereas the plot for site 15, which is not downstream of a reservoir, had the pattern typical of agricultural basins.

Ground Water

The quality of ground water is related to natural and anthropogenic conditions within the study unit. The factors affecting concentrations of nutrients in ground water were determined by statistically analyzing the relation of water-quality constituents with various hydrogeologic characteristics. Data for water years 1970–92 were used to determine differences in water quality among five hydrogeologic units (Mississippi River Valley alluvial aquifer, Western Interior Plains confining system, Springfield Plateau aquifer, Ozark aquifer, and St. Francois aquifer), among three major land-use settings (agriculture, forest, and urban), between springs and wells (site type) in the Springfield Plateau and Ozark aquifers, and between confined and unconfined parts (hydrogeologic type) of the Springfield Plateau and Ozark aquifers. Data also were analyzed to determine the relation between water quality and well depth.

Nutrients

The nutrient species considered in this analysis of ground water include nitrite plus nitrate, ammonia, ammonia plus organic nitrogen, total nitrogen, total phosphorus, and orthophosphate. Summary statistics for the ground-water data used in this report for nutrients are listed in table 10.

Nitrite Plus Nitrate

Nitrite plus nitrate concentrations for 245 ground-water samples were available for analysis. Because nitrite concentrations generally were small (more than 93 percent of the available samples had nitrite concentrations less than the reporting limit of 0.01 mg/L), 138 samples analyzed only for nitrate were included to make a total of 383 samples.

Nitrite plus nitrate concentrations in the samples ranged from less than 0.1 to 42 mg/L as nitrogen. Median nitrite plus nitrate concentration was 0.25 mg/L as nitrogen (table 10), and 15 samples had concentrations exceeding the MCL of 10 mg/L as nitrogen for drinking water (table 11).

Nitrite plus nitrate concentrations differed significantly among the five hydrogeologic units, among the three land-use settings, between samples collected from wells and springs, and between the confined and unconfined parts of the Ozark and Springfield Plateau aquifers (fig. 22). Results indicate that nitrite plus nitrate concentrations in ground water generally were affected by land use. The median nitrite plus nitrate concentration in ground water collected from the agricultural land-use setting was larger than that of the other two land-use settings. Nitrite plus nitrate concen-

Table 10. Statistical summary of nutrient data for ground water in the Ozark Plateaus study unit

[All units are milligrams per liter; N, nitrogen; <, less than; P, phosphorus]

Constituent	Number of samples	Minimum	Percentiles 10	25	50 (median)	75	90	Maximum
Nitrite plus nitrate as N	383	<0.1	<0.1	<0.1	0.25	1.4	4.1	42
Ammonia as N	156	<.01	<.01	.01	.04	.09	.28	25
Ammonia plus organic nitrogen	87	.01	.04	.06	.10	.27	.55	25
Total nitrogen as N	87	<.1	.15	.31	.55	1.9	3.8	25
Total phosphorus	161	<.01	<.01	<.01	<.01	.02	.06	.84
Orthophosphate as P	85	<.01	<.01	<.01	.01	.03	.05	.54

trations in ground water can be elevated in agricultural land-use settings as a result of fertilizers and animal wastes applied to the land surface. Nitrate concentrations exceeding the MCL of 10 mg/L as nitrogen were present in samples primarily from agricultural areas (table 11). Land use in the Western Interior Plains confining system and Springfield Plateau aquifer, which had the largest median nitrite plus nitrate concentration in ground water among the hydrogeologic units, is mostly agricultural.

Hydrogeology also affects nitrite plus nitrate concentrations in ground water. The Mississippi River Valley alluvial aquifer had the smallest median nitrite plus nitrate concentration in ground water among the hydrogeologic units. Similar to the Western Interior Plain confining system, the land use overlying the Mississippi River Valley alluvial aquifer is intensely agricultural; however, thin clay layers in these unconsolidated sediments probably retard the vertical transport of surface contaminants into the aquifer.

Nitrite plus nitrate concentrations were greater in shallow parts of the ground-water system as compared to deep parts of the system. Samples collected from springs had higher median nitrite plus nitrate concentrations than those collected from wells in both the Ozark and Springfield Plateau aquifers. In addition, samples collected from springs in both aquifers had significantly lower median specific conductance (356 µS/cm) and alkalinity (144 mg/L as $CaCO_3$) than samples collected from wells (508 µS/cm and 221 mg/L). Lower specific conductance and alkalinity in spring samples indicate less water-rock interaction and a more shallow source of water discharging from springs than water withdrawn from wells; hence, water from springs probably is more vulnerable to surface contamination than water withdrawn from wells.

Nitrite plus nitrate concentrations were larger in samples from shallow wells than in samples from deep wells. Wells completed in formations of the Western Interior Plains confining system from which samples were withdrawn were relatively shallow (median depth of 40.5 ft). In addition to having a high median nitrite plus nitrate concentration, 9 samples from these wells had nitrite plus nitrate concentrations exceeding the MCL of 10 mg/L as nitrogen. In contrast, median nitrite plus nitrate concentrations in water samples from urban land-use settings were lowest among the land-use settings, primarily because these mostly deep (median depth of 855 ft), public-supply wells are less vulnerable to surface contamination than shallow wells or springs.

Median nitrite plus nitrate concentrations were larger in samples collected from the unconfined parts of the Ozark and Springfield Plateau aquifers than those collected from the confined parts of the aquifers. The shallow depth to water, as indicated by the median well depths, probably makes the unconfined parts of the aquifers more vulnerable to surface contamination than water in the relatively deep, confined parts of the Ozark and Springfield Plateau aquifers. In addition, the shale units that, in places, confine the Ozark and

Table 11. Ground-water samples with nitrate concentrations exceeding the maximum contaminant level

[mg/L, milligrams per liter; SPAQ, Springfield Plateau aquifer; OZAQ, Ozark aquifer; ALVM, Mississippi River Valley alluvial aquifer; WIPC, Western Interior Plains confining system]

Map number (figs. 6 and 7)	Station number	Site type	County	State	Nitrate (mg/L as nitrogen)	Hydrogeologic unit	Land use
1	362226093102201	Spring	Boone	Arkansas	13	SPAQ	Agriculture
2	362636092374201	Well	Marion	Arkansas	29	OZAQ	Urban
3	362923093081001	Spring	Boone	Arkansas	11	SPAQ	Agriculture
4	363344090215701	Well	Butler	Missouri	15	ALVM	Agriculture
5	363529090303501	Well	Butler	Missouri	14	ALVM	Agriculture
6	370931093275701	Well	Greene	Missouri	14	OZAQ	Agriculture
7	373833094580801	Well	Crawford	Kansas	14	WIPC	Agriculture
8	373932094584101	Well	Crawford	Kansas	13	WIPC	Agriculture
9	373937094500401	Well	Crawford	Kansas	32	WIPC	Agriculture
10	374708094083401	Well	Vernon	Missouri	12	WIPC	Agriculture
11	375123094303801	Well	Vernon	Missouri	42	WIPC	Agriculture
12	375153094522801	Well	Bourbon	Kansas	23	WIPC	Agriculture
13	375733094341901	Well	Vernon	Missouri	18	WIPC	Agriculture
14	380125094212301	Well	Vernon	Missouri	26	WIPC	Agriculture
15	380442094092901	Well	Bates	Missouri	14	WIPC	Agriculture

Springfield Plateau aquifers probably retard the vertical transport of contaminants from overlying hydrogeologic units.

Well depth did not directly correlate with nitrite plus nitrate concentrations in ground water. Open-hole construction techniques of most of the sampled wells allow water to be withdrawn from shallow and deep parts of the same aquifer or even from several hydrogeologic units; therefore, well depth is not always a good indicator of the depth from which a sample was withdrawn.

Ammonia

Ammonia concentrations of 156 ground-water samples ranged from less than 0.01 to 25 mg/L as nitrogen. Median ammonia concentration was 0.04 mg/L as nitrogen (table 10).

Ammonia concentrations differed significantly among four of the hydrogeologic units, among the three land-use settings, and between the confined and unconfined parts of the Ozark aquifer (fig. 23). Ammonia concentrations were not significantly different in samples collected between well and spring samples, or between the confined and unconfined parts of the Springfield Plateau aquifer. Ammonia concentrations did not correlate with well depth.

Ammonia concentrations in ground water probably are related to land use and oxidation-reduction conditions of the hydrogeologic unit because ammonia is a reduced species of nitrogen. Similar to nitrite plus nitrate, median ammonia concentrations were largest in the Western Interior Plains confining system and in the agricultural land-use setting. In contrast to nitrite plus nitrate, ammonia concentrations were larger in the deeper parts of the ground-water system, such as the confined parts of the Ozark aquifer. The source of

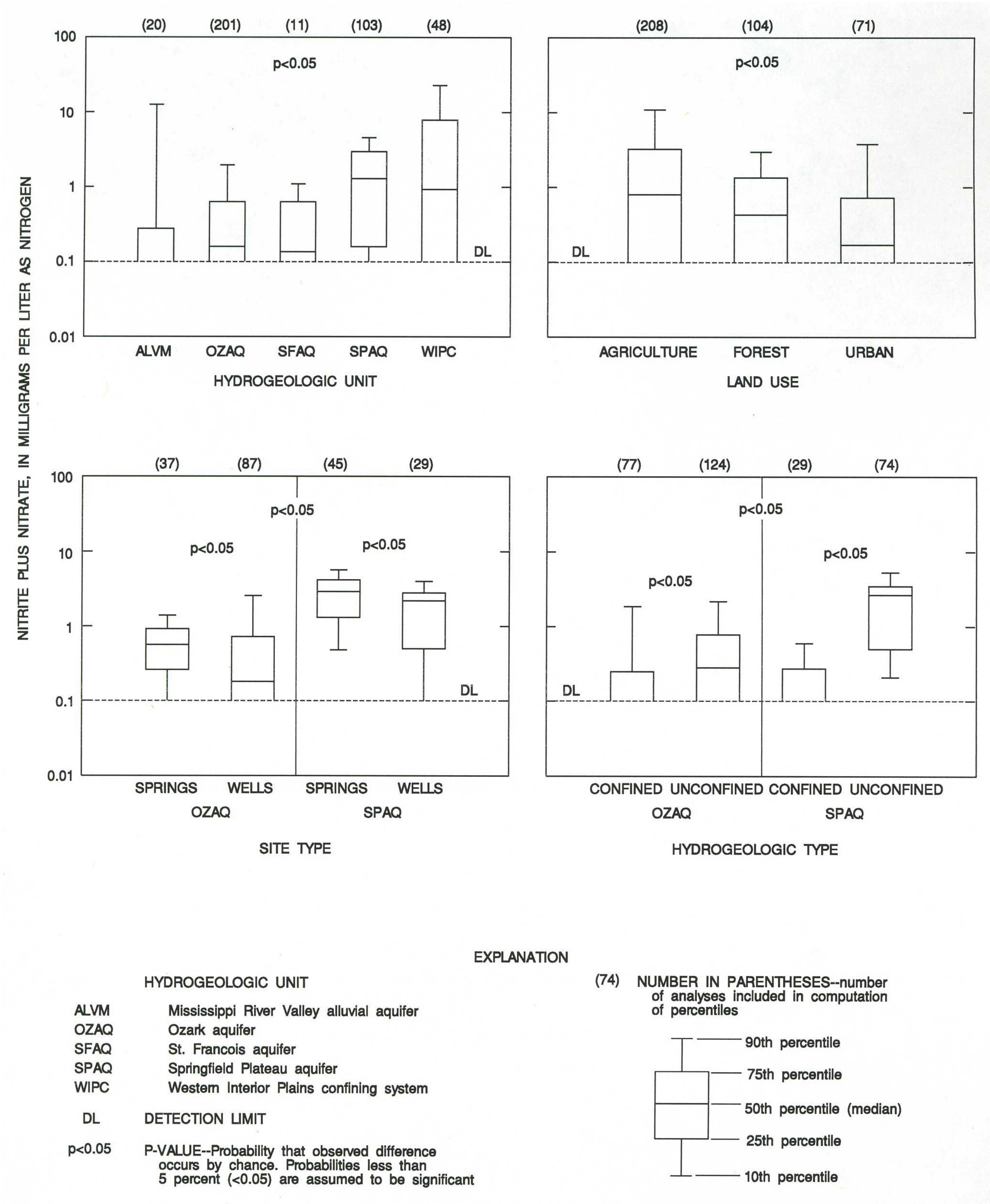

Figure 22. Statistical distribution of nitrite plus nitrate concentrations in ground water for water years 1970-92.

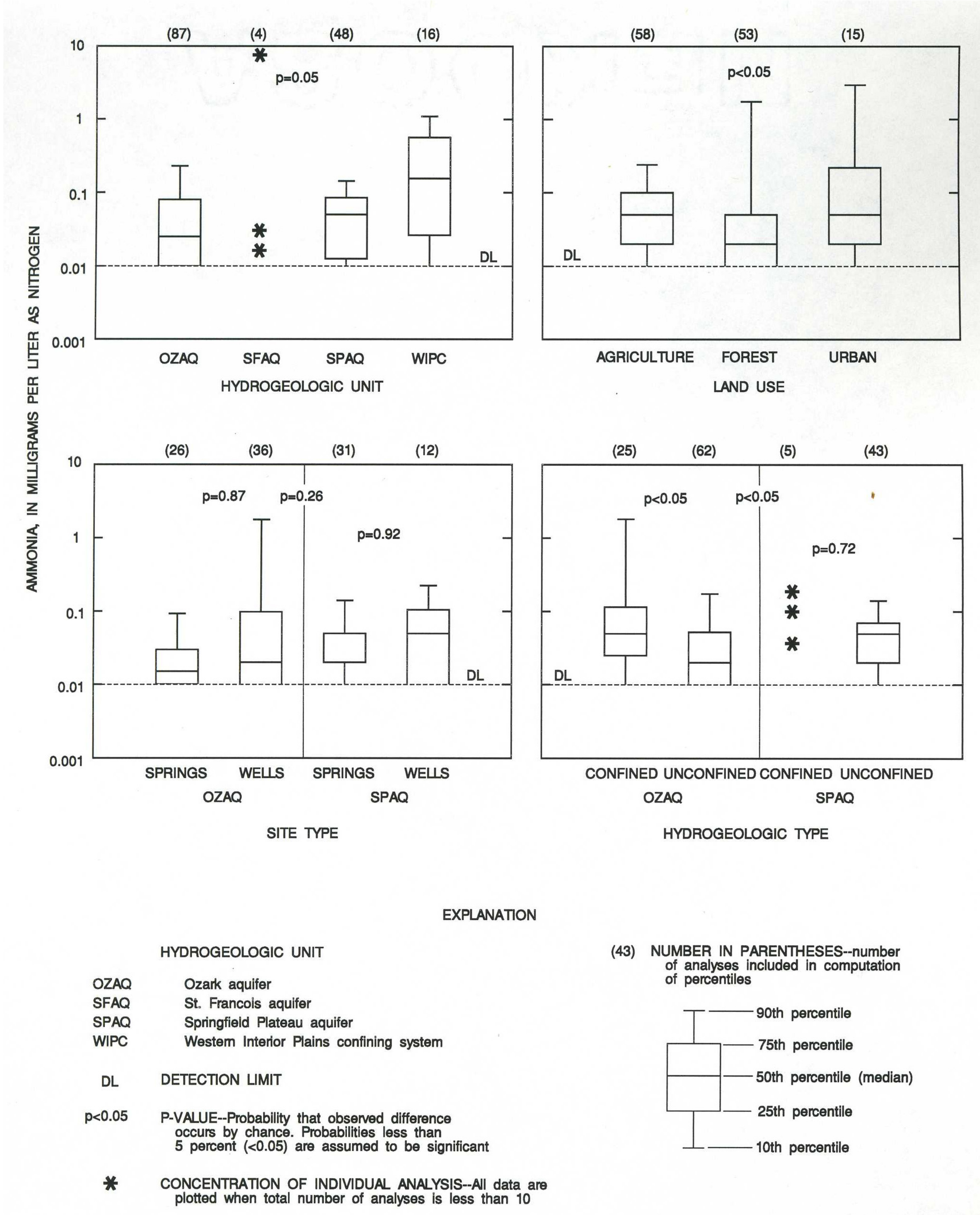

Figure 23. Statistical distribution of ammonia concentrations in ground water for water years 1970-92.

ammonia in the confined parts of the Ozark aquifer could be organic matter in some of the rock units, particularly the shales. In the confined parts of the Ozark aquifer, dissolved oxygen is depleted and reducing conditions exist, allowing ammonia to be stable.

Ammonia Plus Organic Nitrogen

Ammonia plus organic nitrogen concentrations for only 87 ground-water samples were available for analysis. Concentrations ranged from 0.01 to 25 mg/L as nitrogen. Median ammonia plus organic nitrogen concentration was 0.10 mg/L as nitrogen (table 10).

Ammonia plus organic nitrogen concentrations do not seem to be related to site characteristics (fig. 24). In many cases, data were few and may not be sufficient to indicate if relations exist.

Total Nitrogen

Total nitrogen concentrations for only 87 ground-water samples were available for analysis. Concentrations ranged from less than 0.1 to 25 mg/L as nitrogen. Median total nitrogen concentration was 0.55 mg/L (table 10).

Nitrite plus nitrate comprised at least 50 percent of the total nitrogen in 70 percent of the samples. Hence, the distribution of total nitrogen in ground-water samples was similar to the distribution of nitrite plus nitrate (figs. 22 and 25). Total nitrogen concentrations in ground-water samples were significantly different between the Ozark and Springfield Plateau aquifers, among land-use settings, between springs and wells in the Ozark and Springfield Plateau aquifers, and between confined and unconfined parts of the Ozark aquifer. As with nitrite plus nitrate, total nitrogen concentrations probably were affected by land use and hydrogeology.

Total Phosphorus

Total phosphorus concentrations of 161 ground-water samples ranged from less than 0.01 to 0.84 mg/L as phosphorus. Median total phosphorus concentration was less than 0.01 mg/L as phosphorus (table 10). More than 68 percent of the samples had a total phosphorus concentration less than or equal to the reporting limit of 0.01 mg/L.

Total phosphorus concentrations differed significantly among the five hydrogeologic units, between wells and springs in the Ozark and Springfield Plateau aquifers, and between samples collected from the confined and unconfined parts of the Ozark aquifer (fig. 26). Total phosphorus concentrations were not significantly different among samples collected from the three land-use settings and were not correlated with well depth.

Total phosphorus concentrations in ground water can be related to water-rock interactions or land-use setting. For example, all six samples from the Mississippi River Valley alluvial aquifer had total phosphorus concentrations greater than the reporting limit of 0.01 mg/L. Nitrite plus nitrate concentrations for these samples were small (less than or equal to 0.55 mg/L as nitrogen), indicating these samples were not affected by agricultural land use. Hence, the total phosphorus concentrations in these samples could be a result of mineral dissolution. In contrast, total phosphorus concentrations in samples from the Western Interior Plains confining system and in samples from springs could be affected by agricultural land use, as indicated by the elevated nitrite plus nitrate concentrations in some of the samples.

Orthophosphate

Orthophosphate concentrations for only 85 ground-water samples were available for analysis. Concentrations ranged from less than 0.01 to 0.54 mg/L as phosphorus. Median orthophosphate concentration was 0.01 mg/L as phosphorus (table 10). More than 57 percent of the samples had concentrations less than or equal to the reporting limit of 0.01 mg/L as phosphorus.

Orthophosphate concentrations differed significantly among four hydrogeologic units, among the three land-use settings, between samples collected from wells and springs, and between samples collected from confined and unconfined parts of the Ozark aquifer (fig. 27). As with total phosphorus concentrations, orthophosphate concentrations can be related to agricultural practices in the study unit. Orthophosphate concentrations were larger in samples collected from the intensely agricultural area underlain by the Western Interior Plains confining system and the Springfield Plateau aquifer than in samples from areas underlain by the other hydrogeologic units. Orthophosphate concentrations were larger in agricultural land-use settings as compared to forest and urban land-use settings. In addition, orthophosphate concentrations were larger in ground water with shallow sources, such as springs and wells completed in the unconfined parts of the Springfield Plateau aquifer, as

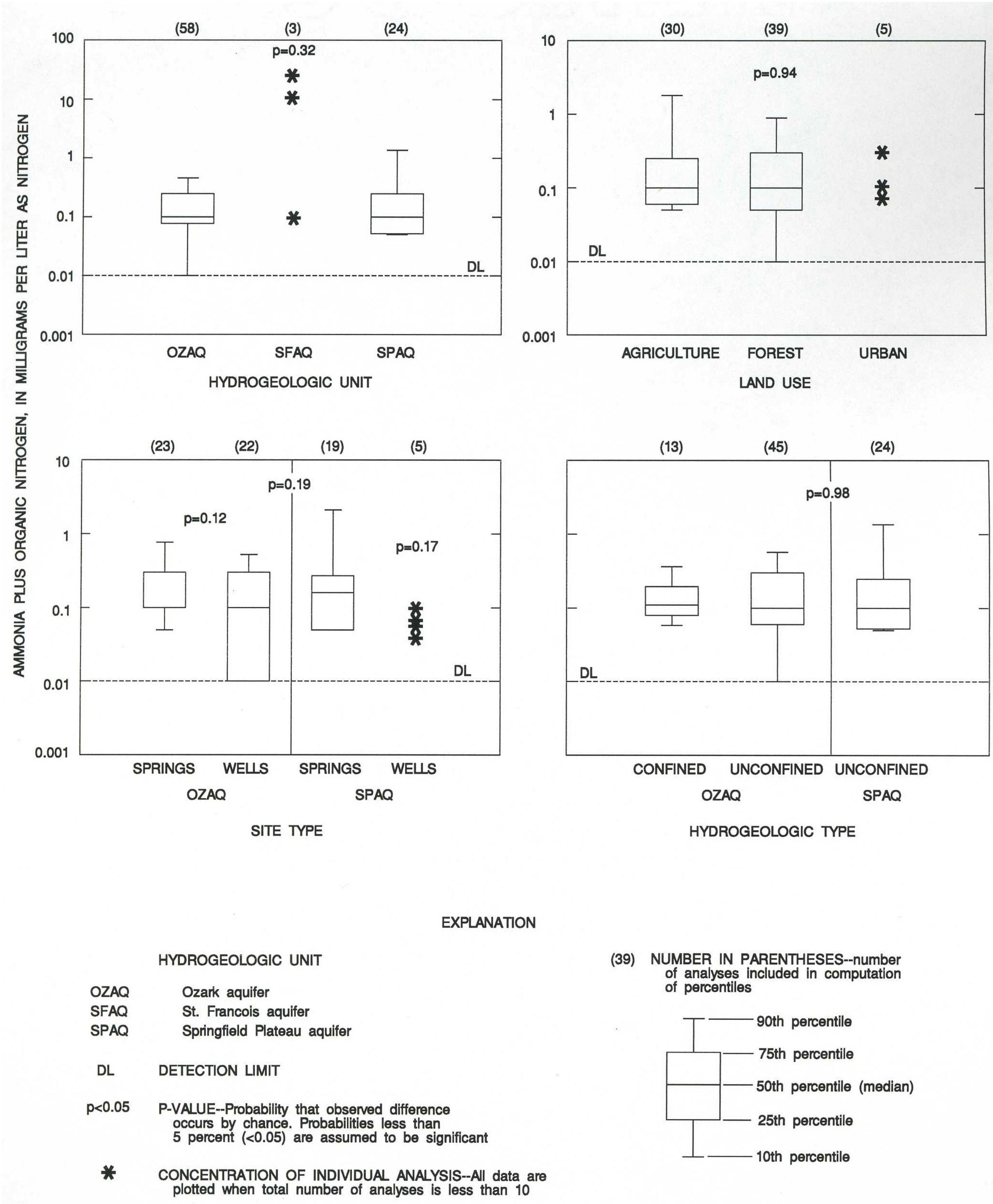

Figure 24. Statistical distribution of ammonia plus organic nitrogen concentrations in ground water for water years 1970-92.

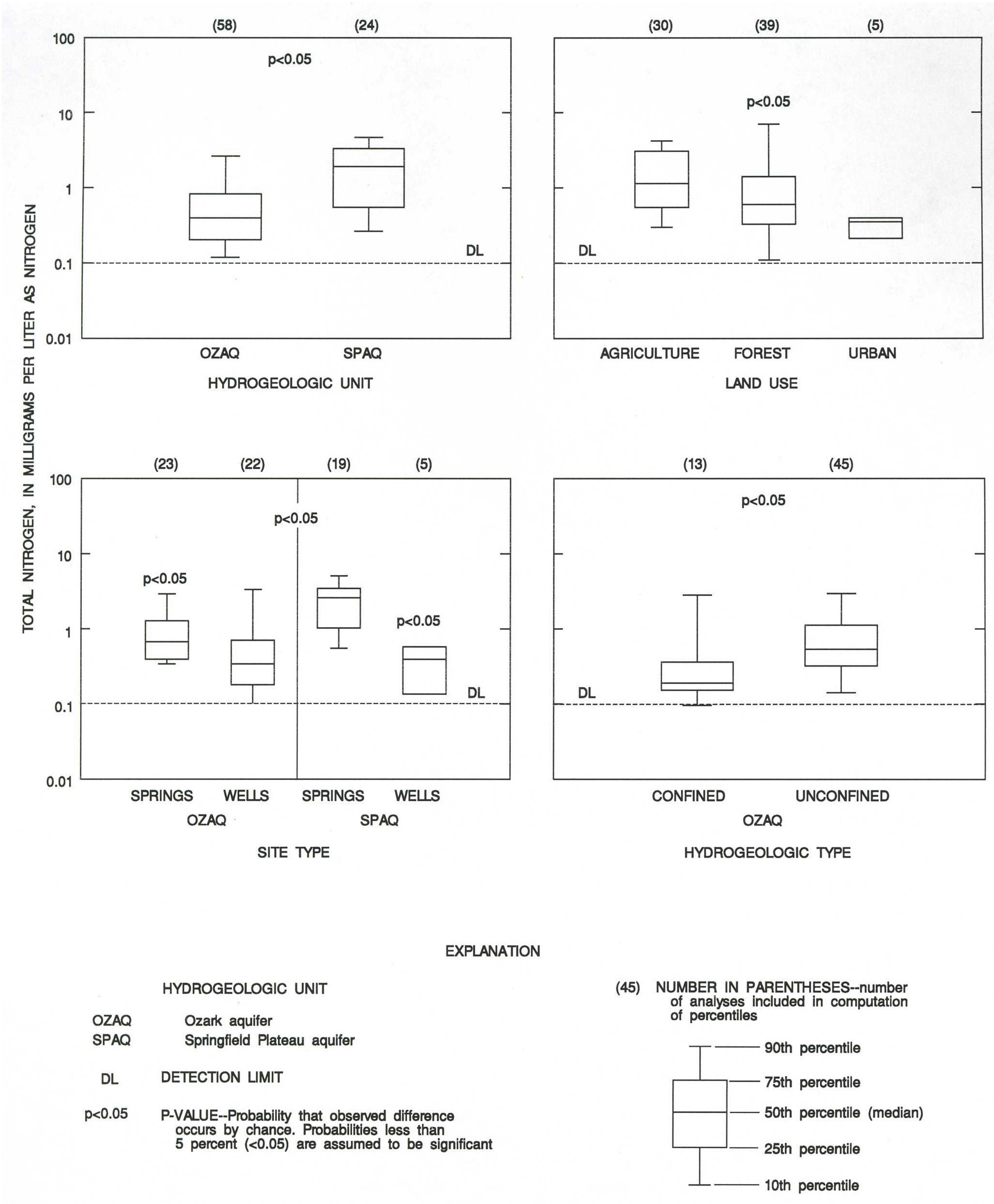

Figure 25. Statistical distribution of total nitrogen concentrations in ground water for water years 1970-92.

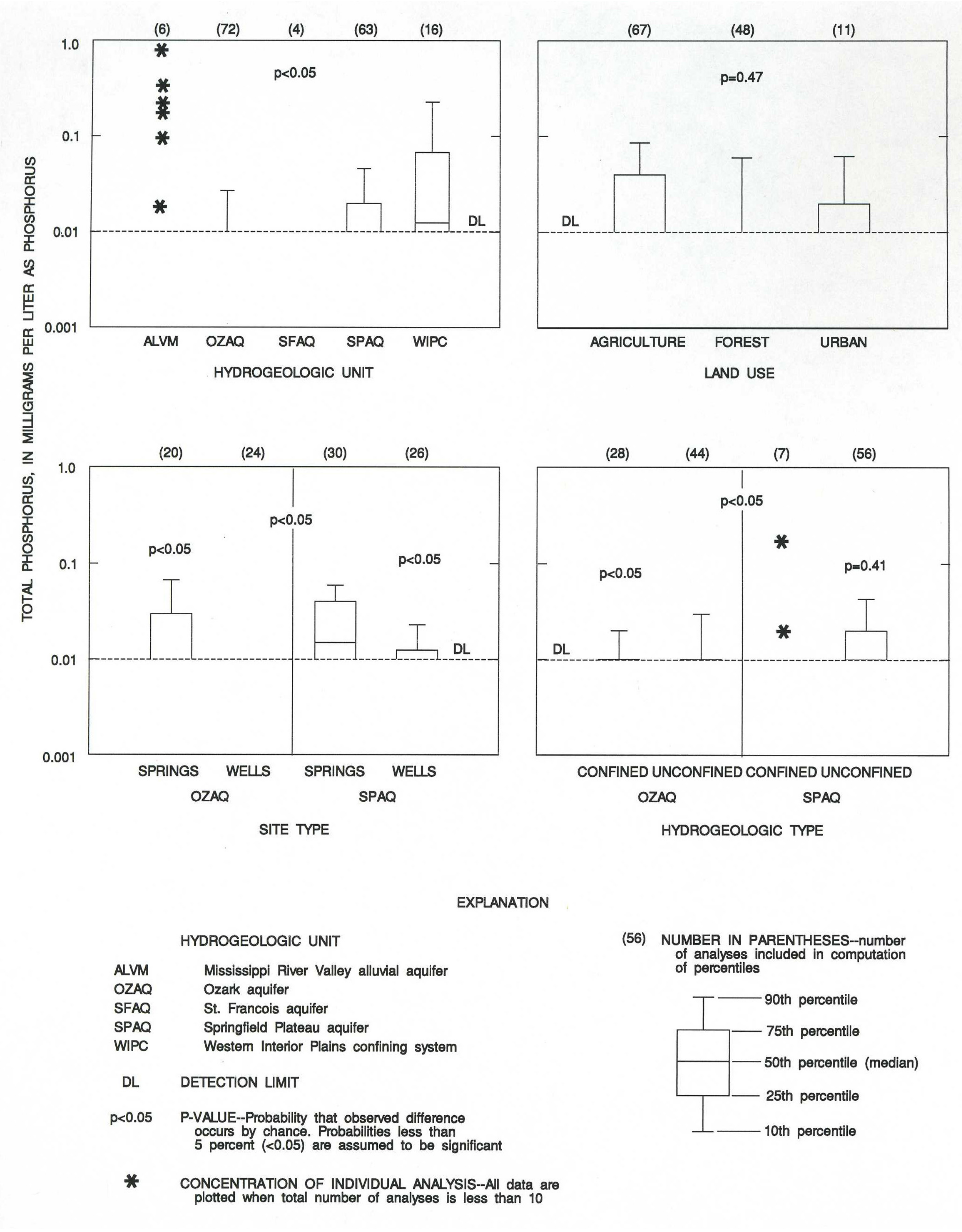

Figure 26. Statistical distribution of total phosphorus concentrations in ground water for water years 1970-92.

compared to concentrations in water from deep sources. Water in the shallow parts of the system is more susceptible to surface contamination than water from deep parts of the system.

Orthophosphate concentrations were less than or equal to total phosphorus concentrations in 75 percent of the ground-water samples; however, in the remaining samples, orthophosphate concentrations exceeded total phosphorus concentrations by as much as a factor of 10. Because total phosphorus concentrations include orthophosphate, these results could indicate some analytical error in the data.

LONG-TERM TRENDS

The analysis of long-term trends in water quality provides another method to assess water quality, in addition to the previously discussed spatial and hydrologic assessment. The following section describes changes in quality of surface water during water years 1970–90. A discussion of changes in quality of ground water also is included but is limited because of the limited amount of data available.

Surface Water

Water-quality trends have been a subject of several water-quality investigations of streams in the Ozark Plateaus study unit (Arkansas Department of Pollution Control and Ecology, 1980, 1984, 1986, 1992; Kansas Department of Health and Environment, 1988; Brown and others, 1991; Mott, 1991; Davis and Schumacher, 1992; John C. Ford, Missouri Department of Natural Resources, written commun., 1992; Petersen, 1992; Davis, 1993; Kenny, 1993; Kurklin, 1993; Petersen and Green, 1993; Yu and Zou, 1993; Wright, 1994). Several trend-analysis methods and periods have been used in these investigations.

Generalizations and comparisons based on existing trend-analysis results that would apply to the entire study unit are difficult because of differing trend-analysis methods, periods, and station densities. For example, most of the sites for which data have been analyzed for trends are in Arkansas, southwestern Missouri, and the Illinois River Basin in northeastern Oklahoma. However, based on the results of these previous investigations, it seems that nitrite plus nitrate, phosphorus, and orthophosphate concentrations have increased at a disproportionately large number of sites in northwestern Arkansas, northeastern Oklahoma, and southwestern Missouri. Statistically significant downward trends in total phosphorus concentrations have occurred at several sites in the Spring River Basin of southwestern Missouri. The downward trends at most of these sites in the Spring River Basin can be attributed to the aging of two large phosphogypsum waste piles, which has resulted in decreasing phosphorus concentrations in the leachate from the sites (Davis and Schumacher, 1992). In Arkansas, where most of the sites are located for which the data have been analyzed (Petersen, 1992), about one-third of the sites had downward trends in total ammonia data.

Trends in water-quality data can be caused not only by changes in ambient concentrations, but also by changes in field and laboratory methods. For example, a study of quality-assurance records by Alexander and others (1993) has shown that for standards analyzed at the USGS National Water Quality Laboratory in Denver, Colo., a larger positive bias existed for ammonia, ammonia plus organic nitrogen, and phosphorus during the early 1980’s as compared to more recent periods. Airborne ammonia contamination may be one cause; the cause of the phosphorus contamination is unknown. Improvements (decreases in bias) after the early 1980’s would result in more apparent downward trends than actually occurred. Also, a change in laboratory methods of the Arkansas Department of Pollution Control and Ecology for analysis of nitrite, nitrate, ammonia, and total phosphorus occurred in March 1977 (Richard Thompson, Arkansas Department of Pollution Control and Ecology, written commun., 1990). Other agencies also have changed laboratory and field methods between 1970 and 1990. These changes must be considered in analyses of water-quality data for time trends.

Thirty-nine sites were selected for subsequent examination of changes in water quality for water years 1970–90 (table 12). Site selection was primarily based on the length of time for which data are available. Sites were chosen with the longest periods of data for the selected constituents. Some chosen sites had little data for one or more of the constituents. Also, sites that were considered to be substantially affected by STP discharges or were immediately downstream of reservoirs were not included.

Water-quality data (nitrite plus nitrate, ammonia, total ammonia plus organic nitrogen, total phosphorus, orthophosphate, suspended-sediment, and suspended-solids concentrations) for water years

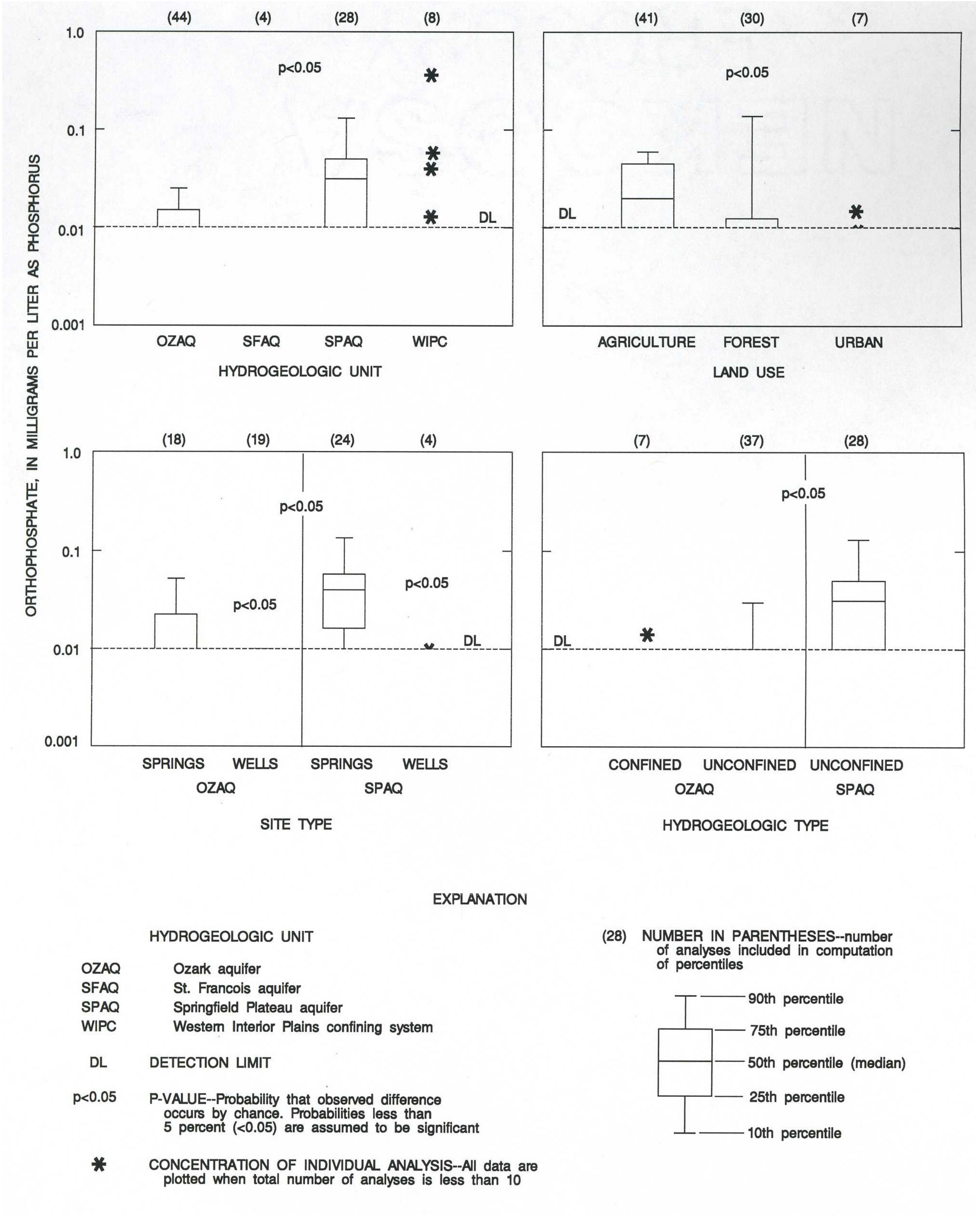

Figure 27. Statistical distribution of orthophosphate concentrations in ground water for water years 1970-92.

Table 12. Sites selected for examination of changes in water quality

[See table 6 for location, site name, collecting agency, and land-use information]

Physiographic area	Site numbers (fig. 3 and table 6)
Springfield Plateau	26, 34, 41, 60, 63, 64, 66, 69, 71, 72
Salem Plateau	10, 11, 12, 23, 33, 45, 50, 51, 53, 55
Boston Mountains	18, 20
St. Francois Mountains	16
Osage Plains	1, 2, 7, 56, 57, 81
Integrator sites	9, 15, 25, 36, 39, 42, 48, 54, 58, 80

1970–90 were plotted for all 39 sites. The LOWESS procedure was used to draw an "inferred concentration trend line" on plots. This procedure cannot be used to draw a concentration trend line when the proportion of censored values is large. Therefore, lines were not drawn on some plots.

Rather than including plots for all 39 sites in this report, a group of sites representative of most physiographic areas, land-use settings, and collecting agencies was selected. Data for these sites are shown in figures 28 to 33. The largest concentrations for several sites were not shown on several plots so that the remaining data were plotted at a more usable scale. However, all data for a site were included in the calculations used to draw the LOWESS lines.

No statistical-trend tests were performed for this report; therefore, decreasing or increasing trends mentioned in the following sections were subjectively determined by inspection of the plots of concentration for all 39 sites. Factors not always considered included laboratory and field method changes and the effects of streamflow on concentration. Plots of concentrations adjusted for streamflow (Helsel and Hirsch, 1992) also were inspected, and, in general, the "flow-adjusted concentration trend lines" were similar to the concentration trend lines. However, because a substantially smaller number of sites had sufficient streamflow data available, the flow-adjusted data are not shown.

Nitrogen

The concentrations of most species of nitrogen did not increase between water years 1970–90, yet nitrogen fertilizer application rates substantially increased between 1965 and 1985 in all of the major river basins of the study unit (table 2).

Concentrations of nitrite plus nitrate had not changed substantially at most sites (fig. 28). However, decreases had occurred at most sites in the Osage Plains (sites 1, 2, 7, 56, and 81) and some integrator sites (sites 9, 15, and 80). Data indicate increases occurred at some sites in the Springfield Plateau (sites 64, 66, and 69), but the causes of these changes are unknown. None of the sites were considered to be substantially affected by discharges from STP's. However, several of the sites (2, 9, 15, 56, 64, 66, 80, and 81) are downstream of STP's (table 6; fig. 2). The decreases at sites in the Osage Plains may be the result of some changes in agricultural practices. The sites in the Springfield Plateau, where concentrations appear to have increased, have basins with substantial amounts of agricultural activity.

Concentrations of ammonia decreased at several sites (fig. 29). Many of these decreases were relatively small and occurred in concentrations that were near the detection or reporting limits where analytical variability may be greater. Decreases occurred at all of the sites in the Osage Plains (sites 1, 2, 7, 56, 57, and 81), at four or more sites in the Salem Plateau (sites 50, 51, 53, and 55), and at all of the integrator sites. The causes of these decreases in concentration are unknown. Although sites were not considered to be substantially affected by STP discharges, some are downstream of STP's that might be affecting concentrations enough to cause these changes in water quality. Some indicator sites (1, 7, 50, 53, 55, and 57) are in agricultural basins and not downstream of STP's (table 6; fig. 2). At integrator sites operated solely by the USGS (sites 9, 15, 39, and 54), concentrations generally decreased in the middle to late 1980's, but at sites operated by the Arkansas Department of Pollution Control and Ecology (sites 25, 36, 42, and 48), concentrations generally decreased in the late 1970's. Most sites in the Salem Plateau with decreases also are operated by the Arkansas Department of Pollution Control and Ecology (sites 50, 51, 53, and 55) and had decreasing concentrations in the late 1970's. These agency-related patterns indicate that field or laboratory methods of the two agencies (such as the early 1980's bias of USGS data) may partially explain these decreases in reported concentration.

Concentrations of total ammonia plus organic nitrogen seem to have decreased at several sites (fig. 30). Most of these decreases in concentration were at

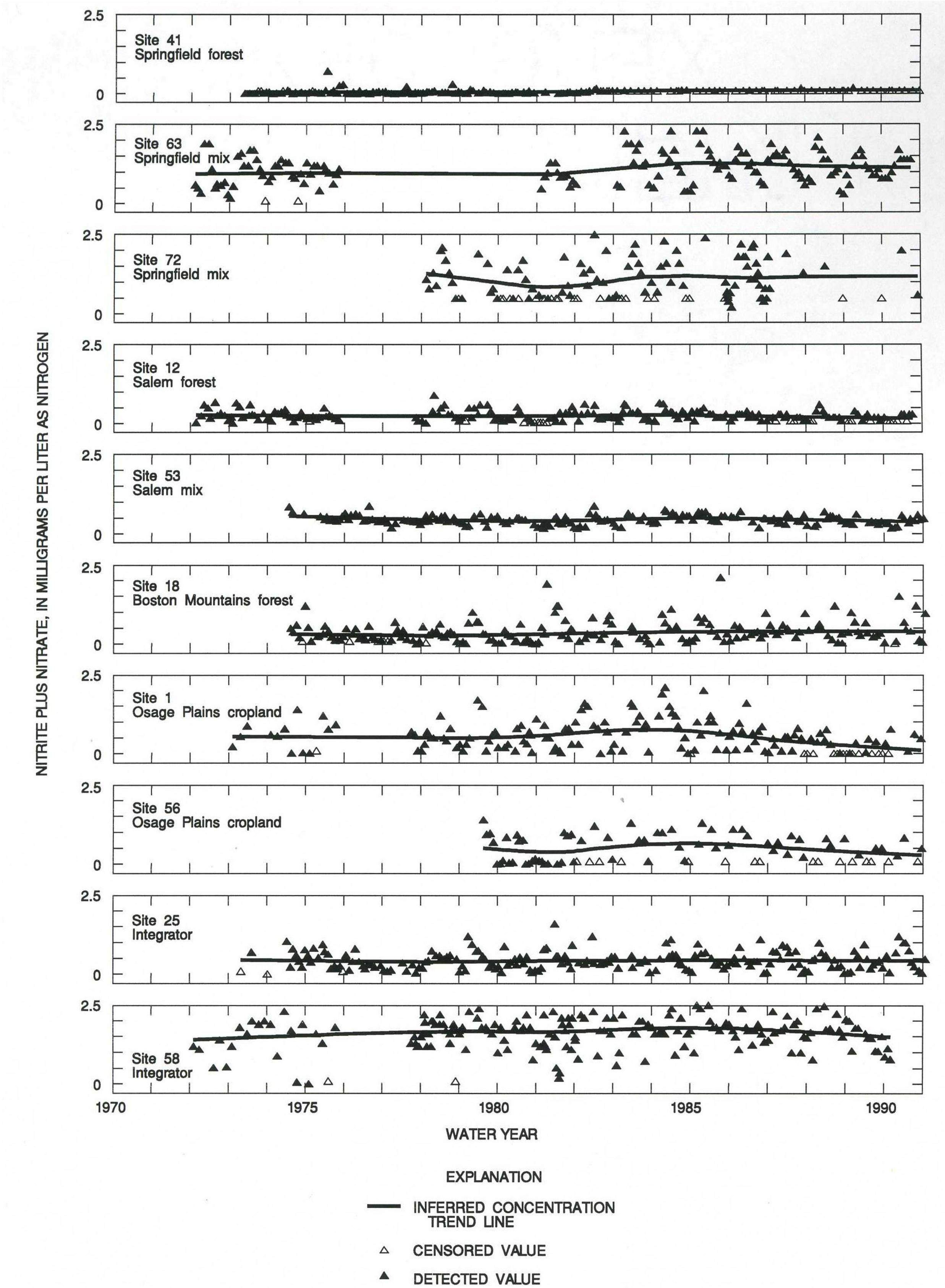

Figure 28. Concentrations of nitrite plus nitrate for water years 1970-90 at selected surface-water sites.

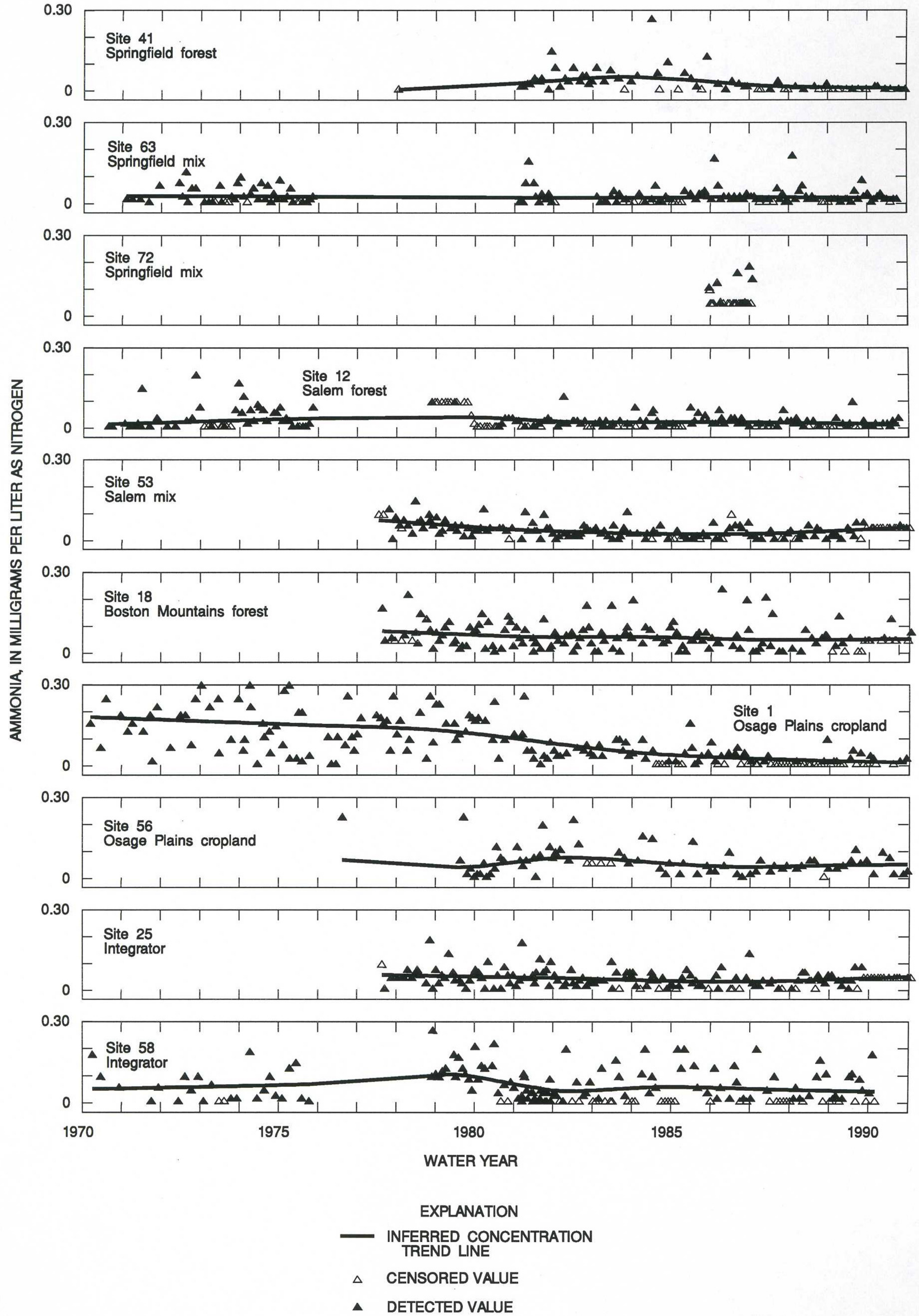

Figure 29. Concentrations of ammonia for water years 1970-90 at selected surface-water sites.

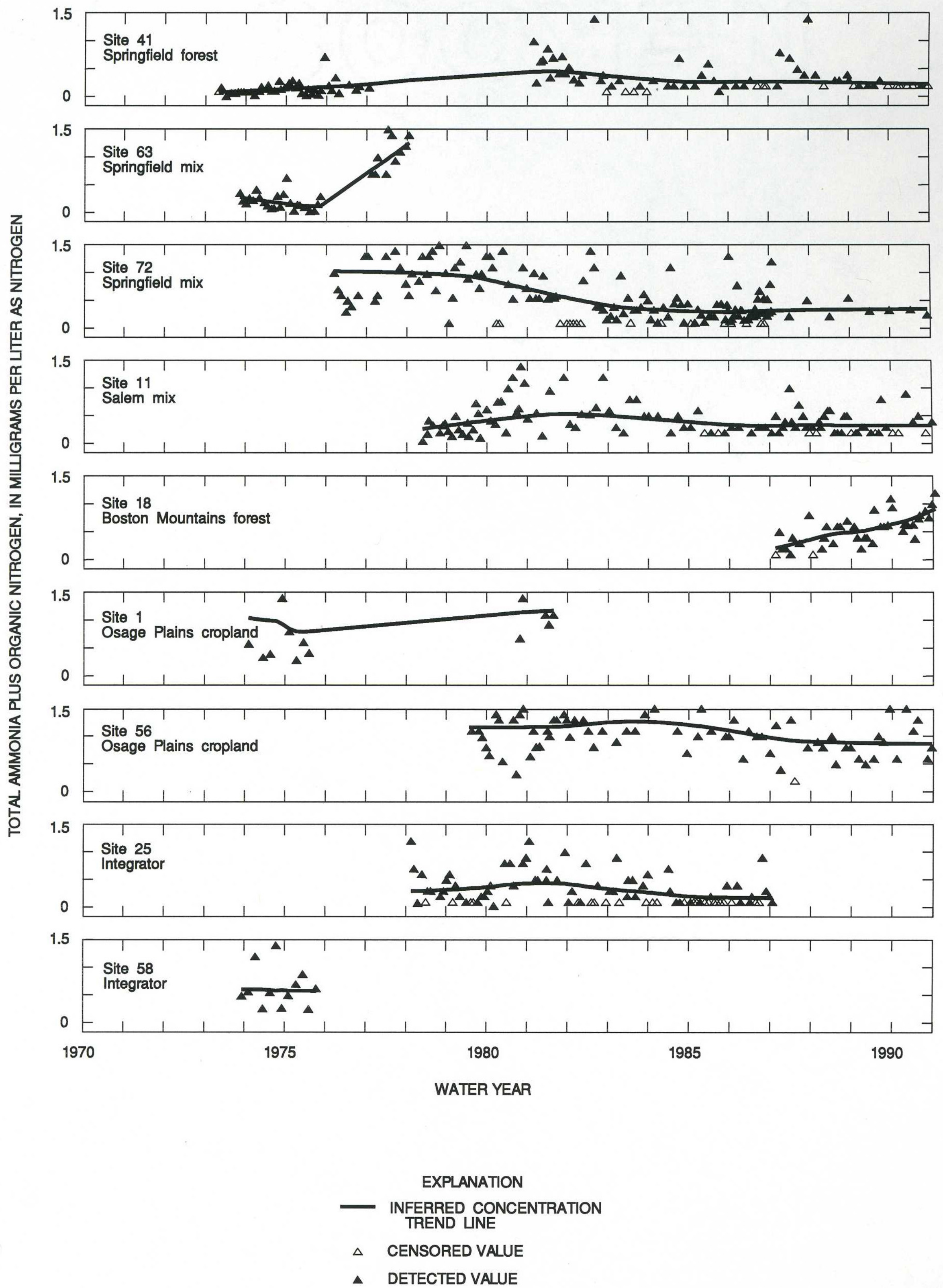

Figure 30. Concentrations of total ammonia plus organic nitrogen for water years 1970-90 at selected surface-water sites.

sites in the Springfield Plateau (sites 34, 64, 71, and 72) and Osage Plains (sites 2, 7, and 56), and at integrator sites (sites 9, 15, 25, 54, and 80). The causes of these decreases are unknown. Although the sites were not considered to be substantially affected by STP's, some are downstream of STP's that might be affecting concentrations enough to cause these changes in water quality. Some sites (2 and 7) are in agricultural basins and not downstream of any STP's.

Phosphorus

Concentrations of total phosphorus had not changed substantially at most sites (fig. 31). Increases in total phosphorus concentrations had occurred at about one-half of the sites in the Springfield Plateau (sites 64, 66, 69, 71, 72; and site 60 since about 1980). All of the Springfield Plateau sites with increasing concentrations are pasture or forest/pasture mix type sites (table 6). Decreases in total phosphorus concentrations had occurred at about one-third of the sites in the Salem Plateau (sites 10, 11, and 12). Most of the sites with decreasing concentrations are Salem Plateau forest sites (table 6). The USGS laboratory bias in the early 1980's may at least partially explain these decreases. These sites also are downstream of STP's, although the STP's are not considered to be substantially affecting the water quality at these sites.

Concentrations of orthophosphate had not changed substantially at most sites (fig. 32). The relatively few number of sites and limited amount of orthophosphate data make any definition of areal or land-use patterns of water-quality trends difficult. Concentrations may have decreased at some sites in the Osage Plains during the relatively short periods that data are available (sites 2, 56, and 57). Decreases in orthophosphate concentration also may have occurred at some integrator sites (sites 9, 15, and 25).

Suspended Sediment and Suspended Solids

Few suspended-sediment concentration data were available. Concentrations have not changed substantially at sites for which data were available.

Concentrations of suspended solids had not changed substantially at most sites (fig. 33). However, decreases had occurred at the two sites representative of the Osage Plains (sites 1 and 81) and at the integrator site on the Spring River (site 80), which has a substantial part of the Osage Plains in its drainage area. Decreases in concentration also have occurred at several sites in the Salem Plateau (sites 50, 51, 53, 55, and possibly others). The decreasing concentrations may be the result of some change in agricultural or forestry practice that has decreased the amount of soil and other suspended particles transported into streams.

Ground Water

Few ground-water sites had sufficient data for determining changes in water quality over time. Only five sites had water-quality samples collected for more than 10 years. These sites, which are all springs in the Ozark aquifer, are located in the mostly forested Current River Basin of southeastern Missouri (table 13; fig. 7).

Water-quality data for these sites are insufficient for statistical trend analysis because the samples were not collected seasonally. In addition, samples were not analyzed for nitrate between about 1983 to 1991, and samples were not analyzed for orthophosphate until 1991.

Nitrite plus nitrate, ammonia, and ammonia plus organic nitrogen concentrations in water samples from these springs do not indicate any trends. In general, concentrations of nitrogen species in water issuing from these springs were small, probably as a result of the relatively pristine condition of the basin.

Total phosphorus concentrations generally were less than detection limits in most of the water samples collected from the springs. Relatively high concentrations of total phosphorus in ground-water samples occurred in the early 1980's, but probably resulted from biases in the data caused by analytical procedures.

SURFACE-WATER LOADS

Nutrient inputs to the study unit can be estimated using data of varying accuracy and completeness, between 1980 and 1991. Inputs from poultry and livestock, commercial fertilizers, atmospheric deposition, and point sources were estimated. Inputs of naturally occurring organic material were not estimated.

Approximately 650,000 tons of nitrogen per year were input into the study unit from poultry and livestock, commercial fertilizer, atmospheric deposition, and point sources. Inputs from streams that flow into the study unit were not included in this estimate. About 55 percent of the 650,000 tons of nitrogen was from poultry and livestock (table 3), about 25 percent

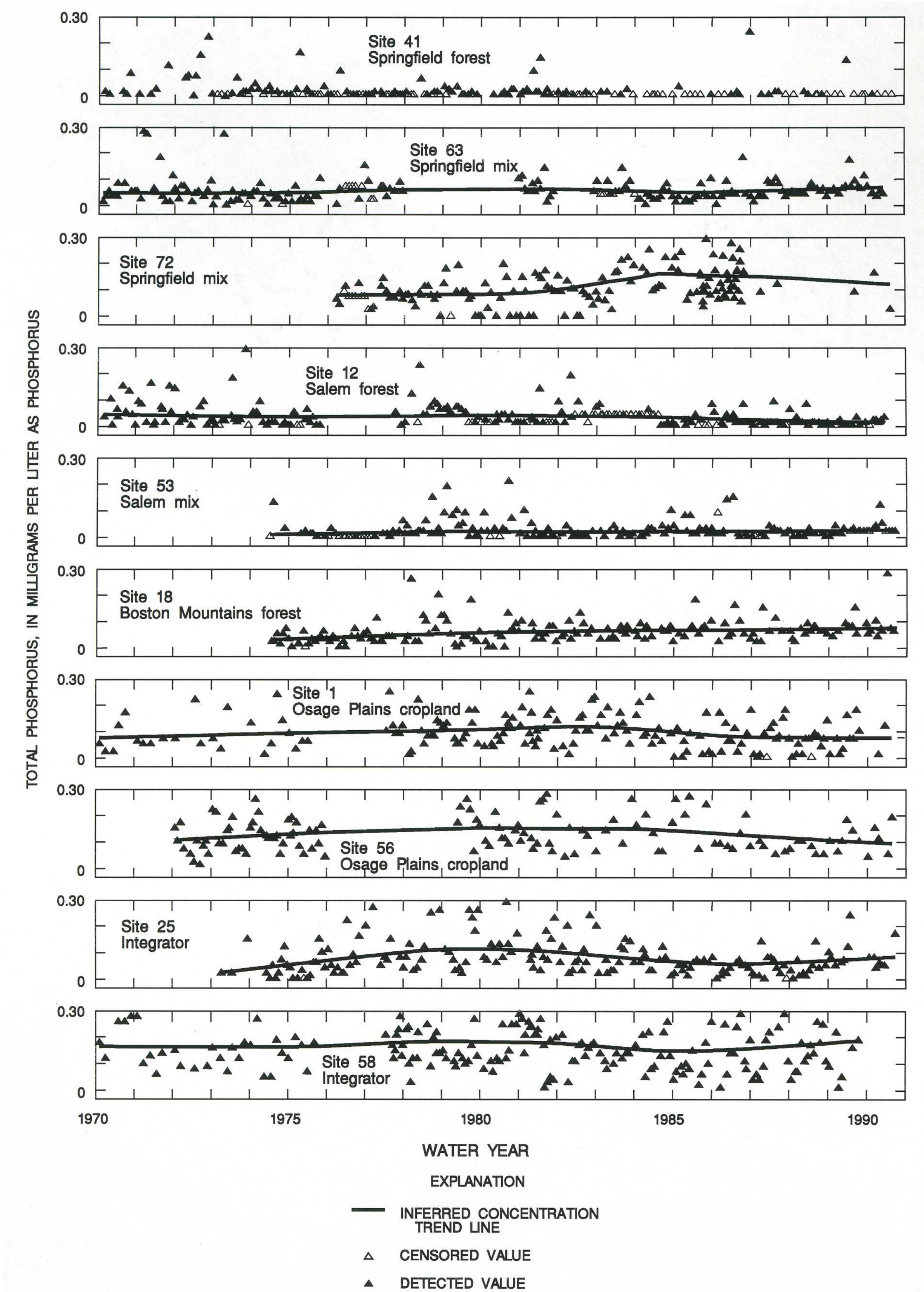

Figure 31. Concentrations of total phosphorus for water years 1970-90 at selected suface-water sites.

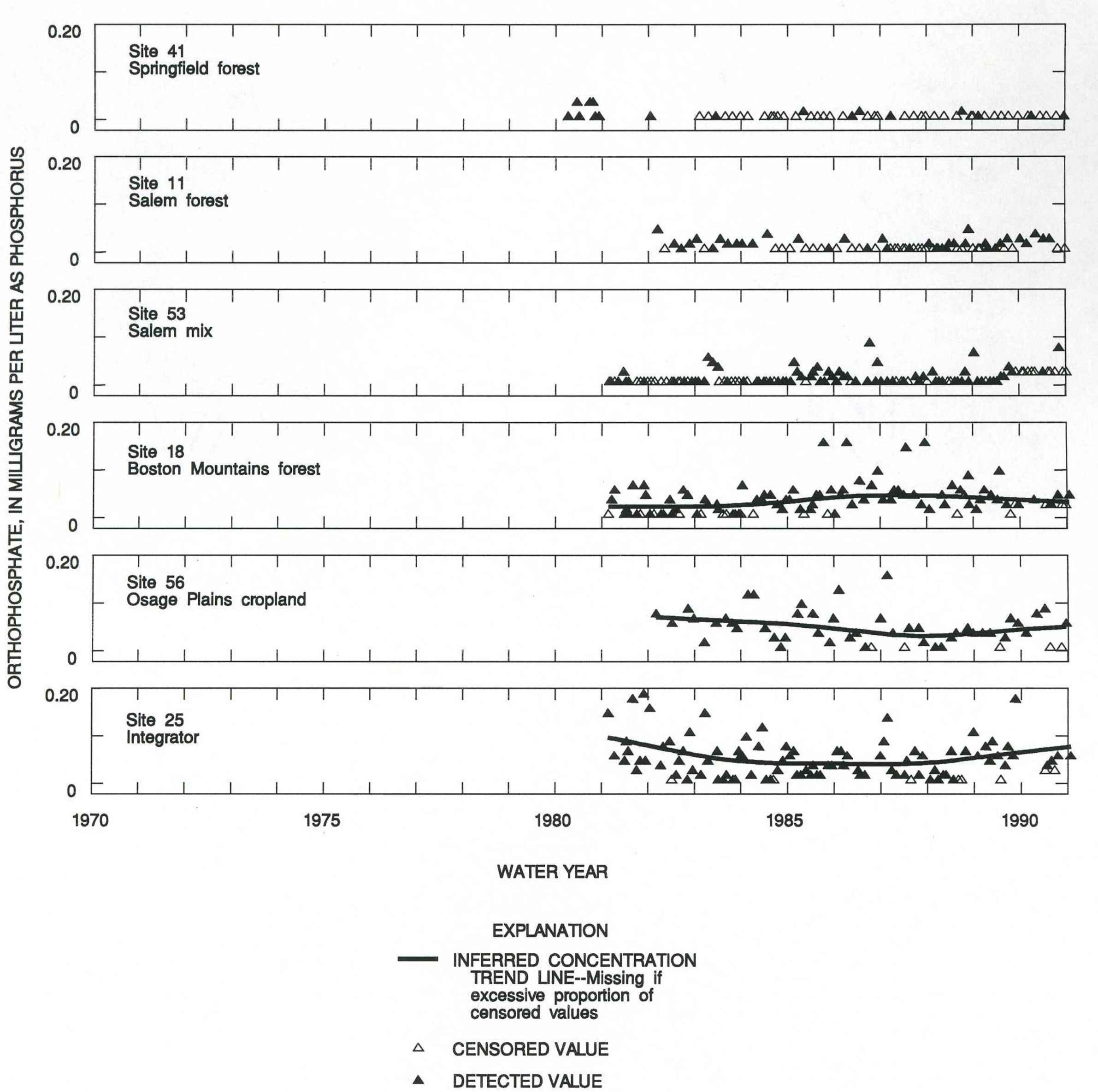

Figure 32. Concentrations of orthophosphate for water years 1970-90 at selected surface-water sites.

was from commercial fertilizers (table 2), 15 percent was ammonia and nitrate from atmospheric deposition (refer to the "Climate, Population, Land Use, and Water Use" section of this report), and less than 5 percent was ammonia and organic nitrogen from point sources (Gianessi and Peskin, 1984). Point sources probably contributed an amount of nitrate as nitrogen about equal to the amount of ammonia and organic nitrogen.

Approximately 150,000 tons of phosphorus per year were input into the study unit from poultry and livestock, commercial fertilizer, atmospheric deposition, and point sources. Inputs from streams that flow into the study unit were not included in this estimate. About 80 percent of the 150,000 tons of phosphorus was from poultry and livestock (table 3), less than about 20 percent was from commercial fertilizers (table 2), and a few percent was from point sources (Gianessi and Peskin, 1984). The amount of phosphorus from atmospheric deposition was unknown, but in general, the amount of wet deposition of phosphorus probably is minor, whereas the amount of dry deposition can be substantial but is affected by local sources

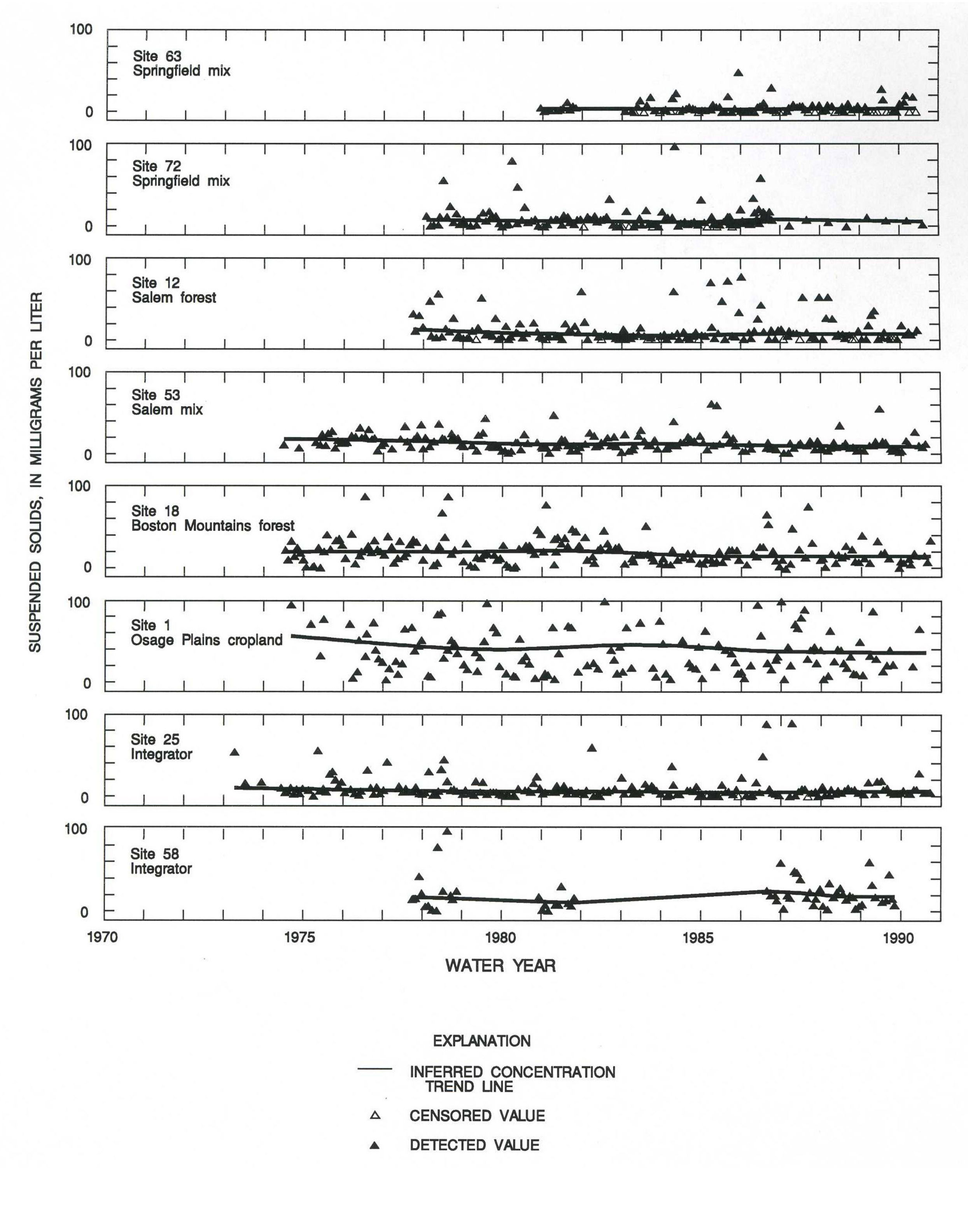

Figure 33. Concentrations of suspended solids for water years 1970-90 at selected surface-water sites.

Table 13. Ground-water sites with water-quality samples collected for more than 10 years

Map number (fig. 7)	Station number	Station name	Period of record	Hydrogeologic unit
16	07064400	Montauk Springs at Montauk, Mo.	July 1974–Oct. 1991	Ozark aquifer
17	07064530	Welch Spring near Akers, Mo.	Apr. 1973–Oct. 1991	Ozark aquifer
18	07065000	Round Spring at Round Spring, Mo.	Apr. 1973–Oct. 1991	Ozark aquifer
19	07065500	Alley Spring at Alley, Mo.	Apr. 1973–Oct. 1991	Ozark aquifer
20	07066550	Blue Spring near Eminence, Mo.	Apr. 1973–Oct. 1991	Ozark aquifer

(R.P. Hooper, U.S. Geological Survey, oral commun., 1993).

The amount of nitrogen and phosphorus from each of these input sources greatly differs among the basins in the study unit. Inputs per square mile were estimated for selected basins (tables 14 and 15). Of the selected basins, nutrient inputs from municipal point sources and animal manure (generally the largest non-point source) were largest for the basins in the north-western Arkansas and southwestern Missouri area (White and Elk River Basins). The North Sylamore Creek Basin (fig. 3; table 6), a relatively undisturbed basin, had the smallest inputs of nitrogen and phosphorus from all sources.

The effect of each of these input sources varies from basin to basin depending on factors such as the proportion of each input in that basin, the volume of streamflow, and other hydrologic and physiographic conditions. For example, although atmospheric inputs probably were relatively constant throughout the study unit, inputs from poultry and livestock were greater in northwestern Arkansas, southwestern Missouri, and northeastern Oklahoma. Also, although nutrient inputs from point sources only were a small fraction of total nutrient inputs, these inputs were discharged directly into streams and reservoirs. Much of the nutrients from the poultry, livestock, and commercial fertilizers will be taken up by plants or volatilized before reaching the surface or ground water.

Ten sites in the study unit were selected for estimation of annual loads of total nitrogen, total phosphorus, and suspended sediment. An attempt was made to estimate loads for the largest basins in the study unit, if adequate data were available. Loads were estimated for sites on the Osage, Gasconade, Meramec, White, Black, and Neosho Rivers. Loads also were estimated for North Sylamore Creek (a small tributary to the White River, with a basin relatively

Table 14. Estimated annual inputs of nitrogen for selected basins

[Inputs are in tons per square mile upstream of the specific site, in each basin. Original data from the U.S. Environmental Protection Agency Permit Compliance System data base (point source), National Atmospheric Deposition Program data base (atmospheric), U.S. Department of Agriculture fertilizer use estimates (Alexander and Smith, 1990), and the 1987 Census of Agriculture (manure) were used to calculate these estimates. Atmospheric nitrogen values are for wet plus dry deposition of ammonia and nitrate]

Basin (fig. 3 and table 6)	Point sources (1985–91)		Nonpoint sources		
	Municipal	Industrial	Atmospheric (1980–90)	Fertilizer (1985)	Manure (1987)
Gasconade (site 11)	0.04	0.11	1.9	4.3	6.2
Meramec (site 15)	.02	.009	1.9	1.9	2.6
White (site 39)	.19	.003	1.9	2.7	6.2
North Sylamore (site 41)	None	None	1.9	.06	.25
Elk (site 63)	.26	.02	1.9	3.3	13

Table 15. Estimated annual inputs of phosphorus for selected basins

[Inputs are in tons per square mile upstream of the specific site in each basin. Original data from the U.S. Environmental Protection Agency Permit Compliance System data base (point source), U.S. Department of Agriculture fertilizer use estimates (Alexander and Smith, 1990), and the 1987 Census of Agriculture (manure) were used to calculate these estimates. --, data are not available; <, less than]

Basin (fig. 3 and table 6)	Point sources (1985–91)		Nonpoint sources		
	Municipal	Industrial	Atmospheric (1980–90)	Fertilizer (1985)	Manure (1987)
Gasconade (site 11)	0.005	0.04	--	0.75	1.7
Meramec (site 15)	.02	.004	--	.34	.86
White (site 39)	.02	<.001	--	.41	1.9
North Sylamore (site 41)	None	None	--	.007	.07
Elk (site 63)	.03	.007	--	.52	4.2

unaffected by human activities), the Current River (a major tributary to the Black River), and the Elk River (a major tributary to the Neosho River, with substantial numbers of poultry, livestock, and STP's in the basin). Loads were not estimated for the Illinois and St. Francis Rivers because of a lack of appropriate data.

The regression models used for each load estimate are shown in table 16. In addition to being a function of streamflow, load estimates usually were a function of time (the date in decimal years) and sometimes were a function of season (the sine and cosine variables).

The small amount of data collected during high flows at most sites limited the number and accuracy of the load estimates (table 17). Data for the upper decile of flow (flows greater than 90 percent of the daily mean flows) were inadequate (less than four values) for estimating the load of some constituents at 2 of the 10 sites. Data were marginally adequate for estimating most of the loads for the remaining sites (fig. 5). The approximate 95-percent confidence interval around the estimated loads commonly was plus or minus 20 to 40 percent of the estimated load and was calculated as the estimated load plus or minus 1.96 times the standard error of the prediction (table 17). Some confidence intervals were as wide as the estimated load plus or minus 80 to 90 percent of the estimated load.

Loads were estimated for water year 1981 (a low-flow year), 1984 (a moderate-flow year), and 1985 (a high-flow year). Annual mean streamflows for these three years are listed in table 18. Streamflows in 1984 generally were about two to three times the streamflows for 1981 (the low-flow year), and in 1985 generally were about three to six times the streamflows for 1981. Loads for 1984 were always substantially higher than loads for 1981 and substantially lower than loads for 1985 (table 17). Loads during 1985 were approximately 2 to 10 times higher than loads during 1981.

Loads of total nitrogen, total phosphorus, and suspended sediment generally increased with drainage area. Smallest loads occurred at North Sylamore Creek near Fifty Six, Ark. (site 41), the site with the smallest drainage area. Largest loads generally occurred at the Osage River near St. Thomas, Mo. (site 9), the site with the largest drainage area. However, total phosphorus loads were substantially larger at the Gasconade River above Jerome, Mo. (site 11), Meramec River near Eureka, Mo. (site 15), and Neosho River near Parsons, Kans. (site 56), than at the site on the White River at Calico Rock, Ark. (site 39), even though the drainage area at Calico Rock is more than double the drainage areas of the other three sites. Similar, but less pronounced patterns occurred for total nitrogen. The White River system is regulated upstream of Calico Rock by several dams; two of these dams are within 60 river miles of the site. Phosphorus typically is transported in association with sediment, and the reservoirs upstream would be expected to be sinks for sediment.

Loads and yields (loads per square mile) of nutrients and suspended sediment are affected by geology, hydrology, and inputs from natural sources, poultry and livestock, commercial fertilizers, STP's and other point sources, and atmospheric deposition. Total nitrogen, total phosphorus, and suspended-sediment yields were substantially larger for the sites on the

Table 16. Regression models used to estimate daily constituent loads at selected sites

[ln(L) = I + a ln(Q) + bT + c(sin(2πT)) + d(cos(2πT)) + e(sin(4πT)) + f(cos(4πT)): where ln is the natural logarithm, L is the load in kilograms per day; I is the regression intercept; a, b, c, d, e, and f are regression coefficients; Q is streamflow in cubic feet per second; T is the date in decimal years; π is 3.141592; --, indicates that the coefficient was not used in the model]

Site number (fig. 3)	Site name (table 6)	Regression coefficients						
		I	a	b	c	d	e	f
	Total nitrogen							
9	Osage River near St. Thomas, Mo.	9.264	1.033	- 0.034	--	--	--	--
11	Gasconade River above Jerome, Mo.	8.231	1.442	-.082	--	--	0.137	0.204
15	Meramec River near Eureka, Mo.	8.668	1.369	-.104	--	--	--	--
39	White River at Calico Rock, Ark.	9.307	1.130	-.048	--	--	--	--
41	North Sylamore Creek near Fifty Six, Ark.	2.212	1.060	-.243	--	--	--	--
56	Neosho River near Parsons, Kans.	7.340	1.162	-.038	--	--	--	--
65	Neosho River below Fort Gibson Lake near Fort Gibson, Okla.	7.487	1.078	-.036	0.196	- 0.032	--	--
	Total phosphorus							
9	Osage River near St. Thomas, Mo.	6.317	1.033	- 0.034	--	--	--	--
11	Gasconade River above Jerome, Mo.	4.813	1.317	-.086	--	--	--	--
15	Meramec River near Eureka, Mo.	5.987	1.414	--	--	--	--	--
39	White River at Calico Rock, Ark.	5.429	.972	-.093	--	--	--	--
41	North Sylamore Creek near Fifty Six, Ark.	-.825	1.039	-.093	--	--	- 0.011	0.367
45	Black River at Poplar Bluff, Mo.	4.498	1.562	--	- 0.256	- 0.631	--	--
46	Current River at Doniphan, Mo.	5.092	1.688	-.111	--	--	--	--
56	Neosho River near Parsons, Kans.	4.997	1.162	-.059	--	--	--	--
63	Elk River near Tiff City, Mo.	4.245	.904	--	--	--	--	--
65	Neosho River below Fort Gibson Lake near Fort Gibson, Okla.	4.657	1.047	--	--	--	--	--
	Suspended sediment							
11	Gasconade River above Jerome, Mo.	11.694	1.36	- 0.148	--	--	--	--
39	White River at Calico Rock, Ark.	11.445	1.442	-.183	0.421	--	--	--
41	North Sylamore Creek near Fifty Six, Ark.	5.444	.780	.070	--	--	--	--
56	Neosho River near Parsons, Kans.	11.232	1.406	--	--	--	--	--

Table 17. Estimated total nitrogen, total phosphorus, and suspended-sediment loads and yields at selected sites

[1981, 1984, and 1985 are water years with relatively low, moderate, and high annual mean streamflows; SEP is the standard error of the prediction; a 95-percent confidence interval can be approximated as the estimated load plus or minus 1.96 times the SEP; tons/yr is tons per year; mi^2 is square miles; --, unless otherwise noted, indicates that data were examined but were inadequate for estimation of loads or yields]

Site number (fig. 3)	Site name (drainage area) (table 6)	Constituent	1981			1984			1985		
			Load (tons/yr)	SEP (tons/yr)	Yield [(tons/yr)/mi^2]	Load (tons/yr)	SEP (tons/yr)	Yield [(tons/yr)/mi^2]	Load (tons/yr)	SEP (tons/yr)	Yield [(tons/yr)/mi^2]
9	Osage River near St. Thomas, Mo. (14,500 mi^2)	Total nitrogen	11,900	1,010	0.821	19,900	1,420	1.37	25,500	1,890	1.76
		Total phosphorus	477	60	.033	848	91	.058	1,090	123	.075
		Suspended sediment	--	--	--	--	--	--	--	--	--
11	Gasconade River above Jerome, Mo. (2,570 mi^2)	Total nitrogen	2,700	407	1.05	7,020	1,010	2.73	13,800	2,430	5.37
		Total phosphorus	94	23	.037	252	64	.098	416	123	.162
		Suspended sediment	167,000	69,000	65.0	391,000	161,000	152	608,000	287,000	237
15	Meramec River near Eureka, Mo. (3,788 mi^2)	Total nitrogen	4,390	710	1.16	6,000	772	1.58	10,800	1,740	2.85
		Total phosphorus	228	39	.060	411	61	.108	849	159	.224
		Suspended sediment[1]	--	--	--	--	--	--	--	--	--
39	White River at Calico Rock, Ark. (9,978 mi^2)	Total nitrogen	2,690	251	.270	7,340	543	.074	15,100	1,390	1.51
		Total phosphorus	95	18	.009	190	28	.019	342	61	.034
		Suspended sediment	20,300	4,080	2.03	87,600	14,900	8.78	245,000	49,500	24.6
41	North Sylamore Creek near Fifty Six, Ark. (58 mi^2)	Total nitrogen	13	3.4	.224	14	4.1	.241	22	8.7	.379
		Total phosphorus	.37	.10	.006	.57	.17	.010	1.1	.41	.019
		Suspended sediment	82	16	1.41	176	36	3.03	311	80	5.36
45	Black River at Poplar Bluff, Mo. (1,245 mi^2)	Total nitrogen[2]	--	--	--	--	--	--	--	--	--
		Total phosphorus	39	11	.031	57	13	.046	152	42	.122
		Suspended sediment[2]	--	--	--	--	--	--	--	--	--

Table 17. Estimated total nitrogen, total phosphorus, and suspended-sediment loads and yields at selected sites—Continued

Site number (fig. 3)	Site name (drainage area) (table 6)	Constituent	1981			1984			1985		
			Load (tons/yr)	SEP (tons/yr)	Yield [(tons/yr)/mi²]	Load (tons/yr)	SEP (tons/yr)	Yield [(tons/yr)/mi²]	Load (tons/yr)	SEP (tons/yr)	Yield [(tons/yr)/mi²]
46	Current River at Doniphan, Mo. (2,038 mi²)	Total nitrogen[2]	--	--	--	--	--	--	--	--	--
		Total phosphorus	28	5.9	0.014	78	14	0.038	223	68	0.109
		Suspended sediment[2]	--	--	--	--	--	--	--	--	--
56	Neosho River near Parsons, Kans. (4,905 mi²)	Total nitrogen	1,980	263	.404	7,670	929	1.56	11,600	1,410	2.36
		Total phosphorus	201	23	.004	732	78	.149	1,080	116	.220
		Suspended sediment	142,000	24,900	29.0	744,000	129,000	152	1,240,000	219,000	253
63	Elk River near Tiff City, Mo. (872 mi²)	Total nitrogen[2]	--	--	--	--	--	--	--	--	--
		Total phosphorus	13	1.2	.014	38	4.1	.044	93	12	.107
		Suspended sediment[2]	--	--	--	--	--	--	--	--	--
65	Neosho River below Fort Gibson Lake near Fort Gibson, Okla. (12,495 mi²)	Total nitrogen	2,750	260	.220	14,700	1,210	1.18	25,700	2,030	2.06
		Total phosphorus	130	6.7	.010	649	37	.052	1,230	72	.098
		Suspended sediment	--	--	--	--	--	--	--	--	--

[1]No appropriate model found.
[2]No data available.

Table 18. Annual mean streamflow for sites used for load estimation

[1981, 1984, and 1985 are water years with low, moderate, and high annual mean streamflows]

Site number	Site name	Annual mean streamflow (cubic feet per second)		
		1981	1984	1985
9	Osage River near St. Thomas, Mo.	7,833	15,150	20,060
11	Gasconade River above Jerome, Mo.	1,591	4,165	6,491
15	Meramec River near Eureka, Mo.	2,640	4,599	7,407
39	White River at Calico Rock, Ark.	3,482	9,434	18,960
41	North Sylamore Creek near Fifty Six, Ark.	17.3	37.0	73.5
45	Black River at Poplar Bluff, Mo.	819	1,445	2,858
46	Current River at Doniphan, Mo.	1,578	3,258	5,856
56	Neosho River near Parsons, Kans.	876	3,283	4,979
63	Elk River near Tiff City, Mo.	186	627	1,648
65	Neosho River below Fort Gibson Lake near Fort Gibson, Okla.	1,948	9,194	17,210

Gasconade River above Jerome, Mo. (site 11), the Meramec River near Eureka, Mo. (site 15), and the Neosho River near Parsons, Kans. (site 56), than for other sites. The row-crop agriculture occurring in the Neosho River Basin upstream of the Parsons site and the density of STP's discharging into the lower Meramec River or tributaries upstream of the Meramec near Eureka, Mo., site (fig. 2) probably were the major causes of these relatively larger yields. Causes of the relatively high estimated yields for the Gasconade River above Jerome, Mo., are less easy to identify. Inputs of nitrogen and phosphorus from industrial sources (primarily fertilizer production) are relatively large in this basin (tables 14 and 15). However, total nitrogen yields of the Gasconade River above Jerome, Mo. (site 11), exceeded yields of rivers at other sites by the largest amounts during water years with moderate and high flows, indicating that point sources were a relatively unimportant cause of these larger nitrogen yields. Nonpoint sources of fertilizer also were relatively high in the basin (tables 14 and 15). Suspended-sediment yields at this site exceeded yields at other sites by the largest amount during the water year with low flow. The smaller total phosphorus yields for the Osage River near St. Thomas, Mo. (site 9), White River at Calico Rock, Ark. (site 39), and Neosho River below Fort Gibson Lake, Okla. (site 65), probably were strongly affected by upstream reservoirs. The total phosphorus yield of the Neosho River below Fort Gibson Lake, Okla., was approximately one-third of the yield of the Neosho River near Parsons, Kans. (site 56). Total nitrogen yields were affected less by the upstream reservoirs because of the greater proportion of dissolved nitrogen. The yields were lowest for the site on North Sylamore Creek at Fifty Six, Ark., a site with a forested basin relatively unaffected by human activity.

SUMMARY

This report includes an overview of the environmental setting of the Ozark Plateaus study unit of the National Water-Quality Assessment Program, an assessment of methods used to analyze data, spatial and temporal distribution characteristics of nutrient data for surface and ground water and suspended-sediment and suspended-solids data for surface water. Descriptions of water-quality conditions in selected physiographic, hydrogeologic, and land-use settings using statistical summaries of nutrient, suspended-sediment, and suspended-solids data, and limited trend analysis and surface-water load calculations for selected constituents are presented using water-quality data collected during water years 1970–90 for 83 sur-

face-water sites and during 1970–92 for 395 ground-water sites.

The interpretation of surface- and ground-water quality in the Ozark Plateaus study unit was somewhat limited by the available data. Data were collected over a long period by different agencies with different objectives, resulting in field collection and laboratory analysis techniques that varied over time and between agencies. For example, some nitrogen species often were not included in laboratory analysis of samples, which meant that total nitrogen concentrations could not be calculated. Incomplete geographic distribution, insufficient data for some hydrogeologic units and site types, and a lack of good ancillary data such as well depth, casing length, and land-use setting hindered data analysis. Long-term analysis of surface-water sites was somewhat limited because of insufficient streamflow data for flow-adjusting concentrations and for ground-water sites because few sites had long-term data available for temporal analysis. Surface-water load calculations could not be done at many of the 83 sites because of the lack of continuous streamflow data and the fact that few samples were collected at higher flows, which is when a stream carries the largest constituent loads. In spite of these limitations, however, analysis of existing data resulted in an initial description of the water-quality conditions in the study unit.

Median nitrite plus nitrate concentrations in streams substantially affected by sewage-treatment plants (STP) in all physiographic areas were significantly larger than at any other type of site. Within the Boston Mountains and Springfield and Salem Plateaus, nitrite plus nitrate concentrations increased significantly at sites in basins with more intense land-use activities (from forest to forest/pasture mix to pasture). Concentrations were smallest at sites in forested basins in the Springfield Plateau, which are 85 percent or greater forested. With the exception of the STP sites, the largest nitrite plus nitrate concentrations were in streams in Springfield Plateau forest/pasture mix and pasture, where some of the largest densities of poultry, cattle, and swine are located. Ammonia, total ammonia plus organic nitrogen, and total nitrogen patterns were similar to nitrite plus nitrate patterns except that within agricultural areas, the largest concentrations of ammonia and total ammonia plus organic nitrogen occurred in streams in Osage Plains cropland.

Total phosphorus concentration patterns were similar to those discussed for the nitrogen species. With the exception of the STP sites, the largest concentrations were in streams within agricultural land-use settings in the Osage Plains and Springfield Plateau. The larger concentrations in the Osage Plains could be related not only to agricultural land use but also to the large suspended-sediment concentrations in streams in the area. Orthophosphate concentrations generally had the same pattern as total phosphorus except that concentrations in streams from Osage Plains cropland were significantly smaller than those from either of the agricultural land-use settings in the Springfield Plateau, indicating that much of the phosphorus in the Osage Plains cropland streams was associated with sediment particles.

Suspended-solids data were used in the statistical analysis because only 14 of the 83 surface-water sites had suspended-sediment data. Suspended-solids concentrations were largest in streams in the Osage Plains because of easily erodible soils and intensive field- and row-crop agriculture. Concentrations differed significantly among streams from different land-use settings in the Springfield and Salem Plateaus with concentrations generally increasing with more intense land-use activities.

Indicator sites were chosen in basins that have relatively homogeneous land use and physiography to represent specific land-use settings within specific physiographic areas. The basins containing integrator sites have more heterogeneous land use and physiography. Three basins—the Meramec River, the Osage River, and the White River—were chosen for comparison of nitrite plus nitrate and total phosphorus concentrations at indicator and integrator sites. Concentrations at integrator sites generally were intermediate between those detected at indicator sites.

The relation between constituent concentrations and discharge is a function of which phase the nutrient prefers (dissolved or particulate phase), point or nonpoint source origin of the nutrient, the overall magnitude and availability of the constituent in the basin, and the degree of streamflow regulation by reservoirs. Concentrations of nitrite plus nitrate, which primarily exist in the dissolved phase, generally increase with the washoff of available material by precipitation and then decrease. This occurrence was most pronounced in sites representing agricultural land use. At sites primarily affected by point sources, concentrations were generally largest at low flows and decreased in response to precipitation. Streamflow regulation resulted in poor correlation between concentration and discharge. Concentrations of total phosphorus, which tends to adsorb to sediment, generally increased with increasing streamflow. The total phosphorus concentration and discharge relation is similar to nitrite plus nitrate at sites primarily affected by point sources of phosphorus. Streamflow regulation affects the total phosphorus concentration-discharge relation because of sediment trapping by the reservoir.

Ground-water samples were not regularly collected from 1970–92. Ground-water samples have been collected for numerous, short-term projects, the objectives of which were to study the water quality in small parts of the Ozark Plateaus. Well depth in the data set ranges from 5 to 3,420 ft below land surface. Well depth is related to the thickness, depth, and use of each hydrogeologic unit. Well depth generally is greatest in the confined Ozark and St. Francois aquifers and least in the surficial Mississippi River Valley alluvial aquifer and Western Interior Plains confining system. Well depth also can be related to land and well use; median depth is greater for public-supply wells in the urban land-use setting than for wells in the other two land-use settings.

Results indicate nitrite plus nitrate concentrations in ground water were affected by agricultural land use. Nitrite plus nitrate concentrations in ground water also were largest where specific conductance and alkalinity data indicate that the water source is shallow and more susceptible to surface contamination than where data indicate the water source is deep. In addition, clay and shale confining layers can retard migration of surface contaminants and prevent excessive nitrate concentrations in ground water.

Ammonia concentrations in ground water were larger in samples collected from agricultural areas than in other land-use settings, and they were larger in samples collected from deep parts of the hydrogeologic units than in shallow parts. The relation with depth of water source probably is related to oxidation-reduction conditions within the hydrogeologic units.

Ammonia plus organic nitrogen concentrations in ground water generally were small in the study unit. Data are insufficient to make conclusions about the distribution of ammonia plus organic nitrogen in ground water of the Ozark Plateaus.

More than 50 percent of the total nitrogen concentrations in most (70 percent) ground-water samples were composed of nitrite plus nitrate. As with nitrite plus nitrate, total nitrogen is affected by land use and hydrogeology.

The distribution and occurrence of total phosphorus concentrations in ground water probably are related to geology and land use. Orthophosphate concentrations in ground water are related to land use.

Changes in water quality have occurred at several surface-water sites in the study unit during the last 10 to 20 years. Results of previous investigations of water-quality trends in the study unit have indicated that a disproportionately larger number of sites in northwestern Arkansas, northeastern Oklahoma, and southwestern Missouri have upward trends in nitrite plus nitrate, phosphorus, and orthophosphate.

Nonstatistical examination of plots of concentrations and flow-adjusted concentrations of selected nutrients, suspended sediment, and suspended solids during water years 1970–90 indicates that concentrations for sites associated with certain physiographic areas or land uses have changed more often than for other types of sites. Nitrite plus nitrate concentrations have decreased at most sites in the Osage Plains but have increased at some sites in the Springfield Plateau. Ammonia concentrations seem to have decreased at several sites, including all sites in the Osage Plains and several sites in the Salem Plateau. Total ammonia plus organic nitrogen concentrations have decreased at several sites, primarily in the Osage Plains and Springfield Plateau. Total phosphorus concentrations increased at about one-half of the sites in the Springfield Plateau, whereas decreases occurred at about one-third of the sites in the Salem Plateau. Suspended-solids concentrations have decreased at two Osage Plains sites and several Salem Plateau sites. Many of these increasing and decreasing trends may be related to agricultural practices. Other possible causes include laboratory or field method bias or STP effluents. However, sites selected for examination were chosen because they were not considered to be substantially affected by effluents.

Water-quality data for ground-water sites generally were not sufficient for statistical trend analysis. Five ground-water sites had water-quality data for a period of record of 10 or more years. All five sites are springs located in southeastern Missouri. Nitrite plus nitrate, ammonia, ammonia plus organic nitrogen, and total phosphorus concentrations in water samples from these springs do not indicate changes over time.

Surface-water loads of nutrients and suspended sediment were affected in the study unit by several factors, including streamflow, climate, drainage area, reservoir operation, and inputs from point and nonpoint sources. Annual loads were largest in large basins, with large inputs of nutrients or sediment during periods of high streamflows at locations where reservoir operation effects are not substantial. Smallest loads occurred at North Sylamore Creek near Fifty Six, Ark., a site with a small basin relatively unimpacted by human activities. Largest loads generally occurred at the Osage River near St. Thomas, Mo., the site with the largest drainage area.

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TABLES

Table 6. Site and basin characteristics of surface-water sites in the Ozark Plateaus study unit

[Abbreviations for collecting agency: USGS, U.S. Geological Survey; Coop, cooperative program; KWO, Kansas Water Office; KDHE, Kansas Department of Health and Environment; NASQAN, National Stream Quality Accounting Network; MDNR, Missouri Department of Natural Resources; OFA, other Federal agency; COE, U.S. Army Corps of Engineers; ADPCE, Arkansas Department of Pollution Control and Ecology; Springfield, Springfield Plateau; Salem, Salem Plateau; St. Francois, St. Francois Mountains; AGC, Arkansas Geological Commission; HBM, Hydrologic BenchMark network; SCS, Soil Conservation Service; ODEQ, Oklahoma Department of Environmental Quality; NPS, National Park Service. Abbreviations for frequency of collection: B-M, bimonthly; D, daily; W, weekly; M, monthly; Q, quarterly; SD, sampling day; yr, year; W water year; mon, month; --, data unavailable; STP, sewage-treatment plant; Pb-Zn, lead-zinc; site designated as a "mix" site type has greater than on third but less than two-thirds pasture land use in the basin]

Site number (fig. 3)	Site name	Latitude	Longitude	Drainage area (square miles)	Collecting agency	Period of record (through water year 1990)	Number of samples (through water year 1990)
1	Little Osage River at Fulton, Kans.	38 01 09	94 42 48	295	USGS (Coop-KWO), KDHE	Dec. 1968-Sept. 1990	1,019
2	Osage River above Schell City, Mo.	38 03 20	94 08 44	5,410	USGS (NASQAN)	Mar. 1979-Sept. 1990	143
3	Sac River near Dadeville, Mo.	37 26 35	93 41 05	257	USGS (Coop-MDNR)	Nov. 1983-June 1987	44
4	Little Sac River near Walnut Grove, Mo.	37 23 55	93 24 36	--	USGS (Coop-MDNR)	Oct. 1983-June 1990	50
5	Pomme de Terre River near Polk, Mo.	37 40 56	93 22 12	276	USGS (Coop-MDNR)	Nov. 1983-Feb. 1986	28
6	South Grand River at Urich, Mo.	38 27 08	94 00 13	670	USGS (Coop-MDNR)	Oct. 1979-June 1987	46
7	West Fork Tebo Creek near Lewis, Mo.	38 25 16	93 39 36	--	USGS (OFA-COE)	Oct. 1983-Sept. 1990	84
8	Niangua River at Bennett Springs, Mo.	37 44 17	92 51 37	--	USGS (Coop-MDNR)	Oct. 1982-Sept. 1988	72
9	Osage River below St. Thomas, Mo.	38 25 18	92 12 31	14,500	USGS (NASQAN)	Oct. 1974-Sept. 1990	238
10	Big Piney River at Devil's Elbow, Mo.	37 50 53	92 03 44	--	USGS (Coop-MDNR)	July 1977-June 1989	144
11	Gasconade River above Jerome, Mo.	37 55 12	91 58 33	2,570	USGS (NASQAN)	Aug. 1962-Sept. 1990	190
12	Meramec River near Sullivan, Mo.	38 09 30	91 06 30	1,475	USGS (Coop-MDNR)	Aug. 1963-June 1990	338
13	Bourbeuse River above Union, Mo.	38 25 55	91 01 11	808	USGS (Coop-MDNR)	Aug. 1963-June 1987	226
14	Big River near Richwoods, Mo.	38 09 34	90 42 22	735	USGS (Coop-MDNR)	Nov. 1983-Sept. 1989	52
15	Meramec River near Eureka, Mo.	38 30 20	90 35 30	3,788	USGS (NASQAN)	Jan. 1978-Sept. 1990	177
16	St. Francis River near Saco, Mo.	37 23 06	90 28 27	664	USGS (Coop-MDNR)	Oct. 1982-June 1989	66
17	St. Francis River at Fisk, Mo.	36 46 50	90 12 10	1,370	USGS (OFA-COE)	Oct. 1977-Sept. 1990	155
18	West Fork White River east of Fayetteville, Ark.	36 03 00	94 04 42	--	ADPCE	Apr. 1974-Sept. 1990	196
19	White River near Goshen, Ark.	36 06 22	94 00 41	412	USGS (OFA-COE), ADPCE	Aug. 1963-Sept. 1990	389
20	Richland Creek at Goshen, Ark.	36 06 14	94 00 26	138	USGS (OFA-COE)	Aug. 1963-Sept. 1990	47
21	Holman Creek near Huntsville, Ark.	36 07 25	93 44 02	--	ADPCE	Nov. 1983-Sept. 1990	82

Table 6. Site and basin characteristics of surface-water sites in the Ozark Plateaus study unit—Continued

Site number (fig. 3)	Site name	Frequency of collection	Physiographic area	Major land uses[1]	Site type	Major point sources
1	Little Osage River at Fulton, Kans.	B-M, Dec. 1968-June 1975; D-W, Oct. 1977-Aug. 1982; M, Sept. 1982-Sept. 1990	Osage Plains	cropland	Osage Plains cropland	0
2	Osage River above Schell City, Mo.	M, Mar. 1979-Sept. 1980; B-M, Nov. 1980-Sept. 1990	Osage Plains	cropland/coal/ mining	Osage Plains cropland	2
3	Sac River near Dadeville, Mo.	M	Springfield	pasture/forest	Springfield pasture	0
4	Little Sac River near Walnut Grove, Mo.	M, Oct. 1983-Feb. 1986; M, Oct. 1988-June 1990	Springfield	pasture/forest/ urban	Springfield STP	1
5	Pomme de Terre River near Polk, Mo.	M	Springfield	pasture/forest	Salem pasture	1
6	South Grand River at Urich, Mo.	M	Osage Plains	cropland	Osage Plains cropland	3
7	West Fork Tebo Creek near Lewis, Mo.	M	Osage Plains	cropland/coal/ mining	Osage Plains cropland	0
8	Niangua River at Bennett Springs, Mo.	M	Salem	pasture/forest	Salem mix	1
9	Osage River below St.Thomas, Mo.	M, Oct. 1974-Nov. 1981; B-M, Jan. 1982-Sept. 1990	Salem, Spring-field, and Osage Plains	cropland/ pasture/forest/ coal mining	Integrator	7
10	Big Piney River at Devil's Elbow, Mo.	M	Salem	forest/pasture	Salem forest	1
11	Gasconade River above Jerome, Mo.	M, Aug. 1962-June 1963; M, July 1977-Oct. 1980; B-M, Nov. 1980-Sept. 1986; M, Oct. 1986-Sept. 1990	Salem	forest/pasture	Salem mix	3
12	Meramec River near Sullivan, Mo.	M, Aug. 1963-July 1975; M, July 1977-June 1990	Salem	forest/pasture	Salem forest	1
13	Bourbeuse River above Union, Mo.	M, Aug. 1963-July 1975; M, Nov. 1983-June 1987	Salem	forest/pasture	Salem mix	1
14	Big River near Richwoods, Mo.	M, Nov. 1983-June 1987; Q, Feb. 1988-Sept. 1989	Salem and St. Francois	forest/pasture/ Pb-Zn mining	Salem forest	1
15	Meramec River near Eureka, Mo.	M, Jan. 1978-Nov. 1980; B-M, Jan. 1981-Sept. 1990	Salem and St. Francois	forest/pasture/ Pb-Zn mining	Integrator	5
16	St. Francis River near Saco, Mo.	M, Oct. 1982-June 1987; M, Oct. 1988-June 1989	St. Francois	forest/pasture/ Pb-Zn mining	St. Francois forest	1
17	St. Francis River at Fisk, Mo.	M	Mississippi Alluvial Plain, Salem, and St. Francois	forest/pasture/ cropland/ Pb-Zn mining	Integrator	1
18	West Fork White River east of Fayetteville, Ark.	M	Boston Mountains and Springfield	forest/pasture/ urban	Boston Mountains forest	1
19	White River near Goshen, Ark.	1 SD, 1963; M, July 1969-Sept. 1990	Boston Mountains and Springfield	forest/urban	Boston Mountains STP	1
20	Richland Creek at Goshen, Ark.	1 SD, 1963; 2 SD, 1980; 2-5 SD/yr, May 1984-July 1990	Boston Mountains and Springfield	forest/pasture	Boston Mountains mix	0
21	Holman Creek near Huntsville, Ark.	M	Boston Mountains	forest/pasture/ urban	Boston Mountains STP	1

Table 6. Site and basin characteristics of surface-water sites in the Ozark Plateaus study unit—Continued

Site number (fig. 3)	Site name	Latitude	Longitude	Drainage area (square miles)	Collecting agency	Period of record (through water year 1990)	Number of samples (through water year 1990)
22	White River at Beaver Dam near Eureka Springs, Ark.	36 25 15	93 50 50	1,192	USGS (OFA-COE)	Mar. 1967-Sept. 1990	260
23	Osage Creek southwest of Berryville, Ark.	36 20 55	93 35 26	--	ADPCE	Nov. 1983-Sept. 1990	84
24	Osage Creek west of Berryville, Ark.	36 21 50	93 36 26	--	ADPCE	Nov. 1983-Sept. 1990	62
25	Kings River near Berryville, Ark.	36 25 36	93 37 15	527	ADPCE	July 1945-Sept. 1990	363
26	James River near Wilson Creek, Mo.	37 04 35	93 22 15	--	USGS (Coop-MDNR)	Aug. 1964-June 1987	313
27	James River near Boaz, Mo.	37 00 25	93 21 50	462	USGS (Coop-MDNR)	Aug. 1964-June 1987	304
28	Long Creek near Denver, Ark.	36 25 46	93 18 22	--	ADPCE	Nov. 1983-Sept. 1990	83
29	White River below Table Rock Dam near Branson, Mo.	36 35 42	93 18 32	4,020	USGS (OFA-COE)	Oct. 1974-Sept. 1990	250
30	White River at Bull Shoals Dam near Flippin, Ark.	36 21 54	92 34 30	6,051	USGS (OFA-COE)	July 1954-Sept. 1990	460
31	Crooked Creek at Harrison, Ark.	36 13 57	93 05 28	--	ADPCE	Nov. 1983-Sept. 1990	86
32	Crooked Creek near Harrison, Ark.	36 14 38	93 04 38	--	ADPCE	Nov. 1983-Sept. 1990	83
33	Crooked Creek at Yellville, Ark.	36 13 23	92 40 47	406	ADPCE	Oct. 1979-Sept. 1990	129
34	Buffalo River near St. Joe, Ark.	35 59 02	92 44 44	829	ADPCE	July 1945-Sept. 1990	346
35	Hicks Creek near Mountain Home, Ark.	36 17 32	92 22 34	--	ADPCE	Nov. 1983-Sept. 1990	83
36	White River near Norfork, Ark.	36 13 24	92 18 06	--	ADPCE	Apr. 1974-Sept. 1990	201
37	North Fork River near Tecumseh, Mo.	36 37 22	92 14 53	561	USGS (Coop-MDNR)	July 1969-June 1987	115
38	North Fork River at Norfork Dam near Norfork, Ark.	36 14 57	92 14 18	1,808	USGS (OFA-COE)	Oct. 1946-Sept. 1990	459
39	White River at Calico Rock, Ark.	36 06 58	92 08 35	9,978	USGS (Coop-AGC)	Nov. 1945-Aug. 1990	241
40	Mill Creek near Melbourne, Ark.	36 03 13	91 54 58	--	ADPCE	Nov. 1983-Aug. 1990	82
41	North Sylamore Creek near Fifty Six, Ark.	35 59 43	92 12 45	58	USGS (HBM)	June 1966-Sept. 1990	323

Table 6. Site and basin characteristics of surface-water sites in the Ozark Plateaus study unit—Continued

Site number (fig. 3)	Site name	Frequency of collection	Physiographic area	Major land uses[1]	Site type	Major point sources
22	White River at Beaver Dam near Eureka Springs, Ark.	3 SD, 1967 and 1968; M, May 1972-Sept. 1989; 3 SD, 1990	Springfield, Salem, and Boston Mountains	forest/pasture	Integrator (reservoir)	2
23	Osage Creek southwest of Berryville, Ark.	M	Salem, Springfield, and Boston Mountains	forest/pasture	Salem forest	0
24	Osage Creek west of Berryville, Ark.	M	Salem, Springfield, and Boston Mountains	forest/pasture/urban	Salem STP	1
25	Kings River near Berryville, Ark.	1-5 SD/yr, July 1945-Sept. 1953; M, Oct. 1953-Aug. 1963; M, Oct. 1972-Sept. 1990	Salem, Springfield, and Boston Mountains	forest/pasture	Integrator	1
26	James River near Wilson Creek, Mo.	2 SD, 1964 and 1965; M, Oct. 1967-June 1987	Springfield	pasture/forest/urban	Springfield pasture	0
27	James River near Boaz, Mo.	2 SD, 1964 and 1965; M, Oct. 1967-June 1987	Springfield	pasture/forest/urban	Springfield STP	1
28	Long Creek near Denver, Ark.	M	Springfield	pasture/forest	Springfield mix	0
29	White River below Table Rock Dam near Branson, Mo.	M	Salem, Springfield, and Boston Mountains	pasture/forest	Integrator (reservoir)	5
30	White River at Bull Shoals Dam near Flippin, Ark.	M, July 1954-Sept. 1967; 3 SD, 1968; M, Dec. 1973-Sept. 1989; 3 SD, 1990	Salem, Springfield, and Boston Mountains	pasture/forest	Integrator (reservoir)	6
31	Crooked Creek at Harrison, Ark.	M	Springfield	pasture/forest	Springfield pasture	0
32	Crooked Creek near Harrison, Ark.	M	Springfield	pasture/forest/urban	Springfield STP	1
33	Crooked Creek at Yellville, Ark.	M	Salem and Springfield	pasture/forest	Salem mix	1
34	Buffalo River near St. Joe, Ark.	1-3 SD/yr, July 1945-Aug. 1953; M, Oct. 1953-Sept. 1957; 1 SD, 1963; M, Apr. 1974-Sept. 1990	Springfield and Boston Mountains	forest	Springfield forest	0
35	Hicks Creek near Mountain Home, Ark.	M	Salem	forest/pasture/urban	Salem STP	1
36	White River near Norfork, Ark.	M	Salem, Springfield, and Boston Mountains	forest/pasture	Integrator	9
37	North Fork River near Tecumseh, Mo.	M, July 1969-June 1972; M, Oct. 1978-Sept. 1979; M, Nov. 1983-June 1987	Salem	forest/pasture	Salem forest	0
38	North Fork River at Norfork Dam near Norfork, Ark.	M, Oct. 1946-Nov. 1967; M, Dec. 1973-Sept. 1989; 3 SD, WY90	Salem	forest/pasture	Salem forest (reservoir)	0
39	White River at Calico Rock, Ark.	1-2 SD/yr, Nov. 1945-Aug. 1960 (no samples 1958); M, Oct. 1972-Aug. 1980; B-M, Oct. 1980-Aug. 1990	Salem, Springfield, and Boston Mountains	forest/pasture	Integrator	9
40	Mill Creek near Melbourne, Ark.	M	Salem	pasture/forest/urban	Salem STP	0
41	North Sylamore Creek near Fifty Six, Ark.	M, June 1966-Aug. 1982; B-M, Oct. 1982-Aug. 1990	Springfield	forest	Springfield forest	0

Table 6. Site and basin characteristics of surface-water sites in the Ozark Plateaus study unit—Continued

Site number (fig. 3)	Site name	Latitude	Longitude	Drainage area (square miles)	Collecting agency	Period of record (through water year 1990)	Number of samples (through water year 1990)
42	White River at Oil Trough, Ark.	35 38 36	91 27 42	--	ADPCE	Apr. 1974-Aug. 1990	193
43	Black River below Annapolis, Mo.	37 19 30	90 45 50	--	USGS (OFA-COE)	Oct. 1962-Dec. 1985	142
44	Black River at Clearwater Dam, Mo.	37 07 55	90 46 05	898	USGS (OFA-COE)	Mar. 1978-Aug. 1990	114
45	Black River at Poplar Bluff, Mo.	36 45 34	90 23 17	1,245	USGS (Coop-MDNR)	Nov. 1983-Aug. 1987	46
46	Current River at Doniphan, Mo.	36 37 19	90 50 51	2,038	USGS (Coop-MDNR)	Oct. 1979-June 1989	94
47	Little Black River below Fairdealing, Mo.	36 37 54	90 34 31	194	USGS (OFA-SCS)	Aug. 1980-Aug. 1987	39
48	Current River near Pocahontas, Ark.	36 17 55	90 51 30	2,606	ADPCE	Oct. 1954-Sept. 1990	280
49	Black River at Pocahontas, Ark.	36 15 14	90 58 12	4,845	ADPCE	July 1945-Sept. 1990	190
50	South Fork Spring River at Saddle, Ark.	36 21 00	91 38 00	--	ADPCE	Mar. 1974-Sept. 1990	197
51	Spring River at Ravenden, Ark.	36 13 30	91 15 03	--	ADPCE	Mar. 1974-Sept. 1990	198
52	Eleven Point River near Bardley, Mo.	36 38 55	91 12 03	793	USGS (Coop-MDNR)	Oct. 1983-Sept. 1990	46
53	Eleven Point River near Pocahontas, Ark.	36 14 43	91 05 05	1,192	ADPCE	Mar. 1974-Sept. 1990	203
54	Black River at Black Rock, Ark.	36 06 15	91 05 50	7,369	USGS (Coop-AGC)	Oct. 1945-Sept. 1990	331
55	Strawberry River near Smithville, Ark.	36 01 40	91 19 31	539	ADPCE	Mar. 1974-Sept. 1990	201
56	Neosho River near Parsons, Kans.	37 18 39	95 06 37	4,905	USGS (NASQAN)	Mar. 1958-Sept. 1990	481
57	Lightning Creek near McCune, Kans.	37 16 54	95 01 56	197	USGS (Coop-KWO)	Apr. 1940-Sept. 1990	209
58	Spring River near Waco, Mo.	37 14 44	94 33 58	1,164	USGS (Coop-MDNR), KDHE	Sept. 1964-Oct. 1989	329
59	Turkey Creek near Joplin, Mo.	37 07 15	94 34 55	42	USGS (Coop-MDNR), KDHE	Aug. 1963-Aug. 1990	440
60	Shoal Creek near Galena, Kans.	37 02 31	94 38 34	--	USGS (Coop-KDHE), KDHE	July 1967-Aug. 1990	255
61	McKisic Creek tributary near Bentonville, Ark.	36 24 26	94 12 46	--	ADPCE	Nov. 1983-Sept. 1990	85
62	Butler Creek near Sulphur Springs, Ark.	36 30 44	94 28 54	35	ADPCE	Oct. 1972-Sept. 1990	240
63	Elk River near Tiff City, Mo.	36 37 50	94 35 12	872	USGS (Coop-MDNR)	Feb. 1960-June 1990	306

Table 6. Site and basin characteristics of surface-water sites in the Ozark Plateaus study unit—Continued

Site number (fig. 3)	Site name	Frequency of collection	Physiographic area	Major land uses[1]	Site type	Major point sources
42	White River at Oil Trough, Ark.	M	Mississippi Alluvial Plain, Salem, Springfield, and Boston Mountains	forest/pasture/ cropland	Integrator	10
43	Black River below Annapolis, Mo.	9 SD, WY63; M, July 1969-Aug. 1972; Q, Oct. 1972-July 1975; 2-4 SD/yr, Mar. 1978-Dec. 1985	Salem and St. Francois	forest/Pb-Zn mining	Salem forest	0
44	Black River at Clearwater Dam, Mo.	3-5 SD/yr, Mar. 1978-Dec. 1980; M, Feb. 1981-Sept. 1989; 3 SD 1990	Salem and St. Francois	forest/Pb-Zn mining	Salem forest (reservoir)	0
45	Black River at Poplar Bluff, Mo.	M	Salem and St. Francois	forest/pasture/ Pb-Zn mining	Salem forest	0
46	Current River at Doniphan, Mo.	M (no samples WY83)	Salem	forest	Salem forest	0
47	Little Black River below Fairdealing, Mo.	B-M	Salem	forest/pasture	Salem forest	0
48	Current River near Pocahontas, Ark.	M, Oct. 1954-Sept. 1958; 1 SD, 1966; M, Oct. 1972-Sept. 1990	Mississippi Alluvial Plain and Salem	forest/pasture/ cropland	Integrator	0
49	Black River at Pocahontas, Ark.	1-3 SD/yr, July 1945-July 1956; M, Oct. 1965-Oct. 1966; M, Oct. 1977-Sept. 1990	Mississippi Alluvial Plain, Salem, and St. Francois	forest/pasture/ cropland/Pb-Zn mining	Integrator	1
50	South Fork Spring River at Saddle, Ark.	M	Salem	forest/pasture	Salem mix	0
51	Spring River at Ravenden, Ark.	M	Salem	forest/pasture	Salem mix	1
52	Eleven Point River near Bardley, Mo.	M, Oct. 1983-June 1987; 1 SD, 1990	Salem	forest/pasture	Salem mix	0
53	Eleven Point River near Pocahontas, Ark.	M	Salem	forest/pasture	Salem mix	0
54	Black River at Black Rock, Ark.	3 SD/mon, WY46; 1-3 SD/yr, Feb. 1947-Sept. 1951; 3 SD/mon, WY53; M, Oct. 1967-Aug. 1980; B-M, Oct. 1980-Sept. 1990	Mississippi Alluvial Plain, Salem, and St. Francois	forest/pasture/ cropland/Pb-Zn mining	Integrator	2
55	Strawberry River near Smithville, Ark.	M	Salem	forest/pasture	Salem mix	0
56	Neosho River near Parsons, Kans.	1 SD, 1958; M, Sept. 1961-Sept. 1981; 8 SD/yr, Nov. 1981-Sept. 1990	Osage Plains	cropland	Osage Plains cropland	1
57	Lightning Creek near McCune, Kans.	sampled 2-8 mon/yr, Apr. 1940-Feb. 1946 (1-4 SD/ mon); 1 SD/yr, 1962,63,66,68; M, Dec. 1975-Sept. 1990	Osage Plains	cropland/coal mining	Osage Plains cropland	0
58	Spring River near Waco, Mo.	1 SD, 1964; M, Nov. 1965-Jan. 1970; B-M, Feb. 1970-Aug. 1975; M, Dec. 1975-Oct. 1989	Springfield and Osage Plains	pasture/cropland	Integrator	2
59	Turkey Creek near Joplin, Mo.	M, Aug. 1963-Oct. 1989; 3 SD, 1990	Springfield	pasture/urban/ Pb-Zn mining	Springfield STP	2
60	Shoal Creek near Galena, Kans.	M	Springfield	pasture/forest/ urban	Springfield mix	3
61	McKisic Creek tributary near Bentonville, Ark.	M	Springfield	pasture/forest/ urban	Springfield STP	1
62	Butler Creek near Sulphur Springs, Ark.	M	Springfield	forest/pasture/ urban	Springfield STP	0
63	Elk River near Tiff City, Mo.	3-10 mon/yr, Feb. 1960-June 1963; M, Nov. 1965-Sept. 1977; M, WY81; M, Oct. 1982-June 1990	Springfield	pasture/forest	Springfield mix	1

Table 6. Site and basin characteristics of surface-water sites in the Ozark Plateaus study unit—Continued

Site number (fig. 3)	Site name	Latitude	Longitude	Drainage area (square miles)	Collecting agency	Period of record (through water year 1990)	Number of samples (through water year 1990)
64	Spavinaw Creek near Cherokee City, Ark.	36 20 31	94 35 15	104	ADPCE	Feb. 1961-Sept. 1990	148
65	Neosho River below Fort Gibson Lake near Fort Gibson, Okla.	35 51 10	95 13 45	12,495	USGS (NASQAN)	Oct. 1951-Aug. 1990	673
66	Illinois River at Savoy, Ark.	36 06 11	94 20 39	167	ADPCE	Sept. 1968-Sept. 1990	255
67	Osage Creek near Elm Springs, Ark.	36 13 19	94 17 18	130	ADPCE	Sept. 1951-Sept. 1990	256
68	Illinois River near Siloam Springs, Ark.	36 08 41	94 29 41	509	ADPCE	Sept. 1978-Sept. 1990	107
69	Baron Fork at Dutch Mills, Ark.	35 52 48	94 29 11	41	ADPCE	Mar. 1959-Aug. 1990	293
70	Illinois River at Highway 64 Bridge, Okla.	35 31 00	95 05 28	--	ODEQ	Oct. 1959-Aug. 1990	492
71	Baron Fork at Eldon, Okla.	35 55 16	94 50 18	--	ODEQ	Oct. 1959-Aug. 1990	202
72	Illinois River near Tahlequah, Okla.	35 55 17	94 55 15	959	ODEQ	Nov. 1959-Aug. 1990	251
73	Buffalo River at Wilderness Boundary, Ark.	35 56 35	93 24 20	58	NPS	Jan. 1990-Sept. 1990	10
74	Illinois River near Watts, Okla.	36 07 48	94 34 12	635	ODEQ	June 1973-Aug. 1990	173
75	Neosho River above Industrial Park, Okla.	36 10 51	95 16 25	--	ODEQ	Oct. 1977-Sept. 1990	103
76	Flint Creek near West Siloam Springs, Okla.	36 12 58	94 36 15	--	ADPCE	Oct. 1981-Sept. 1990	119
77	Neosho River near Langley, Okla.	36 26 15	95 02 44	--	ODEQ	Nov. 1975-Sept. 1990	139
78	Spring River near Thayer, Mo.	36 30 10	91 31 31	--	ADPCE	Dec. 1970-Sept. 1990	214
79	Little Sugar Creek at Caverna, Mo.	36 30 10	94 16 30	--	ADPCE	Feb. 1968-Oct. 1985	285
80	Spring River at Devils Prominade Bridge, Okla.	36 56 04	94 44 45	--	ODEQ	Nov. 1959-Aug. 1990	171
81	Neosho River near Chetopa, Kans.	37 02 10	95 04 50	--	KDHE	July 1967-Oct. 1989	212
82	Marmaton River near Fort Scott, Kans.	37 51 47	94 40 36	--	KDHE	July 1967-Aug. 1990	227
83	Osage River below Truman Dam at Warsaw, Mo.	38 15 41	93 24 10	--	COE	Aug. 1973-Sept. 1989	2,282

Table 6. Site and basin characteristics of surface-water sites in the Ozark Plateaus study unit—Continued

Site number (fig. 3)	Site name	Frequency of collection	Physiographic area	Major land uses[1]	Site type	Major point sources
64	Spavinaw Creek near Cherokee City, Ark.	2 SD, 1961; M, Oct. 1978-Sept. 1990	Springfield	pasture/forest	Springfield pasture	1
65	Neosho River below Fort Gibson Lake near Fort Gibson, Okla.	M, Oct. 1951-Dec. 1981; B-M, Feb. 1982-Aug. 1990	Springfield and Osage Plains	cropland/ pasture/forest	Integrator (reservoir)	13
66	Illinois River at Savoy, Ark.	1 SD, 1968; M, Apr. 1974-Sept. 1990	Springfield	pasture/forest	Springfield pasture	1
67	Osage Creek near Elm Springs, Ark.	1-4 SD/yr, 1951-57,1959-60,1968; M, Apr. 1974-Sept. 1990	Springfield	pasture/forest/ urban	Springfield STP	2
68	Illinois River near Siloam Springs, Ark.	sporadic, Sept. 1978-Sept. 1981; M, Oct. 1983-Sept. 1990	Springfield	pasture/forest	Springfield pasture	3
69	Baron Fork at Dutch Mills, Ark.	1 SD, 1959; 11 SD, 1960; 4 SD, 1961; M, Oct. 1972-Aug. 1990	Springfield	forest/pasture	Springfield mix	0
70	Illinois River at Highway 64 Bridge, Okla.	M, Oct. 1959-Nov. 1988 (many months with multiple SD); 7 months, 1989; 3 months, 1990	Springfield	pasture/forest	Springfield mix (reservoir)	5
71	Baron Fork at Eldon, Okla.	W, Oct. 1959-Mar. 1960; M, Nov. 1975-Sept. 1986; 2-3 SD/yr, Feb. 1987-Aug. 1990	Springfield	forest/pasture	Springfield mix	0
72	Illinois River near Tahlequah, Okla.	W, Nov. 1959-Mar. 1960; M, Apr. 1960-Apr. 1961; M, Nov. 1975-Sept. 1986; 3-6 SD/yr, Feb. 1987-Aug. 1990	Springfield	pasture/forest	Springfield mix	4
73	Buffalo River at Wilderness Boundary, Ark.	M	Boston Mountains	forest	Boston Mountains forest	0
74	Illinois River near Watts, Okla.	5 SD, 1973; M, Nov. 1975-Sept. 1986; 1-3 SD/yr, 1987-90	Springfield	pasture/forest	Springfield pasture	3
75	Neosho River above Industrial Park, Okla.	M, Oct. 1977-Aug. 1986; 1-3 SD/yr, 1987-90	Springfield and Osage Plains	cropland/ pasture/forest	Integrator (reservoir)	13
76	Flint Creek near West Siloam Springs, Okla.	M	Springfield	pasture	Springfield pasture	1
77	Neosho River near Langley, Okla.	M, Nov. 1975-Sept. 1986; 1-3 SD/yr, 1987-90	Springfield and Osage Plains	cropland/ pasture/forest	Integrator (reservoir)	12
78	Spring River near Thayer, Mo.	1 SD, 1970; M, Dec. 1971-Mar. 1974; M, Aug. 1977-Sept. 1990	Salem	forest/pasture/ urban	Salem STP	0
79	Little Sugar Creek at Caverna, Mo.	M, Feb. 1968-Oct. 1983 (many months with multiple SD); 1 SD, 1985	Springfield	forest/pasture/ urban	Springfield STP	0
80	Spring River at Devils Prominade Bridge, Okla.	M, Nov. 1959-Nov. 1960; 3-7 SD, 1961-63; M, Nov. 1975-Sept. 1986; 1-3 SD/yr, 1987-90	Springfield and Osage Plains	cropland/ pasture/forest/ Pb-Zn mining/ coal mining	Integrator	7
81	Neosho River near Chetopa, Kans.	B-M, Jan. 1968-Aug. 1975; M, Dec. 1975-Oct. 1989	Osage Plains	cropland	Osage Plains cropland	2
82	Marmaton River near Fort Scott, Kans.	B-M, Nov. 1967-Aug. 1975; M, Dec. 1975-Oct. 1989; 5 SD, WY90	Osage Plains	cropland/ urban	Osage Plains STP	1
83	Osage River below Truman Dam at Warsaw, Mo.	M, Aug. 1973-Dec. 1987; 4 SD, 1988; 1 SD, 1989 (many multiple-sample months and days)	Springfield and Osage Plains	cropland/ pasture/forest/ coal mining	Integrator (reservoir)	0

[1] Primarily from U.S. Geological Survey (1990).

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90

Site number (fig. 3)	Station name (table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles 10	25	50 (median)	75	90
	Discharge, instantaneous, in cubic feet per second									
1	Little Osage River at Fulton, Mo.	455	0.00	7,880	438	0.20	2.0	42	308	1,330
2	Osage River above Schell City, Mo.	110	15	39,800	2,780	255	620	1,310	3,100	6,020
3	Sac River near Dadeville, Mo.	44	16	1,560	284	30	62	186	388	714
4	Little Sac River near Walnut Grove, Mo.	50	14	895	132	32	42	88	172	272
5	Pomme de Terre River near Polk, Mo.	28	7.5	1,540	300	14	35	132	443	960
7	West Fork Tebo Creek near Lewis, Mo.	84	.10	694	13	.50	1.0	2.7	6.0	18
8	Niangua River at Bennett Springs, Mo	70	40	6,300	700	120	149	305	765	1,630
9	Osage River below St. Thomas, Mo.	114	558	53,000	10,700	706	1,620	5,240	15,500	31,600
10	Big Piney River at Devil's Elbow, Mo.	117	120	4,000	682	231	288	420	856	1,550
11	Gasconade River above Jerome, Mo.	130	350	8,830	2,190	455	614	1,110	3,020	5,700
12	Meramec River near Sullivan, Mo.	130	198	19,400	1,480	315	408	754	1,640	3,150
13	Bourbeuse River above Union, Mo.	44	43	12,100	1,220	59	144	355	614	3,400
14	Big River near Richwoods, Mo.	51	73	8,060	929	157	212	445	855	2,670
15	Meramec River near Eureka, Mo.	110	320	72,400	5,040	681	912	1,560	3,890	20,000
16	St. Francis River near Saco, Mo.	66	10	2,910	656	44	118	362	918	1,810
17	St. Francis River at Fisk, Mo.	130	46	10,400	1,660	89	196	933	2,840	3,880
18	West Fork White River east of Fayetteville, Ark.	84	.00	475	60	.80	4.0	12	60	200
19	White River near Goshen, Ark.	119	.30	4,340	443	16	28	216	479	1,430
20	Richland Creek at Goshen, Ark.	3	.40	12	a	a	a	a	a	a
22	White River at Beaver Dam near Eureka Springs, Ark.	36	.00	8,620	1,140	14	20	110	832	4,450
23	Osage Creek southwest of Berryville, Ark.	2	3.7	7.2	a	a	a	a	a	a
25	Kings River near Berryville, Ark.	133	2.0	3,600	413	25	54	180	500	930
26	James River near Wilson Creek, Mo.	80	7.8	3,550	291	22	39	102	260	804
27	James River near Boaz, Mo.	80	40	8,600	508	64	100	181	450	1,040
29	White River below Table Rock Dam near Branson, Mo.	42	10	22,400	3,110	40	40	250	3,160	14,000
30	White River at Bull Shoals Dam near Flippin, Ark.	84	.00	25,600	6,000	50	365	2,580	11,000	19,200
31	Crooked Creek at Harrison, Ark.	3	3.4	10	a	a	a	a	a	a
33	Crooked Creek at Yellville, Ark.	113	.90	3,800	286	11	32	131	298	722
34	Buffalo River near St. Joe, Ark.	129	23	25,500	1,170	36	67	326	1,070	2,830
36	White River near Norfork, Ark.	132	.00	9,600	1,870	73	300	775	2,280	5,870

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles 10	25	50 (median)	75	90
	Discharge, instantaneous, in cubic feet per second—Continued									
37	North Fork River near Tecumseh, Mo.	44	327	5,790	997	386	443	654	1,380	1,820
38	North Fork River at Norfork Dam near Norfork, Ark.	34	.00	7,060	1,490	30	60	585	2,620	5,920
39	White River at Calico Rock, Ark.	70	728	70,300	12,400	1,620	3,610	8,570	17,600	27,800
41	North Sylamore Creek near Fifty Six, Ark.	88	1.8	414	30	3.5	5.7	11	29	74
44	Black River at Clearwater Dam, Mo.	23	141	3,780	1,400	153	295	537	2,370	3,670
45	Black River at Poplar Bluff, Mo.	45	259	7,510	1,780	420	674	1,160	2,280	4,100
46	Current River at Doniphan, Mo.	93	1,110	61,200	3,710	1,390	1,640	2,360	3,570	6,480
47	Little Black River below Fairdealing, Mo.	39	32	2,170	233	37	50	87	203	685
48	Current River near Pocahontas, Ark.	121	.00	7,900	845	100	240	510	820	1,580
49	Black River at Pocahontas, Ark.	132	1,380	21,500	5,570	1,710	2,220	3,680	8,140	12,100
50	South Fork Spring River at Saddle, Ark.	124	.50	1,980	156	12	26	68	166	378
51	Spring River at Ravenden, Ark.	119	281	9,240	1,200	387	502	828	1,440	2,350
52	Eleven Point River near Bardley, Mo.	46	305	9,390	1,170	383	513	798	1,260	2,000
53	Eleven Point River near Pocahontas, Ark.	137	.00	3,800	276	25	44	80	380	682
54	Black River at Black Rock, Ark.	69	2,230	40,300	9,030	3,060	3,660	6,630	11,800	18,800
55	Strawberry River near Smithville, Ark.	132	.00	11,200	207	2.0	6.0	34	79	211
56	Neosho River near Parsons, Kans.	115	7.4	23,900	2,310	34	89	651	1,970	8,600
57	Lightning Creek near McCune, Kans.	89	.10	8,190	331	.50	5.4	21	80	619
58	Spring River near Waco, Mo.	118	2.0	17,300	832	25	62	192	692	1,900
59	Turkey Creek near Joplin, Mo.	79	.00	181	24	3.0	6.0	16	30	52
60	Shoal Creek near Galena, Kans.	74	2.0	1,360	212	12	48	105	272	543
61	McKisic Creek tributary near Bentonville, Ark.	2	5.4	11	a	a	a	a	a	a
62	Butler Creek near Sulphur Springs, Ark.	87	.00	160	23	2.0	4.0	9.0	33	60
63	Elk River near Tiff City, Mo.	104	46	20,000	1,000	101	172	472	1,050	2,390
64	Spavinaw Creek near Cherokee City, Ark.	133	.00	405	22	.00	2.0	6.0	14	60
65	Neosho River below Fort Gibson Lake near Fort Gibson, Okla.	81	1.0	44,200	6,520	6.0	95	1,700	11,300	19,600
66	Illinois River at Savoy, Ark.	119	1.8	2,740	138	5.0	11	31	133	311
67	Osage Creek near Elm Springs, Ark.	49	35	800	144	54	72	114	171	255
68	Illinois River near Siloam Springs, Ark.	85	14	3,540	523	115	166	310	675	1,020
69	Baron Fork at Dutch Mills, Ark.	122	.20	1,230	34	1.0	2.3	14	35	67

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles 10	25	50 (median)	75	90
	Discharge, instantaneous, in cubic feet per second—Continued									
70	Illinois River at Highway 64 Bridge, Okla.	11	2.2	5,500	1,960	3.8	44	193	4,210	5,240
71	Baron Fork at Eldon, Okla.	50	4.0	4,400	577	77	192	370	710	1,270
72	Illinois River near Tahlequah, Okla.	54	3.0	19,700	1,670	130	231	481	1,680	3,050
74	Illinois River near Watts, Okla.	51	1.0	13,300	822	124	180	314	921	1,540
76	Flint Creek near West Siloam Springs, Okla.	112	.00	268	41	6.6	13	26	56	88
78	Spring River near Thayer, Mo.	75	1.2	625	118	10	25	77	152	301
79	Little Sugar Creek at Caverna, Mo.	8	17	198	96	17	18	80	179	198
81	Neosho River near Chetopa, Kans.	95	.00	8,000	582	3.6	15	160	650	1,240
82	Marmaton River near Fort Scott, Kans.	102	.00	1,100	41	.10	.50	4.0	34	78
	Nitrite plus nitrate, in milligrams per liter as nitrogen[b]									
1	Little Osage River at Fulton, Kans.	118	c	2.1	[d]0.54	0.01	0.09	0.47	0.82	1.2
2	Osage River above Schell City, Mo.	76	c	4.6	[d].71	.10	.27	.55	1.0	1.4
3	Sac River near Dadeville, Mo.	44	0.10	2.3	1.7	1.2	1.4	1.7	2.0	2.1
4	Little Sac River near Walnut Grove, Mo.	50	.50	4.5	2.2	1.1	1.6	2.1	2.7	3.6
5	Pomme de Terre River near Polk, Mo.	28	c	1.3	[d].59	.10	.10	.65	.90	1.1
6	South Grand River at Urich, Mo.	45	c	2.7	[d].94	.10	.40	.90	1.2	1.9
7	West Fork Tebo Creek near Lewis, Mo.	84	c	1.2	[d].26	.03	.06	.10	.40	.70
8	Niangua River at Bennett Springs, Mo.	71	.20	1.5	.82	.42	.70	.80	.95	1.1
9	Osage River below St. Thomas, Mo.	79	c	1.4	[d].37	.10	.18	.32	.51	.68
10	Big Piney River at Devil's Elbow, Mo.	116	.09	6.5	.43	.20	.26	.33	.50	.68
11	Gasconade River above Jerome, Mo.	87	c	.99	[d].35	.12	.17	.28	.49	.71
12	Meramec River near Sullivan, Mo.	130	c	.66	[d].24	.10	.10	.20	.32	.40
13	Bourbeuse River above Union, Mo.	44	c	1.0	[d].35	.10	.10	.30	.50	.75
14	Big River near Richwoods, Mo.	43	c	.90	[d].28	.10	.10	.20	.40	.56
15	Meramec River near Eureka, Mo.	71	c	.78	[d].24	.10	.10	.15	.33	.59
16	St. Francis River near Saco, Mo.	66	c	1.3	[d].25	.04	.07	.20	.40	.65
18	West Fork White River east of Fayetteville, Ark.	109	.01	6.1	.51	.06	.18	.37	.63	.99
19	White River near Goshen, Ark.	148	.02	4.3	.81	.32	.46	.67	1.0	1.4
20	Richland Creek at Goshen, Ark.	24	.02	1.6	.63	.04	.15	.50	1.1	1.4
21	Holman Creek near Huntsville, Ark.	79	.10	25	3.9	.83	1.2	1.6	3.2	12

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles				
						10	25	50 (median)	75	90
	Nitrite plus nitrate, in milligrams per liter as nitrogen[b]—Continued									
22	White River at Beaver Dam near Eureka Springs, Ark.	32	0.16	1.5	0.36	0.20	0.20	0.32	0.40	0.49
23	Osage Creek southwest of Berryville, Ark.	80	.02	2.2	.56	.07	.23	.48	.80	1.1
24	Osage Creek west of Berryville, Ark.	61	.17	3.8	1.1	.52	.70	.96	1.4	2.2
25	Kings River near Berryville, Ark.	118	.03	1.6	.47	.09	.24	.40	.62	.93
26	James River near Wilson Creek, Mo.	89	.30	5.1	1.2	.70	.90	1.1	1.6	1.9
27	James River near Boaz, Mo.	84	.40	8.7	3.1	1.5	2.1	2.8	3.7	4.6
28	Long Creek near Denver, Ark.	80	.41	4.7	1.4	.95	1.1	1.4	1.6	1.9
29	White River below Table Rock Dam near Branson, Mo.	33	.16	.80	.51	.20	.32	.50	.69	.80
30	White River near Bull Shoals Dam near Flippin, Ark.	63	.08	.60	.27	.14	.18	.23	.32	.50
31	Crooked Creek at Harrison, Ark.	81	.55	3.4	1.4	1.1	1.2	1.4	1.5	1.7
32	Crooked Creek near Harrison, Ark.	81	.85	3.9	2.0	1.3	1.6	1.9	2.3	2.7
33	Crooked Creek at Yellville, Ark.	104	.01	1.2	.41	.04	.10	.31	.66	1.0
34	Buffalo River near St. Joe, Ark.	107	c	.58	[d].11	.02	.04	.07	.15	.27
35	Hicks Creek near Mountain Home, Ark.	68	.52	18	4.2	1.0	1.6	2.2	5.0	12
36	White River near Norfork, Ark.	105	.02	1.2	.28	.11	.18	.24	.36	.49
37	North Fork River near Tecumseh, Mo.	44	.40	1.0	.65	.50	.50	.60	.70	.95
38	North Fork River at Norfork Dam near Norfork, Ark.	33	.07	.60	.24	.10	.13	.20	.34	.46
39	White River at Calico Rock, Ark.	68	.02	.59	.25	.10	.16	.23	.33	.42
40	Mill Creek near Melbourne, Ark.	71	.56	16	1.3	.77	.90	1.1	1.3	1.5
41	North Sylamore Creek near Fifty Six, Ark.	82	c	.18	[d].06	.02	.03	.05	.10	.11
42	White River at Oil Trough, Ark.	107	.02	.57	.27	.11	.18	.28	.35	.45
43	Black River below Annapolis, Mo.	19	c	.30	[d].16	.05	.10	.16	.23	.30
44	Black River at Clearwater Dam, Mo.	19	c	.32	[d].15	.03	.10	.18	.20	.24
45	Black River at Poplar Bluff, Mo.	43	.10	.60	.25	.20	.20	.20	.30	.40
46	Current River at Doniphan, Mo.	92	.09	1.6	.30	.18	.20	.28	.31	.44
47	Little Black River below Fairdealing, Mo.	37	c	.77	[d].13	.01	.02	.10	.20	.32
48	Current River near Pocahontas, Ark.	108	.05	1.1	.24	.12	.16	.23	.31	.37
49	Black River at Pocahontas, Ark.	106	.02	1.4	.21	.10	.14	.19	.25	.32
50	South Fork Spring River at Saddle, Ark.	100	.02	1.2	.28	.04	.09	.18	.39	.65
51	Spring River at Ravenden, Ark.	102	.03	.96	.39	.19	.27	.38	.49	.68

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles				
						10	25	50 (median)	75	90
	Nitrite plus nitrate, in milligrams per liter as nitrogen[b]—Continued									
52	Eleven Point River near Bardley, Mo.	45	0.30	1.0	0.58	0.40	0.50	0.60	0.70	0.80
53	Eleven Point River near Pocahontas, Ark.	102	.18	.88	.45	.24	.34	.44	.57	.65
54	Black River at Black Rock, Ark.	66	.00	.54	.23	.13	.19	.22	.26	.32
55	Strawberry River near Smithville, Ark.	101	.01	1.1	.24	.02	.07	.17	.31	.53
56	Neosho River near Parsons, Kans.	76	c	5.5	[d].52	.05	.08	.38	.81	1.1
58	Spring River near Waco, Mo.	127	.20	3.0	1.7	.99	1.4	1.7	2.0	2.4
59	Turkey Creek near Joplin, Mo.	119	.01	7.8	2.3	.29	.86	1.8	3.7	5.0
60	Shoal Creek near Galena, Kans.	119	.20	3.0	1.7	1.2	1.4	1.7	2.0	2.3
61	McKisic Creek tributary near Bentonville, Ark.	80	.21	20	5.2	.97	2.3	3.9	6.8	12
62	Butler Creek near Sulphur Springs, Ark.	112	.23	2.6	1.2	.74	.92	1.2	1.5	1.8
63	Elk River near Tiff City, Mo.	104	.30	2.3	1.2	.60	.85	1.2	1.5	1.8
64	Spavinaw Creek near Cherokee City, Ark.	112	.68	4.4	2.4	1.5	2.0	2.3	2.8	3.3
65	Neosho River below Fort Gibson Lake near Fort Gibson, Okla.	72	c	3.5	[d].45	.04	.09	.34	.73	.90
66	Illinois River at Savoy, Ark.	117	.25	5.9	1.7	.80	1.0	1.6	2.0	2.6
67	Osage Creek near Elm Springs, Ark.	120	.14	8.7	3.8	2.2	2.9	3.9	4.6	5.2
68	Illinois River near Siloam Springs, Ark.	88	1.0	32	2.6	1.4	1.8	2.2	2.8	3.1
69	Baron Fork at Dutch Mills, Ark.	116	.03	5.5	1.7	.10	.37	1.6	2.6	3.4
70	Illinois River at Highway 64 Bridge, Okla.	125	c	2.0	[d].63	.26	.37	.60	.90	1.1
71	Baron Fork at Eldon, Okla.	96	c	2.5	[d].92	.29	.45	.80	1.3	1.8
72	Illinois River near Tahlequah, Okla.	100	c	2.7	[d]1.1	.35	.50	.90	1.6	2.1
73	Buffalo River at Wilderness Boundary, Ark.	16	c	.17	[d].05	.007	.01	.04	.09	.14
74	Illinois River near Watts, Okla.	96	c	3.5	[d]1.6	.58	.77	1.5	2.2	2.8
75	Neosho River above Industrial Park, Okla.	72	c	3.1	[d].67	.16	.27	.50	1.0	1.4
76	Flint Creek near West Siloam Springs, Okla.	106	.15	3.3	1.3	.45	.65	1.1	1.9	2.5
77	Neosho River near Langley, Okla.	71	c	2.3	[d].79	.28	.42	.70	1.1	1.5
78	Spring River near Thayer, Mo.	111	.02	1.8	.55	.26	.36	.49	.71	.91
79	Little Sugar Creek at Caverna, Mo.	41	.06	2.8	1.2	.24	.54	1.2	1.8	2.2
80	Spring River at Devil's Prominade Bridge, Okla.	70	.50	6.9	2.7	1.2	1.8	2.6	3.3	4.3
81	Neosho River near Chetopa, Kans.	115	c	1.6	[d].57	.08	.14	.52	.84	1.2
82	Marmaton River near Fort Scott, Kans.	119	.00	11	1.3	.18	.32	.67	1.2	3.0
83	Osage River below Truman Dam at Warsaw, Mo.	94	c	1.0	[d].42	.09	.16	.34	.66	.84

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles 10	25	50 (median)	75	90
		Ammonia, in milligrams per liter as nitrogen[e]								
1	Little Osage River above Fulton, Kans.	117	c	0.43	[d]0.05	0.005	0.01	0.02	0.06	0.10
2	Osage River above Schell City, Mo.	74	0.00	.33	.08	.02	.03	.06	.10	.18
3	Sac River near Dadeville, Mo.	44	c	.10	[d].03	.01	.02	.03	.04	.06
4	Little Sac River near Walnut Grove, Mo.	50	c	2.0	[d].14	.01	.02	.05	.09	.30
5	Pomme de Terre River near Polk, Mo.	28	c	.17	[d].04	.008	.02	.03	.06	.09
6	South Grand River at Urich, Mo.	45	.01	.51	.11	.02	.03	.09	.16	.23
7	West Fork Tebo Creek near Lewis, Mo.	84	.01	.48	.12	.05	.07	.10	.15	.20
8	Niangua River at Bennett Springs, Mo.	71	c	.08	[d].03	.01	.02	.03	.04	.06
9	Osage River below St. Thomas, Mo.	79	c	.49	[d].06	.01	.02	.03	.06	.13
10	Big Piney River at Devil's Elbow, Mo.	116	c	.18	[d].02	.004	.008	.02	.03	.05
11	Gasconade River above Jerome, Mo.	87	c	.28	[d].04	.007	.01	.02	.04	.07
12	Meramec River near Sullivan, Mo.	128	c	.63	[d].03	.005	.009	.02	.03	.04
13	Bourbeuse River above Union, Mo.	43	c	.17	[d].05	.01	.02	.03	.06	.10
14	Big River near Richwoods, Mo.	42	c	.11	[d].03	.009	.01	.03	.04	.06
15	Meramec River near Eureka, Mo.	72	c	.48	[d].05	.008	.02	.03	.06	.10
16	St. Francis River near Saco, Mo.	66	c	.44	[d].04	.004	.01	.02	.04	.08
18	West Fork White River east of Fayetteville, Ark.	118	c	2.5	[d].10	.01	.02	.05	.09	.18
19	White River near Goshen, Ark.	130	c	5.0	[d].47	.06	.08	.17	.40	1.4
20	Richland Creek at Goshen, Ark.	5	.00	.25	a	a	a	a	a	a
21	Holman Creek near Huntsville, Ark.	71	c	18	[e]2.6	.03	.12	.80	3.6	10
22	White River at Beaver Dam near Eureka Springs, Ark.	14	.00	.08	.04	.00	.02	.05	.06	.08
23	Osage Creek southwest of Berryville, Ark.	73	c	.24	[d].04	.007	.01	.03	.06	.10
24	Osage Creek west of Berryville, Ark.	52	c	1.9	[d].38	.02	.06	.13	.50	1.4
25	Kings River near Berryville, Ark.	125	c	.58	[d].05	.01	.02	.04	.06	.09
26	James River near Wilson Creek, Mo.	91	c	1.6	[d].04	.003	.006	.01	.04	.06
27	James River near Boaz, Mo.	87	c	.33	[d].04	.005	.01	.03	.06	.09
28	Long Creek near Denver, Ark.	72	c	1.1	[d].06	.009	.02	.04	.07	.11
29	White River below Table Rock Dam near Branson, Mo.	14	.00	.13	.07	.01	.03	.06	.10	.12
30	White River at Bull Shoals Dam near Flippin, Ark.	59	c	.13	[d].04	.01	.02	.04	.05	.08
31	Crooked Creek at Harrison, Ark.	74	c	.12	[d].03	.009	.01	.03	.05	.06

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles 10	25	50 (median)	75	90
	Ammonia, in milligrams per liter as nitrogen[e]—Continued									
32	Crooked Creek near Harrison, Ark.	71	c	2.0	[d]0.25	0.02	0.06	0.13	0.24	0.70
33	Crooked Creek at Yellville, Ark.	116	c	.87	[d].04	.006	.01	.02	.04	.06
34	Buffalo River near St. Joe, Ark.	119	c	.14	[d].03	.006	.01	.02	.04	.06
35	Hicks Creek near Mountain Home, Ark.	73	c	8.0	[d]1.4	.008	.03	.15	2.2	4.1
36	White River near Norfork, Ark.	120	c	.36	[d].04	.006	.01	.02	.04	.07
37	North Fork River near Tecumseh, Mo.	43	c	.06	[d].02	.007	.01	.02	.03	.04
38	North Fork River at Norfork Dam near Norfork, Ark.	14	c	.23	[d].08	.02	.04	.07	.11	.20
39	White River at Calico Rock, Ark.	69	c	.19	[d].04	.006	.01	.02	.06	.09
40	Mill Creek near Melbourne, Ark.	74	c	.57	[d].13	.03	.06	.10	.15	.32
41	North Sylamore Creek near Fifty Six, Ark.	69	c	.34	[d].04	.005	.01	.02	.05	.09
42	White River at Oil Trough, Ark.	118	c	.72	[d].04	.007	.01	.03	.05	.08
43	Black River below Annapolis, Mo.	14	c	.10	[d].04	.008	.01	.03	.06	.09
44	Black River at Clearwater Dam, Mo.	14	c	.15	[d].08	.01	.04	.06	.12	.14
45	Black River at Poplar Bluff, Mo.	43	c	.13	[d].03	.009	.02	.03	.04	.06
46	Current River at Doniphan, Mo.	91	c	.14	[d].02	.003	.006	.01	.02	.04
47	Little Black River below Fairdealing, Mo.	37	c	.30	[d].06	.02	.03	.04	.09	.11
48	Current River near Pocahontas, Ark.	122	c	.31	[d].04	.01	.02	.04	.06	.08
49	Black River at Pocahontas, Ark.	118	c	.36	[d].05	.007	.01	.03	.06	.09
50	South Fork Spring River at Saddle, Ark.	118	c	.17	[d].04	.009	.01	.03	.06	.09
51	Spring River at Ravenden, Ark.	120	c	.36	[d].03	.006	.01	.02	.04	.06
52	Eleven Point River near Bardley, Mo.	44	c	.22	[d].03	.005	.01	.02	.03	.06
53	Eleven Point River near Pocahontas, Ark.	121	c	.38	[d].04	.01	.01	.03	.05	.06
54	Black River at Black Rock, Ark.	64	c	.59	[d].04	.006	.01	.02	.06	.09
55	Strawberry River near Smithville, Ark.	119	c	.85	[d].05	.006	.01	.03	.05	.08
56	Neosho River near Parsons, Kans.	76	c	.22	[d].06	.01	.02	.05	.08	.12
58	Spring River near Waco, Mo.	127	c	.77	[d].10	.005	.01	.04	.11	.24
59	Turkey Creek near Joplin, Mo.	118	0.01	13	1.9	.10	.28	1.0	2.8	4.5
60	Shoal Creek near Galena, Kans.	117	c	.27	[d].04	.004	.008	.02	.05	.09
61	McKisic Creek tributary near Bentonville, Ark.	76	c	15	[d]1.4	.004	.03	.07	1.0	5.3
62	Butler Creek near Sulphur Springs, Ark.	124	c	1.1	[d].06	.008	.02	.03	.05	.08

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles				
						10	25	50 (median)	75	90
	Ammonia, in milligrams per liter as nitrogen[e]—Continued									
63	Elk River near Tiff City, Mo.	104	c	0.96	[d]0.04	0.006	0.01	0.02	0.04	0.06
64	Spavinaw Creek near Cherokee City, Ark.	124	c	1.3	[d].05	.01	.02	.03	.05	.06
65	Neosho River below Fort Gibson Lake near Fort Gibson, Okla.	76	c	1.0	[d].09	.02	.03	.06	.12	.18
66	Illinois River at Savoy, Ark.	131	c	1.2	[d].07	.01	.02	.04	.08	.15
67	Osage Creek near Elm Springs, Ark.	128	c	1.9	[d].18	.01	.03	.08	.19	.41
68	Illinois River near Siloam Springs, Ark.	85	c	.76	[d].04	.005	.01	.02	.04	.08
69	Baron Fork at Dutch Mills, Ark.	122	c	1.4	[d].07	.01	.02	.04	.05	.11
70	Illinois River at Highway 64 Bridge, Okla.	50	c	.52	[d].09	.02	.03	.06	.12	.22
71	Baron Fork at Eldon, Okla.	27	c	.40	[d].08	.02	.03	.06	.09	.14
72	Illinois River near Tahlequah, Okla.	30	c	.39	[d].07	.009	.02	.04	.11	.16
73	Buffalo River at Wilderness Boundary, Ark.	16	c	.17	[d].06	.01	.02	.04	.08	.15
74	Illinois River near Watts, Okla.	27	c	.43	[d].16	.04	.06	.14	.23	.36
76	Flint Creek near West Siloam Springs, Okla.	110	c	.12	[d].03	.009	.01	.03	.04	.07
78	Spring River near Thayer, Mo.	118	c	.62	[d].07	.01	.02	.05	.09	.14
79	Little Sugar Creek at Caverna, Mo.	49	0.01	.24	.07	.02	.03	.05	.08	.14
81	Neosho River near Chetopa, Kans.	114	c	.38	[d].06	.007	.01	.03	.08	.13
82	Marmaton River near Fort Scott, Kans.	118	.00	8.2	.79	.04	.10	.18	.39	2.0
83	Osage River below Truman Dam at Warsaw, Mo.	97	c	.30	[d].04	.006	.01	.03	.06	.09
	Ammonia plus organic nitrogen, total, in milligrams per liter as nitrogen									
1	Little Osage River at Fulton, Kans.	6	0.68	1.8	1.2	0.68	0.87	1.1	1.5	1.8
2	Osage River above Schell City, Mo.	72	.00	2.9	1.1	.50	.70	.98	1.4	1.9
7	West Fork Tebo Creek near Lewis, Mo.	83	.20	3.0	.59	.24	.40	.50	.70	1.1
9	Osage River below St. Thomas, Mo.	78	.20	1.9	.66	.40	.45	.60	.74	1.1
11	Gasconade River above Jerome, Mo.	86	c	4.0	[d].49	.15	.20	.38	.60	.97
15	Meramec River near Eureka, Mo.	72	c	1.5	[d].55	.18	.30	.49	.70	1.2
18	West Fork White River east of Fayetteville, Ark.	42	.10	3.5	.67	.20	.36	.60	.80	1.2
19	White River near Goshen, Ark.	64	.10	12	1.3	.24	.50	.81	1.3	2.2
20	Richland Creek at Goshen, Ark.	5	.44	1.3	a	a	a	a	a	a
21	Holman Creek near Huntsville, Ark.	45	.10	26	5.5	.44	.80	1.7	8.0	16

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles 10	25	50 (median)	75	90
	Ammonia plus organic nitrogen, total, in milligrams per liter as nitrogen—Continued									
22	White River at Beaver Dam near Eureka Springs, Ark.	14	c	3.2	[d]0.72	0.08	0.21	0.36	1.1	2.2
23	Osage Creek southwest of Berryville, Ark.	76	c	1.4	[d].41	.09	.10	.37	.60	.80
24	Osage Creek west of Berryville, Ark.	52	c	6.0	[d].82	.10	.20	.50	.82	2.1
25	Kings River near Berryville, Ark.	72	c	29	[d].84	.02	.06	.20	.50	.97
28	Long Creek near Denver, Ark.	1	f	.70	f	f	f	f	f	f
29	White River below Table Rock Dam near Branson, Mo.	14	c	1.4	[d].50	.12	.19	.48	.67	1.1
30	White River at Bull Shoals Dam near Flippin, Ark.	14	c	.80	[d].38	.16	.20	.40	.51	.66
31	Crooked Creek at Harrison, Ark.	76	c	1.2	[d].36	.07	.10	.30	.53	.77
32	Crooked Creek near Harrison, Ark.	75	c	6.5	[d].67	.10	.20	.50	.74	1.4
34	Buffalo River near St. Joe, Ark.	76	c	1.5	[d].28	.03	.06	.10	.40	.76
35	Hicks Creek near Mountain Home, Ark.	45	0.10	9.0	1.8	.46	.60	.88	2.2	4.7
38	North Fork River at Norfork Dam near Norfork, Ark.	14	c	1.5	[d].58	.15	.20	.48	.85	1.3
39	White River at Calico Rock, Ark.	64	c	1.9	[d].47	.17	.25	.40	.60	.84
40	Mill Creek near Melbourne, Ark.	46	c	1.5	[d].41	.10	.20	.36	.50	.83
41	North Sylamore Creek near Fifty Six, Ark.	68	c	6.4	[d].52	.07	.20	.30	.48	.88
43	Black River below Annapolis, Mo.	14	c	3.1	[d].47	.05	.13	.29	.40	1.8
44	Black River at Clearwater Dam, Mo.	15	.20	2.7	.68	.20	.30	.46	1.0	1.8
47	Little Black River below Fairdealing, Mo.	37	c	1.8	[d].53	.19	.30	.41	.70	1.0
54	Black River at Black Rock, Ark.	64	c	2.7	[d].51	.14	.26	.40	.60	.80
56	Neosho River near Parsons, Kans.	74	.20	2.3	1.1	.60	.80	1.1	1.4	1.6
61	McKisic Creek tributary near Bentonville, Ark.	43	.10	2.7	.71	.10	.40	.68	.90	1.2
64	Spavinaw Creek near Cherokee City, Ark.	66	c	2.3	[d].33	.04	.08	.20	.50	.70
65	Neosho River below Fort Gibson Lake near Fort Gibson, Okla.	76	.20	2.3	.82	.40	.60	.76	.94	1.3
66	Illinois River at Savoy, Ark.	19	c	2.0	[d].42	.05	.10	.30	.50	1.0
67	Osage Creek near Elm Springs, Ark.	22	.10	2.2	.57	.13	.20	.50	.70	1.2
68	Illinois River near Siloam Springs, Ark.	20	c	.74	[d].30	.06	.10	.20	.50	.69
69	Baron Fork at Dutch Mills, Ark.	18	c	2.4	[d].40	.01	.03	.10	.62	1.6
70	Illinois River at Highway 64 Bricge, Okla.	142	c	4.0	[d].50	.12	.25	.40	.58	.92
71	Baron Fork at Eldon, Okla.	116	c	2.6	[d].37	.05	.09	.20	.54	.96
72	Illinois River near Tahlequah, Okla.	120	c	2.6	[d].48	.10	.22	.34	.56	1.1

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles 10	25	50 (median)	75	90
	Ammonia plus organic nitrogen, total, in milligrams per liter as nitrogen—Continued									
73	Buffalo River at Wilderness Boundary, Ark.	13	0.21	0.60	0.38	0.21	0.27	0.35	0.48	0.60
74	Illinois River near Watts, Okla.	116	c	2.8	[d].78	.22	.46	.66	.98	1.5
75	Neosho River above Industrial Park, Okla.	90	c	8.3	[d].69	.18	.39	.56	.74	1.3
76	Flint Creek near West Siloam Springs, Okla.	21	c	.70	[d].26	.06	.10	.20	.45	.58
77	Neosho River near Langley, Okla.	91	c	2.1	[d].63	.22	.34	.55	.74	1.2
80	Spring River at Devils Prominade Bridge, Okla.	90	c	3.1	[d].84	.33	.45	.68	1.1	1.7
83	Osage River below Truman Dam at Warsaw, Mo.	5	.43	.93	a	a	a	a	a	a
	Nitrogen, total, in milligrams per liter as nitrogen[g]									
1	Little Osage River at Fulton, Kans.	8	0.00	1.8	0.97	0.00	0.23	1.1	1.4	1.8
2	Osage River above Schell City, Mo.	72	.10	4.3	1.7	.74	1.0	1.5	2.2	3.0
7	West Fork Tebo Creek near Lewis, Mo.	83	c	3.5	[d].78	.22	.34	.60	.90	1.8
9	Osage River below St. Thomas, Mo.	78	.34	2.2	1.0	.50	.72	.98	1.2	1.6
11	Gasconade River above Jerome, Mo.	86	c	4.3	[d].84	.35	.47	.70	1.1	1.4
15	Meramec River near Eureka, Mo.	71	c	2.1	[d].79	.30	.40	.63	1.2	1.4
18	West Fork White River east of Fayetteville, Ark.	40	c	9.6	[d]1.2	.52	.72	.93	1.3	2.1
19	White River near Goshen, Ark.	63	.46	12	2.2	.78	1.1	1.5	2.4	4.8
20	Richland Creek at Goshen, Ark.	5	.94	2.9	a	a	a	a	a	a
21	Holman Creek near Huntsville, Ark.	44	1.0	32	11	1.8	3.0	8.0	18	27
22	White River at Beaver Dam near Eureka Springs, Ark.	14	c	3.5	[d]1.0	.20	.37	.78	1.5	2.6
23	Osage Creek southwest of Berryville, Ark.	75	c	2.0	[d].89	.36	.51	.78	1.2	1.6
24	Osage Creek west of Berryville, Ark.	51	c	7.8	[d]1.9	.90	1.1	1.5	2.3	4.0
25	Kings River near Berryville, Ark.	59	c	4.3	[d].86	.20	.30	.67	.96	2.0
28	Long Creek near Denver, Ark.	1	f	1.7	f	f	f	f	f	f
29	White River below Table Rock Dam near Branson, Mo.	14	c	1.9	[d].93	.50	.61	.90	1.0	1.7
30	White River at Bull Shoals Dam near Flippin, Ark.	14	c	1.4	[d].67	.36	.50	.64	.76	1.1
31	Crooked Creek at Harrison, Ark.	74	c	3.8	[d]1.7	1.1	1.3	1.6	2.0	2.3
32	Crooked Creek near Harrison, Ark.	73	c	8.4	[d]2.6	1.7	2.0	2.5	2.9	3.9
34	Buffalo River near St. Joe, Ark.	62	c	1.2	[d].31	.08	.12	.21	.41	.71

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles 10	25	50 (median)	75	90
	Nitrogen, total, in milligrams per liter as nitrogen[g]—Continued									
35	Hicks Creek near Mountain Home, Ark.	36	1.8	19	7.2	2.2	3.5	5.5	12	14
38	North Fork River at Norfork Dam near Norfork, Ark.	14	c	1.6	[d].78	.30	.34	.70	1.0	1.5
39	White River at Calico Rock, Ark.	64	c	2.2	[d].72	.36	.46	.68	.86	1.1
40	Mill Creek near Melbourne, Ark.	42	c	2.2	[d]1.3	1.0	1.1	1.3	1.5	1.7
41	North Sylamore Creek near Fifty Six, Ark.	70	c	6.5	[d].57	.12	.20	.35	.57	.86
43	Black River below Annapolis, Mo.	14	c	3.2	[d].61	.13	.19	.44	.70	2.0
44	Black River at Clearwater Dam, Mo.	15	c	2.9	[d].82	.36	.47	.52	1.2	2.0
47	Little Black River below Fairdealing, Mo.	37	c	1.9	[d].61	.23	.28	.50	.75	1.4
54	Black River at Black Rock, Ark.	65	c	3.0	[d].73	.30	.48	.64	.80	1.2
56	Neosho River near Parsons, Kans.	74	.33	6.8	1.6	.78	1.1	1.6	2.1	2.5
61	McKisic Creek tributary near Bentonville, Ark.	40	c	18	[d]6.3	1.7	3.4	4.9	7.9	14
64	Spavinaw Creek near Cherokee City, Ark.	51	c	4.7	[d]2.3	1.3	1.6	2.0	2.8	3.5
65	Neosho River below Fort Gibson Lake near Fort Gibson, Okla.	72	.59	4.4	1.3	.70	.82	1.1	1.5	2.0
66	Illinois River at Savoy, Ark.	18	c	3.3	[d]2.1	1.5	1.7	1.8	2.4	3.0
67	Osage Creek near Elm Springs, Ark.	21	c	6.3	[d]4.5	3.0	3.8	4.4	5.4	6.1
68	Illinois River near Siloam Springs, Ark.	18	c	3.4	[d]2.6	2.2	2.4	2.5	2.8	3.2
69	Baron Fork at Dutch Mills, Ark.	17	c	5.4	[d]2.6	1.1	1.6	2.4	3.4	4.2
70	Illinois River at Highway 64 Bridge, Okla.	123	c	2.3	[d]1.1	.66	.77	.96	1.3	1.7
71	Baron Fork at Eldon, Okla.	96	c	3.8	[d]1.2	.54	.66	.85	1.6	2.4
72	Illinois River near Tahlequah, Okla.	100	c	4.5	[d]1.5	.64	.81	1.2	2.0	2.5
73	Buffalo River at Wilderness Boundary, Ark.	13	c	.65	[d].43	.25	.32	.45	.52	.64
74	Illinois River near Watts, Okla.	96	c	4.0	[d]2.4	1.4	1.7	2.2	3.0	3.4
75	Neosho River above Industrial Park, Okla.	72	c	11	[d]1.3	.52	.60	.83	1.6	2.3
76	Flint Creek near West Siloam Springs, Okla.	19	c	2.8	[d]1.5	.73	.84	1.2	2.3	2.5
77	Neosho River near Langley, Okla.	71	c	3.3	[d]1.4	.73	.76	1.1	1.9	2.6
80	Spring River at Devils Prominade Bridge, Okla.	70	c	8.1	[d]3.5	2.0	2.4	3.4	4.5	5.3
81	Neosho River near Chetopa, Kans.	6	h	.00	h	h	h	h	h	h
82	Marmaton River near Fort Scott, Kans.	2	h	.00	h	h	h	h	h	h
83	Osage River below Truman Dam at Warsaw, Mo.	2	h	h	h	h	h	h	h	h

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (Table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles 10	25	50 (median)	75	90
	Phosphorus, total, in milligrams per liter as phosphorus									
1	Little Osage River at Fulton, Kans.	118	0.01	0.55	0.12	0.02	0.06	0.10	0.17	0.24
2	Osage River above Schell City, Mo.	73	.02	.62	.16	.06	.09	.12	.16	.29
3	Sac River near Dadeville, Mo.	44	c	.24	d.07	.01	.02	.045	.095	.16
4	Little Sac River near Walnut Grove, Mo.	50	.08	2.2	.55	.10	.14	.30	.74	1.8
5	Pomme de Terre River near Polk, Mo.	28	c	.32	d.06	.01	.02	.035	.075	.14
6	South Grand River at Urich, Mo.	45	.01	.49	.16	.046	.09	.13	.18	.32
7	West Fork Tebo Creek near Lewis, Mo.	84	.01	.44	.05	.02	.03	.04	.05	.08
8	Niangua River at Bennett Springs, Mo.	71	c	.16	d.04	.01	.02	.04	.05	.08
9	Osage River below St. Thomas, Mo.	79	.02	.25	.06	.03	.03	.04	.06	.11
10	Big Piney River at Devil's Elbow, Mo.	116	c	.18	d.04	.01	.02	.03	.05	.08
11	Gasconade River above Jerome, Mo.	87	c	.27	d.04	.00	.01	.02	.04	.07
12	Meramec River near Sullivan, Mo.	129	c	.20	d.03	.01	.02	.02	.05	.06
13	Bourbeuse River above Union, Mo.	44	.01	.39	.06	.015	.02	.05	.07	.10
14	Big River near Richwoods, Mo.	43	.01	.18	.04	.01	.02	.03	.04	.08
15	Meramec River near Eureka, Mo.	72	.01	.23	.05	.02	.02	.04	.06	.12
16	St. Francis River near Saco, Mo.	66	c	.31	d.04	.01	.02	.03	.04	.08
18	West Fork White River east of Fayetteville, Ark.	111	.01	.87	.10	.04	.05	.07	.10	.16
19	White River near Goshen, Ark.	148	.01	6.8	.65	.07	.13	.26	.73	2.0
20	Richland Creek at Goshen, Ark.	24	c	.32	d.05	.01	.012	.03	.06	.165
21	Holman Creek near Huntsville, Ark.	75	.06	5.2	1.2	.09	.15	.62	2.0	3.5
22	White River at Beaver Dam near Eureka Springs, Ark.	32	c	.06	d.02	.000	.006	.01	.02	.04
23	Osage Creek southwest of Berryville, Ark.	77	c	.33	d.05	.01	.02	.04	.06	.10
24	Osage Creek west of Berryville, Ark.	58	.02	3.5	.56	.04	.09	.20	.77	1.8
25	Kings River near Berryville, Ark.	124	.01	1.2	.14	.03	.05	.08	.13	.34
26	James River near Wilson Creek, Mo.	82	c	.83	d.06	.013	.03	.045	.06	.09
27	James River near Boaz, Mo.	80	.05	4.4	.96	.17	.32	.68	1.3	2.1
28	Long Creek near Denver, Ark.	77	.01	.14	.05	.02	.03	.04	.05	.08
29	White River below Table Rock Dam near Branson, Mo.	33	c	3.0	d.12	.000	.02	.03	.04	.06
30	White River at Bull Shoals Dam near Flippin, Ark.	74	c	.05	d.01	.000	.006	.01	.02	.02
31	Crooked Creek at Harrison, Ark.	78	.01	.27	.05	.02	.03	.05	.06	.08

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (Table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles				
						10	25	50 (median)	75	90
	Phosphorus, total, in milligrams per liter as phosphorus—Continued									
32	Crooked Creek near Harrison, Ark.	77	0.04	0.98	0.44	0.12	0.22	0.42	0.64	0.75
33	Crooked Creek at Yellville, Ark.	114	c	.30	[d].02	.000	.01	.02	.03	.05
34	Buffalo River near St. Joe, Ark.	119	c	.32	[d].03	.000	.01	.01	.03	.05
35	Hicks Creek near Mountain Home, Ark.	76	.11	7.2	2.5	.41	.74	2.6	4.0	4.6
36	White River near Norfork, Ark.	118	c	.60	[d].03	.000	.01	.02	.04	.06
37	North Fork River near Tecumseh, Mo.	43	c	.05	[d].01	.000	.01	.01	.02	.03
38	North Fork River at Norfork Dam near Norfork, Ark.	33	c	.25	[d].04	.000	.01	.02	.06	.10
39	White River at Calico Rock, Ark.	68	c	.19	[d].02	.000	.01	.01	.02	.04
40	Mill Creek near Melbourne, Ark.	76	c	.53	[d].10	.01	.03	.05	.15	.26
41	North Sylamore Creek near Fifty Six, Ark.	81	c	.25	[d].02	.000	.01	.01	.02	.03
42	White River at Oil Trough, Ark.	115	.01	.64	.06	.016	.03	.04	.06	.11
43	Black River below Annapolis, Mo.	19	c	.29	[d].02	.000	.000	.002	.01	.05
44	Black River at Clearwater Dam, Mo.	19	c	.13	[d].03	.000	.008	.02	.03	.07
45	Black River at Poplar Bluff, Mo.	43	c	.99	[d].05	.000	.01	.02	.03	.09
46	Current River at Doniphan, Mo.	92	c	.13	[d].02	.000	.003	.008	.02	.04
47	Little Black River below Fairdealing, Mo.	37	c	.15	[d].03	.01	.01	.03	.04	.05
48	Current River near Pocahontas, Ark.	120	.01	.33	.05	.02	.03	.04	.06	.09
49	Black River at Pocahontas, Ark.	121	.01	.21	.06	.03	.04	.06	.08	.11
50	South Fork Spring River at Saddle, Ark.	121	c	.21	[d].03	.01	.01	.02	.03	.07
51	Spring River at Ravenden, Ark.	121	c	.28	[d].03	.01	.01	.02	.04	.07
52	Eleven Point River near Bardley, Mo.	43	c	.16	[d].02	.000	.005	.01	.02	.04
53	Eleven Point River near Pocahontas, Ark.	122	c	.22	[d].03	.01	.01	.02	.04	.06
54	Black River at Black Rock, Ark.	65	.01	.33	.05	.02	.03	.04	.06	.10
55	Strawberry River near Smithville, Ark.	121	c	1.9	[d].06	.01	.02	.03	.05	.08
56	Neosho River near Parsons, Kans.	74	.05	1.2	.16	.06	.09	.12	.19	.27
57	Lightning Creek near McCune, Kans.	1	f	.14	f	f	f	f	f	f
58	Spring River near Waco, Mo.	127	.02	1.1	.20	.06	.11	.18	.26	.35
59	Turkey Creek near Joplin, Mo.	118	.08	8.3	1.6	.51	.72	1.3	1.9	3.2
60	Shoal Creek near Galena, Kans.	119	.04	2.2	.19	.07	.10	.14	.21	.34
61	McKisic Creek tributary near Bentonville, Ark.	72	.84	14	6.1	1.9	3.6	6.4	8.0	9.9

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (Table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles				
						10	25	50 (median)	75	90
	Phosphorus, total, in milligrams per liter as phosphorus—Continued									
62	Butler Creek near Sulphur Springs, Ark.	118	0.01	4.5	0.08	0.01	0.02	0.04	0.05	0.07
63	Elk River near Tiff City, Mo.	104	.01	.62	.07	.03	.04	.06	.08	.11
64	Spavinaw Creek near Cherokee City, Ark.	117	.01	.61	.10	.05	.07	.08	.11	.13
65	Neosho River below Fort Gibson Lake near Fort Gibson, Okla.	76	.03	.13	.07	.04	.05	.06	.08	.09
66	Illinois River at Savoy, Ark.	125	.03	1.8	.13	.05	.07	.09	.12	.19
67	Osage Creek near Elm Springs, Ark.	123	.10	7.5	1.0	.36	.56	.92	1.4	1.8
68	Illinois River near Siloam Springs, Ark.	83	.11	.85	.30	.16	.20	.27	.38	.50
69	Baron Fork at Dutch Mills, Ark.	117	.03	1.6	.16	.07	.08	.12	.16	.25
70	Illinois River at Highway 64 Bridge, Okla.	117	c	.95	[d].11	.000	.008	.08	.14	.24
71	Baron Fork at Eldon, Okla.	119	c	1.4	[d].11	.000	.005	.06	.14	.27
72	Illinois River near Tahlequah, Okla.	122	.00	1.2	.17	.03	.10	.13	.20	.33
73	Buffalo River at Wilderness Boundary, Ark.	13	c	.08	[d].04	.02	.03	.04	.06	.08
74	Illinois River near Watts, Okla.	118	.00	3.4	.33	.15	.21	.28	.40	.48
75	Neosho River above Industrial Park, Okla.	90	.00	2.4	.14	.000	.05	.10	.17	.24
76	Flint Creek near West Siloam Springs, Okla.	105	.01	.58	.07	.03	.04	.06	.08	.11
77	Neosho River near Langley, Okla.	91	.00	2.4	.17	.000	.03	.11	.18	.28
78	Spring River near Thayer, Mo.	121	.01	.47	.08	.01	.03	.05	.10	.22
79	Little Sugar Creek at Caverna, Mo.	45	.12	.66	.34	.19	.25	.32	.42	.50
80	Spring River at Devils Prominade Bridge, Okla.	90	.03	.68	.24	.13	.16	.21	.30	.42
81	Neosho River near Chetopa, Kans.	115	.00	1.1	.19	.06	.10	.14	.26	.40
82	Marmaton River near Fort Scott, Kans.	117	.00	8.7	.70	.07	.12	.19	.56	2.0
83	Osage River below Truman Dam at Warsaw, Mo.	96	c	.26	[d].05	.027	.05	.05	.07	.09
	Orthophosphate, in milligrams per liter as phosphorus[i]									
2	Osage River above Schell City, Mo.	57	c	0.19	[d]0.04	0.01	0.02	0.03	0.04	0.07
9	Osage River below St. Thomas, Mo.	55	c	.11	[d].02	.008	.01	.02	.03	.04
11	Gasconade River above Jerome, Mo.	69	c	.05	[d].02	.004	.006	.01	.02	.03
14	Big River near Richwoods, Mo.	5	0.00	.02	a	a	a	a	a	a
15	Meramec River near Eureka, Mo.	53	c	.07	[d].02	.003	.006	.01	.02	.04

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (Table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles 10	25	50 (median)	75	90
	Orthophosphate, in milligrams per liter as phosphorus[i]—Continued									
18	West Fork White River east of Fayetteville, Ark.	103	c	0.45	[d]0.05	0.007	0.01	0.04	0.06	0.10
19	White River near Goshen, Ark.	150	c	4.9	[d].49	.02	.06	.17	.56	1.5
20	Richlanc Creek at Goshen, Ark.	24	c	.23	[d].03	.001	.002	.01	.02	.18
21	Holman Creek near Huntsville, Ark.	73	c	4.8	[d].97	.05	.12	.45	1.5	2.8
22	White River at Beaver Dam near Eureka Springs, Ark.	32	c	.03	[d].01	.003	.005	.008	.01	.02
23	Osage Creek southwest of Berryville, Ark.	76	c	.19	[d].02	.004	.01	.01	.03	.06
24	Osage Creek west of Berryville, Ark.	58	0.01	2.9	.43	.03	.06	.14	.59	1.2
25	Kings River near Berryville, Ark.	112	c	1.0	[d].10	.01	.02	.05	.09	.31
26	James River near Wilson Creek, Mo.	12	h	h	h	h	h	h	h	h
27	James River near Boaz, Mo.	8	.95	2.1	1.4	.95	1.1	1.2	1.8	2.1
28	Long Creek near Denver, Ark.	71	c	.12	[d].03	.009	.01	.03	.05	.06
29	White River below Table Rock Dam near Branson, Mo.	33	c	.06	[d].02	.005	.009	.01	.02	.03
30	White River at Bull Shoals Dam near Flippin, Ark.	67	c	.04	[d].005	.000	.001	.002	.005	.01
31	Crooked Creek at Harrison, Ark.	75	c	.13	[d].03	.01	.02	.03	.04	.06
32	Crooked Creek near Harrison, Ark.	74	.03	.82	.37	.09	.15	.38	.54	.64
33	Crooked Creek at Yellville, Ark.	105	c	.09	[d].01	.002	.004	.009	.02	.03
34	Buffalo River near St. Joe, Ark.	109	c	.05	[d].01	.003	.005	.01	.01	.03
35	Hicks Creek near Mountain Home, Ark.	72	.04	5.7	2.2	.30	.55	2.2	3.6	4.2
36	White River near Norfork, Ark.	106	c	.21	[d].01	.002	.003	.007	.01	.03
38	North Fork River at Norfork Dam near Norfork, Ark.	33	c	.07	[d].02	.002	.004	.01	.03	.05
39	White River at Calico Rock, Ark.	35	c	.18	[d].01	.000	.001	.002	.01	.01
40	Mill Creek near Melbourne, Ark.	76	c	.32	[d].05	.004	.01	.02	.08	.14
41	North Sylamore Creek near Fifty Six, Ark.	60	c	.13	[d].008	.004	.001	.003	.01	.02
42	White River at Oil Trough, Ark.	108	c	.10	[d].02	.004	.007	.01	.03	.05
43	Black River below Annapolis, Mo.	19	h	h	h	h	h	h	h	h
44	Black River at Clearwater Dam, Mo.	19	c	.07	[d].01	.000	.001	.004	.01	.06
47	Little Black River below Fairdealing, Mo.	37	c	.07	[d].02	.005	.009	.02	.02	.05
48	Current River near Pocahontas, Ark.	113	c	.17	[d].03	.006	.01	.02	.03	.05
49	Black River at Pocahontas, Ark.	112	c	.08	[d].03	.007	.01	.03	.04	.06
50	South Fork Spring River at Saddle, Ark.	108	c	.20	[d].02	.003	.005	.01	.02	.04

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (Table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles 10	25	50 (median)	75	90
	Orthophosphate, in milligrams per liter as phosphorus[i]—Continued									
51	Spring River at Ravenden, Ark.	112	c	0.07	[d]0.01	0.003	0.005	0.01	0.02	0.04
53	Eleven Point River near Pocahontas, Ark.	114	c	.09	[d].02	.003	.006	.01	.02	.03
54	Black River at Black Rock, Ark.	35	c	.19	[d].02	.002	.004	.01	.02	.05
55	Strawberry River near Smithville, Ark.	112	c	1.7	[d].03	.002	.004	.01	.02	.04
56	Neosho River near Parsons, Kans.	53	c	.16	[d].05	.01	.02	.04	.07	.10
61	McKisic Creek tributary near Bentonville, Ark.	73	0.78	13	5.2	1.4	2.6	5.0	7.1	8.9
62	Butler Creek near Sulphur Springs, Ark.	107	c	.22	[d].03	.01	.01	.02	.04	.06
64	Spavinaw Creek near Cherokee City, Ark.	108	.01	1.6	.09	.03	.05	.07	.10	.13
65	Neosho River below Fort Gibson Lake near Fort Gibson, Okla.	48	c	.09	[d].03	.007	.01	.03	.04	.06
66	Illinois River at Savoy, Ark.	112	.01	1.7	.09	.01	.03	.04	.07	.16
67	Osage Creek near Elm Springs, Ark.	108	.01	2.5	.80	.24	.41	.74	1.1	1.5
68	Illinois River near Siloam Springs, Ark.	79	.04	.66	.25	.11	.15	.23	.34	.41
69	Baron Fork at Dutch Mills, Ark.	105	.01	.55	.11	.03	.05	.09	.14	.21
70	Illinois River at Highway 64 Bridge, Okla.	25	c	.37	[d].06	.005	.01	.03	.06	.19
71	Baron Fork at Eldon, Okla.	27	c	.29	[d].04	.002	.006	.02	.04	.10
72	Illinois River near Tahlequah, Okla.	30	c	.26	[d].09	.02	.06	.08	.12	.20
73	Buffalo River at Wilderness Boundary, Ark.	17	c	.09	.03	.006	.01	.02	.04	.07
74	Illinois River near Watts, Okla.	27	.10	.47	.20	.12	.13	.16	.23	.40
76	Flint Creek near West Siloam Springs, Okla.	102	c	.53	[d].05	.01	.03	.04	.06	.10
78	Spring River near Thayer, Mo.	108	c	.42	[d].05	.005	.01	.02	.06	.15
79	Little Sugar Creek at Caverna, Mo.	36	.14	.54	.30	.16	.22	.28	.37	.46
83	Osage River below Truman Dam at Warsaw, Mo.	43	c	.15	[d].02	.003	.006	.01	.03	.04
	Suspended solids, residue on evaporation at 105 degrees Celsius, in milligrams per liter									
1	Little Osage River at Fulton, Kans.	110	4	2,990	83	8	17	32	68	124
3	Sac River near Dadeville, Mo.	44	c	480	[d]30	1	5	12	24	66
4	Little Sac River near Walnut Grove, Mo.	49	c	194	[d]15	1	2	7	14	22
5	Pomme de Terre River near Polk, Mo.	27	1	72	13	1	4	8	16	36
6	South Grand River at Urich, Mo.	44	1	1,970	137	6	22	38	92	353

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (Table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles				
						10	25	50 (median)	75	90
	Suspended solids, residue on evaporation at 105 degrees Celsius, in milligrams per liter—Continued									
8	Niangua River at Bennett Springs, Mo.	69	c	184	d13	0	1	4	10	30
10	Big Piney River at Devil's Elbow, Mo.	116	c	104	d8	1	2	6	10	14
12	Meramec River near Sullivan, Mo.	130	d	220	d16	1	2	6	12	48
13	Bourbeuse River above Union, Mo.	44	1	523	46	4	8	12	27	134
14	Big River near Richwoods, Mo.	43	c	243	d24	1	3	8	16	78
16	St. Francis River near Saco, Mo.	65	c	38	d7	1	3	5	8	16
18	West Fork White River east of Fayetteville, Ark.	121	1	316	29	6	10	18	30	50
19	White River near Goshen, Ark.	118	3	429	30	7	12	18	31	67
21	Holman Creek near Huntsville, Ark.	80	1	303	13	3	4	7	10	15
23	Osage Creek southwest of Berryville, Ark.	81	1	126	13	1	4	8	13	18
24	Osage Creek west of Berryville, Ark.	62	c	90	d10	1	3	7	11	18
25	Kings River near Berryville, Ark.	130	0	91	9	1	3	6	10	18
26	James River near Wilson Creek, Mo.	80	1	105	18	2	8	14	21	33
27	James River near Boaz, Mo.	80	1	370	19	2	5	11	20	30
28	Long Creek near Denver, Ark.	81	1	51	7	2	3	4	8	18
30	White River at Bull Shoals Dam near Flippin, Ark.	45	c	22	d3	0	1	2	2	6
31	Crooked Creek at Harrison, Ark.	82	1	54	10	2	5	8	13	21
32	Crooked Creek near Harrison, Ark.	82	0	59	10	3	5	8	12	21
33	Crooked Creek at Yellville, Ark.	124	c	242	d8	1	2	4	8	14
34	Buffalo River near St. Joe, Ark.	128	c	228	d7	1	1	3	5	13
35	Hicks Creek near Mountain Home, Ark.	83	1	263	11	2	3	4	8	18
36	White River near Norfork, Ark.	129	c	558	d10	2	3	4	6	13
37	North fork River near Tecumseh, Mo.	43	c	44	d5	1	1	3	5	9
40	Mill Creek near Melbourne, Ark.	80	1	124	10	2	3	5	9	16
42	White River at Oil Trough, Ark.	120	2	651	23	4	6	10	16	42
45	Black River at Poplar Bluff, Mo.	42	1	103	22	5	11	18	31	39
46	Current River at Doniphan, Mo.	92	c	288	d15	1	2	5	9	30
47	Little Black River below Fairdealing, Mo.	35	0	224	20	3	6	12	23	33
48	Current River near Pocahontas, Ark.	120	2	219	20	5	7	13	20	36
49	Black River at Pocahontas, Ark.	120	1	213	31	10	14	24	36	56

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (Table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles				
						10	25	50 (median)	75	90
	Suspended solids, residue on evaporation at 105 degrees Celsius, in milligrams per liter—Continued									
50	South Fork Spring River at Saddle, Ark.	130	1	118	9	2	3	6	8	17
51	Spring River at Ravenden, Ark.	118	2	104	14	4	6	10	15	24
52	Eleven Point River near Bardley, Mo.	43	c	250	[d]15	0	1	5	9	16
53	Eleven Point River near Pocahontas, Ark.	120	1	136	14	3	6	10	16	24
55	Strawberry River near Smithville, Ark.	120	2	300	21	4	8	14	22	36
58	Spring River near Waco, Mo.	50	1	280	32	4	8	18	30	59
59	Turkey Creek near Joplin, Mo.	42	1	50	9	2	4	7	10	18
60	Shoal Creek near Galena, Kans.	42	1	41	10	2	3	9	13	20
61	McKisic Creek tributary near Bentonville, Ark.	80	1	128	10	2	4	6	10	16
62	Butler Creek near Sulphur Springs, Ark.	126	c	41	[d]4	1	2	3	4	8
63	Elk River near Tiff City, Mo.	100	c	50	[d]6	1	1	4	8	16
64	Spavinaw Creek near Cherokee City, Ark.	127	c	12	[d]3	1	1	2	4	6
66	Illinois River at Savoy, Ark.	131	1	367	19	4	6	10	18	36
67	Osage Creek near Elm Springs, Ark.	130	1	118	13	4	6	10	16	23
68	Illinois River near Siloam Springs, Ark.	88	0	140	16	4	6	10	16	36
69	Baron Fork at Dutch Mills, Ark.	123	1	480	15	2	3	6	9	16
70	Illinois River at Highway 64 Bridge, Okla.	117	1	405	14	2	4	6	12	16
71	Baron Fork at Eldon, Okla.	119	c	221	[d]7	0	1	2	5	13
72	Illinois River near Tahlequah, Okla.	122	c	418	[d]20	1	4	8	13	31
74	Illinois River near Watts, Okla.	118	1	417	31	6	12	23	34	52
75	Neosho River above Industrial Park, Okla.	90	1	239	17	3	5	11	19	34
76	Flint Creek near West Siloam Springs, Okla.	111	c	164	[d]7	1	2	4	6	10
77	Neosho River near Langley, Okla.	91	c	155	[d]12	1	4	6	12	22
78	Spring River near Thayer, Mo.	131	1	121	10	2	5	7	12	18
79	Little Sugar Creek at Caverna, Mo.	48	2	123	22	4	8	14	22	58
80	Spring River at Devils Prominade Bridge, Okla.	90	1	431	34	3	9	18	36	74
81	Neosho River near Chetopa, Kans.	108	4	1,320	132	16	25	55	147	341
82	Marmaton River near Fort Scott, Kans.	111	1	2,480	82	8	20	44	80	151
83	Osage River below Truman Dam at Warsaw, Mo.	427	0	63	12	4	6	10	12	22

Table 8. Statistical summary, by station, of discharge, nutrient, suspended-solids, and suspended-sediment data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Site number (fig. 3)	Station name (Table 6)	Number of samples	Minimum	Maximum	Mean	Percentiles 10	25	50 (median)	75	90
		Suspended sediment, in milligrams per liter								
1	Little Osage River at Fulton, Kans.	383	0	5,060	289	16	29	68	277	817
2	Osage River above Schell City, Mo.	64	1	3,000	285	35	66	115	330	926
6	South Grand River at Urich, Mo.	1	f	57	f	f	f	f	f	f
9	Osage River below St. Thomas, Mo.	71	2	1,070	69	6	15	28	63	107
11	Gasconade River above Jerome, Mo.	81	1	1,810	64	4	10	21	44	88
14	Big River near Richwoods, Mo.	3	7	20	a	a	a	a	a	a
15	Meramec River near Eureka, Mo.	75	1	1,530	131	11	20	37	125	416
17	St. Francis River at Fisk, Mo.	130	11	199	53	26	33	47	61	91
39	White River at Calico Rock, Ark.	44	0	32	9	1	3	6	11	28
41	North Sylamore Creek near Fifty Six, Ark.	85	0	47	6	0	1	4	8	16
56	Neosho River near Parsons, Kans.	84	5	470	102	12	25	46	124	319
57	Lightning Creek near McCune, Kans.	75	2	736	78	14	25	40	84	168
58	Spring River near Waco, Mo.	1	f	23	f	f	f	f	f	f
65	Neosho River below Fort Gibson Lake near Fort Gibson, Okla.	71	1	165	17	6	8	12	16	28

[a] If the total number of observations is greater than 1 and less than or equal to 5, only the maximum and minimum are reported.

[b] Most analyses used in the computation of the summary statistics were for dissolved nitrite plus nitrate. Total nitrite plus nitrate data were substituted in the few cases that dissolved data were unavailable.

[c] The minimum of censored properties is an estimated value and is not reported.

[d] The mean and percentiles have been estimated by using a log-probability regression to predict the values of data less than the detection limit.

[e] Most analyses used in the computation of the summary statistics were for dissolved ammonia. Total ammonia data were substituted in the few cases that dissolved data were unavailable.

[f] If the number of observations is equal to 1, only the maximum is reported.

[g] Total nitrogen is the sum of total ammonia plus organic nitrogen and total nitrite plus nitrate. Dissolved nitrite plus nitrate data were substituted when total data were unavailable.

[h] If the number of observations above the detection limit is less than 5, the estimated values are considered unreliable and are not reported.

[i] Most analyses used in the computation of the summary statistics were for dissolved orthophosphate. Total orthophosphate data were substituted in the few cases that dissolved data were unavailable.

Table 9. Statistical summary, by physiographic area and land use, of nutrient and suspended-solids data for surface wat
in the Ozark Plateaus study unit for water years 1980–90

[<, less than; STP, sewage treatment plant; mix is forest/pasture mix; --, indicates insufficient data available]

Physiographic area and land use	Number of samples	Minimum	Percentiles 10	25	50 (median)	75	90	Maximum
Nitrite plus nitrate, in milligrams per liter as nitrogen								
Osage Plains	633	<0.10	<0.10	0.10	0.50	0.90	1.3	11
Cropland	514	<.10	<.10	.10	.46	.84	1.2	5.5
STP	119	<.10	.18	.32	.67	1.2	3.0	11
Boston Mountains	376	<.10	.10	.35	.64	1.2	2.0	25
Forest	125	<.10	.10	.10	.32	.60	.97	6.1
Mix	24	<.10	.10	.15	.50	1.1	1.4	1.6
STP	227	.10	.38	.58	.90	1.5	3.1	25
Springfield Plateau	2,348	<.10	.25	.79	1.5	2.2	3.4	32
Forest	189	<.10	<.10	<.10	.10	.11	.19	.58
Mix	740	.10	.50	.60	1.2	1.7	2.2	5.5
Pasture	732	.10	.69	1.1	1.6	2.2	2.8	32
STP	687	<.10	.80	1.3	2.1	3.7	5.0	20
Salem Plateau	1,751	<.10	.10	.20	.38	.67	1.0	18
Forest	656	<.10	.10	.20	.30	.40	.68	6.5
Mix	784	<.10	.10	.18	.37	.60	.82	1.5
STP	311	<.10	.36	.55	.94	1.5	2.6	18
St. Francois Mountains								
Forest	66	<.10	<.10	.10	.20	.40	.65	1.3
Integrators	1,462	<.10	.10	.19	.33	.63	1.6	6.9

Table 9. Statistical summary, by physiographic area and land use, of nutrient and suspended-solids data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Physiographic area and land use	Number of samples	Minimum	Percentiles 10	25	50 (median)	75	90	Maximum
			Ammonia, in milligrams per liter as nitrogen					
Osage Plains	628	<0.01	<0.01	0.02	0.07	0.12	0.25	8.2
Cropland	510	<.01	<.01	.02	.06	.10	.16	.51
STP	118	<.01	.04	.10	.18	.39	2.0	8.2
Boston Mountains	340	<.01	.03	.05	.10	.35	2.0	18
Forest	134	<.01	.01	.03	.05	.09	.16	2.5
Mix	5	.01	--	--	--	--	--	.25
STP	201	<.01	.05	.09	.21	1.0	3.8	18
Springfield Plateau	2,099	<.01	<.01	.02	.04	.08	.23	15
Forest	188	<.01	<.01	.01	.03	.05	.07	.34
Mix	522	<.01	<.01	.02	.04	.07	.11	1.4
Pasture	686	<.01	<.01	.02	.04	.05	.10	1.6
STP	703	<.01	.01	.03	.06	.23	1.7	15
Salem Plateau	1,799	<.01	<.01	.01	.03	.06	.11	8.0
Forest	615	<.01	<.01	.01	.02	.04	.07	.63
Mix	867	<.01	<.01	.01	.03	.05	.07	.87
STP	317	<.01	.02	.05	.08	.16	1.1	8.0
St. Francois Mountains								
Forest	66	<.01	<.01	.01	.02	.04	.08	.44
Integrators	1,274	<.01	<.01	.02	.04	.06	.10	1.0

Table 9. Statistical summary, by physiographic area and land use, of nutrient and suspended-solids data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Physiographic area and land use	Number of samples	Minimum	Percentiles 10	25	50 (median)	75	90	Maximum
Ammonia plus organic nitrogen, total, in milligrams per liter as nitrogen								
Osage Plains								
Cropland	229	<0.10	0.30	0.50	0.80	1.2	1.6	3.0
STP	0	--	--	--	--	--	--	--
Boston Mountains	168	<.10	.26	.44	.80	1.3	6.7	26
Forest	55	<.10	.20	.30	.50	.70	1.0	3.5
Mix	4	.70	--	--	--	--	--	1.3
STP	109	<.10	.40	.54	.92	2.0	11	26
Springfield Plateau	999	<.10	<.10	.15	.35	.61	1.0	6.5
Forest	144	<.10	<.10	.10	.20	.40	.83	6.4
Mix	397	<.10	<.10	.16	.33	.56	.97	4.0
Pasture	318	<.10	<.10	.10	.40	.69	1.0	2.8
STP	140	<.10	.10	.30	.52	.80	1.2	6.5
Salem Plateau	385	<.10	.10	.20	.46	.70	1.2	9.0
Forest	156	<.10	<.10	.20	.40	.60	1.0	3.1
Mix	86	<.10	.20	.20	.38	.60	.97	4.0
STP	143	<.10	.10	.30	.56	.90	2.7	9.0
St. Francois Mountains								
Forest	0	--	--	--	--	--	--	--
Integrators	744	<.10	.20	.33	.51	.78	1.2	29

Table 9. Statistical summary, by physiographic area and land use, of nutrient and suspended-solids data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Physiographic area and land use	Number of samples	Minimum	Percentiles 10	25	50 (median)	75	90	Maximum
Nitrogen, total, in milligrams per liter as nitrogen								
Osage Plains								
Cropland	241	0.10	0.40	0.70	1.1	1.9	2.5	6.8
STP	0	--	--	--	--	--	--	--
Boston Mountains	165	.23	.55	.91	1.6	3.5	14	32
Forest	53	.23	.44	.54	.80	1.1	2.0	9.6
Mix	5	.94	--	--	--	--	--	2.9
STP	107	.46	1.0	1.3	2.3	6.9	18	32
Springfield Plateau	879	<.10	.40	.95	1.6	2.5	3.4	18
Forest	132	<.10	.16	.22	.31	.50	.82	6.5
Mix	337	.26	.67	.92	1.3	1.8	2.5	5.4
Pasture	276	.60	1.3	1.6	2.1	2.6	3.2	4.7
STP	134	1.0	1.9	2.2	3.0	4.7	7.3	18
Salem Plateau	370	<.20	.40	.60	1.0	1.5	2.9	19
Forest	155	<.20	.35	.47	.70	1.1	1.6	3.2
Mix	86	.30	.35	.48	.72	1.1	1.4	4.3
STP	129	.62	1.0	1.2	1.6	3.6	7.6	19
St. Francois Mountains								
Forest	0	--	--	--	--	--	--	--
Integrators	666	<.20	.44	.66	.97	1.5	2.6	11

Table 9. Statistical summary, by physiographic area and land use, of nutrient and suspended-solids data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Physiographic area and land use	Number of samples	Minimum	Percentiles 10	25	50 (median)	75	90	Maximum
			Phosphorus, total, in milligrams per liter as phosphorus					
Osage Plains	627	<0.01	0.03	0.07	0.12	0.20	0.38	8.7
Cropland	510	<.01	.03	.06	.11	.17	.29	1.2
STP	117	.01	.07	.12	.19	.56	2.0	8.7
Boston Mountains	371	<.01	.04	.07	.14	.54	1.7	6.8
Forest	124	.01	.03	.05	.07	.09	.15	.87
Mix	24	<.01	<.01	.01	.03	.06	.16	.32
STP	223	<.01	.08	.14	.32	1.1	2.3	6.8
Springfield Plateau	2,410	<.01	.02	.05	.10	.31	1.0	14
Forest	200	<.01	<.01	<.01	.01	.03	.05	.32
Mix	775	<.01	.01	.05	.09	.15	.25	2.2
Pasture	752	<.01	.03	.05	.08	.19	.34	3.4
STP	683	<.01	.04	.19	.62	1.4	3.6	14
Salem Plateau	1,854	<.01	.01	.01	.03	.05	.14	7.2
Forest	651	<.01	<.01	.01	.02	.05	.07	.99
Mix	872	<.01	.01	.01	.03	.04	.07	1.9
STP	331	<.01	.02	.04	.11	.56	3.1	7.2
St. Francois Mountains								
Forest	66	<.01	.02	.02	.04	.05	.08	.31
Integrators	1,591	<.01	.01	.03	.05	.10	.22	3.0

Table 9. Statistical summary, by physiographic area and land use, of nutrient and suspended-solids data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Physiographic area and land use	Number of samples	Minimum	Percentiles 10	25	50 (median)	75	90	Maximum
Orthophosphate, in milligrams per liter as phosphorus								
Osage Plains								
Cropland	110	<0.01	0.01	0.02	0.04	0.06	0.09	0.19
STP	0	--	--	--	--	--	--	--
Boston Mountains	367	<.01	.01	.03	.08	.37	1.4	4.9
Forest	120	<.01	<.01	.02	.03	.05	.09	.45
Mix	24	<.01	<.01	<.01	.01	.02	.18	.23
STP	223	<.01	.03	.08	.20	.90	1.7	4.9
Springfield Plateau	1,348	<.01	.01	.03	.06	.21	.80	13
Forest	169	<.01	<.01	<.01	.01	.02	.03	.13
Mix	258	<.01	<.01	.03	.05	.09	.15	.55
Pasture	515	<.01	.02	.03	.06	.12	.24	1.7
STP	406	<.01	.02	.05	.40	1.1	4.6	13
Salem Plateau	1,124	<.01	<.01	<.01	.02	.04	.18	5.7
Forest	189	<.01	<.01	<.01	.01	.03	.05	.19
Mix	621	<.01	<.01	<.01	.01	.03	.03	1.7
STP	314	<.01	.01	.02	.07	.44	2.7	5.7
St. Francois Mountains								
Forest	0	--	--	--	--	--	--	--
Integrators	952	<.01	<.01	<.01	.02	.03	.06	1.0

Table 9. Statistical summary, by physiographic area and land use, of nutrient and suspended-solids data for surface water in the Ozark Plateaus study unit for water years 1980–90—Continued

Physiographic area and land use	Number of samples	Minimum	Percentiles 10	25	50 (median)	75	90	Maximum
Suspended solids, residue on evaporation at 105 degrees Celsius, in milligrams per liter								
Osage Plains	373	<1	10	20	42	91	187	2,990
Cropland	262	<1	11	20	40	100	248	2,990
STP	111	<1	8	20	44	80	151	2,480
Boston Mountains	319	<1	4	8	15	25	47	429
Forest	121	1	6	10	18	30	50	316
Mix	0	--	--	--	--	--	--	--
STP	198	<1	4	7	12	22	42	429
Springfield Plateau	2,250	<1	1	3	6	13	23	480
Forest	128	<1	<1	1	3	5	13	228
Mix	704	<1	1	2	5	10	18	480
Pasture	781	<1	2	4	8	16	32	480
STP	637	<1	2	4	7	13	21	370
Salem Plateau	1,733	1	1	3	7	13	25	523
Forest	582	1	1	2	6	13	29	288
Mix	795	1	2	4	8	14	25	523
STP	356	1	2	3	6	10	16	263
St. Francois Mountains								
Forest	65	<1	<1	3	5	8	16	38
Integrators	1,413	<1	2	5	10	17	33	651