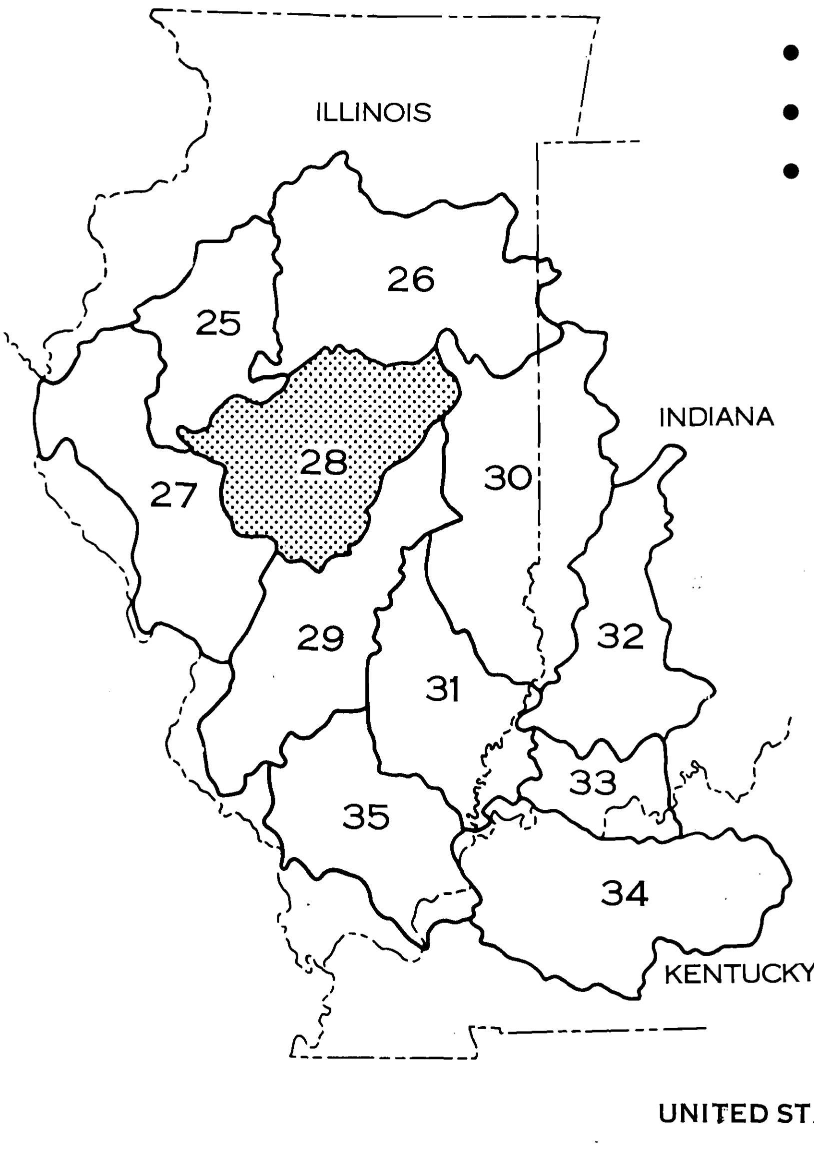
HYDROLOGY OF AREA 28, EASTERN REGION, INTERIOR COAL PROVINCE, ILLINOIS



- SANGAMON RIVER
- SALT CREEK
- SOUTH FORK SANGAMON RIVER

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 83-544

HYDROLOGY OF AREA 28, EASTERN REGION, INTERIOR COAL PROVINCE, ILLINOIS

BY
E.E. ZUEHLS, K.K. FITZGERALD, AND C.A. PETERS

U.S. GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 83-544

URBANA, ILLINOIS
AUGUST, 1984

UNITED STATES DEPARTMENT OF THE INTERIOR

WILLIAM P. CLARK, *SECRETARY*

GEOLOGICAL SURVEY

Dallas L. Peck, *Director*

For additional information write to:

District Chief
U.S. Geological Survey
Water Resources Division
Champaign County Bank Plaza
102 East Main St., Fourth Floor
Urbana, Illinois 61801

CONTENTS

Page

Abstract 1

1.0 Introduction 2

1.1 Objective 2

1.2 Study area 4

2.0 Coal mining potential and history 6

3.0 Geology 8

3.1 Surficial geology 8

3.2 Bedrock geology 10

4.0 Soils 12

5.0 Land use 14

6.0 Water use 16

7.0 Precipitation 18

8.0 Surface-water quantity 20

8.1 Mean annual streamflow 20

8.2 Low flow 22

8.3 Floodflow 24

8.4 Flow-duration curves 26

9.0 Surface-water quality 28

9.1 Available data 28

9.2 Specific conductance and dissolved solids 30

9.3 pH 32

9.4 Iron 34

9.5 Manganese 36

9.6 Sulfate 38

9.7 Alkalinity 40

9.8 Trace elements and other constituents 42

9.9 Suspended sediment 44

10.0 Ground-water quantity 46

11.0 Ground-water quality 48

12.0 Water-data sources 51

12.1 Introduction 51

12.2 National water-data exchange (NAWDEX) 52
12.3 WATSTORE 54
12.4 Index to water-data activities in coal provinces 56
12.5 STORET 58
13.0 Surface-water discharge sites and surface-water-quality sampling sites in the study area 60
14.0 List of references 66

FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM OF UNITS (SI)

For convenience of readers who may want to use the International System of Units (SI), the data may be converted by using the following factors:

Multiply	By	To obtain
inches (in)	25.40	millimeters (mm)
inches per hour (in/h)	25.4	millimeters per hour (mm/h)
	2.54	centimeters per hour (cm/h)
feet (ft)	0.3048	meters (m)
feet per mile (ft/mi)	0.1894	meters per kilometer (m/km)
miles (mi)	1.609	kilometers (km)
square miles (mi^2)	2.590	square kilometers (km^2)
gallons per minute (gal/min)	0.06309	liters per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meters per second (m^3/s)
	3785	cubic meters per day (m^3/d)
cubic feet per second (ft^3/s)	0.02832	cubic meters per second $(m^3/s)/km^2$
cubic feet per second per square mile $[(ft^3/s)/mi^2]$	0.01093	cubic meters per second per square kilometer $[(m^3/s)km^2]$
tons per square mile per year $[(tons/mi^2)/yr]$	0.3503	metric tons per square kilometer per year $[(t/km^2)/a]$
micromhos per centimeter at 25° Celsius (μmhos/cm)	1.000	microsiemens per centimeter at 25° Celsius (μS/cm)

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. NGVD of 1929 is referred to as sea level in this report.

HYDROLOGY OF AREA 28, EASTERN REGION, INTERIOR COAL PROVINCE, ILLINOIS

BY
E.E. ZUEHLS, K.K. FITZGERALD, AND C.A. PETERS

Abstract

The Eastern Region of the Interior Coal Province is divided into 11 hydrologic reporting areas. The divisions are based upon hydrologic factors, location, and size. Hydrologic units (drainage basins) are combined to form each area. Area 28 is located in central Illinois and includes all of the Sangamon River basin, an area of 5,419 square miles.

The area reports are designed to be useful to mining companies, their consultants, and regulatory authorities by presenting information concerning existing hydrologic conditions. The hydrology of the area is presented in a format of a series of sections, each with a brief text and accompanying illustration (s) on a single water-resource-related topic.

Major streams in Area 28, in addition to the Sangamon River, are the South Fork Sangamon River and Salt Creek. The southwestern half of the area is in the Springfield Plain physiographic division and the northeastern half is in the Bloomington Ridged Plain physiographic division. Mean annual rainfall in the area ranges from 35 to 38 inches.

The area is covered with glacial till with a blanket of loess 5 to 10 feet thick on the surface. Pennsylvanian rocks with layers of sandstone, limestone, siltstone, shale, clay, and coal underlie about 90 percent of Area 28. Herrin (No. 6), Harrisburg-Springfield (No. 5), Colchester (No. 2), and Danville (No. 7) coals have been mined in the area. In Illinois, 75 different coal members have been identified in the Pennsylvanian System.

The U.S. Geological Survey operates a network of hydrologic monitoring stations in the study area. Streamflow and water-quality data are collected. These data are available from computer storage through the National Water Data Exchange (NAWDEX) managed by the U.S. Geological Survey.

Mean annual flow, low flow, and floodflow can be estimated at ungaged sites in the study area using equations developed from data collected at streamflow stations. This report presents surface-water-quality data collected at 37 sites. Water samples were analyzed for specific conductance, pH, alkalinity, dissolved sulfate, total recoverable and dissolved iron and manganese, dissolved solids, and other properties. For streams in the study area, specific-conductance values can be multiplied by 0.60 to obtain an estimate of dissolved-solids concentration. The values of pH ranged from 6.5 to 9.5, which is a somewhat wider range than that given by Hem (1970) for water "not influenced by pollution."

Ground water is found in unconsolidated materials and in bedrock aquifers throughout the area. Water taken from bedrock aquifers is of poorer quality than water taken from unconsolidated material. Well yields are smaller in bedrock aquifers than in unconsolidated aquifers in most areas. All water samples from collection sites were moderate to very hard.

1.0 INTRODUCTION

1.1 Objective

Area 28 Report to Aid Permitting

Existing hydrologic conditions and sources of hydrologic information are described.

A need for hydrologic information and analysis on a scale never before required nationally, was initiated when the "Surface Mining Control and Reclamation Act of 1977" was signed into law as Public Law 95-87 on August 3, 1977. This need is partially met by this report, which broadly characterizes the hydrology of Area 28 in the Eastern Region of the Interior Coal Province in central Illinois (fig. 1.1-1). This report is one of a series that covers the coal provinces nationwide. The report contains a brief text with an accompanying map, chart, graph, or other illustration for each of a number of water-resources related topics. The summation of the topical discussions provides a description of the hydrology of the area.

The hydrologic information presented or available through sources identified in this report may be used in describing the hydrology of the "general area" of any proposed mine. Furthermore, it is expected that this hydrologic information will be supplemented with the lease applicant's site-specific data as well as data from other sources to provide a more detailed picture of the hydrology in the vicinity of the mine and the anticipated hydrologic consequences of the mining operation.

The information contained herein should be useful to surface-mine owners, mine operators, and consulting engineers in preparing permits, and to regulatory authorities in appraising the adequacy of permit applications.

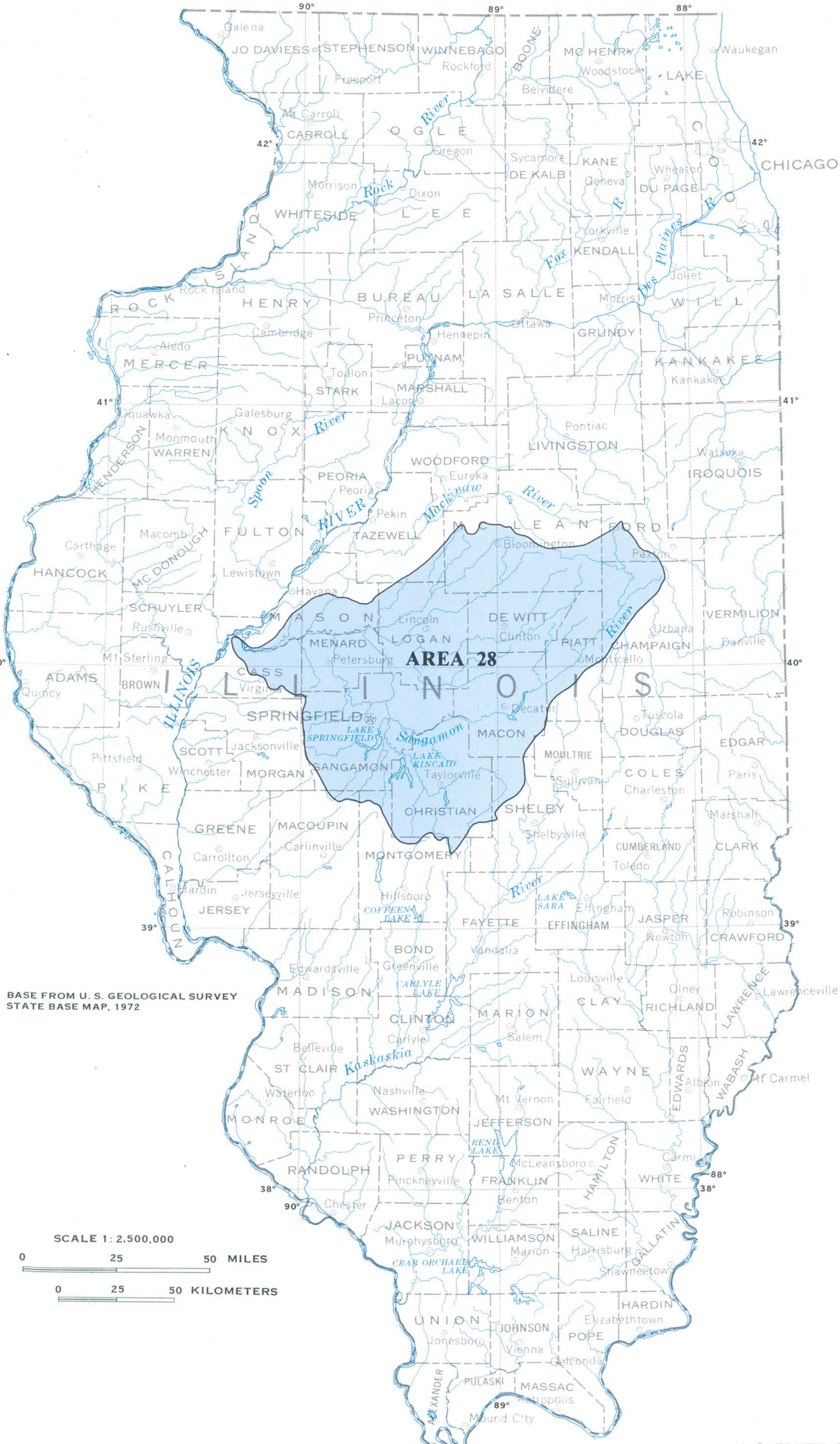


Figure 1.1-1 Location of study area in Illinois.

Area 28 is Located in Central Illinois

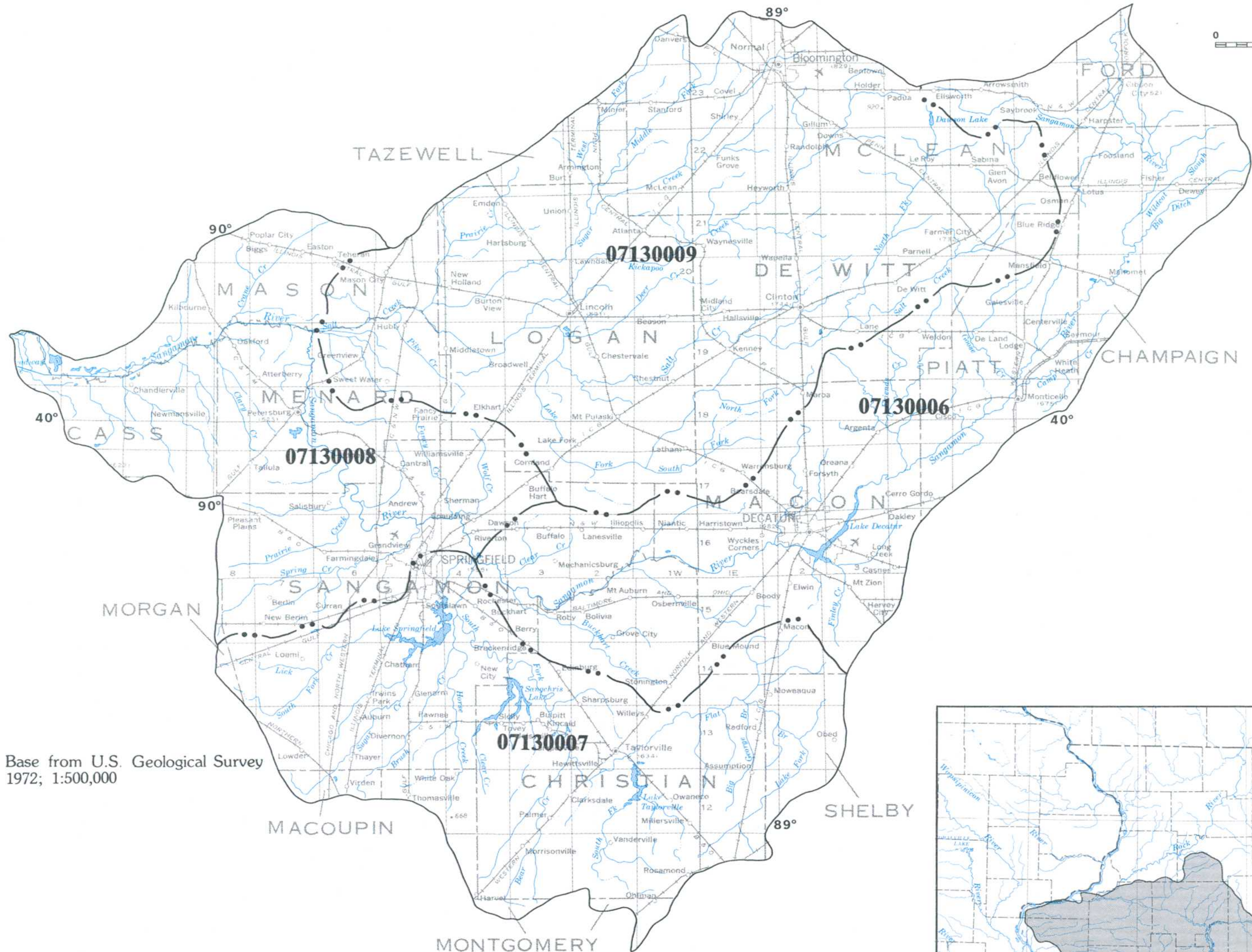
The Sangamon River drains Area 28. Area 28 is within two physiographic divisions: the Bloomington Ridged Plain and the Springfield Plain.

The Eastern Region of the Interior Coal Province, commonly called the Eastern Interior Coal Field (Smith and Stall, 1975), has been divided into 11 hydrologic study areas. These are shown on the cover of this report. The areas are based on hydrologic factors, location, and size. Hydrologic units are combined to form each study area. Area 28 encompasses the Sangamon River basin and is divided into four hydrologic units (fig. 1.2-1). It covers 5,419 square miles in central Illinois (fig. 1.2-2). It includes Christian, De Witt, Logan, Macon, Menard, and Sangamon Counties and parts of Cass, Champaign, Ford, Mason, McLean, Montgomery, Piatt, Shelby, Macoupin, and Tazewell Counties.

The area includes parts of two physiographic divisions: the Bloomington Ridged Plain and the Springfield Plain (fig. 1.2-3). These are divisions of the Till Plains Section of the Central Lowland Province. The topography of the Bloomington Ridged Plain is a series of low, broad, morainic ridges alternating with wide areas of relatively flat or gently undulating till plains. The topography of the Springfield Plain is level to gently undulating (Thornburn, 1963).

The population of the area is about 495,000. The largest cities in the area are Springfield (population 91,753), Decatur (90,397), Bloomington (39,992), and Normal (26,396) (Rockford Map Publishers, 1973).

The Sangamon River flows from the northeast to southwest in central Illinois, then north and west to its confluence with the Illinois River about 9 miles north of Beardstown. Salt Creek, which drains 37 percent of the area, is the major tributary to the Sangamon River and drains the north and central parts of the area.



SCALE 1:1,000,000

0 10 20 30 MILES

0 10 20 30 KILOMETERS

Base from U.S. Geological Survey 1972; 1:500,000

EXPLANATION

07130006	Upper Sangamon River basin (upstream from Springfield, Ill.)
07130007	South Fork Sangmon River basin
07130008	Lower Sangamon River basin (downstream from Springfield, Ill.)
07130009	Salt Creek basin

Figure 1.2-1 Hydrologic units.

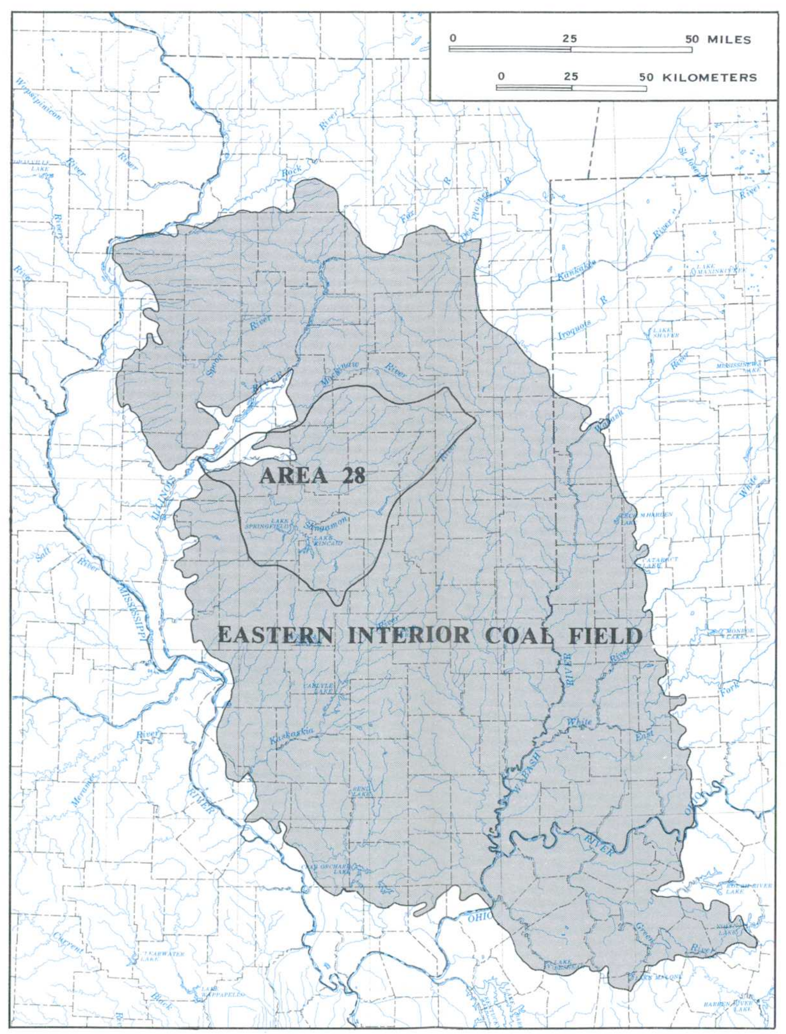


Figure 1.2-2 Location of the study area in the Eastern Interior Coal Field.

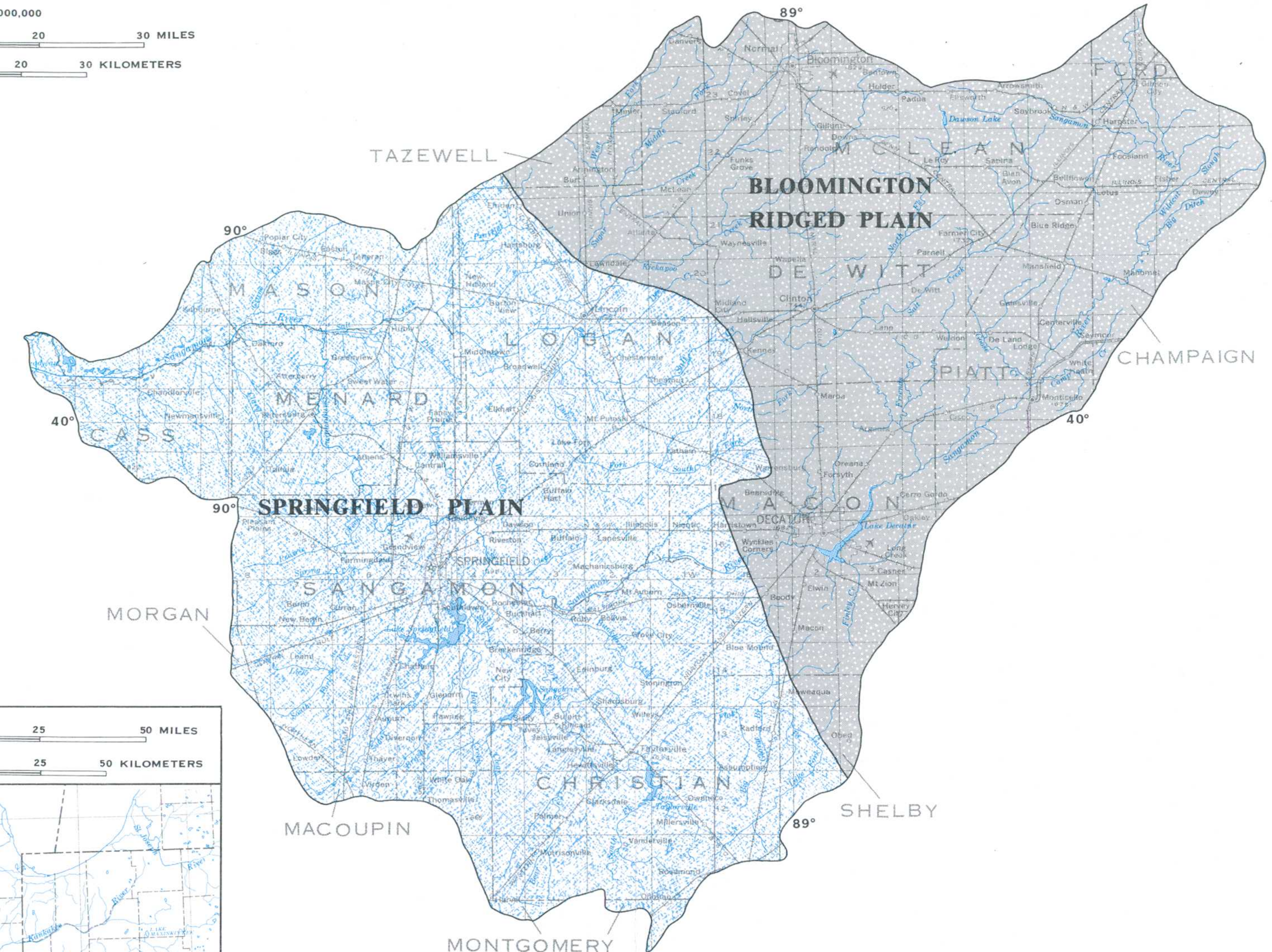


Figure 1.2-3 Physiographic divisions.

2.0 COAL MINING POTENTIAL AND HISTORY

Illinois has Largest Bituminous Coal Reserves in the United States

Illinois is second only to Montana in total coal reserves. Illinois ranks first in total reserves of bituminous coal. These reserves also have the highest total heat content.

Estimated coal reserves in Illinois (as of January 1975, with revisions in 1980) are 161.6 billion tons which is 15.1 percent of the total demonstrated coal reserves in the United States (Nawrot and others, 1980). Illinois ranks first among the States in total bituminous coal reserves. These reserves also have the highest total heat content of any State's reserves in the Nation. Only Montana has larger total coal reserves (Rickert and others, 1979). About 12.1 percent of the Illinois reserves is considered surface-minable (coal seams more than 18 inches thick and less than 150 feet deep), but currently only about 3.6 percent is economically and legally recoverable (Nawrot and others, 1980).

Total identified coal reserves in Area 28, as of January 1976, were about 19.1 billion tons. About 6.6 percent of this reserve is considered surface-minable (Smith and Stall, 1975, updated in 1977). The surface-minable coal reserves and the two active underground mines in the area are shown in figure 2.0-1. These mines produced nearly 3 million tons of coal in 1981. This is 5.7 percent of the total amount of coal produced in Illinois and 10.1 percent of the coal produced from underground mines in 1981 (Illinois Department of Mines and Minerals, 1982).

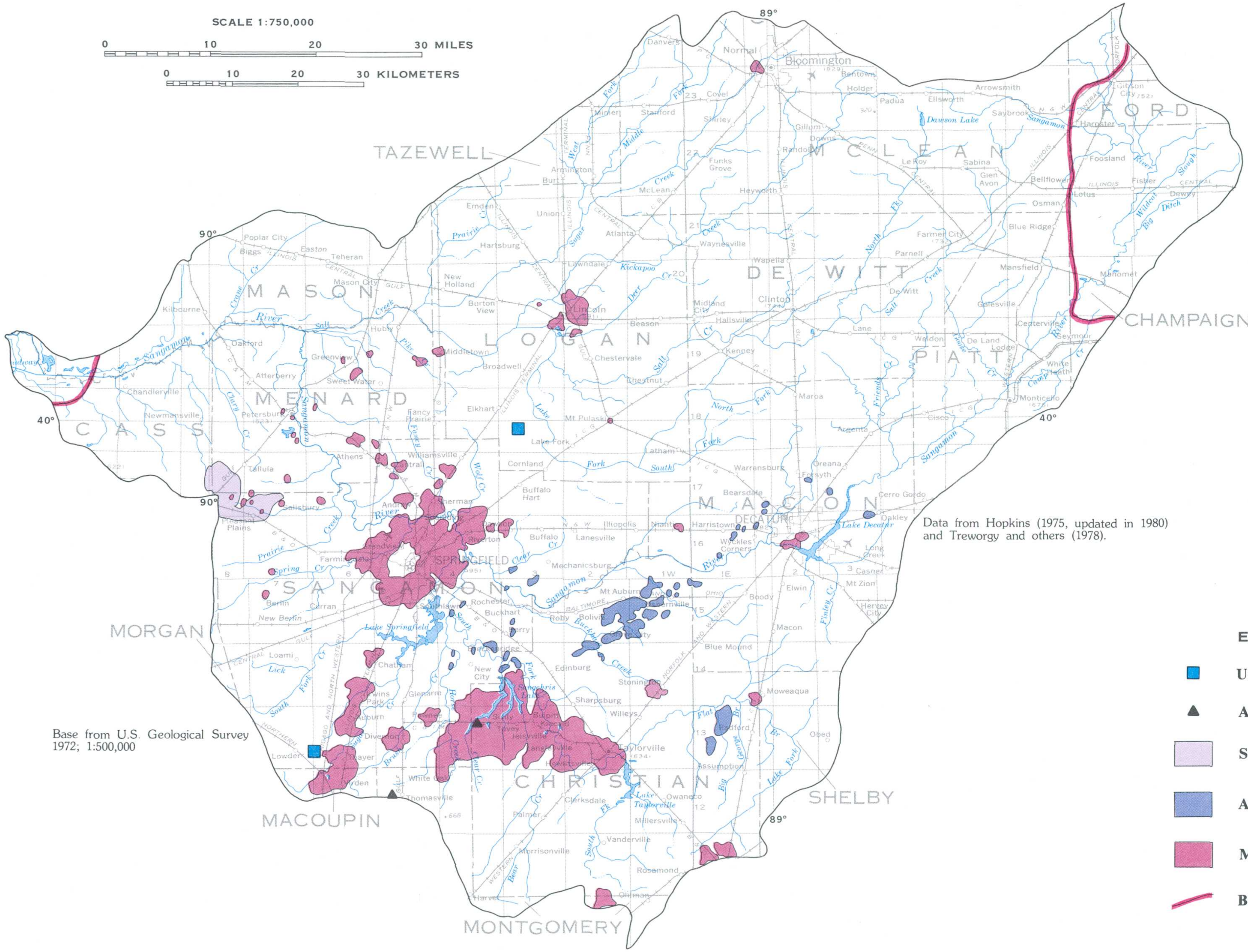
Rickert and others (1979) have shown that Illinois coal resources are among those most likely to be used for synthetic fuel production due to the large amount of coal available, plentiful water supplies, lack of serious geologic constraints, and proximity to northeastern markets. In addition, the Nation's move toward energy independence and diminishing domestic supplies of oil and gas could increase the demand for Midwestern coal.

Oil and gas are also produced in Christian, Macon, and Sangamon Counties. These counties produced 1.9 percent (over 400,000 barrels) of the State's total oil production in 1979 (Van Den Berg and Elyn, 1981). The most heavily drilled areas are shown in figure 2.0-1.

The first coal discovery in North America was by Marquette and Joliet in 1673 along the Illinois River. The first commercial underground coal mine in Illinois was opened in 1810 in Jackson County (Andros, 1915). The first commercial surface mine in the United States was opened in 1866 near Danville, Illinois. Early surface mining was accomplished by removing overburden with horsedrawn scrapers and hauling coal out of the mine pit in wagons and wheelbarrows. Within two decades, the steam shovel came into use. The first steam shovels were made mostly of wood and were able to remove 8 to 12 feet of overburden and coal seams up to 3 feet thick. From these beginnings, coal mining technology has progressed to the giant electric-powered shovels of today that can remove up to 220 cubic yards of material in a single bite (Lewis, 1972).

Total coal production in Illinois from 1882 through 1981 was 4.8 billion tons. Area 28 accounted for 3.0 percent of that total. Peak production was reached during World War I. The Depression of the 1930's caused a decline in production which was reversed during World War II. Another decline in production occurred when diesel locomotives and alternate industrial fuel sources came into use. Increased energy consumption and declining oil and gas reserves have resulted in an increase and leveling off of production during the past two decades (Nawrot and others, 1980).

In 1981, the 27 surface mines in operation in Illinois produced over 22 million tons of coal and the 31 underground mines produced a total of over 29 million tons (Illinois Department of Mines and Minerals, 1982).



Base from U.S. Geological Survey 1972; 1:500,000

Data from Hopkins (1975, updated in 1980) and Treworgy and others (1978).

EXPLANATION

- Underground mine under construction
- Active underground mines
- Surface-minable coal reserves
- Area heavily drilled for oil and gas
- Mined-out area, underground
- Boundary of the Pennsylvanian system

Figure 2.0-1 Location of coal and oil production.

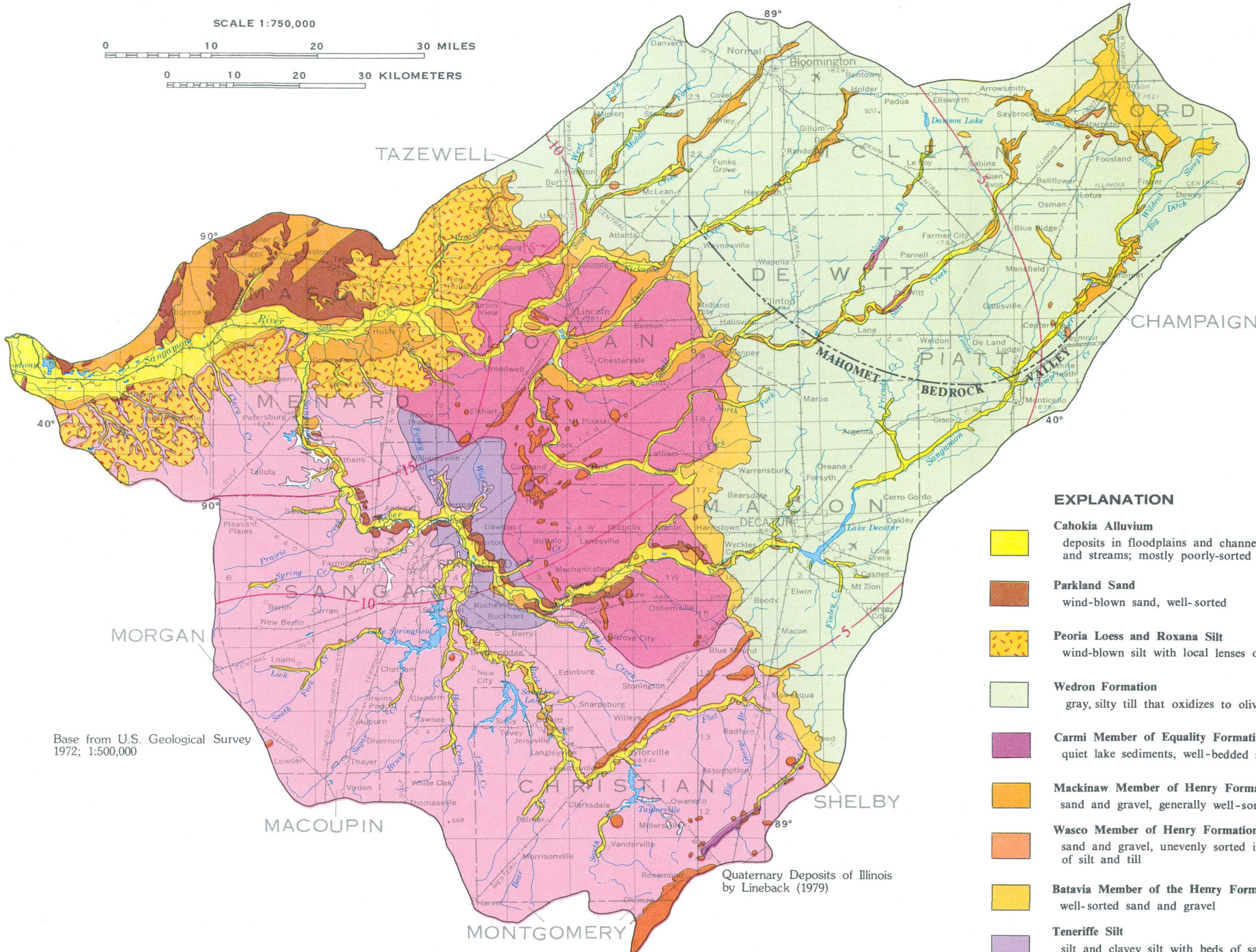
Glacial Deposits Cover the Area

Glacial deposits cover most of Area 28 to a maximum thickness of 400 feet in the Mahomet Bedrock Valley.

The Quaternary System includes glacial deposits and other sediments deposited during the glacial epoch through the present time. Surficial glacial deposits cover all of Illinois except the northwestern corner and the southern tip. Glacial deposits in Area 28 reach a maximum thickness of 400 feet in the Mahomet Bedrock Valley, the axis of which is shown in figure 3.1-1. The glacial deposits are of Illinoian and Wisconsinan age. The Wisconsinan glacier was the last to cover the area. Loess 5 to 10 feet thick, of Wisconsinan age, was deposited when outwash material was blown from the valleys into the uplands (Lineback, 1979).

Stratigraphic members of the Glasford Formation of Illinoian age cover the western half of Area 28. They are silty to sandy tills with interbedded sand and gravel and are generally calcareous. Members of the Wedron Formation of Wisconsinan age cover the eastern half of the area. They are silty to sandy tills with lenses of silt, sand, and gravel. Other formations found in the area are shown and described in figure 3.1-2.

Peoria Loess of Wisconsinan age is a massive, well-sorted silt and blankets most of Area 28. Peoria Loess is the parent material for many of the soils in the area (Willman and others, 1975).



Base from U.S. Geological Survey 1972; 1:500,000

Quaternary Deposits of Illinois by Lineback (1979)

EXPLANATION

Cahokia Alluvium
deposits in floodplains and channels of modern rivers and streams; mostly poorly-sorted sand, silt and clay.

Parkland Sand
wind-blown sand, well-sorted

Peoria Loess and Roxana Silt
wind-blown silt with local lenses of fine sand.

Wedron Formation
gray, silty till that oxidizes to olive brown; some sandy till

Carmi Member of Equality Formation
quiet lake sediments, well-bedded silt

Mackinaw Member of Henry Formation
sand and gravel, generally well-sorted and well-bedded

Wasco Member of Henry Formation
sand and gravel, unevenly sorted irregularly bedded lenses of silt and till

Batavia Member of the Henry Formation
well-sorted sand and gravel

Teneriffe Silt
silt and clayey silt with beds of sand or clay deposited in large preglacial lakes

Radnor Till Member of Glasford Formation
gray compact silty till

Hagarstown Member of Glasford Formation
well-sorted sand and gravel

Vandalia Till Member of Glasford Formation
compact silty, sandy, and clayey till

White areas on map indicate presence of rocks older than Pliocene at or near the surface

—5— **Thickness of loess; contour interval, 5 feet**

Figure 3.1-1 Surficial geology.

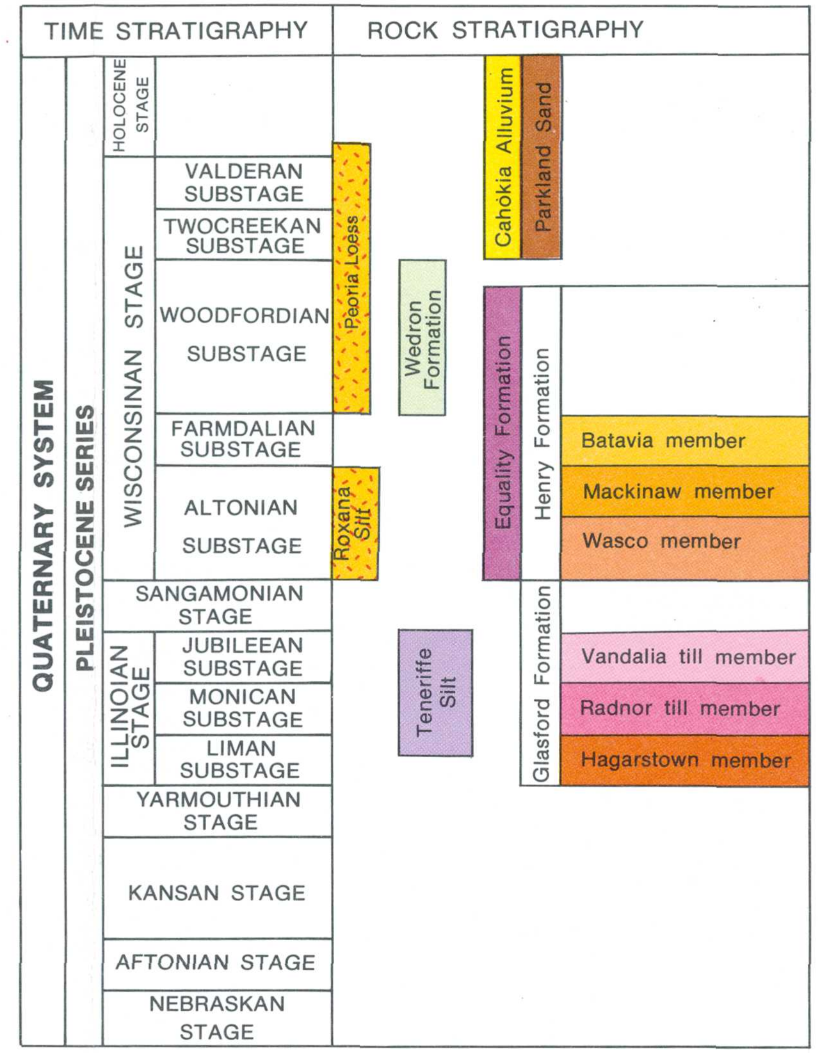


Figure 3.1-2 Stratigraphic column of Quaternary System showing locations of rock units (the stratigraphic nomenclature follows the usage of the Illinois State Geological Survey and differs from the usage of the U.S. Geological Survey). Modified from Willman and Frye, (1970, P. 12).

Four Geologic Units Make Up the Bedrock Surface

The Pennsylvanian System forms the upper bedrock in about 90 percent of Area 28.

The Pennsylvanian System is the uppermost bedrock in about 90 percent of Area 28. The underlying rocks of Mississippian, Devonian, and Silurian age make up the bedrock surface in the rest of the area (fig. 3.2-1).

The Pennsylvanian System in the area ranges from 0 to 1,200 feet thick. The rocks dip gently toward the southeast into the Illinois Basin, which is a spoon-shaped structure that is oriented north-northwest to south-southeast, with the deepest part in southeastern Illinois. The Pennsylvanian System consists of sandstone, siltstone, limestone, shale, clay and coal. The lower section of the Pennsylvanian System in Illinois is 60 percent sandstone, 39 percent siltstone and shale, and less than 1 percent coal and limestone. Twenty-five percent of the middle and upper sections is sandstone, 5 to 10 percent is limestone, and 65 to 70 percent is shale and clay. Coal makes up no more than 2 percent of the Pennsylvanian System, and is more prominent in the middle section (fig. 3.2-2) (Willman and others, 1975).

The depth to the Herrin No. 6 coal, mined at the two active underground mines, ranges from less than 200 feet in the western part of the area to 800 feet in Shelby County (Smith and Stall, 1975). In the past, the Harrisburg-Springfield (No.5), Colchester (No. 2), and Danville (No. 7) coals also have been mined in the area (Nawrot and others, 1980).

Changes in lithology commonly are abrupt, indicating that the depositional environment at times was changing rapidly. The advance of saltwater seas into Illinois resulted in transgressive marine deposition of sandstone, shale, and limestone. As the seas receded, large freshwater swamps developed on broad deltaic plains. When the seas readvanced, marine sediments were deposited on top of the swamp debris. Biochemical and physical changes took place as the partially decayed plant material (peat) was buried, resulting in the formation of 75 identifiable coal members in Illinois.

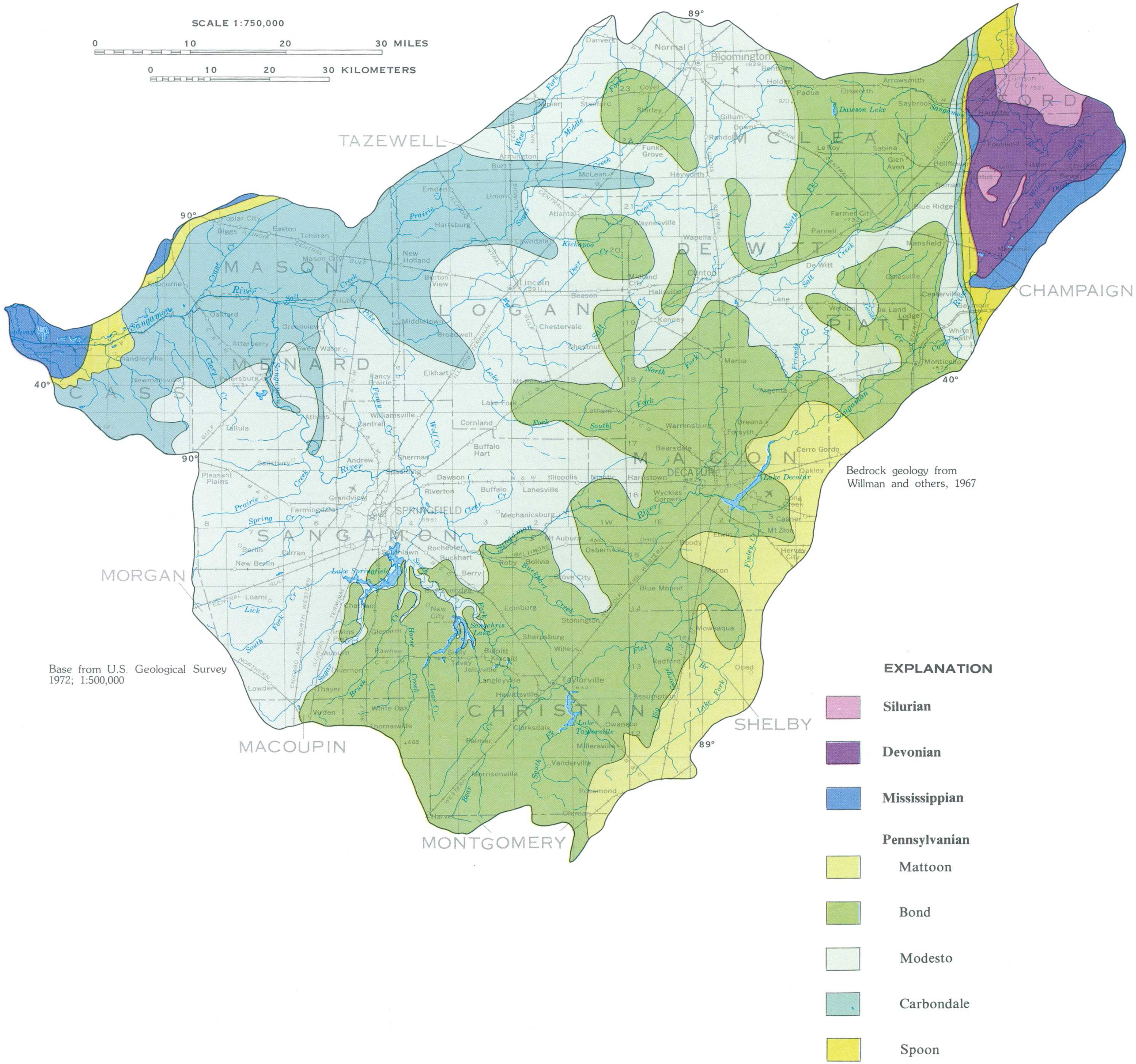


Figure 3.2-1 Bedrock geology.

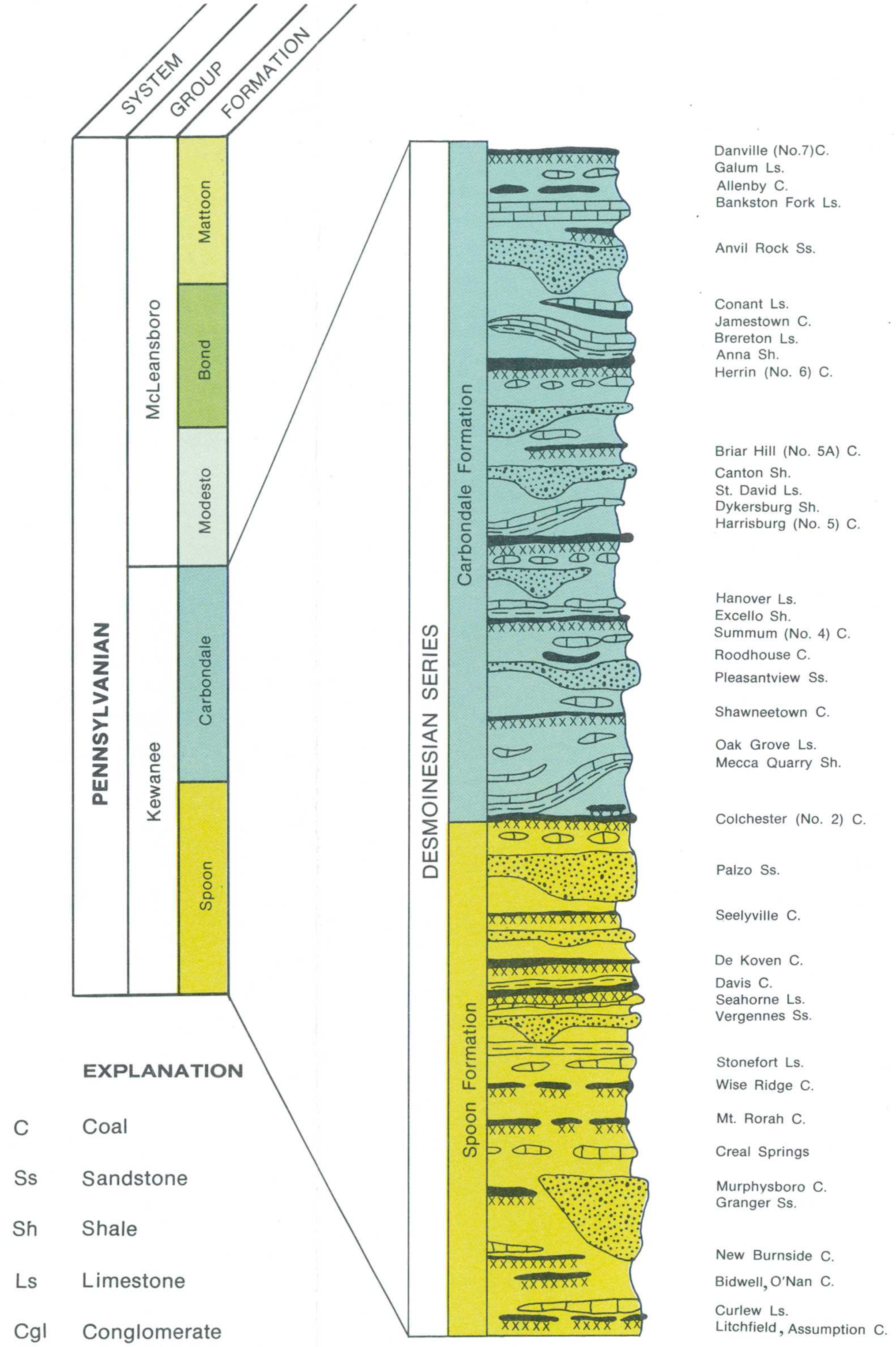


Figure 3.2-2 Stratigraphy of the major coal-bearing units in the Pennsylvanian System (the stratigraphic nomenclature follows the usage of the Illinois State Geological Survey and differs from the usage of the U.S. Geological Survey). Modified from Willman and others (1975, p. 166).

4.0 SOILS

Area Soils are Good for Agricultural Productivity

Soils are of moderate to high productivity. Erosion control is a problem on slopes. Area soils have a wide range of permeability and pH values.

The soils in Area 28 are moderately to highly productive under intensive management (application of plant nutrients, maintenance of drainage, control of flooding and erosion, and control of weeds, diseases, and insects). Soils in Area 28 have permeabilities from 0.2 to 6.30 inches per hour and pH values from 4.5 to 8.4. The predominant soil associations A and B have severe erosion problems on less than 9 percent of their area. Average annual soil loss is 0 to 10 tons per acre (U.S. Department of Agriculture, 1980). Bedrock outcrops are common where soils have been eroded. General descriptions of the soil associations in the area are given in table 4.0-1. These descriptions were compiled from soil surveys for individual counties (U.S. Department of Agriculture, 1974, 1980; Fehrenbacher and others, 1967; and Fehrenbacher and Odell, 1953).

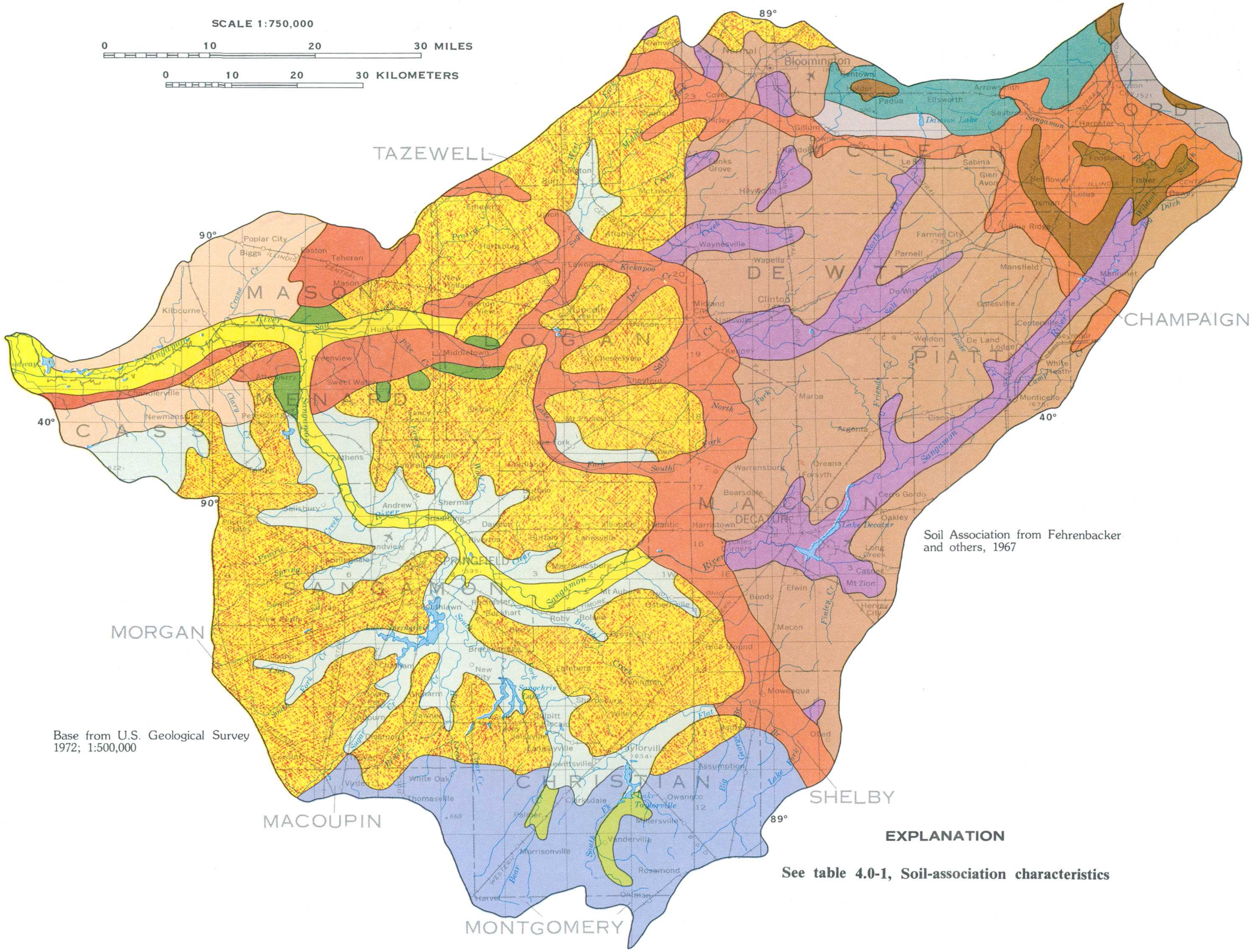
The soil associations present in Area 28 are shown in figure 4.0-1. Most soil associations were developed from loess. Loess is a silty wind deposit that was produced by outwash material blown from the valleys onto the uplands during glacial times. When the loess was deposited, it was calcareous and contained many important plant nutrients. It was a friable, medium-textured silt loam with high moisture-storage capacity and formed very productive soils (Fehrenbacher and others, 1967). Thickness of loess in the area ranges from 5 to 10 feet (Lineback, 1979). Ground-water seepage may occur at the contact of the loess with the underlying drift or bedrock resulting in slope failure. To help prevent slope failure, slopes are benched and gutters are used at the top of the slopes and on the benches (Thornburn, 1963).

Soil association Z was developed from alluvium, which includes recent sediments deposited by streams on their flood plains. The grain size of these sediments range from sand to clay.

Soil associations W and X were developed from outwash materials that were deposited in the major river valleys by meltwater during the Illinoian and Wisconsinan glaciations. The grain sizes of the materials range from gravel to clay.

Soil associations J and K were developed from Illinoian age glacial till (Fehrenbacher and others, 1967). These soils were formed on the steeper slopes in the eastern part of the area and have a lower moisture-storage capacity and are more compact than loess.

Information on the engineering properties of soils in Area 28 and detailed soil maps can be found in soil surveys for individual counties. These are published by the U.S. Soil Conservation Service in cooperation with the University of Illinois Agriculture Experiment Station. Soil surveys and other information can be obtained from State and county offices of the Soil Conservation Service. Recent soil surveys are available for Sangamon, Logan, and Menard Counties. A report by Wischmeier and Smith (1978) contains useful information for predicting erosion losses from rainfall.



EXPLANATION

See table 4.0-1, Soil-association characteristics

Figure 4.0-1 Soil associations.

Table 4.0-1 Soil-association characteristics.

Soil association	Depth to bedrock (feet)	Depth to high water table (feet)	Permeability (inches per hour)	Available water capacity (inches per inch of soil)	Soil reaction pH
Dark-Colored Soils					
Developed primarily from loess					
Joy-Tama-Muscatine-Ipara-Sable	NA	0-6+	0.20-2.0	0.11-0.24	5.1-7.8
Sidell-Catlin-Flanagan-Drummer	NA	NA	0.20-2.0	0.16-0.25	5.6-8.4
Harrison-Herrick-Virden	5+	0-2	0.20-2.0	0.11-0.24	5.6-8.4
Developed primarily from glacial drift					
LaRose-Saybrook-Lisbon	NA	NA	NA	NA	NA
Elliott-Ashkum-Andres	NA	NA	NA	NA	NA
Swygert-Bryce-Clarence-Rowe	NA	NA	NA	NA	NA
Light-Colored-Soils					
Developed primarily from loess					
Seaton-Fayette-Stronghurst	5+	5+	0.60-2.0	0.18-0.23	4.5-7.8
Birkbeck-Ward-Russell	5+	5-10	0.63-2.0	0.14-0.25	5.1-8.4
Clary-Clinton-Keomah	5+	0-4	0.20-2.0	0.18-0.25	4.5-8.4
Hosmer-Stoy-Weir	NA	NA	NA	NA	NA
Developed primarily from glacial drift					
Strawn-Miami	NA	5-10	0.63-2.0	0.14-0.20	5.6-8.4
Dark- and Light-Colored Soils					
Developed primarily from medium and fine textured outwash					
Littleton-Proctor-Plano-Camden-Hurst-Ginat	5+	5-10	0.60-6.3	0.10-0.25	5.1-8.4
Developed primarily from sandy material					
Hagener-Ridgeville-Bloomfield-Alvin	5+	6+	0.60-2.0	0.05-0.20	5.1-7.8
Developed primarily from alluvium					
Lawson-Beaucoup-Darwin-Haymond-Belknap	5+	1-3	0.60-2.0	0.2 -0.25	6.1-7.8

NA-data not available

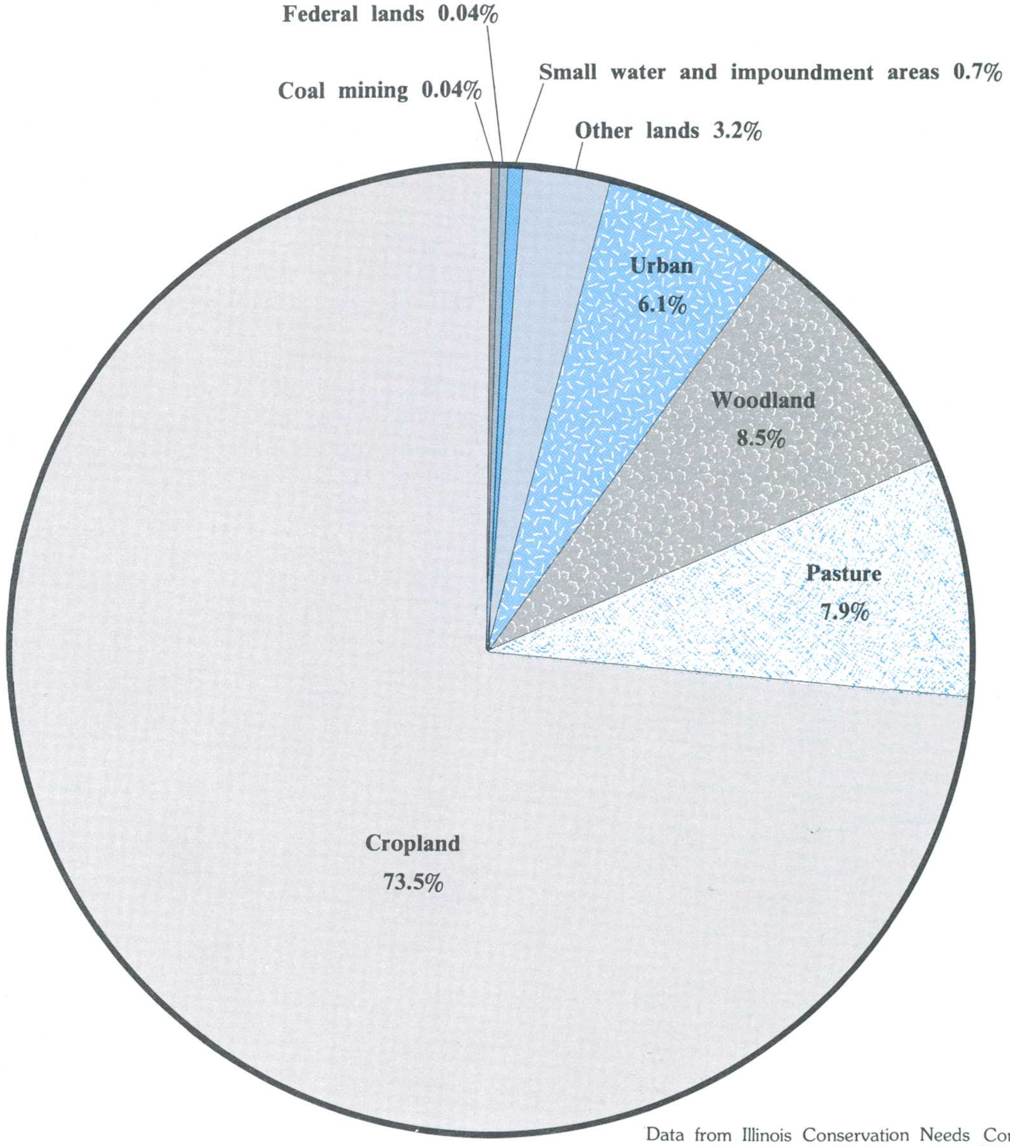
5.0 LAND USE

Agriculture is Dominant Land Use

Eighty-one percent of Area 28 is used for agriculture. There are no surface mines in the area and underground mining has affected 0.04 percent of the total land area.

Area 28 covers about 5,419 square miles in central Illinois. Agriculture is the dominant land use with 73.5 percent cropland and 7.9 percent pasture. The main crops are corn and soybeans. Beef cattle and hogs also are raised. The remainder of the area is used in the following ways (fig. 5.0-1): 8.5 percent woodland, 6.1 percent urban land, 0.5 percent surface-water impoundments, 0.2 percent small water areas (ponds from 2 to 40 acres in size and streams less than ⅛ mile wide), 0.04 percent land affected by underground coal mining, and 3.2 percent other land (rural land not used as cropland, pastureland, or woodland) (Illinois Conservation Needs Committee, 1970; U.S. Department of Agriculture, 1980; Illinois Environmental Protection Agency, 1978).

There are no surface coal mines in Area 28. Although only 0.04 percent of the land surface has been affected by underground coal mining, approximately 4.1 percent of the area has been undermined (13 percent of Christian County and 12 percent of Sangamon County) (Nawrot and others, 1980). There are two active underground mines and two under construction in the area (Hopkins, 1975, updated in 1980). Sand and gravel and stone are also mined in the area. Oil is produced in Christian, Macon, and Sangamon Counties (Samson, 1981).



Data from Illinois Conservation Needs Committee, 1978; Soil Conservation Service, 1980; Illinois Environmental Protection Agency, 1978

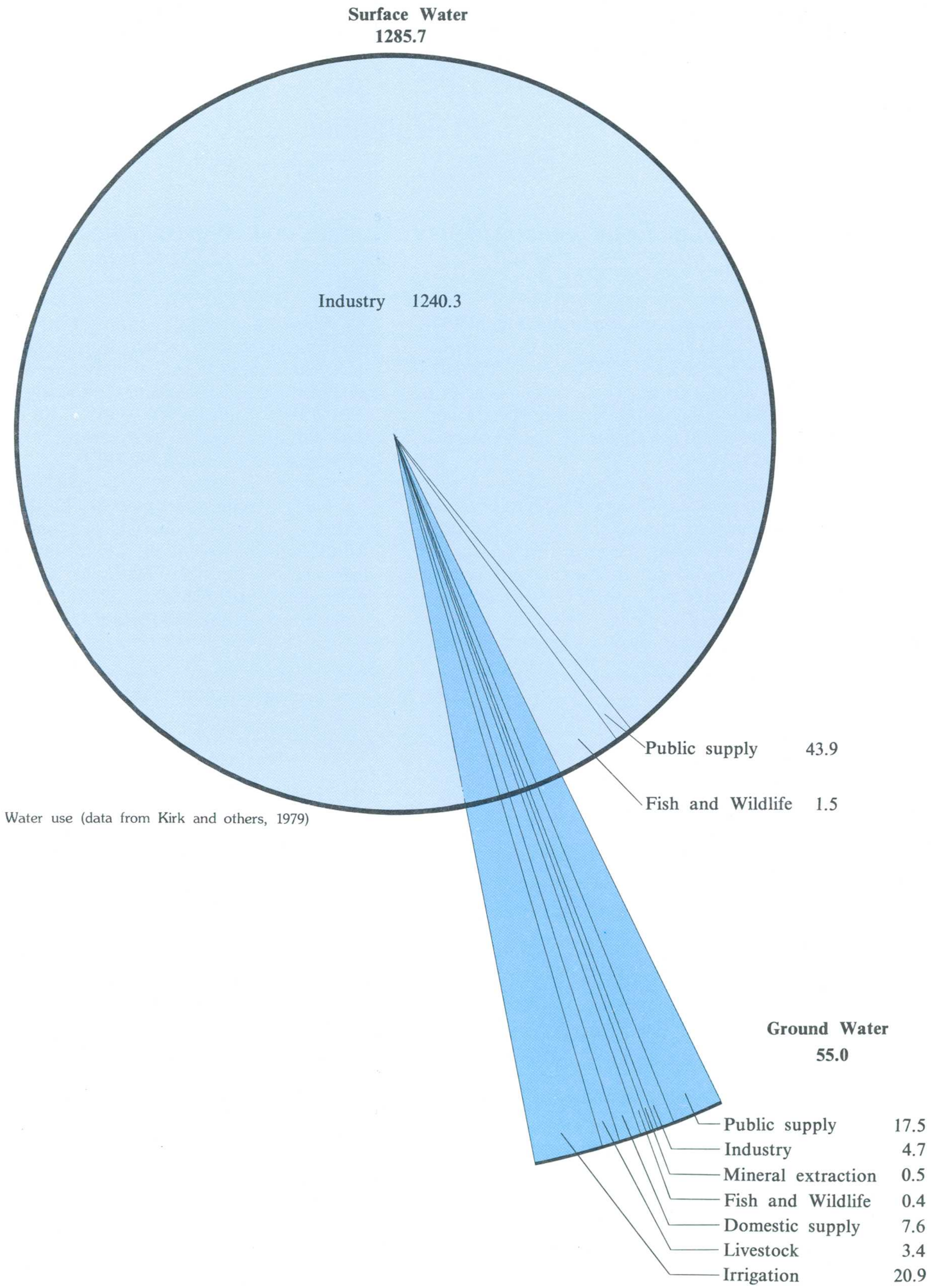
Figure 5.0-1 Land-use distribution.

Surface Water is the Major Source of Water in Area 28

Ninety-six percent of the water used is obtained from surface-water sources, with the remaining 4 percent drawn from ground-water sources.

Total water withdrawal in Area 28 was 1,341 million gallons per day (Mgal/d) in 1978 (Kirk and others, 1979). About 55.0 Mgal/d (4 percent) was from ground water (fig. 6.0-1). Of the total amount of water withdrawn, 93 percent (1,245 Mgal/d) was used for industry, 0.1 percent (0.5 Mgal/d) was used for mineral extraction, 4.6 percent (61.4 Mgal/d) was used for public supply, 2.4 percent (31.9 Mgal/d) was used for rural supplies (domestic, livestock, and irrigation), and 0.1 percent (1.9 Mgal/d) was used for fish and wildlife management.

There are 16 lakes in the area used for recreation (table 6.0-1). Six of the lakes are also used for potable water supply and four of the lakes also provide cooling water (Illinois Environmental Protection Agency, 1978, p. 134-159). There are 78 potential reservoir sites in the area (Dawes and Terstriep, 1966).



Water use (data from Kirk and others, 1979)

Figure 6.0-1 Water use, 1978, in million gallons per day.

Table 6.0-1 Lakes of Area 28.

Lakes by county	Surface area (acres)	Water use
Cass:		
Sanganois Conservation Area	600	Recreation
Champaign:		
Lake of the Woods	25.5	Recreation
Christian:		
Kincaid City Lake	30.7	Rec., P.W.S.
Lake Taylorville	1,148	Do.
Sangchris Lake	2,165	Rec., C.W.P
De Witt:		
Clinton Lake	4,260	Rec., C.W.P.
Weldon Springs Lake	29.4	Recreation
Macon:		
Lake Decatur	3,093	Rec., P.W.S., C.W.P.
Mason:		
Crane Lake	756	Recreation
Ingram Lake	1,283	Do.
Otter Lake	289	Do.
McLean:		
Dawson Lake	150	Recreation
Menard:		
Lake Petersburg	190	Recreation
Sangamon:		
Lake Springfield	4,024	Rec., P.W.S., C.W.P.
Loami City Lake	4.5	Rec., P.W.S.
New Berlin Public Water Supply	4.0	Do.

Rec. = Recreation
P.W.S. = Public water supply
C.W.P. = Cooling water for powerplant

7.0 PRECIPITATION

Precipitation

Mean annual precipitation in Area 28 ranges from 35 to 38 inches, about 60 percent of which occurs between April and September.

The mean annual precipitation ranges from 35 to 38 inches (fig. 7.0-1). February is the driest month followed closely by December. The wettest months generally are May and June. About 60 percent of the annual precipitation occurs between April and September and is produced mostly by spring and summer thunderstorms.

The mean annual snowfall ranges from 18 inches along the southeastern edge of the area to 24 inches in the northernmost part of the area (fig. 7.0-2). The cold winters and high winds produce severe weather conditions, which include below 0°F wind-chill temperatures and reduced visibility. Freezing rain and sleet occur on an average of 10 to 12 days per year (Dawes and Terstriep, 1966).

The 24-hour rainfall amount that can be expected to be equaled or exceeded on the average of once in 2 years ranges from 3.0 inches in the northeastern part of the area to 3.3 inches in the southwestern part (fig. 7.0-3) (Herschfield, 1961). Rainfall amounts that can be expected for various frequencies and durations are given in table 7.0-1.

Daily precipitation records for Illinois are published by the National Oceanic and Atmospheric Administration (NOAA), Environmental Data and Information Service, National Climatic Center, Asheville, North Carolina 28801. NOAA also publishes hourly precipitation data.

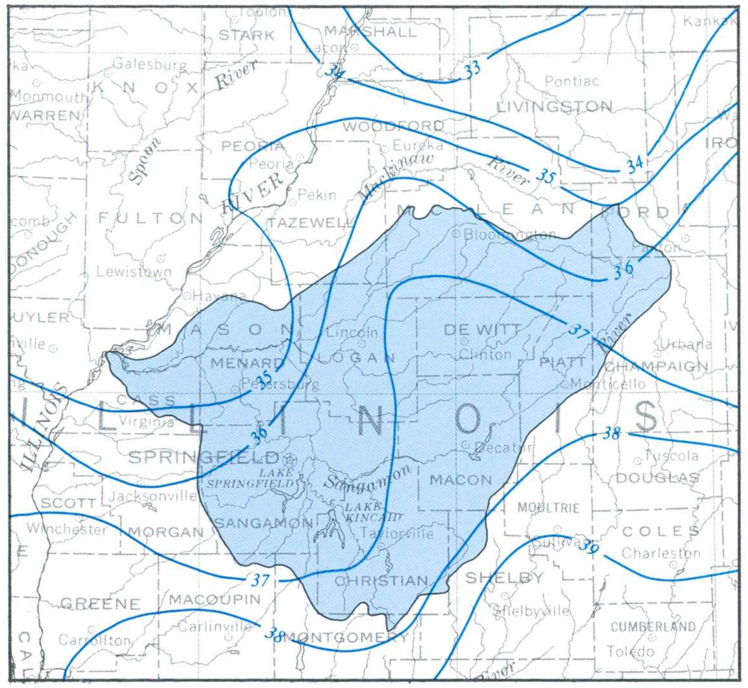


Figure 7.0-1 Mean annual precipitation in the study area (shaded), in inches (from Dawes and Terstriep, 1966).

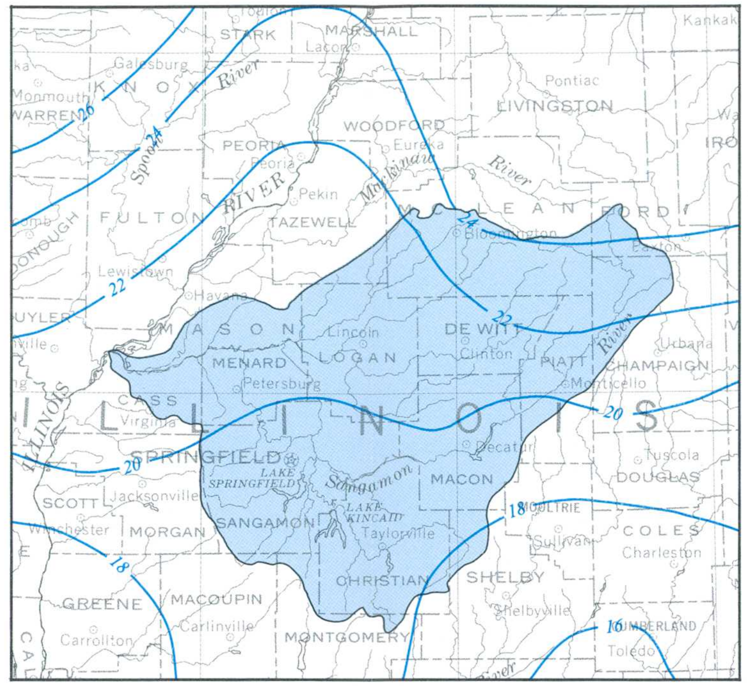


Figure 7.0-2 Mean annual snowfall in the study area (shaded), in inches (from Dawes and Terstriep, 1966).

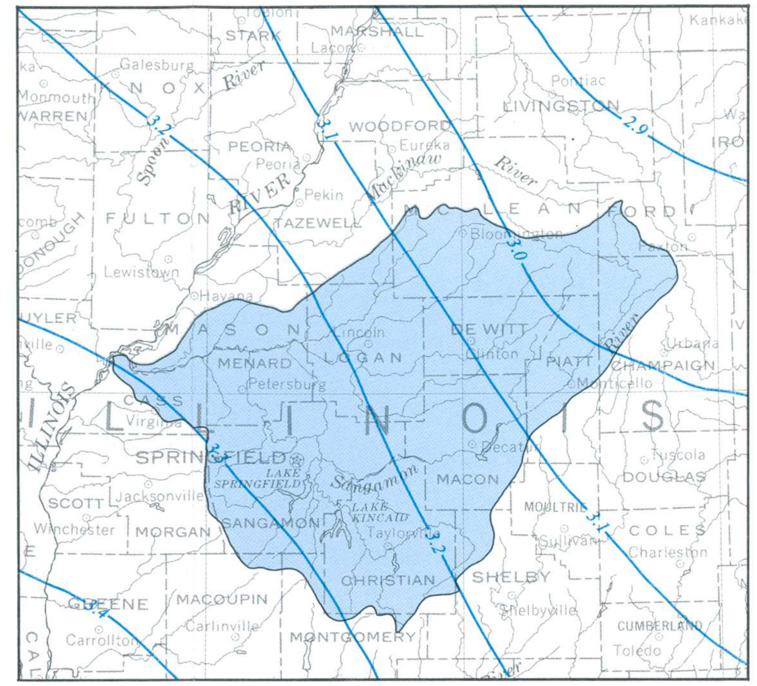


Figure 7.0-3 Two-year, 24-hour rainfall in the study area (shaded), in inches (from Herschfield, 1961).

Table 7.0-1 Precipitation duration-frequency values, in inches

[10-, 30-, 60-minute values from Frederick and others, 1977; 12-, and 24-hour values from Hershfield, 1961]

Frequency (years)	Duration (time)				
	10 minute	30 minute	60 minute	12 hour	24 hour
2	0.70	1.18	1.50	2.80	3.20
5	0.85	1.48	1.91	3.50	4.00
10	0.96	1.70	2.20	4.00	4.50
25	1.11	2.00	2.61	4.50	5.20
50	1.23	2.23	2.93	5.00	5.90
100	1.36	2.47	3.25	5.60	6.40

Mean Annual Flow can be Estimated

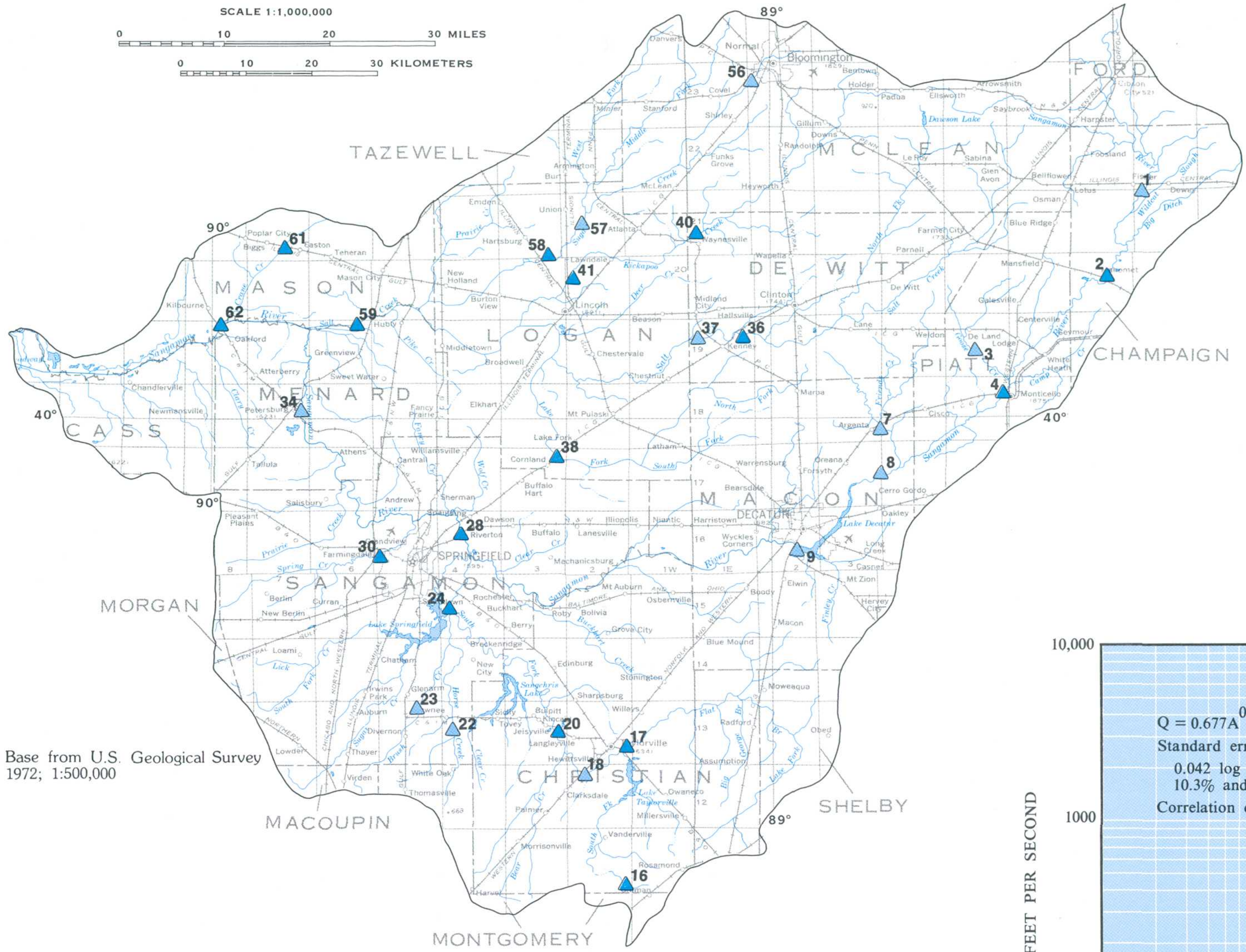
Mean annual streamflow is computed at gaging stations and can be estimated at ungaged sites in the study area.

Area 28 has 28 gaging stations (fig. 8.1-1) with more than 1 year of daily streamflow records. Table 8.1-1 is a list of 12 stations with less than 20 years of streamflow record and table 8.1-2 is a list of 16 stations with more than 20 years of streamflow records. Each station has a computed mean annual streamflow based on existing records.

Mean annual streamflow is estimated at ungaged sites using the equation $Qa = 0.677\ A^{0.999}$, where mean annual streamflow (Qa) is in cubic feet per second and the drainage area (A) is in square miles. This equation is derived from a regression analysis using the 16 gaging-station records found in table 8.1-2 which have an average of 34 years of streamflow record and have drainage areas ranging from 11 to 5,093 square miles. The standard error is 0.042 log units or +10.3 and -9.3 percent. Figure 8.1-2 shows this relation.

Mean annual streamflow is dependent on drainage area, soil characteristics, mean annual precipitation, area of lakes and ponds, area of forests, elevation, and stream length and slope as described by Sieber (1970). Drainage area is the most significant and only variable needed to adequately estimate the mean annual streamflow in the Sangamon River basin. The drainage area can be determined from topographic maps.

All surface-water stations are listed in section 13.0. The U.S. Geological Survey 8-digit station number and the years of record are included along with the station location description.



EXPLANATION

▲ Gaging stations used to determine the mean-annual-discharge equation for ungaged sites in the study area

△ Gaging stations with less than 20 years of record in the study area

△2 Site location and number

See section 14.0 for site description

Figure 8.1-1 Surface-water gaging-station locations.

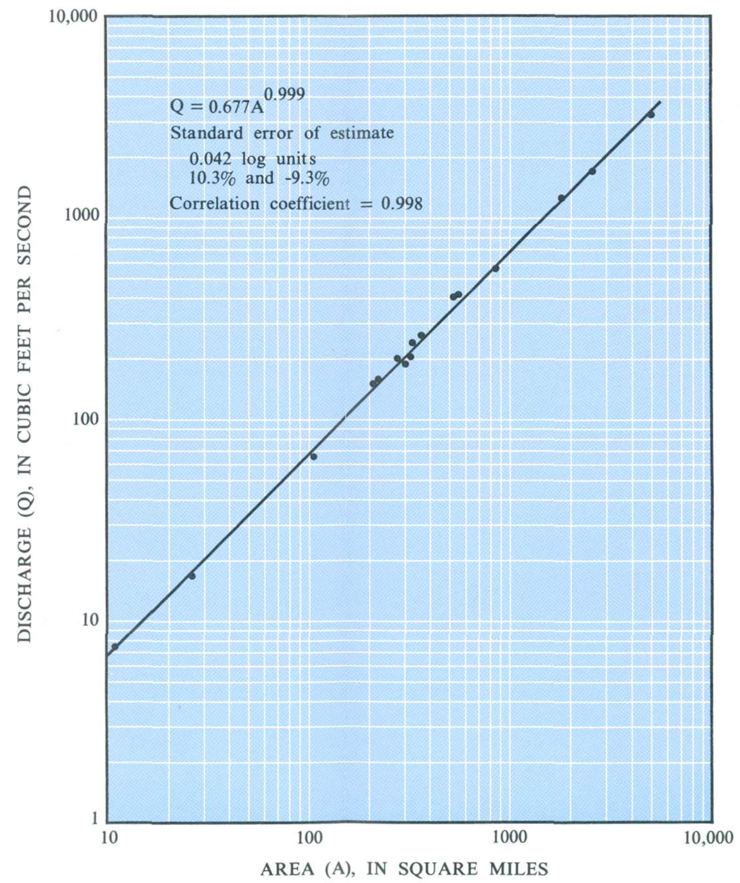


Figure 8.1-2 Mean-annual streamflow.

Table 8.1-1 Gaging stations in the study area with less than 20 years of record.

Map site number	Station name	Drainage area (mi^2)	Mean annual discharge (ft^3/s)	No. of years of record
1	Sangamon River at Fisher	240	259	3
3	Goose Creek near De Land	47.9	25.4	8
7	Friends Creek at Argenta	111	96.3	15
8	Sangamon River near Oakley	774	331	5
9	Sangamon River at Lake Decatur	925	1,080	2
18	South Fork Sangamon River near Taylorville	434	314	3
22	Horse Creek at Pawnee	52.2	40.5	14
23	Brush Creek near Divernon	32.4	21.6	8
34	Sangamon River at Petersburg	3,063	1,620	1
37	Salt Creek near Kenney	390	232	3
56	Sugar Creek near Bloomington	34.6	51.2	7
57	Sugar Creek near Armington	314	125	1

Table 8.1-2 Gaging stations in the study area used to compute the regional-mean-annual-streamflow equation.

Map site number	Station name	Drainage area (mi^2)	Mean annual discharge (ft^3/s)	No. of years of record
2	Sangamon River at Mahomet	362	261	30
4	Sangamon River at Monticello	550	401	71
16	South Fork Sangamon River near Nokomis	11	7.25	24
17	Flat Branch near Taylorville	276	198	32
20	South Fork Sangamon River at Kincaid	562	408	31
24	South Fork Sangamon River near Rochester	867	558	32
28	Sangamon River at Riverton	2,618	1,695	46
30	Spring Creek at Springfield	107	64.8	32
36	Salt Creek near Rowell	335	237	35
38	Lake Fork near Cornland	214	147	33
40	Kickapoo Creek at Waynesville	227	155	33
41	Kickapoo Creek near Lincoln	306	187	27
58	Sugar Creek near Hartsburg	333	197	27
59	Salt Creek near Greenview	1,804	1,245	40
61	Crane Creek near Easton	26.5	16.5	26
62	Sangamon River near Oakford	5,093	3,261	54

Low Flow Values Differ Widely Throughout Area

Low-flow values are low in the southern and eastern parts of the area and relatively high in the northwestern part.

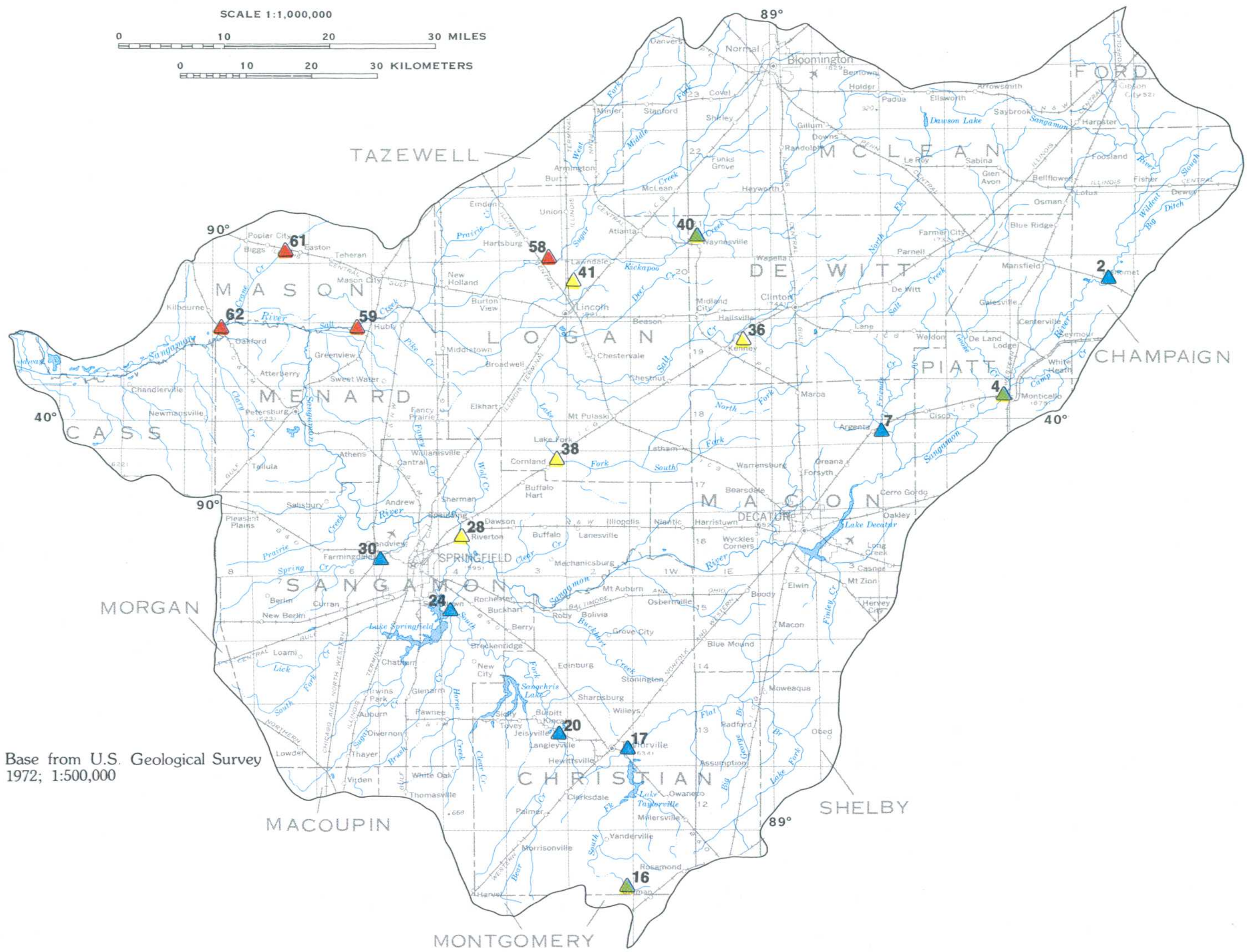
The low-flow discharge of a stream is used to determine its ability to dilute contaminated wastewater which can originate from city or industrial effluent, mine waste runoff, or contaminated ground-water seeps. The 7-day, 10-year low flow ($M_{7,10}$) is the common index used and referred to in environmental laws. It is the lowest average rate of flow or discharge for 7 consecutive days expected to occur once in a 10-year period.

The 7-day, 10-year low flow ($M_{7,10}$) for 17 continuous-record gaging stations is presented in table 8.2-1. The values range from 0.02 to 145 cubic feet per second (ft^3/s). In terms of discharge per square mile, the values range from 0.00018 to 0.04189 ft^3/s. Figure 8.2-1 shows ranges of low flow values and indicates that the higher values occur in the northwestern part and the lower values all occur along the eastern and southern parts of the area in the Sangamon River basin upstream from Springfield.

A log-Pearson Type III frequency distribution analysis for each station record was used to determine the low-flow values. The following regional regression equation was developed to estimate the low flow at ungaged sites (D. M. Mades, written commun., 1983):

$$M_{7,10} = 10^{-8} A^{2.72} S^{2.15}$$

The standard error is 0.48 log units or +202 and -67 percent. The $M_{7,10}$ is the 7-day, 10-year low flow in cubic feet per second per square mile, and A is the drainage area in square miles. S is the river-channel slope based on the difference in altitude divided by the distance between points 10 and 85 percent of the total distance measured along the low-water channel from the site to the basin divide and is in feet of fall per mile of channel.



EXPLANATION

Low flow at gaging stations

Less than 0.002 ft^3/sec./sq. mi.

0.002 to 0.005 ft^3/sec./sq. mi.

0.005 to 0.020 ft^3/sec./sq. mi.

Greater than 0.020 ft^3/sec./sq. mi.

7 Site and number

See section 14.0 for site description

Figure 8.2-1 Gaging stations with calculated 7-day, 10-year low flow values.

Table 8.2-1 Lowflow, 7-day, 10-year (M7,10) at study area gaging stations.

Map site number	Station name	$M_{7,10}$ (ft^3/s)	$M_{7,10}$ per square mile [(ft^3/s)/mi^2]	Drainage area (mi^2)	Slope (ft/mi)
2	Sangamon River at Mahomet	0.53	0.001	362	3.59
4	Sangamon River at Monticello	2.47	.005	550	2.75
7	Friends Creek at Argenta	.02	.0002	111	-
16	South Fork Sangamon River near Nokomis	.053	.005	11.0	18.8
17	Flat Branch near Taylorville	.37	.001	276	2.01
20	South Fork Sangamon River at Kincaid	1.10	.002	562	2.01
24	South Fork Sangamon River near Rochester	.90	.001	867	1.32
28	Sangamon River at Riverton	20.4	.008	2,618	1.48
30	Spring Creek at Springfield	.04	.0004	107	5.39
36	Salt Creek near Rowell	2.83	.008	335	2.59
38	Lake Fork near Cornland	2.54	.012	214	4.65
40	Kickapoo Creek at Waynesville	.74	.003	227	6.23
41	Kickapoo Creek near Lincoln	2.14	.007	306	5.12
58	Sugar Creek near Hartsburg	6.87	.021	333	5.76
59	Salt Creek near Greenview	69.2	.038	1,804	2.20
61	Crane Creek near Easton	1.11	.042	26.5	2.16
62	Sangamon River near Oakford	145	.028	5,093	1.27

Floodflow can be Estimated

Floodflow and peak discharge can be estimated by using equations developed from many years of streamflow records.

Floodflow in a stream occurs when there is excessive rainfall and or rapid snowmelt. Regional floodflow can be estimated at ungaged sites using equations developed from streamflow records. Figure 8.3-1 shows the location of 17 gaging stations with more than 10 years of streamflow data used to develop the regional floodflow equations.

To estimate the 7-day, 10-year floodflow ($V_{7,10}$), use the equation:

$$V_{7,10}{}^{5}16.6\ A^{0.92}$$

The standard error is 0.0767 log units or −19.3 and −16.2 percent. The highest 7-consecutive-day mean discharge in cubic feet per second expected to be exceeded at intervals averaging 10 years, is the 7-day, 10-year floodflow. The drainage area (A) is measured in square miles. The 7-day, 10-year floodflow for each gaging station is plotted against its corresponding drainage area as shown in figure 8.3-2.

The peak discharge (Q_T) for the study area can be estimated using the equations defined by Curtis (1977) as follows:

$$Q_2\ {}^{5}\ 42.7\ A^{0.776}S^{0.466}(I\text{-}2.5)^{0.834}\ Af$$

$$Q_{10}\ {}^{5}\ 90.8\ A^{0.767}S^{0.494}(I\text{-}2.5)^{0.833}\ Af$$

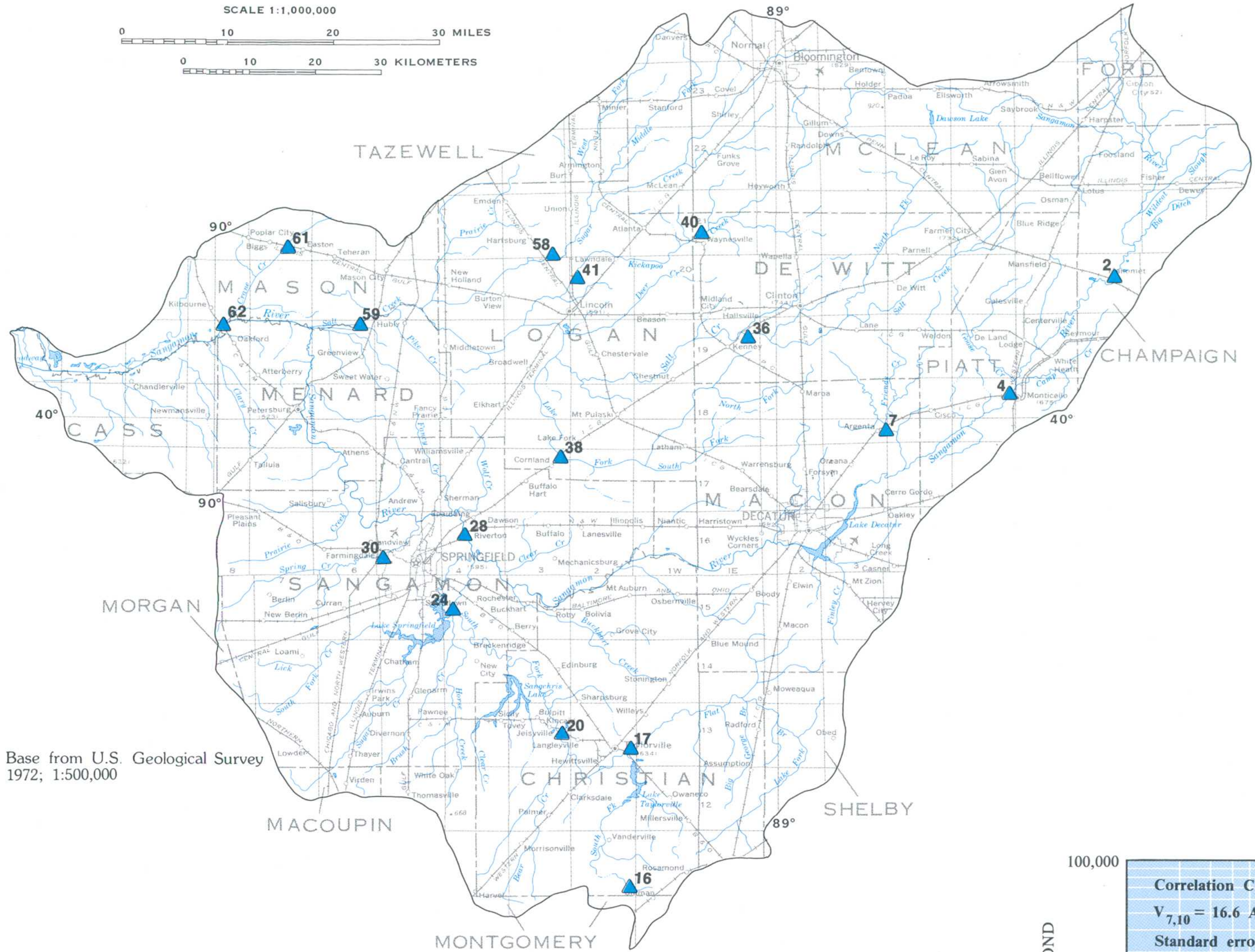
$$Q_{50}\ {}^{5}134\ \ A^{0.763}S^{0.510}(I\text{-}2.5)^{0.836}\ Af$$

$$Q_{100}{}^{5}152\ A^{0.762}S^{0.515}(I\text{-}2.5)^{0.836}\ Af$$

For the peak discharge (Q_T), T is the recurrence interval in years. Therefore Q_2, Q_{10}, Q_{50}, and Q_{100} can be expected to be equaled or exceeded once in any 2-, 10-, 50-, and 100-year period, respectively. The peak discharge is measured in cubic feet per second. The drainage area (A) is in square miles. The river channel slope (S) is measured from the 10 to 85 percent points on the low-water channel as measured from the site to the basin divide. The rainfall intensity (I) is the maximum 24-hour rainfall, in inches, expected to be exceeded at intervals averaging 2 years in length. The areal factor (Af) for the entire study area is 0.85 (Curtis, 1977). Across the Sangamon River basin, rainfall intensity increases from 3.0 inches in the northeast to 3.3 inches in the southwest. The value of rainfall intensity used in the above equation should be the average for the drainage basin under consideration (Curtis, 1977).

The 7-day, 10-year floodflow and 10-year peak discharge equations are based on records from U.S. Geological Survey streamflow gaging stations having an average of 32 years of record. The drainage areas range from 11 to 5,093 square miles.

Table 8.3-1 shows the Q_2, Q_{10}, Q_{50}, and Q_{100} for gaging stations in study area (Curtis, 1977).



EXPLANATION

▲ U.S. Geological Survey gaging stations used to compute the area flood-discharge equation

$V_{7,10} = 16.6 A^{0.92}$

Figure 8.3-1 Location of gaging-stations used in floodflow computations.

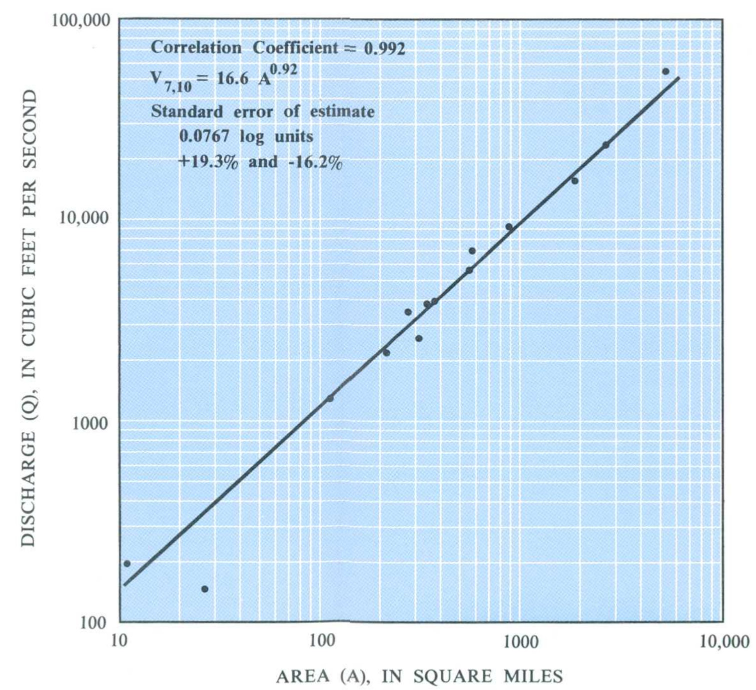


Figure 8.3-2 Relation of $V_{7,10}$ floodflow to drainage area.

Table 8.3-1 Area gaging station peak discharge and floodflow, in cubic feet per second, calculated from station records.

Map site number	Drainage area (mi^2)	Peak discharge Q_2	Q_{10}	Q_{50}	Q_{100}	Flood-flow $V_{7,10}$
2	362	4,180	9,100	13,600	15,500	3,930
4	550	5,140	11,400	17,200	19,600	5,550
7	111	(a)	(a)	(a)	(a)	1,260
16	11.0	1,050	2,670	4,270	4,920	193
17	276	3,630	8,580	13,300	15,100	3,410
20	562	4,680	11,000	17,300	20,100	6,950
24	867	5,290	12,200	18,800	21,600	9,010
28	2,618	14,900	30,800	41,900	45,800	23,200
30	107	1,650	4,500	7,520	8,870	1,090
36	335	3,810	9,930	16,400	19,300	3,770
38	214	2,180	6,100	10,400	12,400	2,180
40	227	3,840	8,370	12,600	14,400	2,170
41	306	4,270	9,230	13,900	15,800	2,580
58	333	4,710	9,790	14,500	16,500	2,320
59	1,804	12,000	25,700	38,400	43,700	15,300
61	26.5	218	529	844	996	145
62	5,093	21,100	47,700	71,800	81,700	53,100

(a) Value not available

(a) Value not available

Shapes of Flow-Duration Curves Vary with Geology and Land Use

Flow-duration curves summarize long-term daily discharge data and flow characteristics.

A flow-duration curve, which is based on streamflow at a site, is used to show the percentage of time that a specific stream discharge can be expected to be equaled or exceeded. Table 8.4-1 shows discharges that will be equaled or exceeded at various percentages of time. The sites for which flow-duration statistics are given are shown in figure 8.4-1.

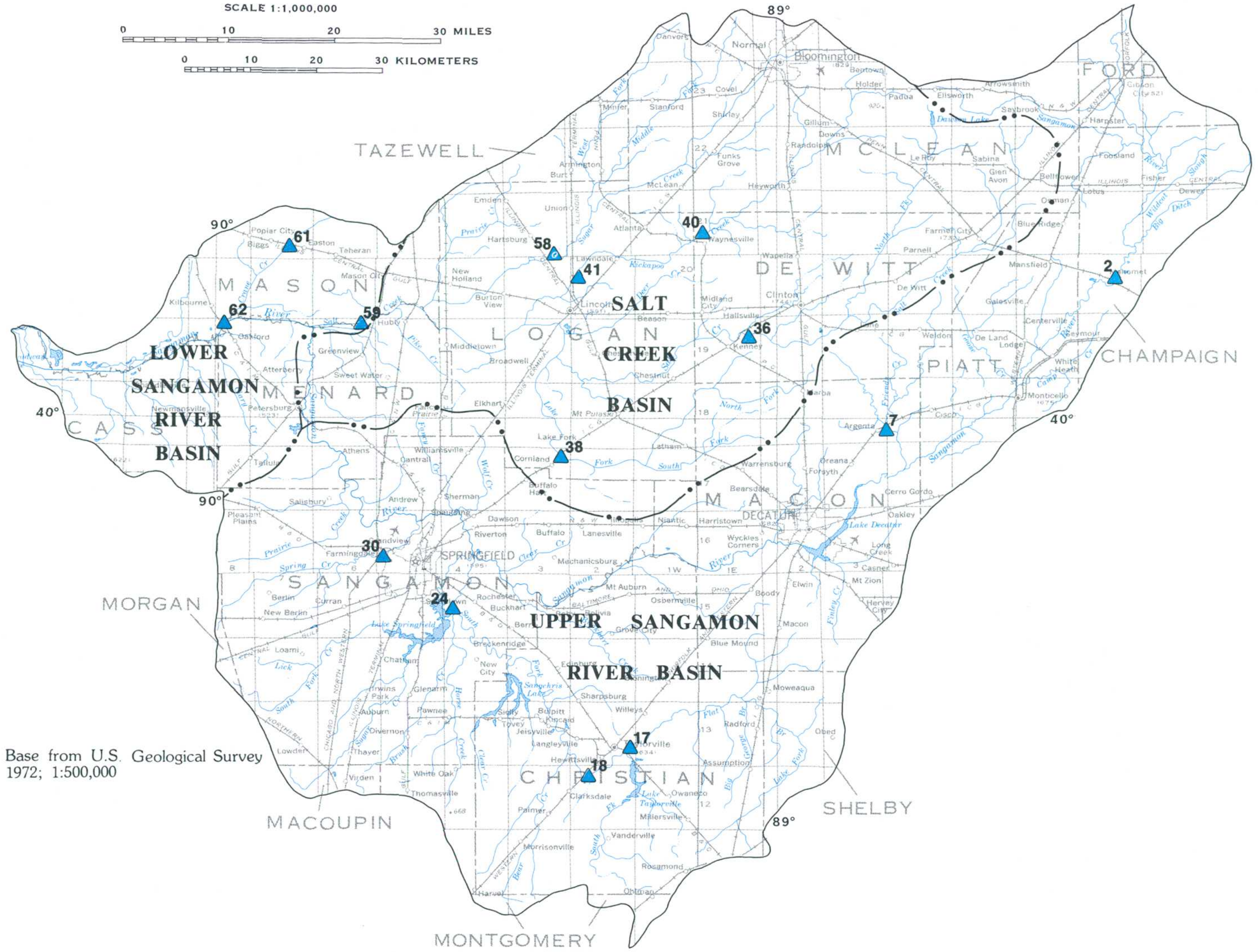
Geologic characteristics and land use are the principle factors that determine the shape of the flow-duration curve. A curve with a steep slope indicates highly variable streamflow such as that resulting from rapid surface runoff. Rapid runoff is caused by impervious soils, roads, and terrain. Streams in the upper Sangamon River basin have steep flow-duration curves (fig. 8.4-2). Although the terrain is relatively flat, many drain tiles in agricultural fields provide rapid runoff after percolation of only a few feet. Flow-duration curves for Salt Creek (fig. 8.4-3) reflect the same flow pattern.

The flow-duration curve for Crane Creek (site No. 61) has a more gentle slope and is characteristic of streams with high base flows. The high base flow may be caused by high ground-water discharge or delayed surface runoff such as from reservoir storage (fig. 8.4-4). Crane Creek is located directly over a sand and gravel aquifer which transmits ground water easily. Low flow is as much as 10 times greater in this basin compared to most of the study area. However, the high flows are less in Crane Creek than at other sites in Area 28.

Flow-duration data are used for planning purposes in waste-water treatment, water supply, and flood control.

Table 8.4-1 Flow-duration statistics, in cubic feet per second per square mile.

Map site number	Station name	Drainage area (mi^2)	Percent of time stream discharge is equaled or exeeded: 95	90	75	70	50	25	10
	Upper Sangamon River basin								
2	Sangamon River at Mahomet	362	0.008	0.02	0.05	0.07	0.25	0.75	1.82
7	Friends Creek at Argenta	111	.0009	.002	.05	.10	.34	.99	2.16
17	Flat Branch near Taylorville	276	.001	.007	.03	.05	.19	.62	1.74
18	South Fork Sangamon River near Taylorville	434	.01	.02	.07	.10	.23	.67	2.28
24	South Fork Sangamon River near Rochester	867	.004	.01	.04	.06	.17	.61	1.73
30	Spring Creek at Springfield	107	0	0	.02	.04	.18	.54	1.40
	Salt Creek basin								
36	Salt Creek near Rowell	335	0.02	0.03	0.07	0.10	0.27	0.78	1.76
38	Lake Fork near Cornland	214	.02	.03	.06	.08	.24	.70	1.68
40	Kickapoo Creek at Waynesville	227	.01	.02	.05	.07	.24	.70	1.59
41	Kickapoo Creek near Lincoln	306	.02	.02	.06	.08	.23	.65	1.47
58	Sugar Creek near Hartsburg	333	.04	.05	.08	.10	.25	.66	1.35
	Lower Sangamon River basin								
59	Salt Creek near Greenview	1,804	0.05	0.07	0.10	0.14	0.33	0.83	1.66
61	Crane Creek near Easton	26.5	.10	.15	.24	.27	.42	.79	1.25
62	Sangamon River near Oakford	5,093	.04	.05	.09	.12	.30	.75	1.65



EXPLANATION

U.S. Geological Survey gaging stations used for flow-duration analysis

Basin boundaries

Figure 8.4-1 Location of gaging stations used in flow-duration analysis.

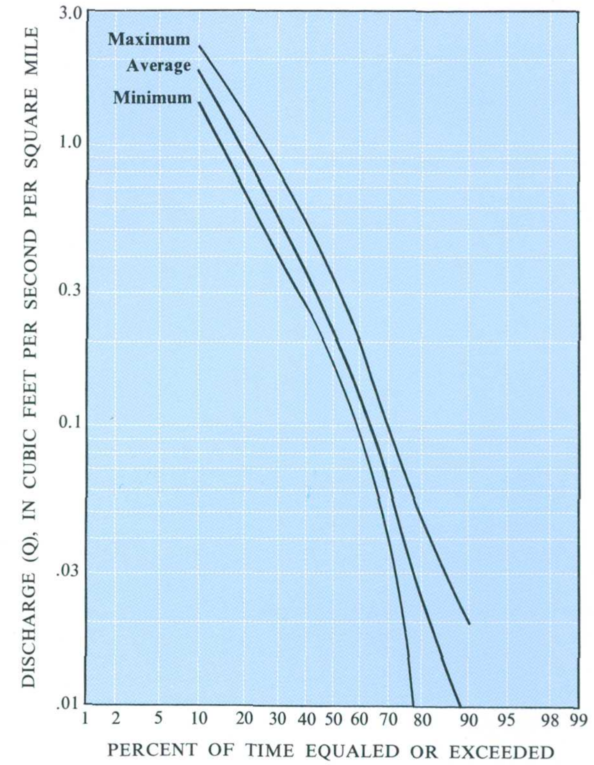


Figure 8.4-2 Flow duration in upper Sangamon River basin.

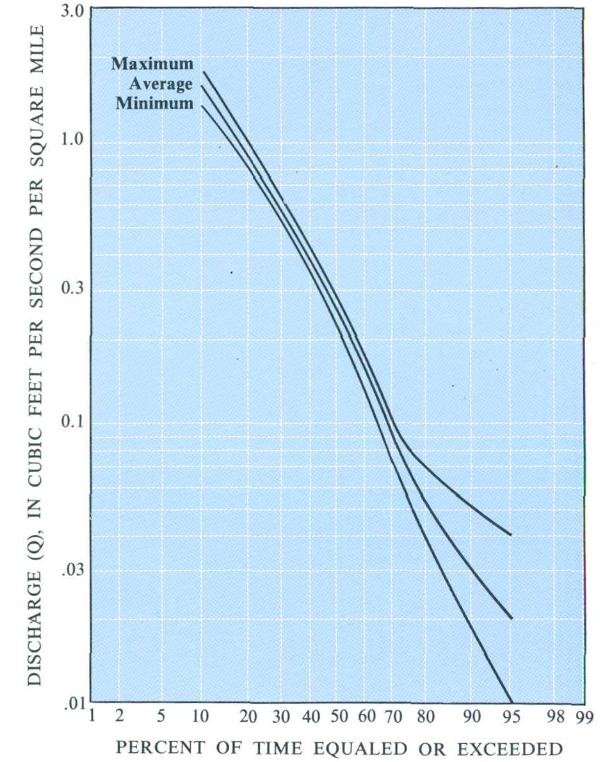


Figure 8.4-3 Flow duration in Salt Creek basin.

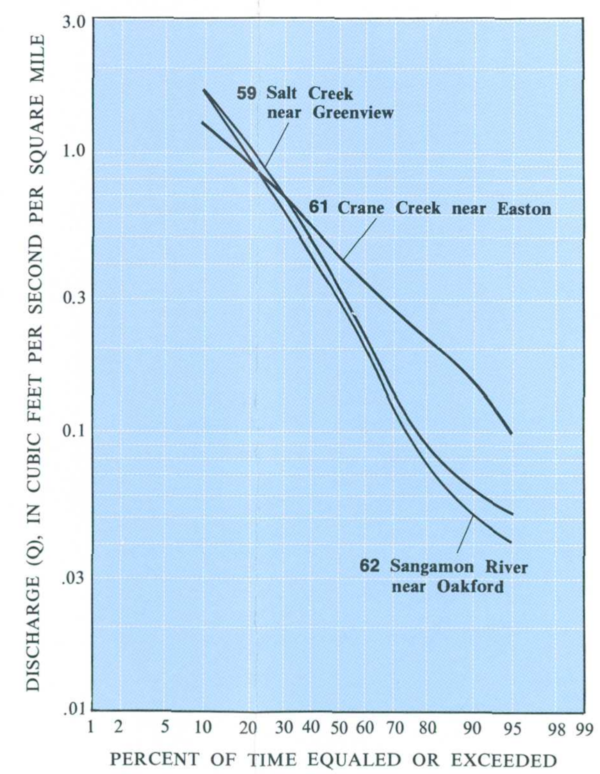
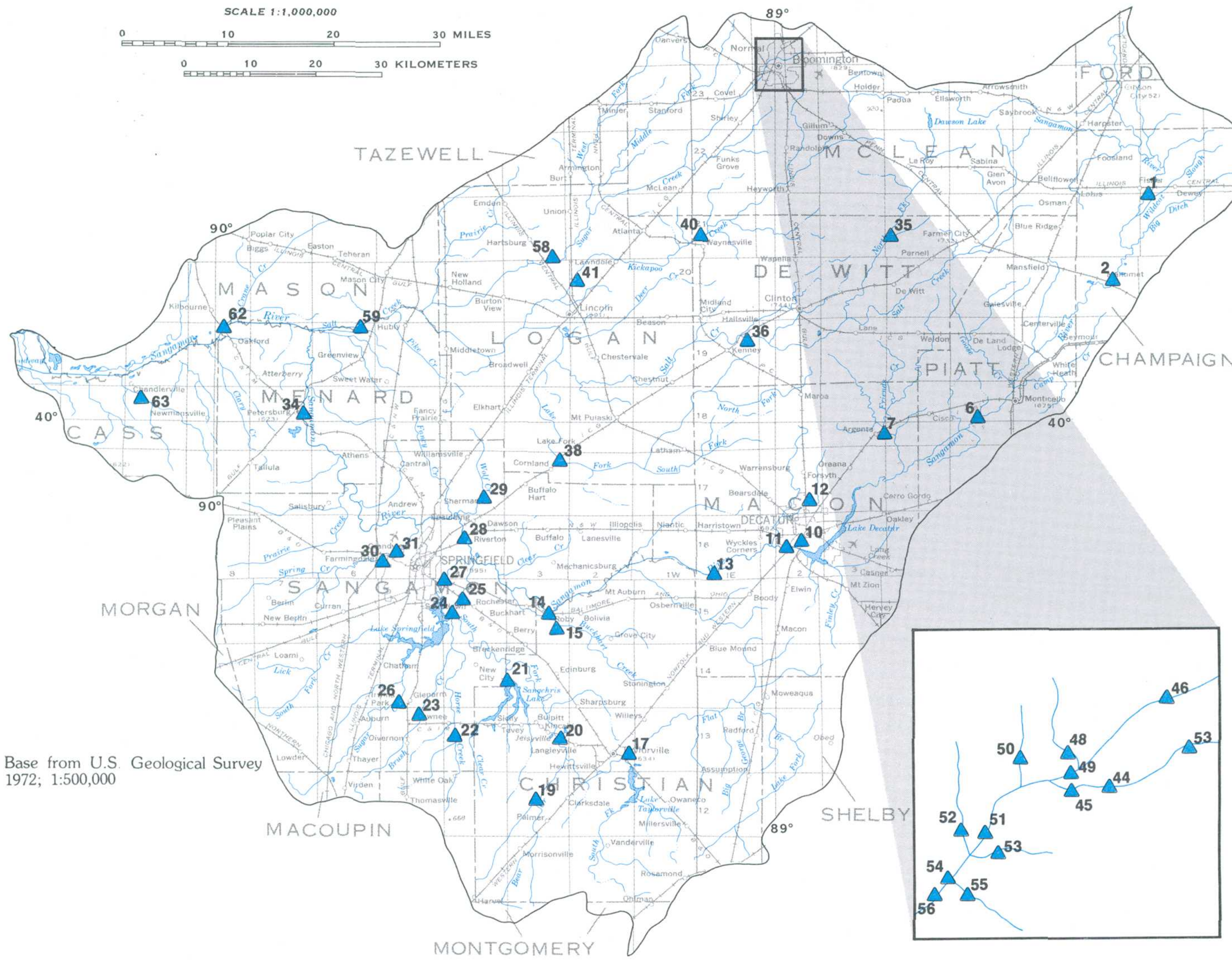


Figure 8.4-4 Flow duration in lower Sangamon River basin.

Water-Quality Data Available for Sites Throughout Area

Chemical and physical water-quality data were collected by the U.S. Geological Survey, Illinois Environmental Protection Agency, and the Bloomington-Normal Sanitary District at 47 sites throughout the study area.

Specific conductance, pH, alkalinity, sulfate, iron, and manganese data are important in assessing the water quality in areas affected by coal mining. The Illinois Environmental Protection Agency collects monthly water-quality samples at 25 sites in Area 28 as part of a statewide ambient water-quality-monitoring network. Synoptic water-quality sampling was done at 24 of the 25 sites plus 9 U.S. Geological Survey sites. Synoptic sampling is collecting samples from various locations within a short period of time. Each of four sets of synoptic samples was collected by the U.S. Geological Survey within a period of 3 days to insure similar streamflow conditions at all sites for each set. The Bloomington-Normal Sanitary District collected samples periodically from 13 sites in and near their cities. Data from four of these sites are used in this report. The water-quality samples from 47 sites (fig. 9.1-1) provide chemical and physical data along with suspended-sediment data for this report. The periods of water-quality record can be found in section 13.0.



EXPLANATION

▲[2] **Water-quality site and number**

See section 14.0 for site description

Figure 9.1-1 Location of water-quality sites (see section 14.0 for station names).

Specific Conductance can be Used to Estimate Dissolved-Solids Concentrations

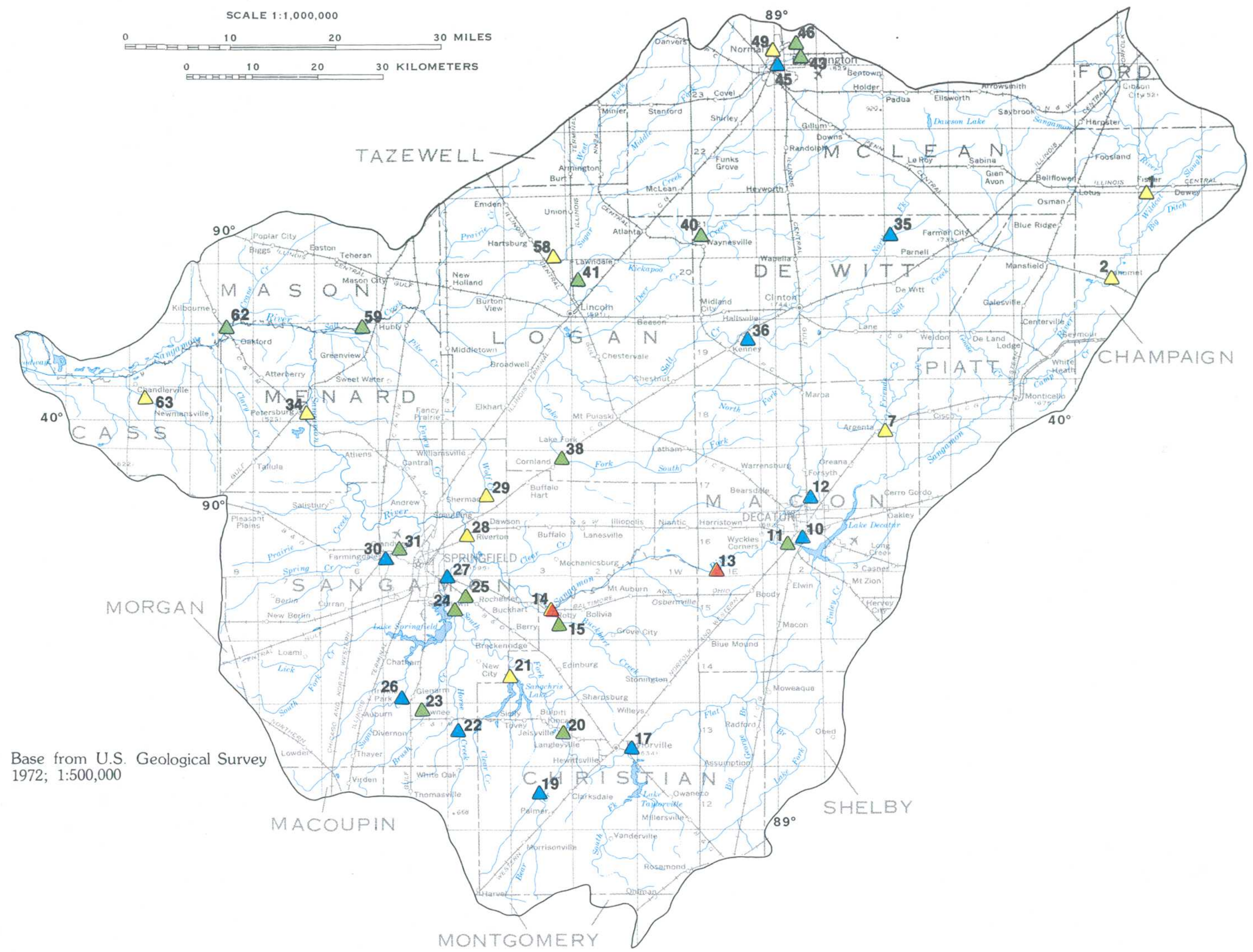
Specific conductance and dissolved-solids concentrations varied inversely with water discharge.

Electrical conductance is a measure of the ability of a substance to conduct electrical current. Specific electrical conductance, or simply specific conductance, is defined as "the reciprocal of the resistance in ohms, measured between opposite faces of a centimeter cube of an aqueous solution at a specific temperature" (Hem, 1970). In this report, the unit of measurement for specific conductance is the micromho per centimeter at 25° Celsius (μmho). Ranges of average values for 37 sites are indicated in figures 9.2-1 and 9.2-2.

Dissolved solids is a measure of the concentration of dissolved minerals expressed in milligrams per liter of water. Because most dissolved solids are present as ions in natural waters, specific conductance gives an indication of the concentration of dissolved solids.

The relation between specific conductance and dissolved solids at 34 sites is nearly linear as shown in figure 9.2-3. Dissolved-solid concentrations (S) can be estimated from specific conductance (K) with the equation $KA = S$. The factor (A) is 0.60 for the study area. For natural streams, A generally ranges from 0.55 to 0.75 with higher values of A being commonly associated with water containing higher concentrations of sulfate (Hem, 1970).

Measured values of specific conductance ranged from 50 to 5,100 μmhos (table 9.2-1). Maximum measured dissolved-solids concentration was 3,260 milligrams per liter (table 9.2-2). The higher dissolved-solids concentrations occur during low-flow periods when ground-water discharge is the principle component of streamflow. In general, lower concentrations occur in the spring due to the increased runoff from snowmelt and spring rains which tend to dilute the ground-water inflows.



EXPLANATION

Average values for specific conductance at each site, in micromhos per centimeter at 25° Celsius

- Less than 550
- 550-700
- 701-850
- Greater than 850
- Site location and number

See section 14.0 for site description

Figure 9.2-1 Average values of specific conductance measured at water-quality sites.

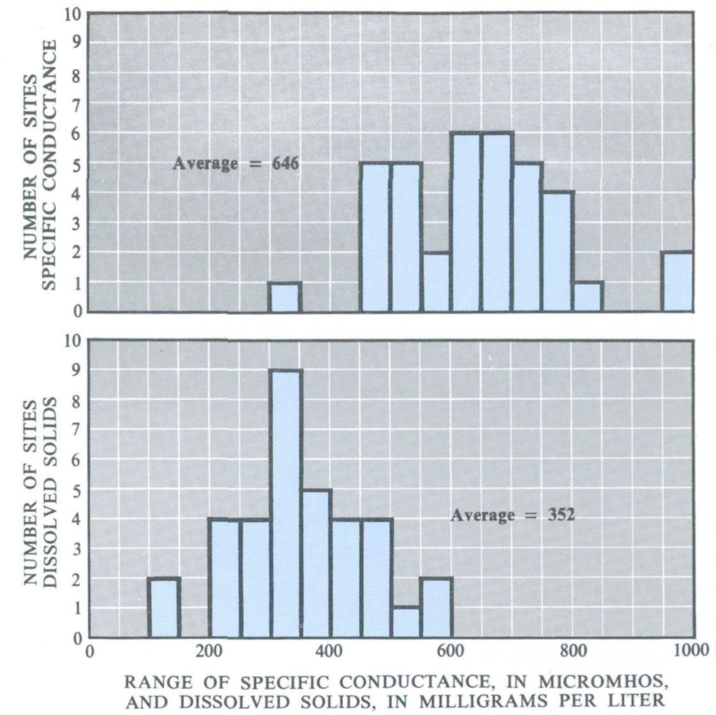


Figure 9.2-2 Range and frequency distribution of average values of specific conductance and dissolved solids for water-quality sites.

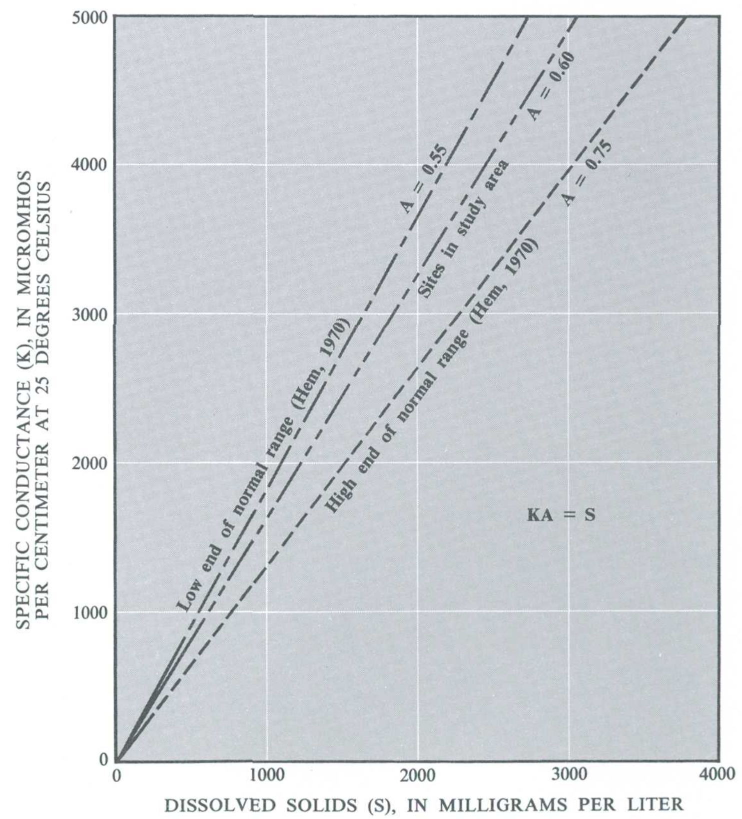


Figure 9.2-3 Relation between specific conductance and dissolved solids.

Table 9.2-1 Specific conductance values measured in the area.

Map site number	Number of observations	Specific conductance (µmho/cm at 25°C) Minimum	Average	Maximum
1	36	380	750	3,600
2	11	600	714	810
7	1	730	730	730
10	29	300	522	625
11	56	380	588	990
12	32	75	314	730
13	70	320	993	2,580
14	56	330	976	2,340
15	1	693	693	693
17	37	50	539	920
19	6	345	486	661
20	53	90	638	1,120
21	27	555	751	1,060
22	2	510	514	519
23	4	445	609	717
24	6	245	595	873
25	47	180	640	1,350
26	7	100	495	640
27	33	295	511	750
28	49	340	777	1,650
29	1	739	739	739
30	6	325	497	667
31	32	200	604	1,390
34	51	300	780	1,380
35	1	454	454	454
36	51	290	548	835
38	54	184	680	950
40	48	350	655	800
41	43	215	618	790
43	2	520	660	800
45	185	76	460	2,530
46	2	380	680	980
49	161	100	721	5,100
58	54	225	731	1,060
59	53	155	651	835
62	64	280	645	1,120
63	1	807	807	807

Table 9.2-2 Dissolved solids, residue at 180° C measured in the area.

Map site number	Number of observations	Dissolved solids (mg/L) Minimum	Average	Maximum
1	3	238	349	447
2	0	---	---	---
7	1	451	451	451
10	1	245	245	245
11	1	287	287	287
12	0	---	---	---
13	1	392	392	392
14	1	411	411	411
15	1	419	419	419
17	3	293	332	398
19	4	264	312	394
20	2	2	130	259
21	1	578	578	578
22	2	315	327	340
23	4	280	370	432
24	3	201	391	537
25	1	216	216	216
26	4	248	319	392
27	1	206	206	206
28	1	275	275	275
29	1	454	454	454
30	4	216	309	396
31	2	2	213	424
34	2	2	146	290
35	1	261	261	261
36	3	313	346	407
38	3	404	454	532
40	2	271	334	396
41	1	416	416	416
43	2	252	295	338
45	123	88	325	2,050
46	2	376	542	708
49	81	60	559	3,260
58	3	392	442	527
59	1	371	371	371
62	53	0	376	565
63	1	457	457	457

Values for pH are Usually in the Near-Neutral Range

The pH values of area streams indicate the presence of carbonates in rocks and surficial deposits.

The activity of hydrogen ions involved in reactions with dissolved constituents is indicated by the pH of a solution. Mathematically, pH is defined as the negative logarithm to base 10 of the hydrogen-ion activity in moles per liter.

The pH values of the study area streams ranged from 6.5 to 9.5 (table 9.3-1 and figs. 9.3-1 and 9.3-2). This range is somewhat larger than the range given by Hem (1970) of 6.5 to 8.5 for "river water in areas not influenced by pollution." A pH of 6.9 or less was observed in more than one sample at only 6 of 37 sites. Waters from most streams in the study area have pH values higher than 7.0 (neutral) and are therefore considered basic. The presence of carbonate rock throughout the area probably is responsible for the above-neutral pH values although the higher values also could be a result of photosynthesis.

The recommended range for the pH of domestic water supplies is 5.0 to 9.0 (U.S. Environmental Protection Agency, 1976, p. 178). This rather wide range is considered acceptable because pH is relatively easy to adjust during water treatment. A pH within the range of 6.5 to 9.0 is recommended to provide adequate protection for survival of freshwater aquatic life. Outside of this range, aquatic animal life may suffer adverse physiological effects.

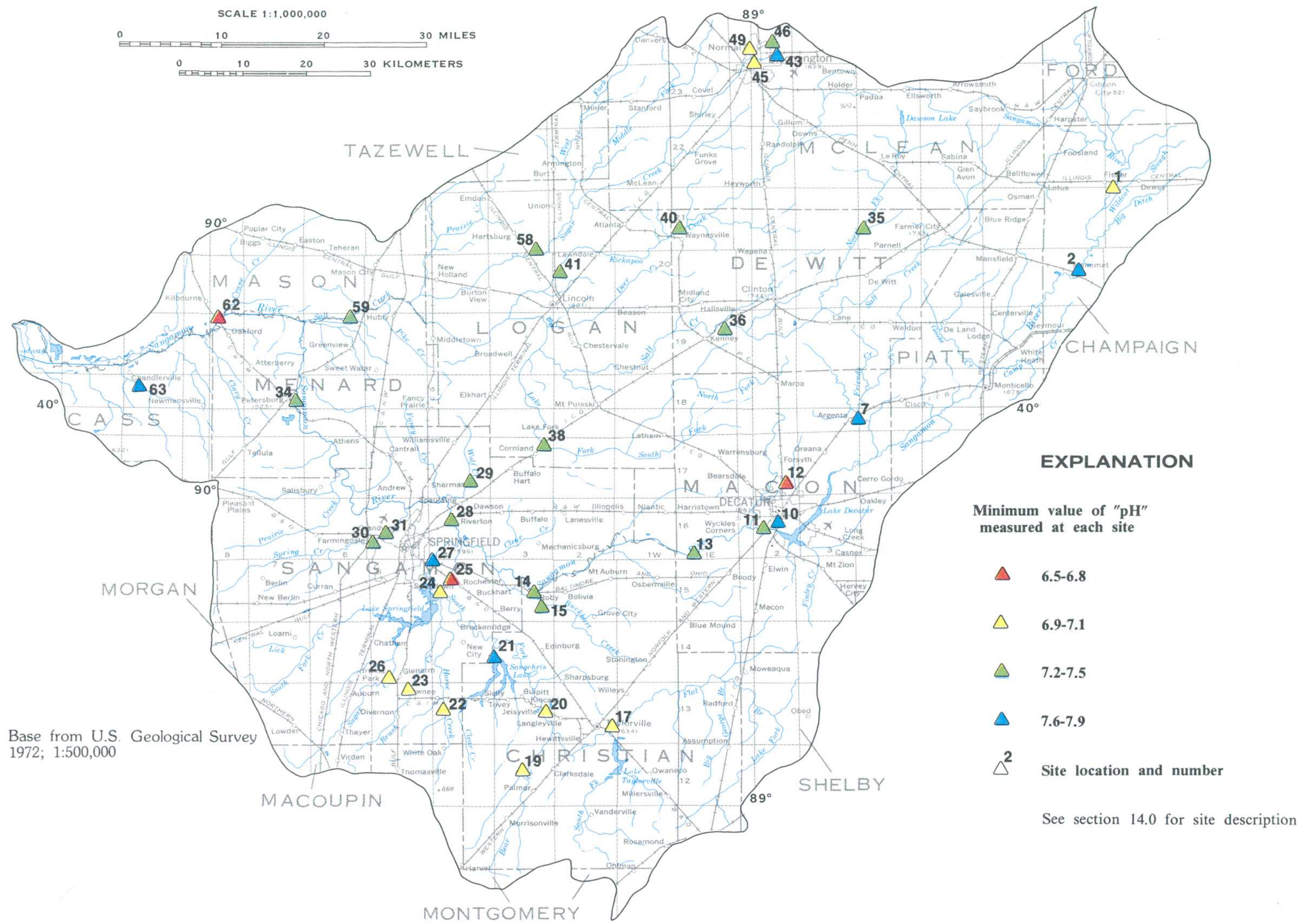


Figure 9.3-1 Minimum values of pH measured at water-quality sites.

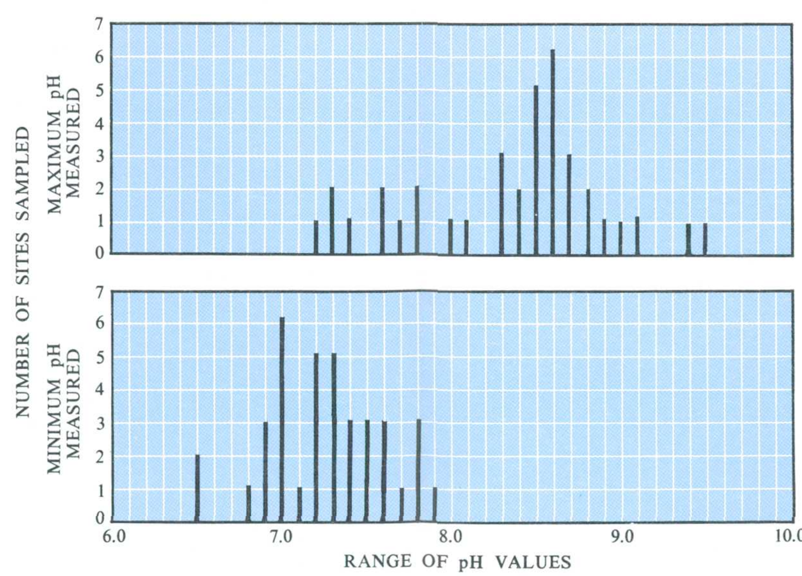


Figure 9.3-2 Range and distribution of maximum and minimum values of pH at water-quality sites.

Table 9.3-1 Maximum and minimum pH values measured in the area.

Map site number	Number of observations	pH values Minimum	pH values Maximum
1	31	6.9	8.5
2	11	7.8	8.5
7	1	7.6	7.6
10	27	7.8	8.8
11	53	7.4	8.6
12	32	6.5	7.7
13	66	7.4	8.5
14	55	7.2	8.9
15	1	7.3	7.3
17	36	7.0	8.5
19	6	7.0	7.6
20	52	6.9	8.1
21	27	7.6	8.4
22	2	6.9	7.3
23	4	7.1	8.0
24	6	7.0	8.3
25	46	6.8	8.7
26	7	7.0	8.3
27	33	7.6	8.6
28	47	7.3	8.5
29	1	7.4	7.4
30	6	7.5	7.8
31	32	7.2	8.3
34	51	7.2	9.0
35	1	7.2	7.2
36	45	7.3	8.8
38	53	7.3	8.7
40	43	7.2	8.6
41	41	7.3	8.6
43	2	7.9	8.4
45	187	7.0	8.6
46	2	7.7	9.4
49	167	7.0	9.5
58	53	7.5	8.7
59	50	7.5	8.6
62	60	6.5	9.1
63	1	7.8	7.8

Concentrations of Iron Vary Widely

Iron, an element essential to plants and animals, is commonly associated with coal in the Pennsylvanian System.

Iron is a common constituent of the surface and ground waters of the study area. It is commonly associated with coal of the Pennsylvanian System in the ferrous form (Fe^{+2}). This soluble form of iron is easily changed to the relatively insoluble ferric form (Fe^{+3}) when it enters an oxidizing system (exposure to air). The dissolution of iron is dependent upon, and inversely related to, pH. Therefore, in streams it can occur as dissolved iron (in solution), precipitated iron (found in bed material), or suspended iron (moving in suspension). Total recoverable iron in this report refers to the dissolved plus the suspended concentrations. Surface mining can increase the amount of iron available to waters downstream by exposing more iron-bearing minerals to weathering.

The average concentrations of total recoverable iron at sites in the area ranged from 441 to 9,700 micrograms per liter (μg/L) (table 9.4-1). The average total recoverable iron concentrations at area sites are shown by ranges in figure 9.4-1.

Average dissolved iron concentrations at area sites ranged from 6 to 1,380 μg/L (table 9.4-2). The average dissolved iron concentrations at area sites are shown by ranges in figure 9.4-2.

The range and distribution of the average values of total and dissolved iron concentrations for sites in the area are shown in figure 9.4-3. The average concentration based on all sampling sites is 126 μg/L for dissolved iron and 2,410 μg/L for total recoverable iron.

Concentrations of dissolved iron in surface waters seldom reach 1,000 μg/L (American Public Health Association, 1976, p. 207). Concentrations were generally below this level in the study area. However, four sites had maximum concentrations that exceeded the 1,000 μg/L level.

Iron is an essential element to plants and animals. It is vital to the oxygen transport mechanism in the blood of all vertebrate animals, and its absence in plants can be a limiting growth factor. However, a maximum limit of 300 μg/L has been recommended by the U.S. Environmental Protection Agency (1976, p. 79) to prevent staining and objectionable tastes in domestic water supplies. The limit for iron is based on aesthetic rather than toxicological considerations. Total recoverable concentrations of iron commonly exceeded 300 μg/L, whereas only two sites had average concentrations of dissolved iron in excess of the recommended limit.

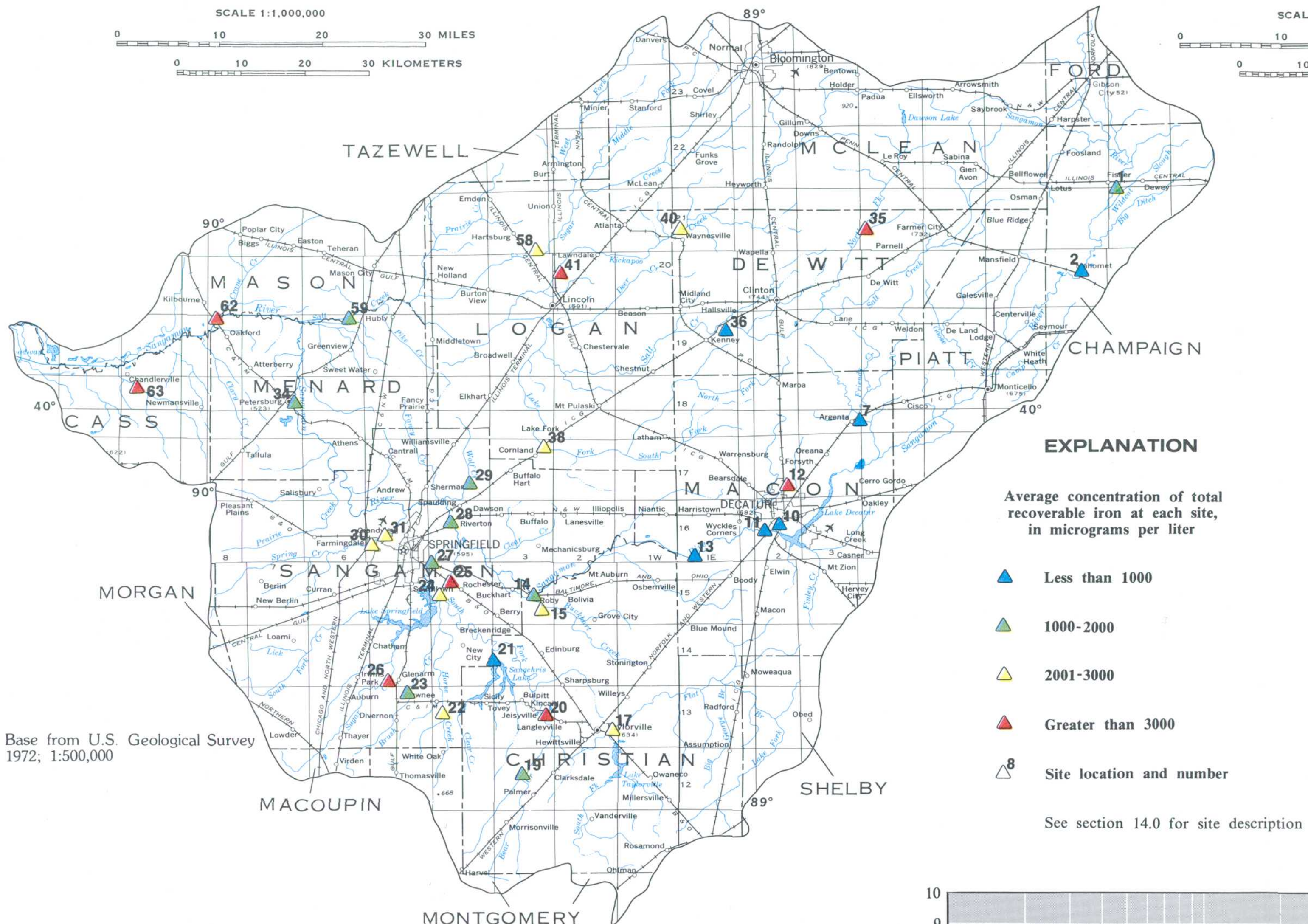


Figure 9.4-1 Average values of total recoverable iron at water-quality sites.

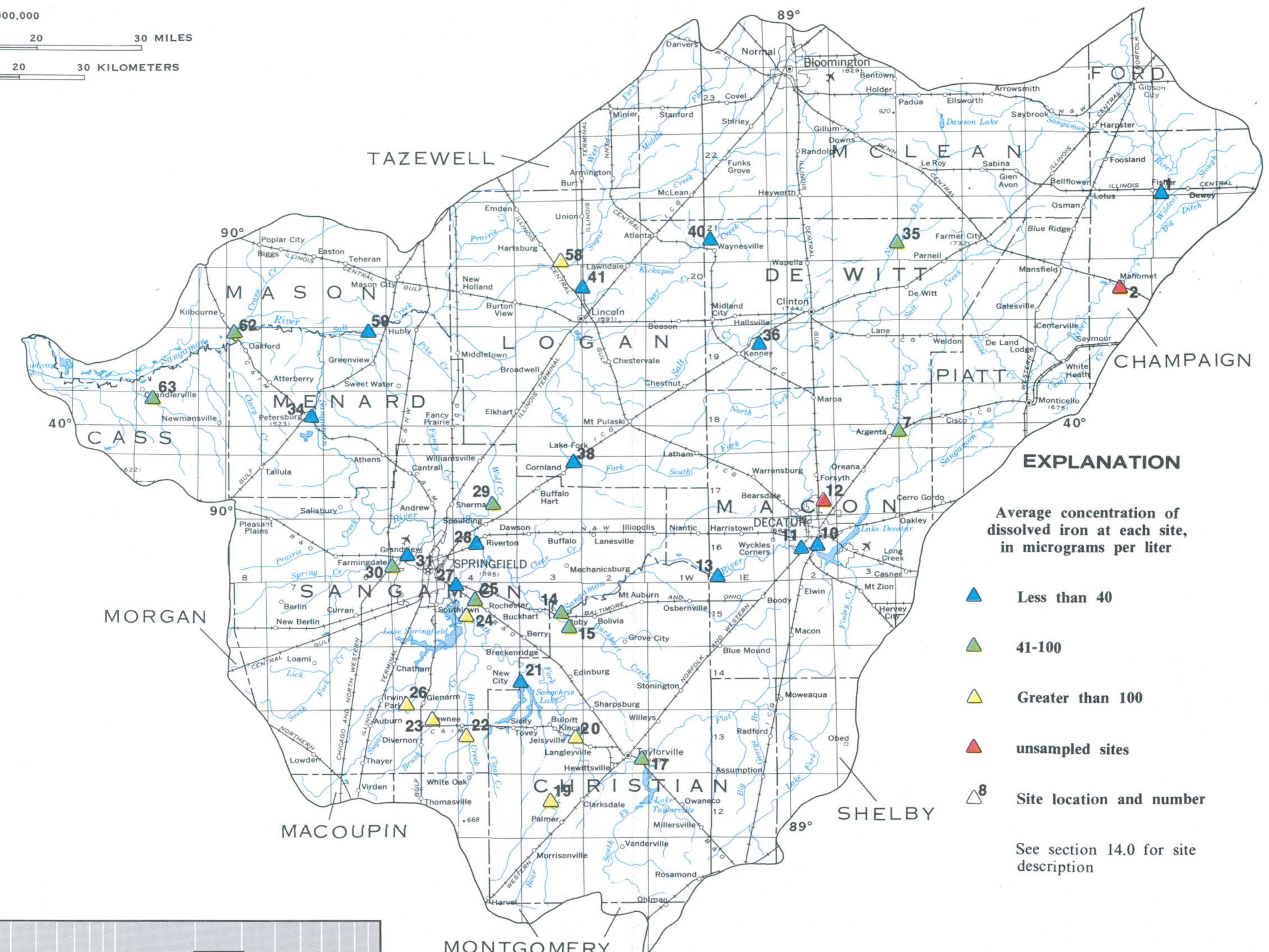


Figure 9.4-2 Average values of dissolved iron at water-quality sites.

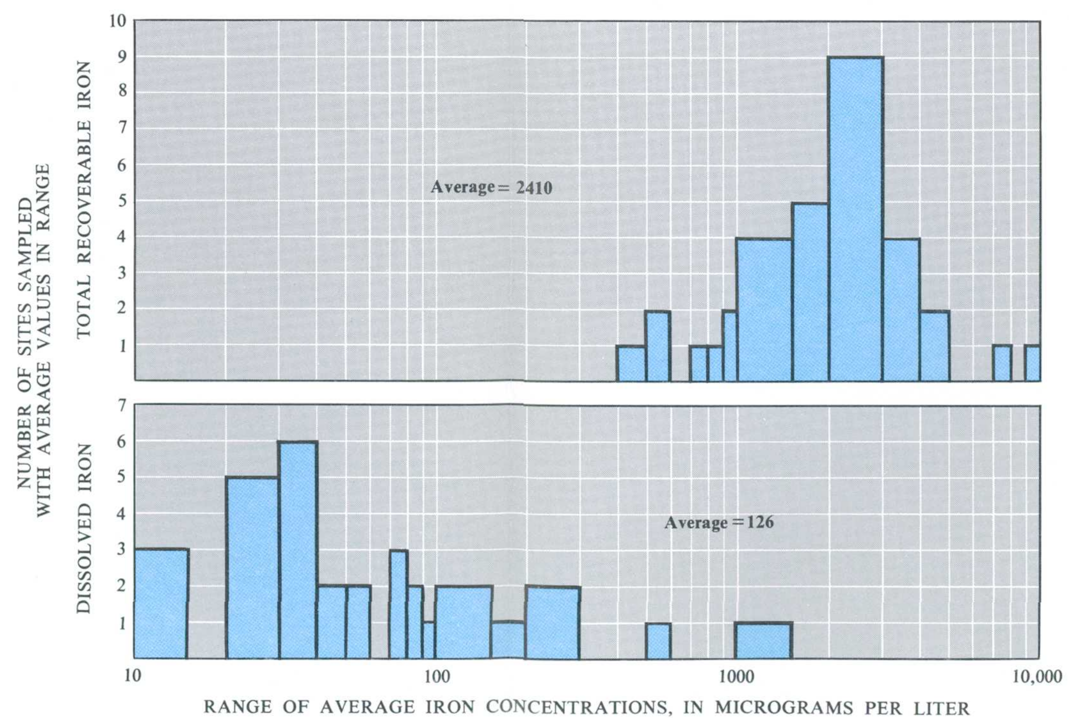


Figure 9.4-3 Range and distribution of average values of total recoverable and dissolved iron concentrations measured at water-quality sites.

Table 9.4-1 Total recoverable iron concentrations measured in the area.

Map site number	Number of observations	Iron, total recoverable (µg/L) Minimum	Average	Maximum
1	36	90	1,210	8,600
2	4	300	575	1,200
7	1	900	900	900
10	29	60	590	1,620
11	58	200	781	3,430
12	32	400	3,350	9,700
13	70	200	907	3,500
14	60	130	1,090	7,800
15	1	2,600	2,600	2,600
17	32	360	2,200	6,300
19	6	590	1,650	2,600
20	51	720	7,880	29,000
21	27	80	441	1,900
22	2	2,200	2,300	2,400
23	4	650	1,210	2,200
24	6	800	2,730	9,300
25	45	650	3,160	19,000
26	7	610	4,070	16,000
27	26	390	1,140	4,600
28	49	360	1,960	7,800
29	1	1,500	1,500	1,500
30	6	390	2,290	8,700
31	27	240	2,350	9,250
34	51	330	1,710	9,700
35	1	9,700	9,700	9,700
36	48	130	838	3,300
38	53	200	2,040	28,200
40	42	140	2,470	16,400
41	44	230	3,080	32,000
58	53	190	2,050	20,800
59	51	230	1,960	10,100
62	64	40	3,820	29,000
63	1	4,900	4,900	4,900

Table 9.4-2 Dissolved iron concentrations measured in the area.

Map site number	Number of observations	Iron, dissolved (µg/L) Minimum	Average	Maximum
1	3	10	39	98
2	0	---	---	---
7	1	47	47	47
10	2	5	14	24
11	3	5	36	60
12	0	---	---	---
13	2	16	23	30
14	4	5	52	100
15	1	70	70	70
17	5	5	86	300
19	6	25	255	1,200
20	4	38	1,380	3,000
21	4	3	6	10
22	2	65	242	420
23	4	37	111	250
24	6	20	198	530
25	6	10	71	230
26	7	30	116	280
27	6	5	26	70
28	2	12	31	50
29	1	76	76	76
30	6	23	83	170
31	3	5	27	64
34	2	5	14	22
35	1	50	50	50
36	6	5	20	40
38	3	5	33	53
40	3	5	35	89
41	6	5	34	140
58	9	5	510	4,260
59	4	17	28	50
62	44	5	91	1,800
63	1	45	45	45

Concentrations of Manganese Often Exceed Recommended Limits

Measured concentrations of manganese were commonly in excess of the U.S. Environmental Protection Agency recommended limit for domestic water supply.

Manganese is an element widely distributed in igneous rocks and soils, but its total abundance in the Earth's crust is small enough to consider it a minor element. Manganese and iron are chemically similar. However, because manganese has a lower affinity for oxygen, it stays in solution longer than does iron (Rankama and Sahama, 1950).

Average concentrations of total recoverable and dissolved manganese for each of 33 water-quality sites are shown in figures 9.5-1 and 9.5-2, respectively. Average concentrations of total recoverable manganese at area sites ranged from 40 to 814 micrograms per liter (μg/L) with the average for all sites being 280 μg/L (table 9.5-1 and fig. 9.5-3). Average dissolved manganese concentrations in the area ranged from 5 to 710 μg/L, with the average for all sites being 180 μg/L (table 9.5-2 and fig. 9.5-3).

Manganese is both vital for plants and animals (U.S. Environmental Protection Agency, 1976, p. 95). Inadequite amounts can inhibit plant growth or adversely affect animal reproduction. A maximum allowable concentration of less than 50 μg/L is recommended for domestic water supplies to prevent staining of laundry and objectionable tastes (U.S. Environmental Protection Agency, 1976, p. 96). Average concentrations of both total recoverable and dissolved manganese in the study area commonly exceeded 50 μg/L.

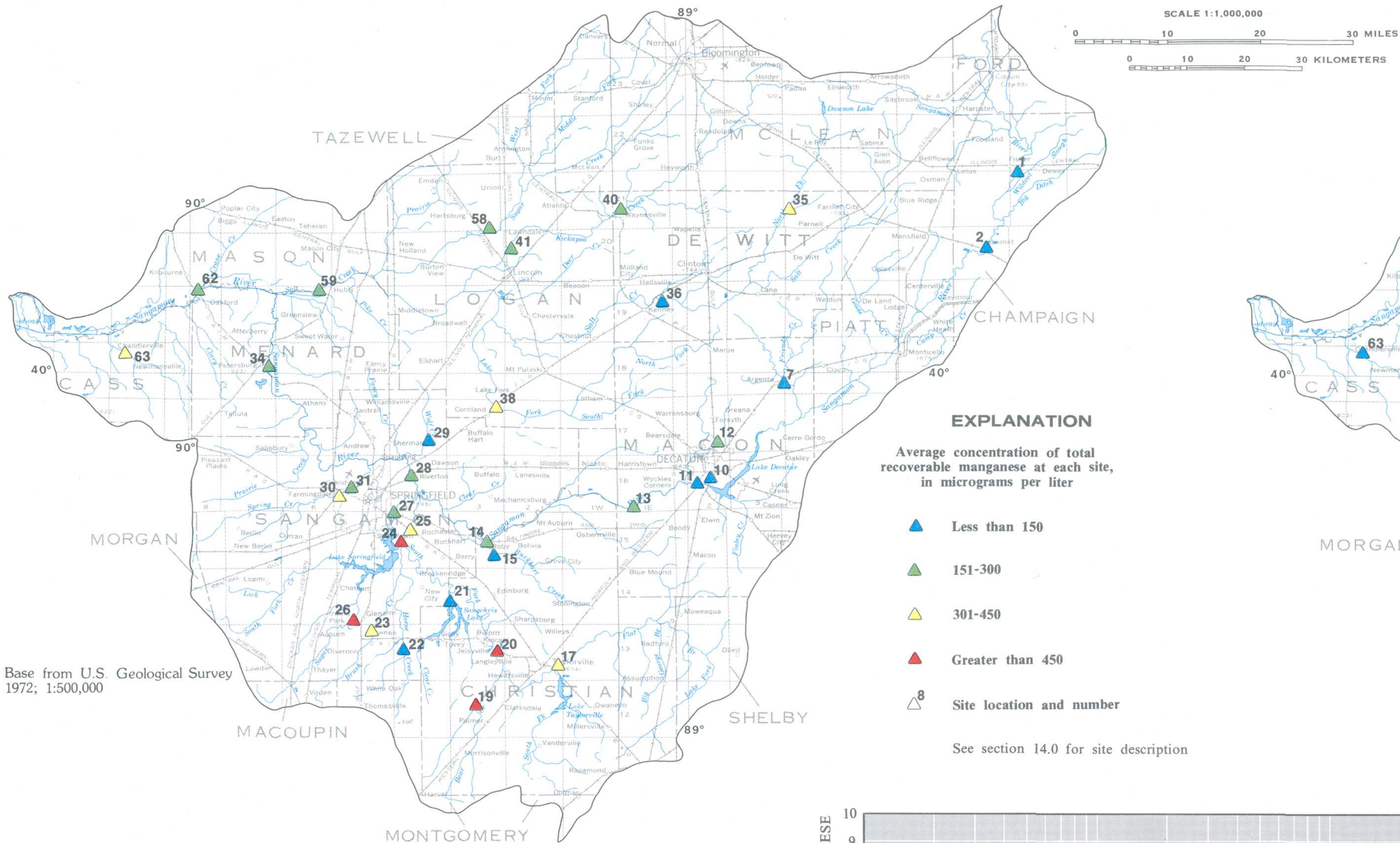


Figure 9.5-1 Average values of total recoverable manganese at water-quality sites.

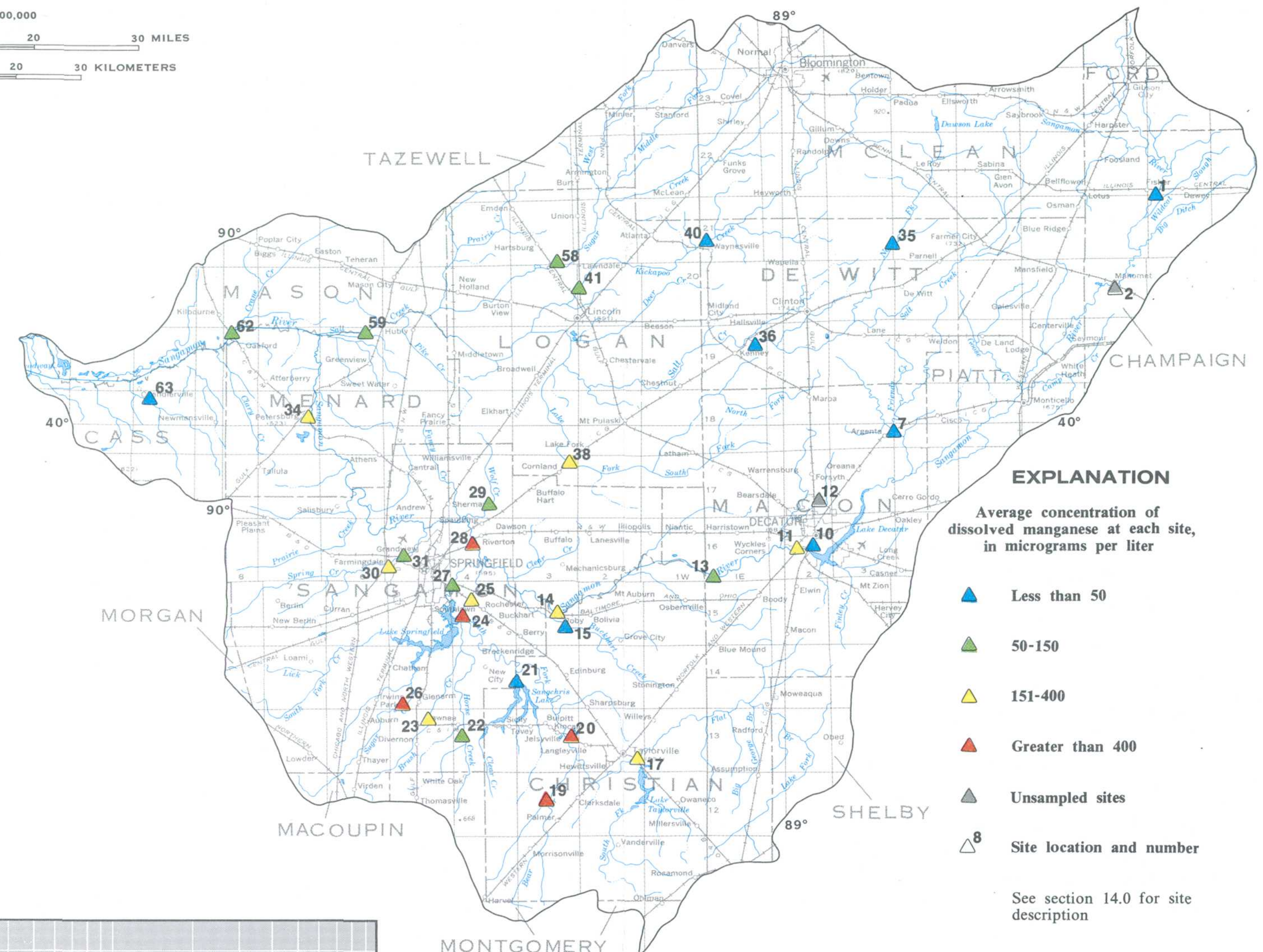


Figure 9.5-2 Average values of dissolved manganese at water-quality sites.

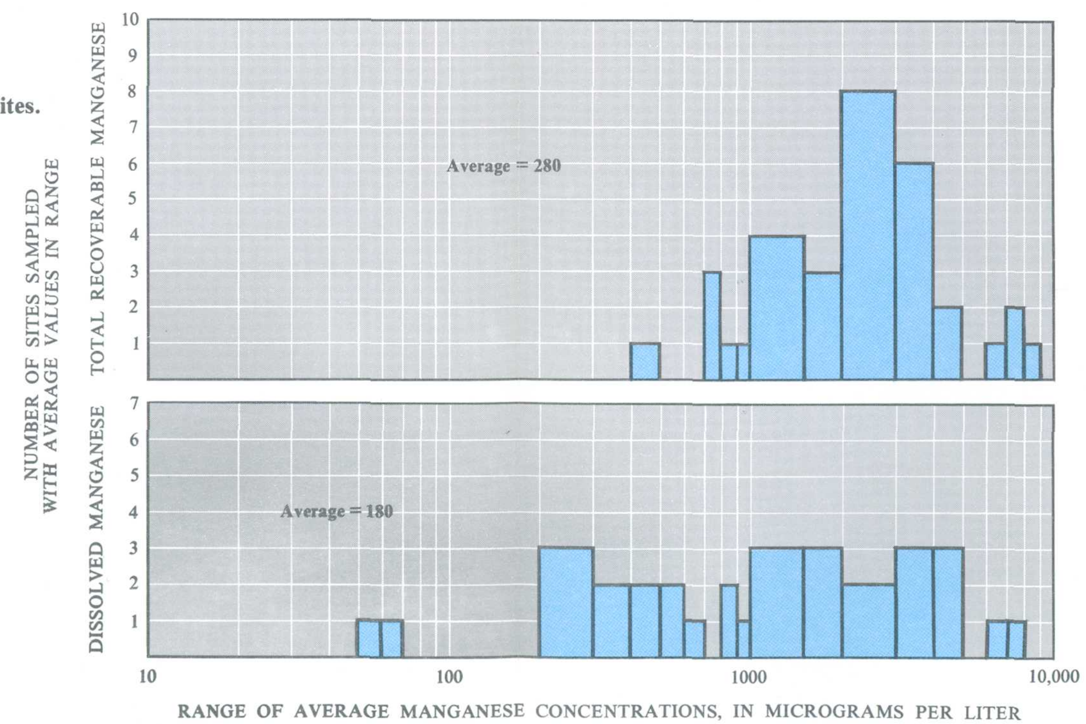


Figure 9.5-3 Range and distribution of average values of total recoverable and dissolved manganese concentrations measured at water-quality sites.

Table 9.5-1 Total recoverable manganese concentrations measured in the area.

Map site number	Number of observations	Manganese, total recoverable (µg/L)		
		Minimum	Average	Maximum
1	21	0	85	240
2	4	60	72	80
7	1	40	40	40
10	27	16	76	200
11	41	14	129	420
12	32	70	170	310
13	70	43	165	640
14	60	12	279	1,200
15	1	130	130	130
17	32	70	382	1,900
19	6	90	737	2,600
20	50	110	663	2,500
21	26	30	72	230
22	1	130	130	130
23	4	140	340	720
24	6	320	731	1,300
25	45	100	401	1,100
26	7	160	814	2,100
27	24	56	204	480
28	49	90	300	990
29	1	90	90	90
30	6	90	376	750
31	23	40	220	920
34	51	70	257	580
35	1	450	450	450
36	29	36	123	260
38	33	69	368	1,600
40	27	60	229	900
41	44	50	220	1,000
58	32	40	184	634
59	29	60	204	640
62	62	40	258	660
63	1	330	330	330

Table 9.5-2 Dissolved manganese concentrations measured in the area.

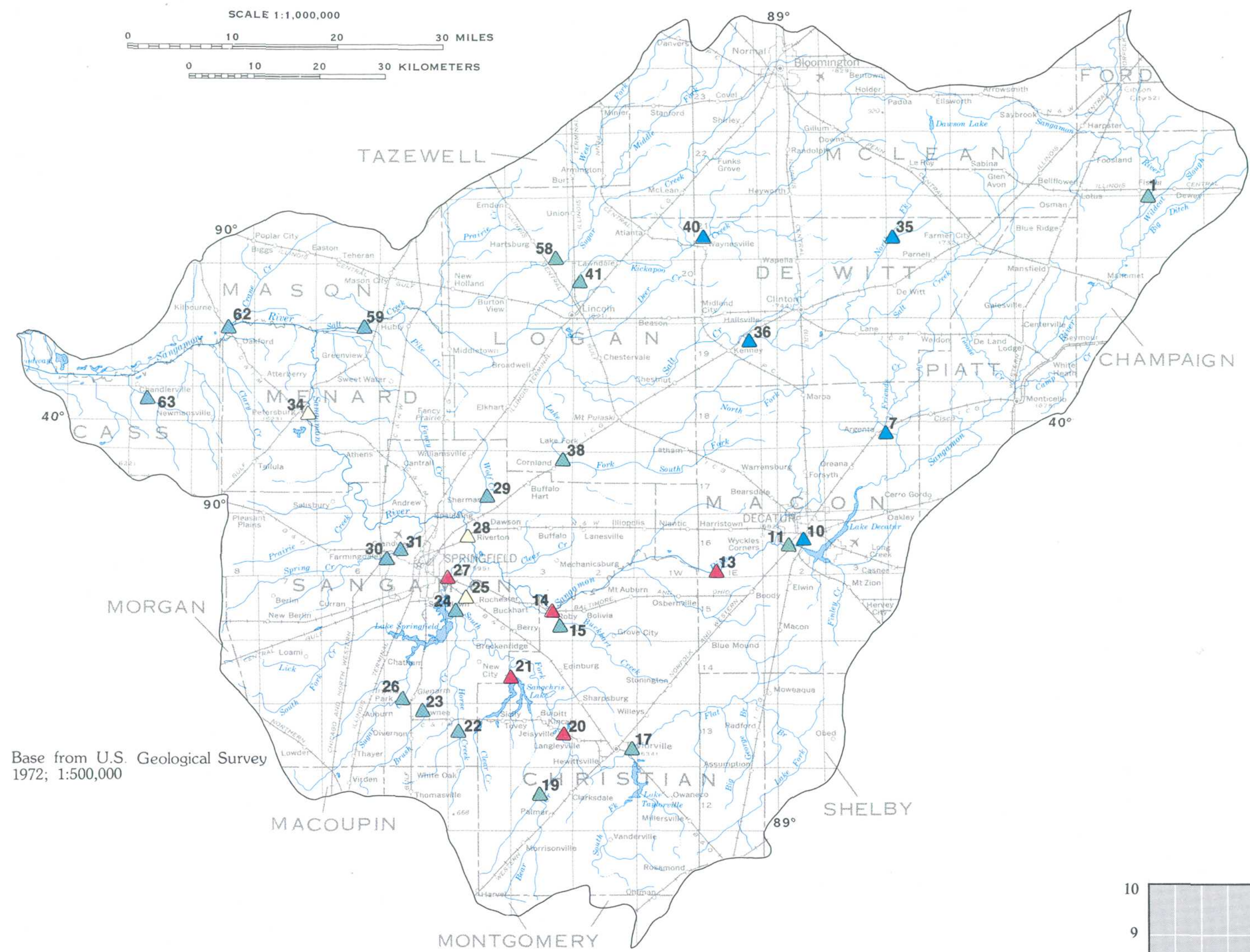
Map site number	Number of observations	Manganese, dissolved (µg/L)		
		Minimum	Average	Maximum
1	3	17	46	70
2	0			
7	1	25	25	25
10	2	5	5	5
11	3	5	242	410
12	0			
13	2	5	128	250
14	4	5	311	690
15	1	43	43	43
17	5	24	321	980
19	6	55	710	2600
20	4	35	432	800
21	4	5	6	8
22	1	85	85	85
23	4	120	305	680
24	6	50	407	1,300
25	6	31	185	290
26	7	40	634	2,100
27	6	10	116	450
28	2	5	488	970
29	1	57	57	57
30	6	30	203	700
31	3	57	84	120
34	2	5	152	300
35	1	35	35	35
36	6	5	28	62
38	3	26	167	440
40	3	10	26	50
41	6	1	59	170
58	9	5	63	160
59	4	18	112	230
62	44	4	90	630
63	1	34	34	34

Sulfate Concentrations are Low to Moderate

Measured concentrations of sulfate seldom exceed the criterion established by the U.S. Environmental Protection Agency.

Metallic sulfides, mainly pyrite (FeS_2) and marcasite (FeS_2), are oxidized to yield sulfate ions. Both pyrite and marcasite are present in coal beds that underlie almost the entire study area. Crystals of pyrite are also commonly found in black shale and bituminous sandstones (Krauskopf, 1967). Sulfate in water can be used as an indicator of acid mine drainage in mined areas (Toler, 1982). The measured concentrations of sulfate in Area 28 ranged from 6 to 270 milligrams per liter (mg/L) with an average of 64 mg/L for all sites. The areal distribution of average sulfate concentrations among sites is shown in figure 9.6-1. The average sulfate concentrations ranged from 27 to 170 mg/L (table 9.6-1 and fig. 9.6-2).

Concentrations of sulfate in excess of 250 mg/L can cause physiological problems, undesirable tastes, and can raise the costs of water treatment (U.S. Environmental Protection Agency, 1976, p. 205). None of the water-quality-sampling sites had average sulfate concentrations in excess of this limit.



EXPLANATION

Average concentration of sulfate at each site, in milligrams per liter

- Less than 45
- 46-65
- 66-85
- Greater than 85
- Site location and number (19)

See section 14.0 for site description

Figure 9.6-1 Average sulfate concentrations measured at water-quality sites.

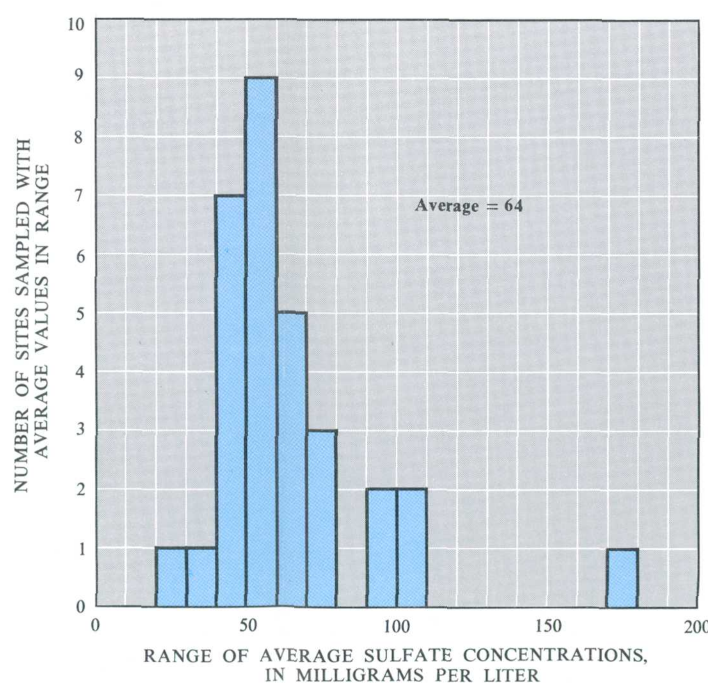


Figure 9.6-2 Range and distribution of average values of sulfate measured at water-quality sites in the study area.

Table 9.6-1 Sulfate concentrations measured in the area.

Map site number	Number of observations	Sulfate concentrations (mg/L) Minimum	Average	Maximum
1	3	27	60	110
2	0	---	---	---
7	1	44	44	44
10	29	29	44	70
11	56	25	55	120
12	0	---	---	---
13	70	28	97	260
14	60	30	100	270
15	1	48	48	48
17	36	24	46	74
19	6	42	47	52
20	50	28	109	270
21	1	170	170	170
22	2	21	58	94
23	4	54	65	75
24	5	26	60	99
25	46	27	76	190
26	7	11	56	79
27	34	32	93	170
28	50	6	78	180
29	1	56	56	56
30	6	29	50	81
31	33	23	54	86
34	51	36	79	160
35	1	27	27	27
36	6	31	41	48
38	3	51	54	57
40	2	32	38	44
41	43	35	54	65
58	54	34	63	86
59	4	42	50	58
62	61	29	60	140
63	1	46	46	46

Alkalinity Concentrations Vary Widely

Alkalinity concentrations generally are large enough to buffer small acid inflows.

Alkalinity, the capacity of a solution to neutralize acid, can be caused by a variety of different solute species. In most natural waters, the alkalinity is produced mainly by carbonate and bicarbonate ions. Because differences occur in the proportions of constituents contributing to alkalinity, its concentrations are commonly reported as an equivalent amount of calcium carbonate ($CaCO_3$) in milligrams per liter (mg/L).

Measurements of alkalinity in 577 samples from Area 28 streams ranged from 9 to 385 mg/L as $CaCO_3$. The areal variation in average alkalinity concentrations at sites in the study area is shown in figure 9.7-1. The average alkalinity concentrations ranged from 90 to 280 mg/L as $CaCO_3$, with an average value of 182 mg/L as $CaCO_3$ for all of the sites (table 9.7-1 and fig. 9.7-2).

Alkalinity values of 20 mg/L as $CaCO_3$ or more are generally recommended for freshwater aquatic life. Values less than this leave the water susceptible to rapid changes in pH. Components of alkalinity, such as carbonate and bicarbonate, can chemically combine with toxic heavy metals and reduce their toxicity markedly (U.S. Environmental Protection Agency, 1976, p. 7). Streams within the study area generally had alkalinities capable of maintaining a sufficient buffering capacity against small volumes of acid inflow.

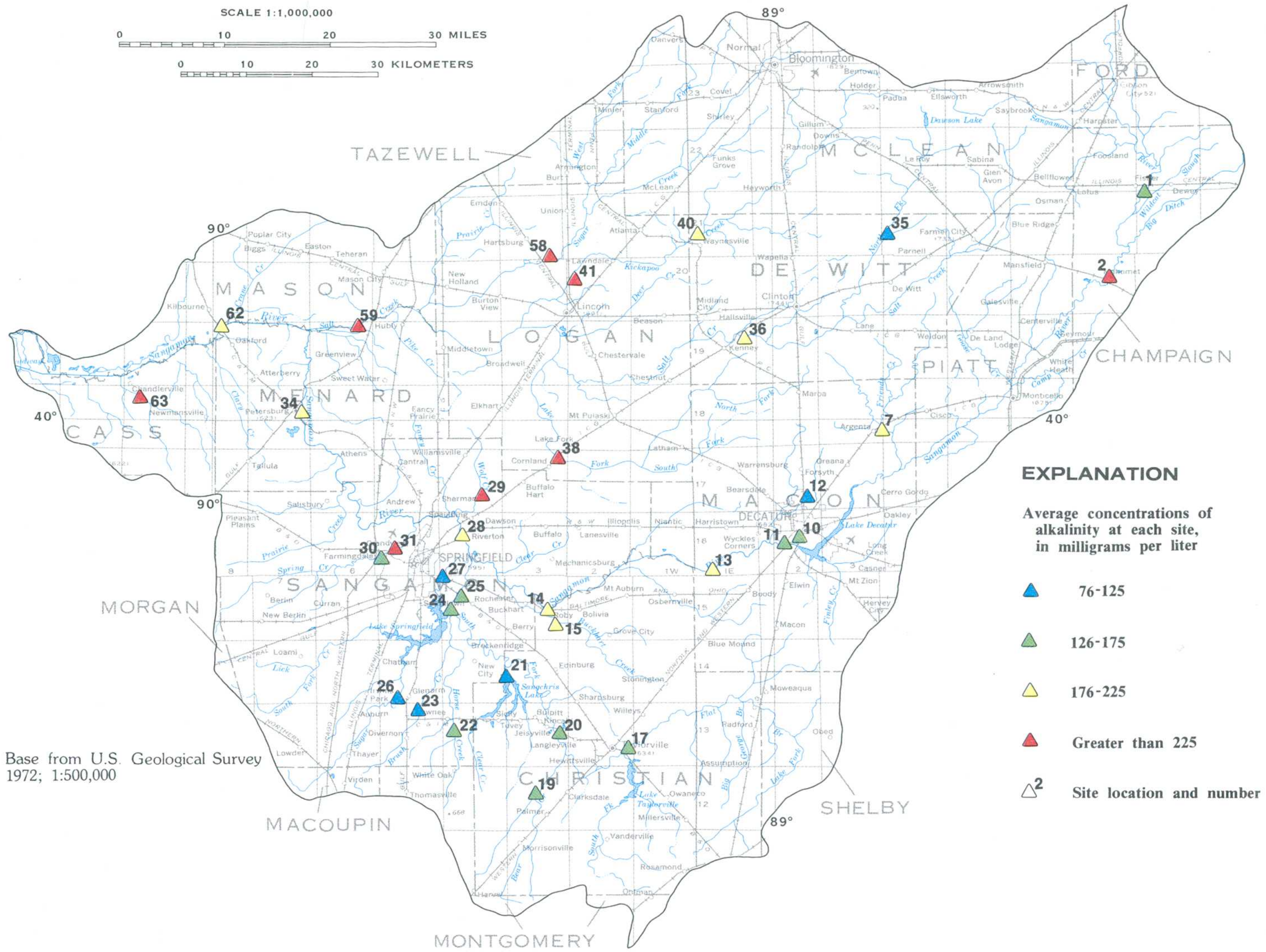


Figure 9.7-1 Average values of alkalinity measured at water-quality sites.

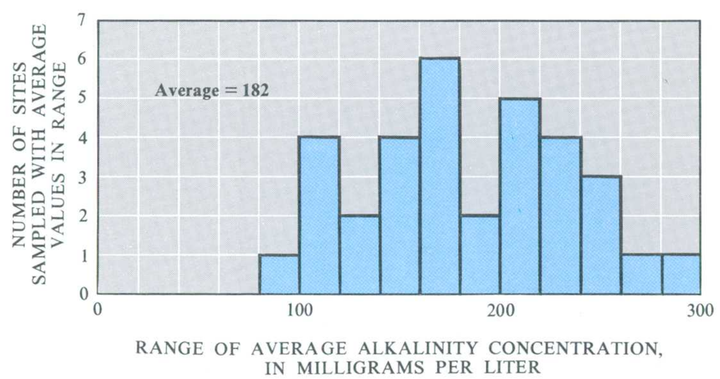


Figure 9.7-2 Range and distribution of average values of alkalinity measured at water-quality sites in the study area.

Table 9.7-1 Alkalinity concentrations measured in the area.

Map site number	Number of observations	Alkalinity as $CaCO_3$ (mg/L)		
		Minimum	Average	Maximum
1	3	81	175	240
2	4	205	232	262
7	1	220	220	220
10	4	143	164	190
11	25	91	170	274
12	32	23	108	270
13	66	42	204	319
14	58	50	210	298
15	1	180	180	180
17	28	10	170	316
19	6	93	147	210
20	53	9	136	285
21	2	89	90	90
22	2	94	147	200
23	4	57	123	200
24	5	67	143	210
25	47	23	152	342
26	7	21	113	200
27	3	96	102	110
28	46	65	176	284
29	1	240	240	240
30	6	87	170	250
31	1	241	241	241
34	51	52	188	385
35	1	110	110	110
36	8	147	202	250
38	6	180	270	358
40	4	160	217	245
41	38	102	230	363
58	13	79	238	305
59	9	178	250	294
62	47	84	212	298
63	1	280	280	280

Concentrations of Trace Elements are Variable

Concentrations of many trace elements and other constituents are dependent on their availability and the pH of surface water.

Trace elements and other constituents commonly occur in most streams. Major sources of these elements include soils, geologic strata underlying the basin, and atmospheric fallout.

Average concentrations of dissolved trace elements and other constituents in Area 28 generally are small due to the near-neutral pH values of streams in the study area, however, concentration ranges generally are large (table 9.8-1). At lower pH values (acidic waters), many minerals are more soluable and concentrations of trace elements are often higher.

In low concentrations, most trace elements are essential to life. However, in high concentrations, the same elements may be toxic to man, plants, or animals. Although high concentrations of trace elements can occur naturally, most high concentrations in surface waters generally are associated with industrial- waste discharge.

The recommended maximum concentrations for selected elements (U.S. Environmental Protection Agency, 1976) are:

Boron, 750 micrograms per liter (μg/L) for field crops;

Cadmium, 10 μg/L for domestic water supply, 0.4 μg/L for the most sensitive aquatic life;

Chloride, 250 milligrams per liter (mg/L) for domestic water supplies;

Chromium, 50 μg/L for domestic water supply, 100 μg/L for aquatic life;

Copper, 1 mg/L for domestic supply;

Nitrate, 10 mg/L nitrate nitrogen (N) for domestic water supply;

Zinc, 5 mg/L for domestic water supplies.

Maximum measured concentrations for all the above elements, except chromium and copper, exceeded the recommended limit. However, average concentrations were well below the limits for all elements except phosphorus which is in fertilizers used extensively in the study area. High phosphorus concentrations often promote nuisance algal growth in lakes, reservoirs, and streams. To prevent these nuisances in natural waters, the U.S. Environmental Protection Agency (1976, p. 188) recommends the following maximum limits for phosphorus concentrations:

25 μg/L within lakes and reservoirs;

50 μg/L in any stream at the point of entry to a lake or reservoir;

100 μg/L in any stream not discharging directly into a lake or reservoir.

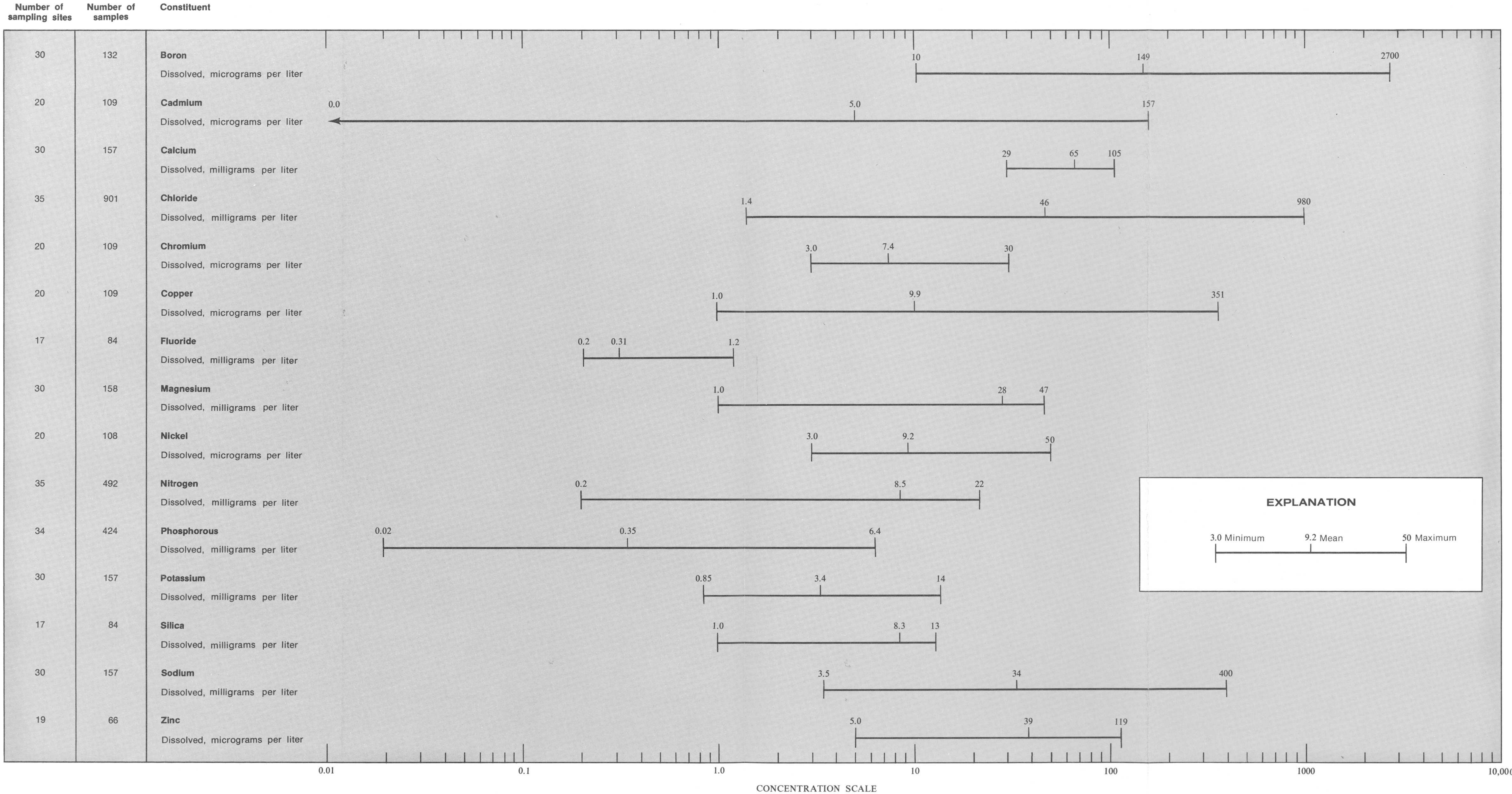


Figure 9.8-1 Range of concentrations of selected constituents measured at water-quality sites.

Suspended-Sediment Yield Related to Water Yield

Correlation exists between suspended-sediment yield and water yield in the study area.

Suspended sediment is the portion of sediment that is carried in suspension by the turbulent component of streamflow. Suspended-sediment discharge is the rate at which suspended material passes a section of a stream.

Suspended-sediment samples were collected during various flow conditions at 17 sites throughout the study area (fig. 9.9-1). Drainage areas at these sites ranged from 32 to 5,090 square miles. Figure 9.9-2 shows the relation of stream yield to the suspended-sediment yield.

The energy available to transport suspended sediment increases as the stream velocity increases. The size and availability of sediment along with stream velocity determine the suspended-sediment yield. Over 93 percent of the suspended sediment was silt and clay size (finer than 0.062 millimeters) in 28 of 39 particle-size analyses. The remaining 11 samples consisted of 78 to 88 percent silt- and clay-sized material.

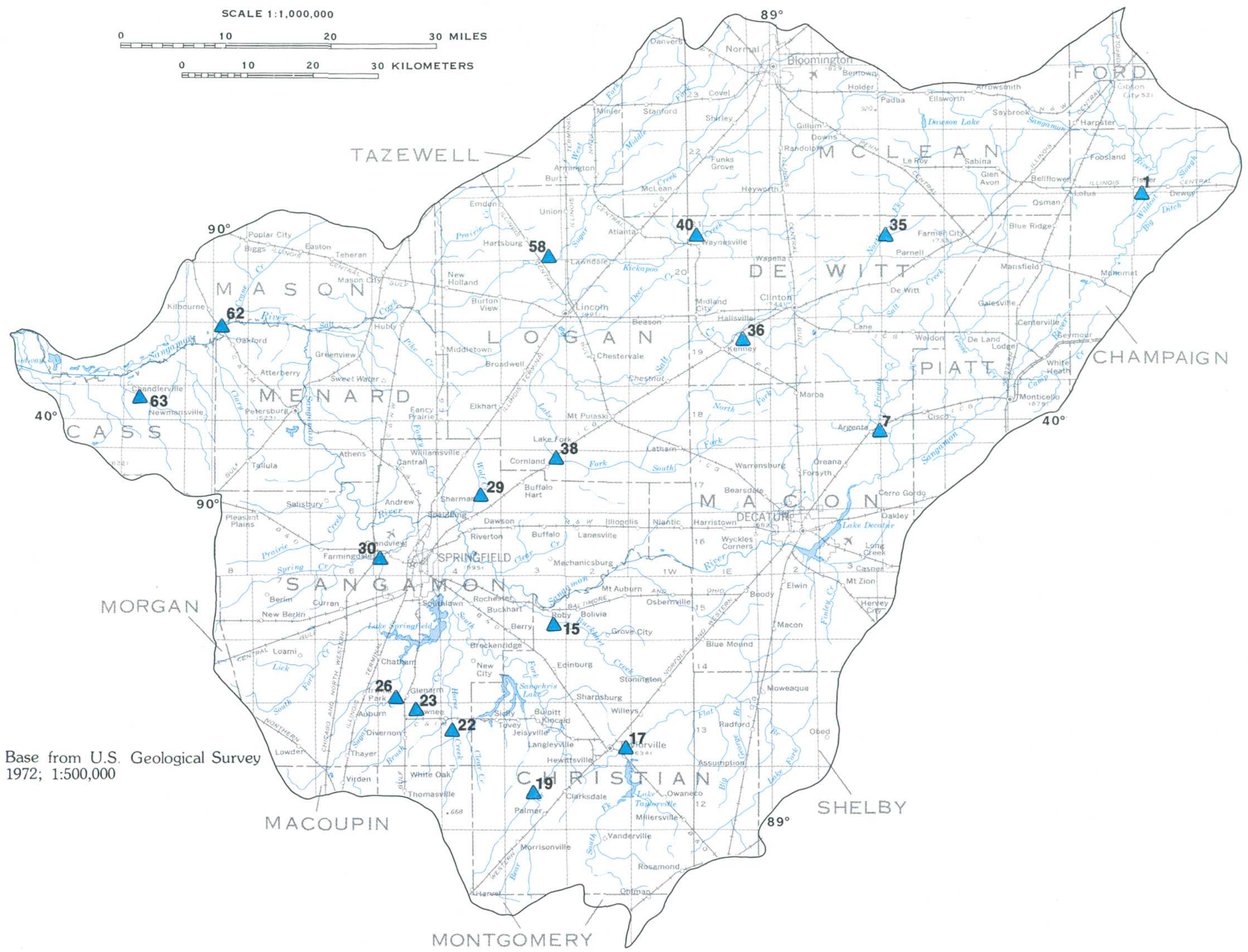


Figure 9.9-1 Suspended-sediment sampling site locations.

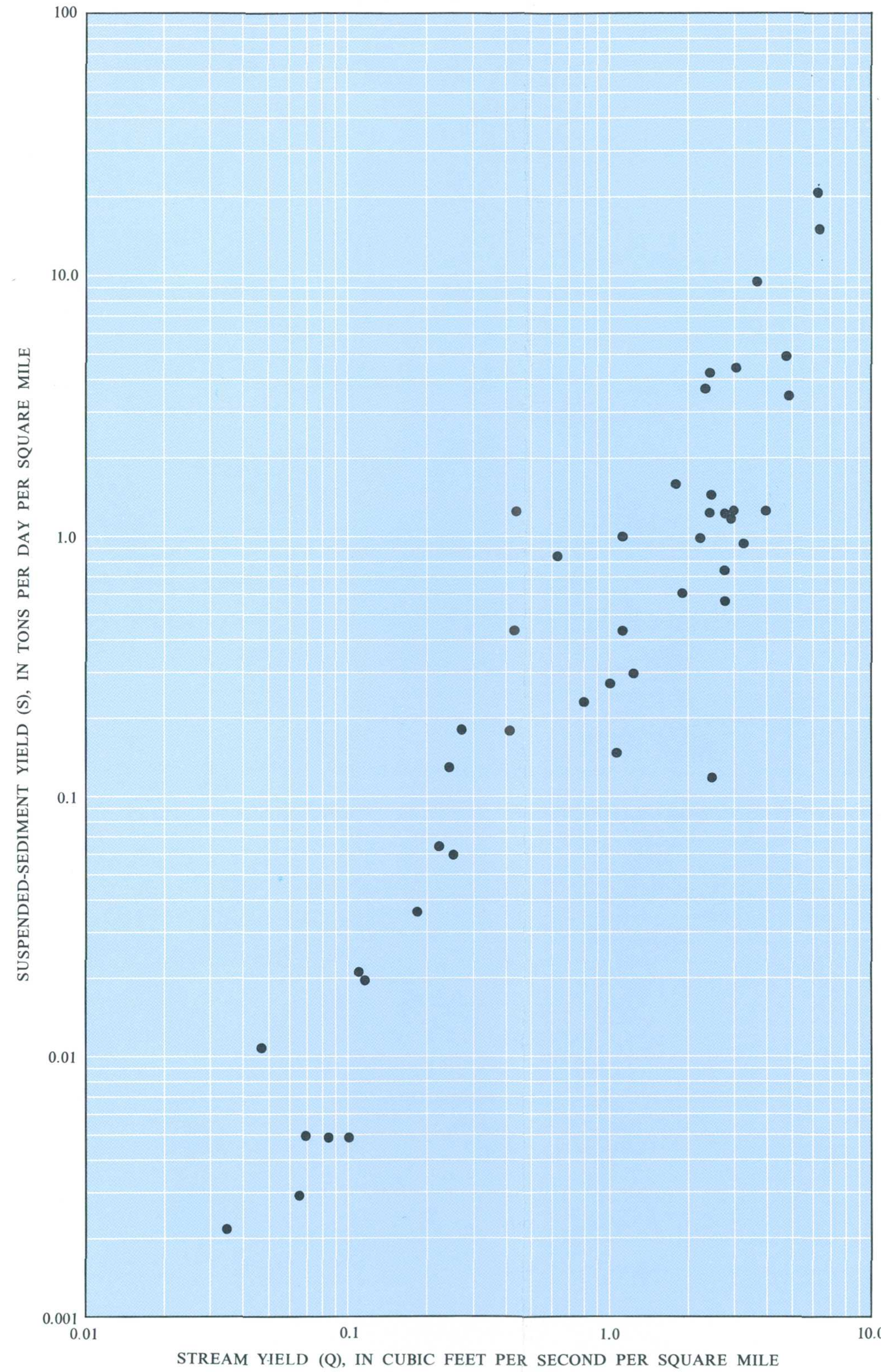


Figure 9.9-2 Relation of stream yield to suspended-sediment yield.

Ground Water is Found in Bedrock and Unconsolidated Aquifers

The only aquifer of high potential ground-water yield in Area 28 is the sand and gravel aquifer of the buried Mahomet Bedrock Valley. Yields from bedrock aquifers are small.

Ground water is recharged by seepage into the earth from precipitation, ponds, and rivers. Seepage occurs through the earth's surface material or directly into sand and gravel or bedrock aquifers at outcrop areas (fig. 10.0-1) (Selkregg and Kempton, 1958).

Ground water is obtained from unconsolidated deposits of sand and gravel in the glacial drift or buried bedrock valleys in almost all of Area 28. Some wells tap bedrock formations of limestone or sandstone. The only aquifer of high potential yield is the sand and gravel aquifer in the buried Mahomet Bedrock Valley (figs. 10.0-2 and 10.0-3).

Most unconsolidated or sand and gravel aquifers in central Illinois (fig. 10.0-3) were deposited by meltwater from glaciers. The sand and gravel was deposited mainly in valleys leading away from the melting ice including the buried Mahomet Bedrock Valley.

Thin sandstone and limestone beds lying directly under the unconsolidated material yield small quantities of water (fig. 10.0-4). Wells tapping these rocks commonly yield less than 25 gallons per minute. Deeper rocks contain water which is too highly mineralized for most uses (Smith and Stall, 1975).

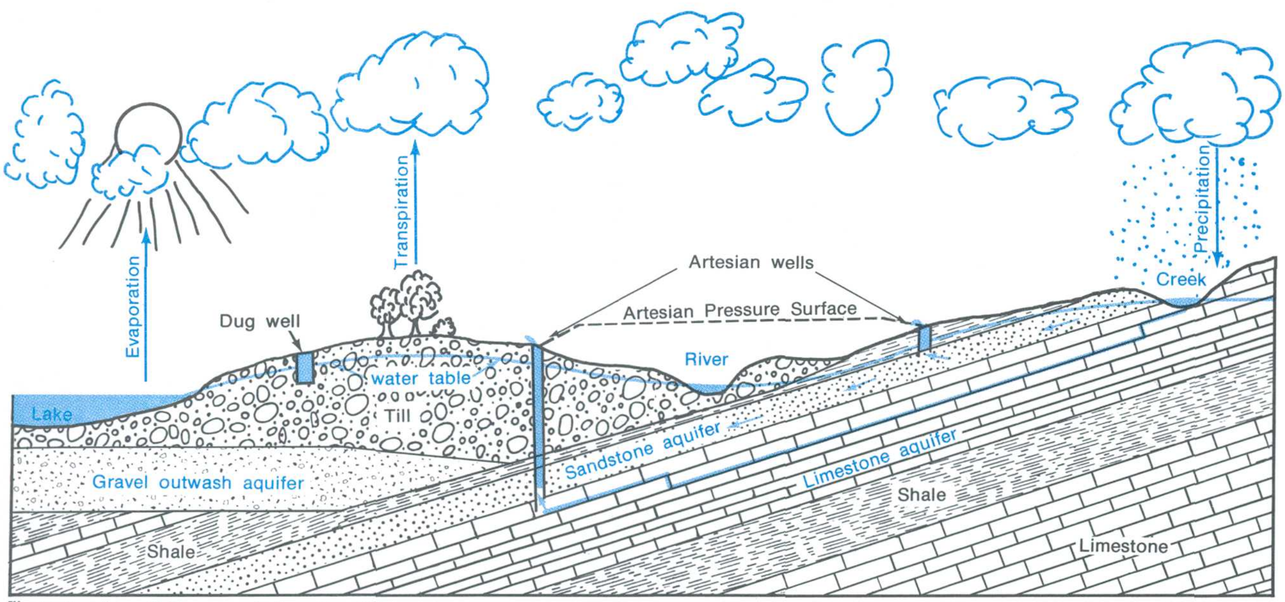
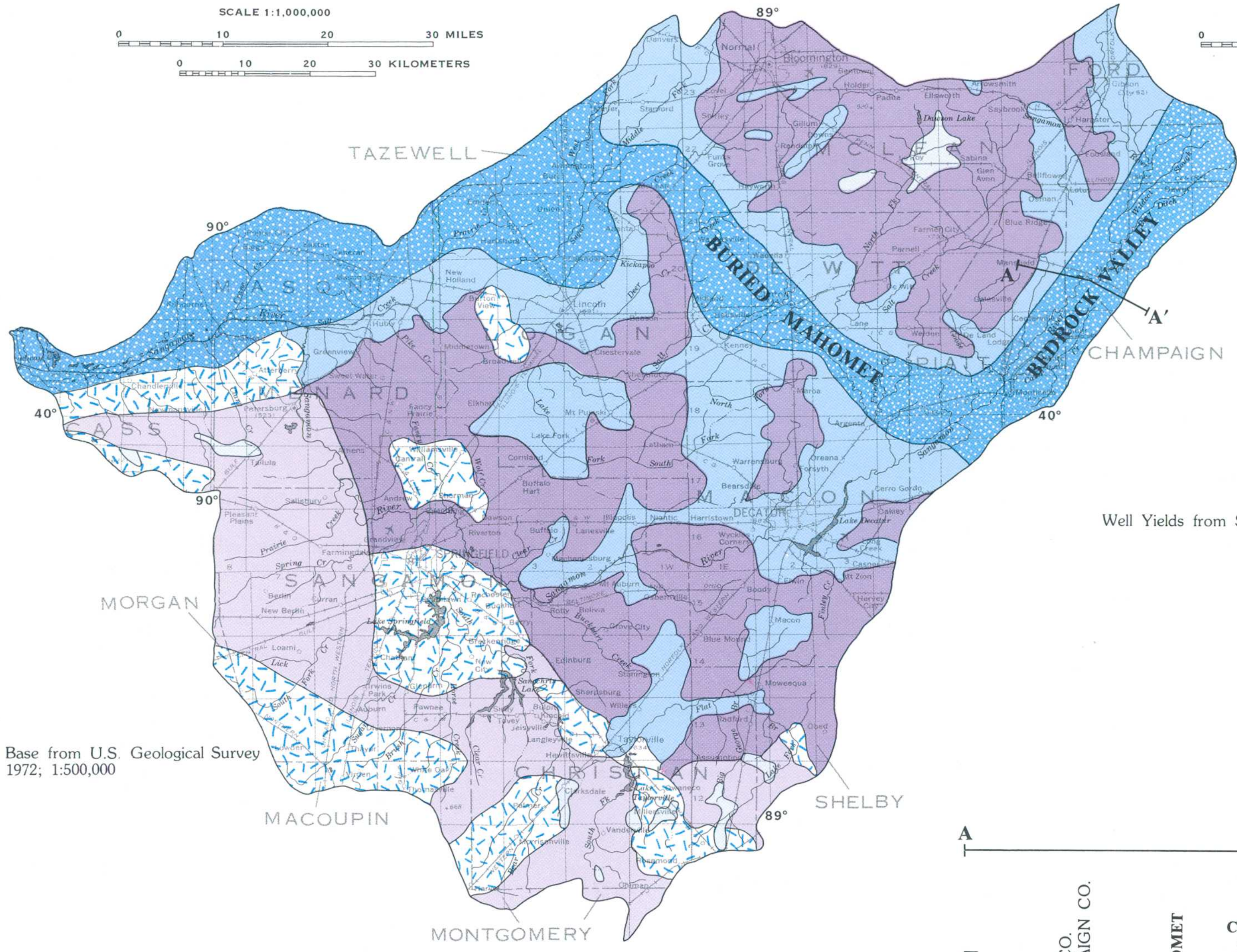


Illustration from Selkregg and Kampton, 1958.

Figure 10.0-1 Hypothetical geologic section showing source, movement, and occurrence of groundwater.



Base from U.S. Geological Survey 1972; 1:500,000

Well Yields from Smith and Stall, 1975.

EXPLANATION

Areas where municipal and industrial water supplies are usually developed from other sources

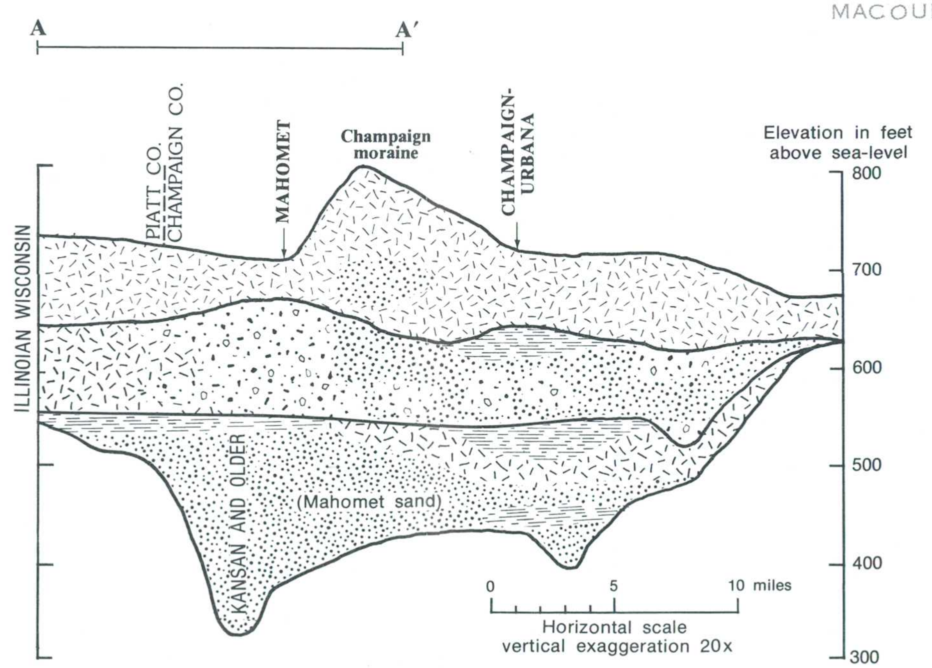
Areas underlain by principal sand and gravel aquifer at least 15 feet thick, where chances are good for obtaining wells with yields of:

- 20 to 99 gal/min
- 100 to 499 gal/min
- 500 gal/min or greater

Location of other possible sand and gravel aquifers, where small industrial and municipal well development may be possible as are chances of obtaining wells with yields of:

- 20 to 99 gal/min
- 100 gal/min or greater

Figure 10.0-2 Yields of sand and gravel aquifers.

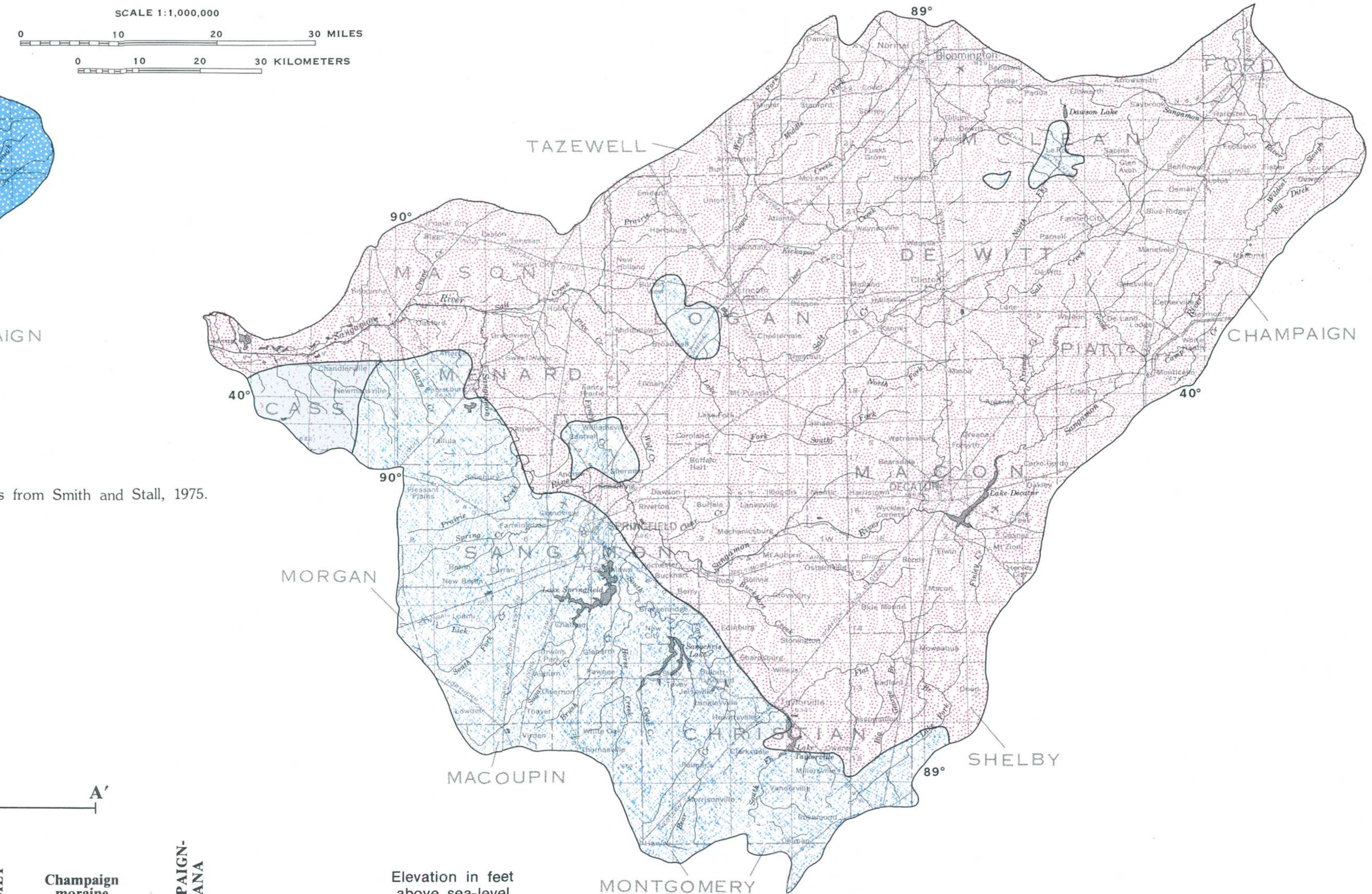


EXPLANATION

Till Sand Gravel Silt

Illustration from Selkregg and Kempton, 1958.

Figure 10.0-3 Geologic section of buried Malhomet Bedrock valley in east-central Illinois (section A - A′ in figure 10.0-1).



EXPLANATION

Chances of obtaining a well with a yield of:

- 20 gal/min or more from Mississippian limestones and sandstones are poor
- 10 to 19 gal/min from Pennsylvanian limestone and sandstone are poor
- Geologic conditions generally favor development of unconsolidated deposits

Figure 10.0-4 Yields of bedrock aquifers (shallow dolomites and Mississippian and Pennsylvanian aquifers).

Water Quality Analyzed for 41 Municipal Supply Wells

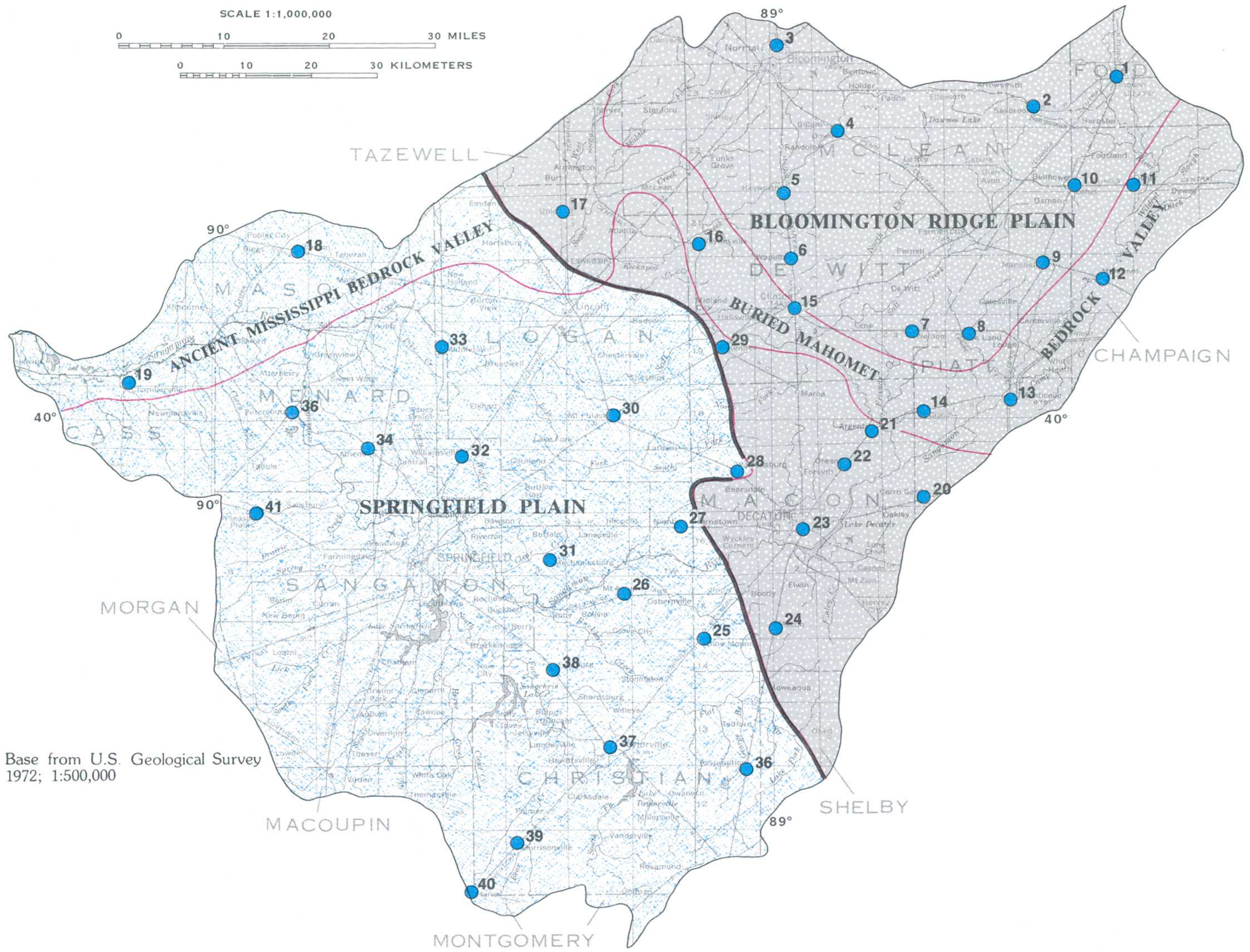
Iron, manganese, nitrate, and dissolved solids exceeded the U.S. Environmental Protection Agency criteria at many locations.

Data for 41 municipal supply wells (fig. 11.0-1) sampled for 18 organic and inorganic constituents and physical properties are shown in table 11.0-1. The U.S. Environmental Protection Agency (USEPA) drinking water criteria (table 11.0-1) for water quality were exceeded for iron at 36 wells, manganese at 25 wells, nitrates at 6 wells, and dissolved solids at 15 wells. All but two wells, numbers 17 and 34, tap unconsolidated (sand and gravel) aquifers.

Iron and manganese concentrations exceeded the USEPA criteria in well waters throughout the study area. The six wells in which the nitrate criterion was exceeded were scattered throughout the study area which indicates localized problems. Dissolved-solids concentrations exceeded the USEPA criterion in 15 of the 41 wells. Dissolved-solids concentrations generally increased toward the northeast. The average dissolved-solids concentration in the Bloomington Ridged Plain division was 517 milligrams per liter (mg/L) and in the Springfield Plain was 400 mg/L.

Precipitation infiltrates the ground and dissolves various minerals. In general, the deeper the water penetrates, or the farther it moves from the point of entry into the ground, the more mineralized it becomes.

Hardness is derived from the dissolution of calcium and magnesium carbonates. Hardness concentrations for the 41 ground-water wells sampled ranged from 126 to 600 mg/L as calcium carbonate. Durfor and Becker (1964) have categorized hardness as follows: 0 to 60 mg/L is soft, 62 to 120 mg/L is moderately hard, 121 to 180 mg/L is hard, and over 180 mg/L is very hard.



EXPLANATION

● Municipal ground-water supply sampled for water-quality analysis

Delineates bedrock valley

Boundary between major physiographic regions

Figure 11.0-1 Ground-water sites.

Table 11.0-1 Concentrations (in milligrams per liter) of various constituents in municipal wells in Area 28 (from Larson, 1963) Numbers in parenthesis below constituent is maximum limit recommended by the U.S. Environmental Protection Agency (1976); minimum limit for pH.

City	Map site number	Treatment	Iron Fe	Manganese Mn	Ammonium NH_4	Sodium Na	Calcium Ca	Magnesium Mg	Silica SiO_2	Boron B	Fluoride F	Nitrate NO_3	Chloride Cl	Sulfate SO_4	Alkalinity (as $CaCO_3$)	Total Hardness	Dissolved Solids	pH	Carbon Dioxide CO_2	Temperature °F
Drinking Water Criteria			(0.3)	(.05)								(10)	(250)				(500)	(5.9)		
Gibson City	1		1.0	0.0	0.1	6	64.7	33.9	18		0.2	3.5	2	27	280	301	341	7.2	45	
Saybrook	2		.1	.1	Tr	17	124.0	46.7	19		.1	28.7	24	133	344	502	620	7.0	99	53.0
Normal	3	IZC1F	11.0	.3	.8	10	185.6	52.5	14	0.1	.1	.3	13	224	452	680	789			
Downs	4	AIC1	2.6	.0	8.4	45	95.0	40.0	23	.6	.4	1.1	5	1	508	402	514			56.0
Heyworth	5	IA	3.3	.0	5.2	107	71.6	29.3	21		.3	.4	96	3	408	300	590	7.4	42	53.5
Wapella	6	I	5.0	.1	4.0	13	84.0	35.0	21	Tr	.3	1.0	2	1	392	357	410			53.5
Weldon	7		1.8	.0	3.1	62	68.1	23.9	23		.5	.1	6	1	404	269	445			55.3
Deland	8	AIC1Z	2.4	.0	17.9	80	106.0	51.1	29	.2	.4	.6	17	1	624	475	655			56.0
Mansfield	9		1.1	.0	1.0	53	72.0	28.6	21		.3	.2	12	2	396	298	426			54.0
Bellflower	10		1.4	.0	Tr	15	69.5	35.1	14	.3	.4	1.2	5	18	324	318	352			54.0
Fisher	11	AIZ	1.9	Tr	14.0	8	92.9	34.9	29		.2	.3	2	91	336	376	461	7.3	49	54.5
Mahomet	12	IA	2.6	.1	.1	9	116.4	51.2	20		.1	.6	21	100	388	502	545	7.1	97	53.5
Monticello	13	IZ	1.6	.1	.5	34	58.0	29.2	12	.4	.2	1.3	5	1	332	265	356			55.5
Cisco	14	I	12.0	.0	24.2	68	100.7	43.5	35		.1	.0	2	7	636	432	657			54.8
Clinton	15	AIC1Z	3.1	.3	2.9	83	71.6	35.8	15	.4	.3	.1	56	1	436	326	523			55.5
Waynesville	16		3.3	.0	4.3	67	95.6	52.6	28		.2	.2	4	16	592	456	634			54.6
Union	17		.1	.1	.9	26	42.3	25.3	14		.4	1.0	2	1	264	210	280	7.5	22	52.3
Easton	18	I	2.1	.2	Tr	3	63.1	28.2	18	.1	.2	1.0	1	24	252	274	284			55.0
Chandlerville	19	L	Tr	.2	Tr	18	115.8	44.1	18		.1	57.8	23	176	248	471	592			
Cerro Gordo	20	IZC1	.8	Tr	Tr	16	85.5	35.7	14		.3	1.0	21	108	244	320	382	7.1	62	55.0
Argenta	21	IZC1	1.4	.0	2.0	97	70.5	36.5	15	.2	.4	2.4	77	1	432	327	572			55.0
Oreana	22	I	9.1	Tr							.3	.4	18		540	372	594			54.5
Decatur	23		2.6	.1	1.4	38	74.1	33.6	15	.4	.1	.5	14	3	388	324	404			55.0
Macon	24	IZ	10.0	Tr	10.2	66	116.5	45.7	30	.9	.3	38.9	19	43	548	480	715			55.5
Blue Mound	25	IZ	.7	.2	Tr	6	74.4	33.3	22		.3	.7	19	81	224	323	365			55.0
Mt. Auburn	26	IZ	2.5	.3	.7	2	96.4	33.0	18		.3	.2	14	37	324	377	417	7.1	65	54.6
Niantic	27	IZ	1.8	Tr	Tr	22	84.1	28.9	16	.1	.2	4.7	14	18	336	330	416			59.0
Warrensburg	28	IZ	3.1	.0	5.6	66	72.4	34.0	21	.4	.5	.7	6	1	472	321	504			55.5
Kenney	29	AIC1	1.5								.4	.2	52		424	316	522			55.0
Mt. Pulaski	30		Tr	.0	Tr	13	119.2	61.5	19	.0	.2	40.5	30	138	360	551	630			57.0
Mechanicsburg	31		1.9	.1							.2	.9	6		288	330	341			56.0
Williamsville	32	I	.4	.1	.1	2	85.7	36.3	17		.2	.1	3	84	276	364	405			
Middletown	33	IA	1.6	.0	1.3	12	62.9	24.8	31		.0	.4	8	1	276	260	294	7.4	28	55.6
Athens	34		16.4	.1	2.3	13	95.1	37.9	21		.1	.1	7	56	360	394	448			
Petersburg	35	ZC1	.4	.3	.2	28	105.0	40.0	18		.2	14.2	34	169	252	427	582			59.5
Assumption	36	IZC1	1.9	.3	Tr	9	91.1	29.4	19		.3	.7	7	125	162	204	272			54.0
Taylorville	37	LC1F	.6	.1	.0	34	32.9	10.9	19		.1	14.3	4	33	148	126	234			55.5
Edinburg	38	AIZ	22.5	.9	1.7	21	63.3	26.0	38			.4	6	3	304	266	353	6.6	196	53.8
Morrisonville	39	IA	1.7	.1	.1	20	65.0	20.5	21		.2	1.9	8	41	236	247	336	7.2	42	54.5
Harvel	40	IA	4.2	.2	Tr	28	92.1	25.1	20	.2	.2	1.0	18	57	308	334	417			57.0
Pleasant Plains	41	I	7.4	1.1	Tr	11	103.1	46.7	21	.0	.3	2.5	14	47	404	450	491			59.5

Tr = trace

Treatment

I - iron removal
A - aeration
L - lime or lime-soda softening
F - fluoridation
Z - zeolite (or ion-exchange) softening
Cl - chlorination

Tr = trace

NAWDEX, WATSTORE, OWDC, STORET have Water-Data Information

Water data are collected in coal areas by a large number of organizations in response to a wide variety of missions and needs.

Three activities within the U.S. Geological Survey help to identify and improve access to the vast amount of existing water data.

(1) The National Water Data Exchange (NAWDEX) indexes the water data available from over 400 organizations and serves as a central focal point to help those in need of water data to determine what information already is available.

(2) The National Water Data Storage and Retrieval System (WATSTORE) serves as the central repository of water data collected by the U.S. Geological Survey and contains large volumes of data on the quantity and quality of both surface and ground waters.

(3) The Office of Water Data Coordination (OWDC) coordinates Federal water-data acquisition activities and maintains a "Catalog of Information on Water Data." To assist in identifying available water-data activities in coal provinces of the United States, special indexes to the catalog are being printed and made available to the public.

In addition to U.S. Geological Survey water data activities, the U.S. Environmental Protection Agency operates a data base called the Water Quality Control Information System (STORET). This data base is used for STOage and RETrieval of data relating to the quality of waterways within and contiguous to the United States.

More detailed explanations of these four activities are given in sections 12.2, 12.3, 12.4, and 12.5.

NAWDEX Simplifies Access to Water Data

The National Water-Data Exchange (NAWDEX) is a nationwide program managed by the U.S. Geological Survey to assist users of water data or water-related data data in identifying, locating, and acquiring needed data.

NAWDEX is a national confederation of water-oriented organizations working together to make their data more readily accessible and to facilitate a more efficient exchange of water data.

Services are available through a Program Office at the Geological Survey National Center in Reston, Va., and a nationwide network of Assistance Centers in 45 states and Puerto Rico, which provide local and convenient access to NAWDEX facilities (fig. 12.2-1). A directory that provides names of organizations and persons to contact, as well as addresses, telephone numbers, and office hours for each of these organizations is available on request (Josefson and Blackwell, 1982).

NAWDEX can assist any organization or individual in identifying and locating water data. To accomplish this service, NAWDEX maintains a computerized Master Water-Data Index (fig. 12.2-2), which identifies sites for which water data are available, the type of data available for each site, and the organization retaining the data. NAWDEX also maintains a Water-Data Sources Directory (fig. 12.2-3) identifying organizations from which water data may be obtained. In addition, NAWDEX has direct access to some large water-data bases of its members and has reciprocal agreements for the exchange of services with others.

Charges for NAWDEX services are assessed at the option of the organization providing the requested data or data service. Search assistance services are provided free by NAWDEX to the greatest extent possible. Charges are assessed, however, for requests requiring computer cost, extensive personnel time, duplicating services, or other costs to NAWDEX providing services. Charges assessed by NAWDEX Assistance Centers will not exceed the direct costs incurred in responding to the data request. Estimates of cost are provided by NAWDEX on request and where costs are anticipated to be substantial.

For additional information concerning the NAWDEX program or its services contact:

Program Office
National Water-Data Exchange (NAWDEX)
U.S. Geological Survey
421 National Center
12201 Sunrise Valley Drive
Reston, VA 22092

Telephone: (703)860-6031
FTS 928-6031

Hours: 7:45 - 4:15 eastern time

NAWDEX ASSISTANCE CENTER
Illinois
U.S. Geological Survey
Water Resources Division
Champaign County Bank Plaza
4th floor
102 East Main Street
Urbana, IL 61801

Telephone: (217) 398-5353
FTS 958-5353

Hours: 8:00 - 4:30 central time

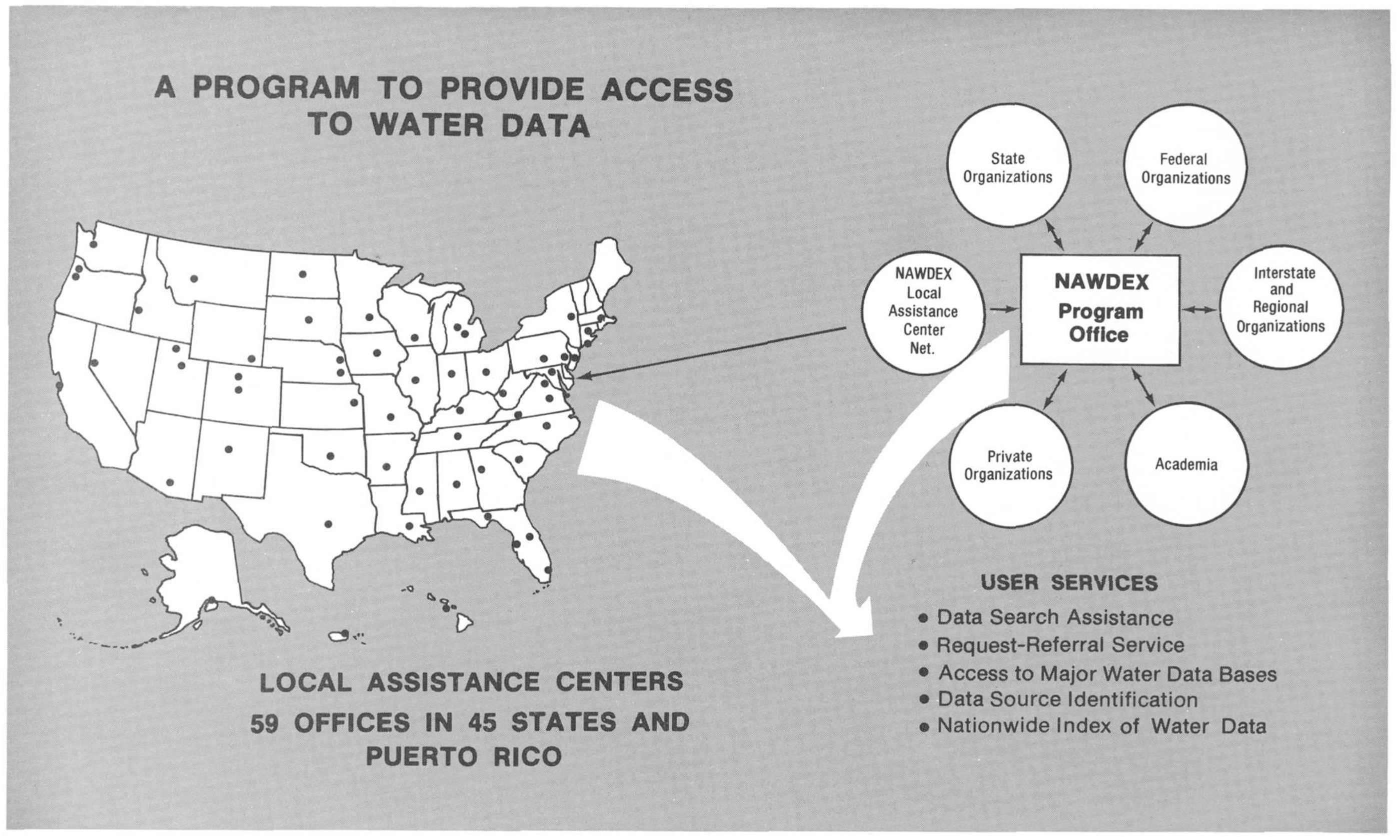


Figure 12.2-1 Access to water data.

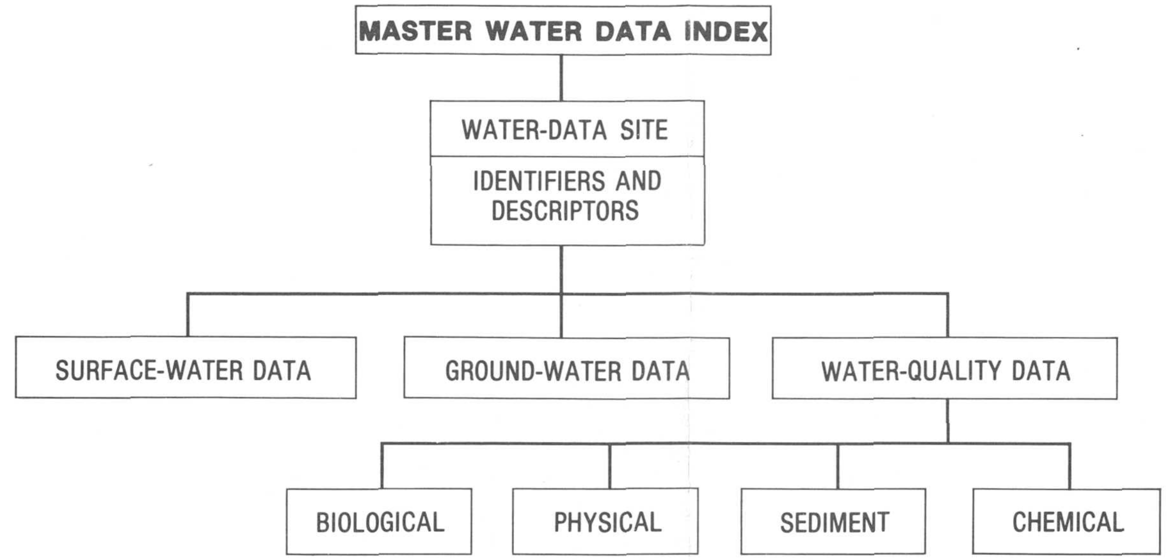


Figure 12.2-2 Master water-data index.

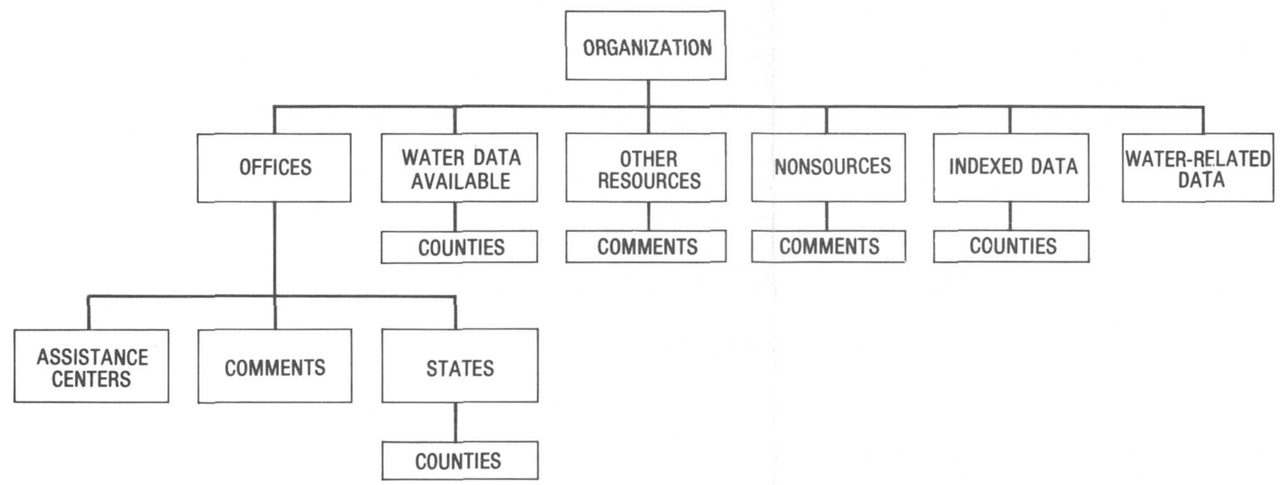


Figure 12.2-3 Water-data sources directory.

WATSTORE Automated Data System

The National Water Data Storage and Retrieval System (WATSTORE) of the U.S. Geological Survey provides computerized procedures and techniques for processing water data and provides effective and efficient management of data-releasing activities.

The National Water Data Storage and Retrieval System (WATSTORE) was established in November 1971 to computerize the U.S. Geological Survey's existing water-data system and to provide for more effective and efficient management of its data-releasing activities. The system is operated and maintained on the central computer facilities of the Survey at its National Center in Reston, Virginia. Data may be obtained from WATSTORE through the Water Resources Division's 46 district offices. General inquiries about WATSTORE may be directed to:

Chief Hydrologist
U.S. Geological Survey
437 National Center
Reston, VA 22092

U.S. Geological Survey
Water Resources Division
Champaign County Bank Plaza
4th Floor
102 East Main Street
Urbana, IL 61801

The Geological Survey currently (1983) collects data at approximately 17,000 stage- or discharge-gaging stations, 5,200 surface-water quality stations, 27,000 water-level observation wells, and 7,400 ground-water quality wells. Each year many water-data collection sites are added and others are discontinued; thus, large amounts of diversified data, both current and historical, are amassed by the Survey's data-collection activities.

The WATSTORE system consists of several files in which data are grouped and stored by common characteristics and data-collection frequencies. The system also is designed to allow for the inclusion of additional data files as needed. Currently, files are maintained for the storage of: (1) Surface-water, quality-of-water, and ground-water measured on a daily or continuous basis; (2) annual peak values for streamflow stations; (3) chemical analyses for surface- and ground-water sites; (4) water parameters measured more frequently than daily; and (5) geologic and inventory data for ground-water sites. In addition, an index file of sites for which data are stored in the system is also maintained. A brief description of each file (fig. 12.3-1) is as follows:

Station Header File: Information pertinent to the identification, location, and physical description of nearly 220,000 sites are contained in this file. All sites for which data are stored in the Daily Values, Peak Flow, Water-Quality, and Unit Values files of WATSTORE are indexed in this file.

Daily Values File: All water-data parameters measured or observed either on a daily or on a continuous basis and numerically reduced to daily values are stored in this file. Instantaneous measurements at fixed-time intervals, daily mean values, and statistics such as daily maximum and minimum values also may be stored. This file currently contains over 200 million daily values including data on streamflow, river stages, reservoir contents, water temperatures, specific conductance, sediment concentrations, sediment discharges, and ground-water levels.

Peak Flow File: Annual maximum (peak) streamflow (discharge) and gage height (stage) values at surface-water sites comprise this file, which currently contains over 400,000 peak observations.

Water-Quality File: Results of more than 1.4 million analyses of water samples are contained in this file. These analyses contain data for as many as 185 different constituents and physical properties that describe the chemical, physical, biological, and radiochemical characteristics of both surface and ground waters.

Unit Values File: Water parameters measured on a schedule more frequent than daily are stored in this file. Rainfall, stream discharge, and temperature data are examples of the types of data stored in the Unit Values File.

Ground-Water Site-Inventory File: This file is maintained within WATSTORE independent of the files discussed above, but it is cross-referenced to the Water-Quality File and the Daily Values File. It contains inventory data about wells, springs, and other sources of ground water. The data included are site location and identification, geohydrologic characteristics, well-construction history, and one-time field measurements such as water temperature. The file is designed to accomodate 270 data elements and currently contains data for nearly 780,000 sites.

All data files of the WATSTORE system are maintained and managed on the central computer facilities of the Geological Survey at its National Center. However, data may be entered into and retrieved from WATSTORE at a number of locations that are part of a nationwide telecommunication network described as follows:

Remote Job Entry Sites: Almost all of the Water Resources Division's district offices are equipped with high-speed computer terminals for remote access to the WATSTORE system. These terminals allow each site to enter data into or retrieve data from the system within an interval of several minutes to overnight, depending upon the priority placed on the request. The number of remote job-entry sites is increased as the need arises.

Digital Transmission Sites: Digital recorders are used at many field locations to record values for parameters such as river stages, conductivity, water temperature, turbidity, wind direction, and chloride concentration. Data are recorded on 16-channel paper tape; the tape is removed from the recorder, and the data are transmitted over telephone lines to the receiver at Reston, Va. The data are re-recorded on magnetic tape for use on the central computer. Extensive testing of satellite data-collection platforms indicates their feasibility for transmitting real-time hydrologic data on a national scale. Battery-operated radios are used as the communication link to the satellite. About 500 data-relay stations are being operated currently (1983) by the Water Resources Division.

Central Laboratory System: The Water Resources Division's two water-quality laboratories, located in Denver, Colo., and Atlanta, Ga., analyze more than 150,000 water samples per year. These laboratories are equipped to automatically perform chemical analyses ranging from determinations of simple inorganic substances, such as chloride, to complex organic compounds, such as pesticides. As each analysis is completed, the results are verified by laboratory personnel and transmitted via a computer terminal to the central computer facilities to be stored in the Water-Quality File of WATSTORE.

Water data are used in many ways by decision-makers for the management, development, and monitoring of our water resources. In addition to its data processing, storage, and retrieval capabilities, WATSTORE can provide a variety of useful products ranging from simple tables of data to complex statistical analyses. A minimal fee, plus the actual computer cost incurred in producing a desired product, is charged to the requestor for the following products:

Computer-Printed Tables: Users most often request data from WATSTORE in the form of tables printed by the computer. These tables may contain lists of actual data or condensed indexes that indicate the availability of data stored in the files. A variety of formats is available to display the many types of data.

Computer-Printed Graphs: Computer-printed graphs for the rapid analysis or display of data are another capability of WATSTORE. Computer programs are available to produce bar graphs (histograms), line graphs, frequency-distribution curves, X-Y point plots, site-location map plots, and other similar items by means of line printers.

Statistical Analyses: WATSTORE interfaces with a proprietary statistical package called SAS (Statistical Analysis System, 1976) to provide extensive analyses of data such as regression analyses, analysis of variance, transformations, and correlations.

Digital Plotting: WATSTORE also makes use of software systems that prepare data for digital plotting on peripheral offline plotters available at the central computer site. Plots that can be obtained include hydrographs, frequency-distribution curves, X-Y point plots, contour plots, and three-dimensional plots.

Data in Machine-Readable Form: Data stored in WATSTORE can be obtained in machine-readable form for use on other computers or for use as input to user-written computer programs. These data are available in the standard format of the WATSTORE system or in the form of punched cards or card images on magnetic tape.

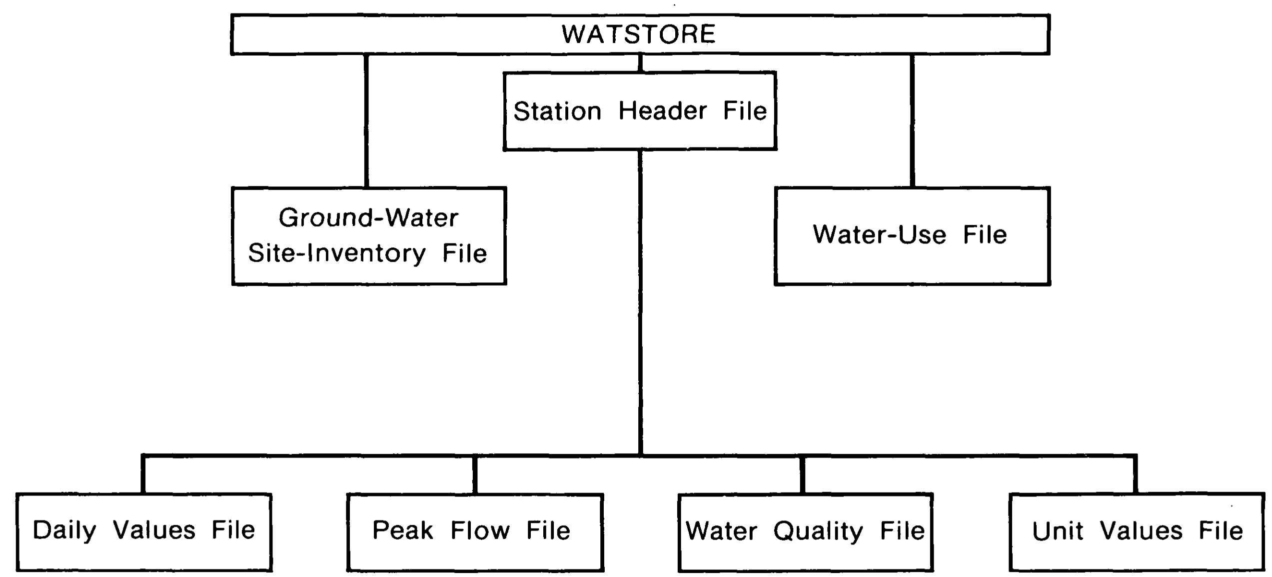


Figure 12.3-1 Index file stored data.

Water Data Indexed for Coal Provinces

A special index, "Index to Water-Data Activities in Coal Provinces of the United States," has been published by the Geological Survey Office of Water Data Coordination (OWDC).

The "Index to Water-Data Activities in Coal Provinces of the United States" was prepared to provide information on the availability of water-resources data in the major coal provinces of the United States for people developing, managing, and regulating the coal resources of the Nation. It is derived from the "Catalog of Information on Water Data," a computerized information file about water-data acquisition in the United States, and some other countries. The index consists of five volumes (fig. 12.4-1): volume I, Eastern Coal province; volume II, Interior Coal province; volume III, Northern Great Plains and Rocky Mountain Coal provinces; volume IV, Gulf Coast Coal province; and volume V, Pacific Coast and Alaska Coal provinces. The volumes presented aid the user in obtaining data for evaluating the effects of coal mining on water resources and in developing plans for meeting additional water-data needs.

Each volume of the special index consists of four parts: Part A, Streamflow and Stage Stations; Part B, Quality of Surface-Water Stations; Part C, Quality of Ground-Water Stations; and Part D, Areal Investigations and Miscellaneous Activities. Information given for each activity in Parts A-C includes (1) identification and location of the station, (2) major types of data collected, (3) frequency of data collection, (4) form in which the data are stored, and (5) agency or organization reporting the activity. Part D summarizes areal hydrologic investigations and water-data activities not included in the other parts of the index. The agencies that submitted the information, agency codes, and the number of activities reported by type are shown in a table.

Assistance in obtaining additional information from the Catalog file or water data is available through the National Water-Data Exchange (NAWDEX) (see section 12.2).

Further information on the index volumes and their availability may be obtained from:

U.S. Geological Survey
Water Resources Division
Champaign County Bank Plaza
4th floor
102 East Main Street
Urbana, IL 61801

Telephone: (217) 398-5353
FTS 958-5353

or

Office of Surface Mining, Region III
U.S. Department of the Interior
U.S. Court and Post Office Building
46 East Ohio Street
Indianapolis, IN 46204

Telephone: (317) 269-2631
FTS 331-2600

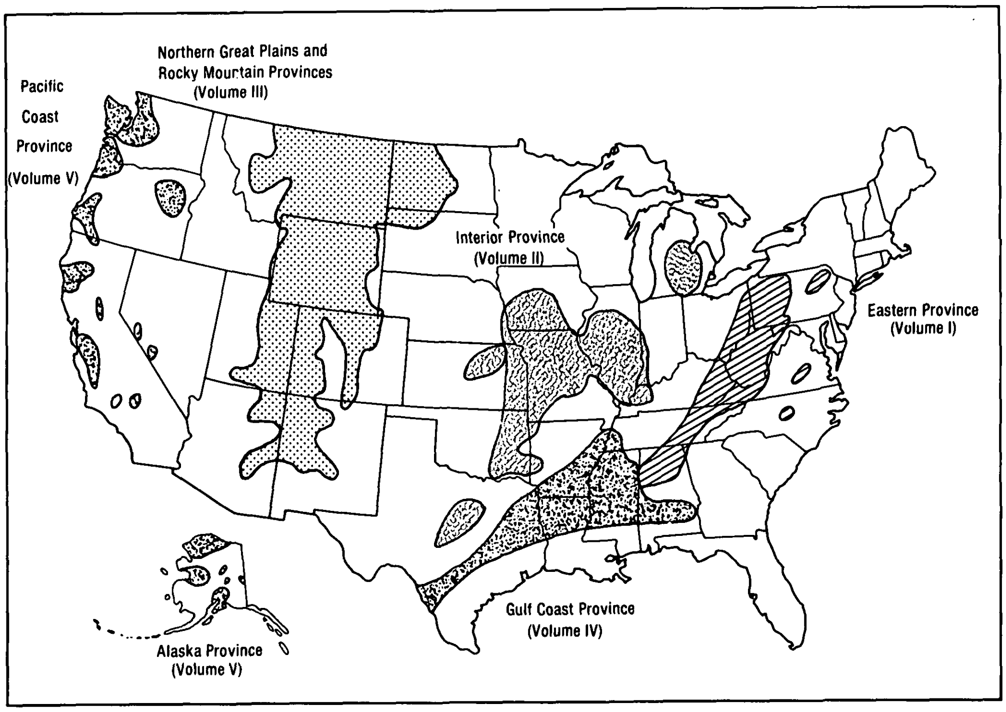


Figure 12.4-1 Index volumes and related provinces.

STORET is U.S. Environmental Protection Agency Computerized Data Base System

STORET is the computerized data base system that is maintained by the U.S. Environmental Protection Agency. The system is used to store many kinds of water-quality data.

"STORET is a computerized data base system maintained by the U.S. Environmental Protection Agency (EPA) for the STOrage and RETrieval of data relating to the quality of the waterways within and contiguous to the United States." The system is used to store data on water quality, water-quality standards, point sources of pollution, pollution-caused fish kills, waste abatement needs, implementation schedules, and other water-quality related information. The Water Quality File (WQF) is the most widely used STORET file.

The data in the Water Quality File is collected through cooperative programs involving EPA, State water pollution control authorities, and other governmental agencies. The U.S. Geological Survey, the U.S. Forest Service, the U.S. Army Corps of Engineers, the Bureau of Reclamation, and the Tennessee Valley Authority all use STORET's WQF to store and retrieve data collected through their water-quality monitoring programs.

There are 1,800 water-quality parameters defined within STORET's WQF. In 1976 there were data from over 200,000 unique collection points in the system. Figure 12.5-1 illustrates the groups of parameters and number of observations that are in the WQF.

State, Federal, interstate, and local government agencies can become STORET users. Information on becoming a user of the system can be obtained by contacting the EPA. The point of contact for Region V is:

Director
Surveillance and Analysis Division
Environmental Protection Agency
230 S. Dearborn Street
Chicago, IL 60604

(312) 353-6738

Source: Handbook Water Quality Control Information System (STORET), U.S. Environmental Protection Agency, Office of Water and Hazardous Materials, Washington, D.C. 20460

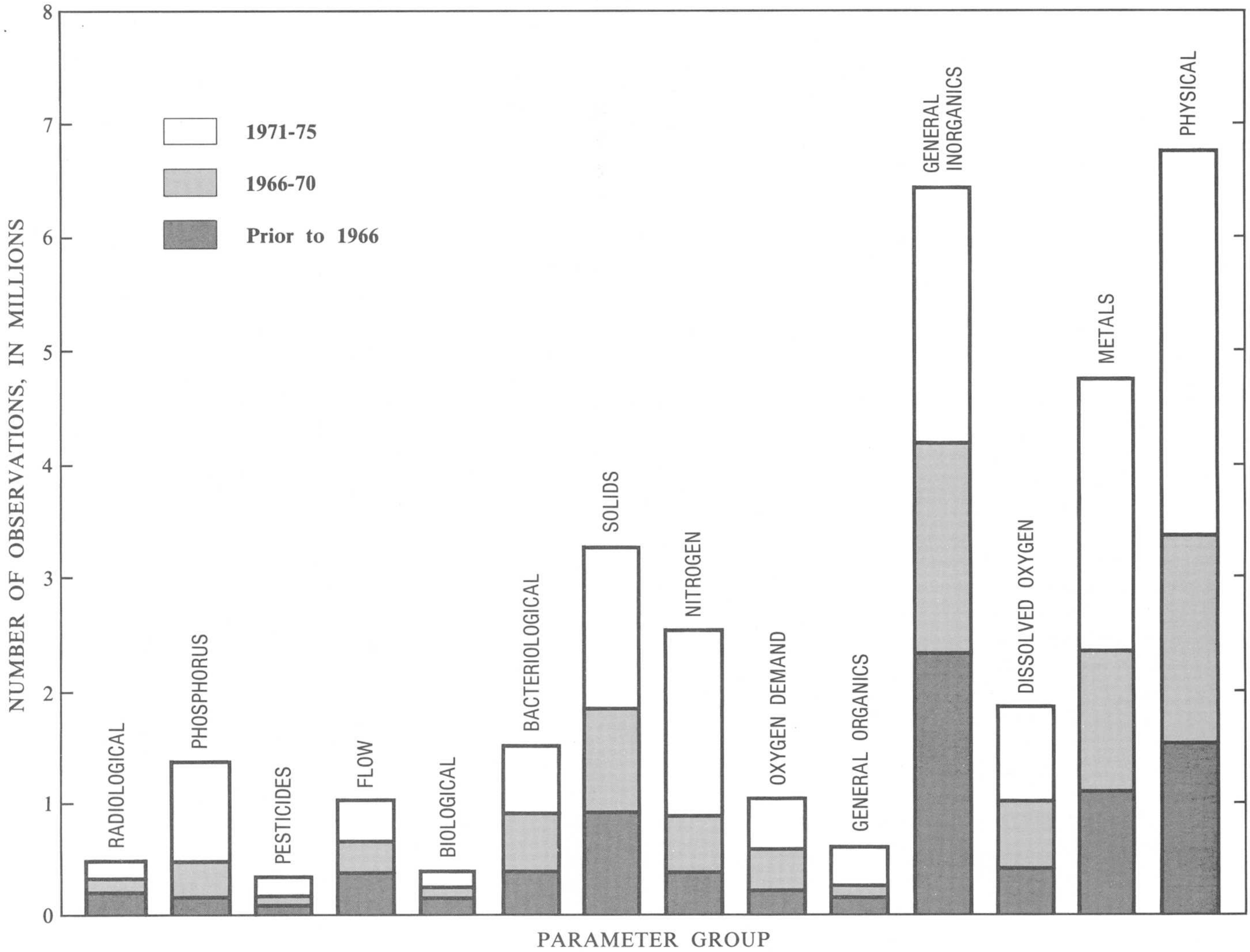


Figure 12.5-1 Parameter groups and number of observations in the Water Quality File.

Map site number	USGS station number	Station name and location	Drainage area (mi^2)	Type of data	Years of record
1	05570910	Sangamon River at Fisher, Ill. Lat 40°18'44", long 88°19'20", sec.5, T.21 N., R.8 E., Champaign County.	240	D WQ	1979-81 1979-81
2	05571000	Sangamon River at Mahomet, Ill. Lat 40°11'30", long 88°24'00", sec.15, T.20 N., R.7 E., Champaign County.	362	D WQ	1948-78 1978
3	05571500	Goose Creek near De Land, Ill. Lat 40°05'40", long 88°37'52", sec.22, T.19 N., R.5 E., Piatt County.	47.9	D	1952-59
4	05572000	Sangamon River at Monticello, Ill. Lat 40°01'51", long 88°35'20", sec.12, T.18 N., R.5 E., Piatt County.	550	D D	1908-12 1914-81
5	05572100	Wildcat Creek tributary near Monticello, Ill. Lat 40°01'37", long 88°38'24", sec.9, T.18 N., R.5 E., Piatt County.	.10	C	1956-76
6	05572125	Sangamon River at Allerton Park near Monticello, Ill. Lat 40°00'08", long 88°38'07", sec.21, T.18 N., R.5 E., Piatt County.	573	WQ	1979-81
7	05572450	Friends Creek at Argenta, Ill. Lat 39°59'21", long 88°48'18", sec.25, T.18 N., R.3 E., Macon County.	111	D WQ	1967-81 1981
8	05572500	Sangamon River near Oakley, Ill. Lat 39°55'09", long 88°48'09", sec.24, T.17 N., R.3 E., Macon County.	774	D F	1951-56 1957-77
9	05573500	Sangamon River at Lake Decatur at Decatur, Ill. Lat 39°49'38", long 88°57'21", sec.22, T.16 N., R.2 E., Macon County.	925	D	1949-51
10	05573504	Sangamon River at Lake Decatur Water Intake at Decatur, Ill. Lat 39°49'44", long 88°57'35", sec.22, T.16 N., R.2 E., Macon County.	927	WQ	1980-81

Type of data

D - Daily water discharge record.
C - Water peak stage and discharge record.
WQ - Surface-water-quality-constituents record (temperature not included).
F - Fragmentary water-discharge record (no low-flow values).

Map site number	USGS station number	Station name and location	Drainage area (mi²)	Type of data	Years of record
11	05573540	Sangamon River at Route 48 at Decatur, Ill. Lat 39°49'52", long 88°58'35", sec.21, T.16 N., R.2 E., Macon County.	938	WQ	1979-81
12	05573600	Spring Creek tributary at Decatur, Ill. Lat 39°52'56", long 88°57'13", sec.35, T.17 N., R.2 E., Macon County.	.3	WQ	1977
13	05573650	Sangamon River near Niantic, Ill. Lat 39°47'48", long 89°06'15", sec.32, T.16 N., R.1 E., Macon County.	1,054	WQ	1978-81
14	05573800	Sangamon River at Roby, Ill. Lat 39°44'32", long 89°23'57", sec.14, T.15 N., R.3 W., Sangamon County.	1,264	WQ	1978-81
15	05573880	Buckhart Creek near Rochester, Ill. Lat 39°43'56", long 89°24'06", sec.23, T.15 N., R.3 W., Christian County.	82.6	WQ	1981
16	05574000	South Fork Sangamon River near Nokomis, Ill. Lat 39°21'12", long 89°15'05", sec.36, T.11 N., R.2 W., Sangamon County.	11.0	D C	1950-75 1976-81
17	05574500	Flat Branch near Taylorville, Ill. Lat 39°33'14", long 89°15'12", sec.24, T.13 N., R.2 W., Christian County.	276	D WQ	1949-81 1979-81
18	05575000	South Fork Sangamon River near Taylorville, Ill. Lat 39°30'26", long 89°20'46", sec.7, T.12 N., R.2 W., Christian County.	434	D D	1908-13 1914-17
19	05575050	Bear Creek near Palmer, Ill. Lat 39°28'50", long 89°25'30", sec.21, T.12 N., R.3 W., Christian County.	60.0	WQ	1979-81
20	05575500	South Fork Sangamon River at Kincaid, Ill. Lat 39°34'44", long 89°23'31", sec.14, T.13 N., R.3 W., Christian County.	562	D D C WQ	1917-34 1944-61 1962-81 1978-81
21	05575570	Sangchris Lake near New City, Ill. Lat 39°39'00", long 89°28'40", sec.19, T.14 N., R.3 W., Christian County.	(a)	WQ	1980-81

(a) Indeterminate

13.0 SURFACE-WATER DISCHARGE SITES AND SURFACE-WATER-QUALITY SAMPLING SITES IN THE STUDY AREA--Continued

Map site number	USGS station number	Station name and location	Drainage area (mi^2)	Type of data	Years of record
22	05575800	Horse Creek at Pawnee, Ill. Lat 39°34'56", long 89°34'20", sec.18, T.13 N., R.4 W., Sangamon County.	52.2	D WQ	1968-81 1981
23	05575830	Brush Creek near Divernon, Ill. Lat 39°35'50", long 89°37'48", sec.3, T.13 N., R.5 W., Sangamon County.	32.4	D WQ	1974-81 1980-81
24	05576000	South Fork Sangamon River near Rochester, Ill. Lat 39°44'32", long 89°34'02", sec.20, T.15 N., R.4 W., Sangamon County.	867	D WQ	1949-81 1979-81
25	05576022	South Fork Sangamon River below Rochester, Ill. Lat 39°45'50", long 89°33'43", sec.8, T.15 N., R.4 W., Sangamon County.	870	WQ	1978-81
26	05576190	Sugar Creek near Glenarm, Ill. Lat 39°36'49", long 89°41'05", sec.32, T.14 N., R.5 W., Sangamon County.	57.5	WQ	1979-81
27	05576250	Sugar Creek near Springfield, Ill. Lat 39°46'48", long 89°35'20", sec.6, T.15 N., R.4 W., Sangamon County.	270	WQ	1979-81
28	05576500	Sangamon River at Riverton, Ill. Lat 39°50'34", long 89°32'52", sec.16, T.16 N., R.4 W., Sangamon County.	2,618	D D C WQ	1908-12 1914-56 1957-81 1978-81
29	05576600	Wolf Creek near Sherman, Ill. Lat 39°53'47", long 89°31'00", sec.26, T.17 N., R.4 W., Sangamon County.	36.6	WQ	1981
30	05577500	Spring Creek at Springfield, Ill. Lat 39°48'57", long 89°41'57", sec.30, T.16 N., R.5 W., Sangamon County.	107	D WQ	1948-81 1979-81
31	05577505	Spring Creek at Burns Lane Bridge at Springfield, Ill. Lat 39°49'16", long 89°41'16", sec.20, T.16 N., R.5 W., Sangamon County.	109	WQ	1979-81
32	05577520	Spring Creek tributary at Springfield, Ill. Lat 39°50'04", long 89°37'14", sec.14, T.16 N., R.5 W., Sangamon County.	1.27	C	1971-76

Map site number	USGS station number	Station name and location	Drainage area (mi^2)	Type of data	Years of record
33	05577700	Sangamon River tributary at Andrew, Ill. Lat 39°53'45", long 89°38'50", sec.27, T.17 N., R.5 W., Sangamon County.	1.50	C	1956-80
34	05578000	Sangamon River at Petersburg, Ill. Lat 40°00'37", long 89°50'42", sec.13, T.18 N., R.7 W., Menard County.	3,063	D WQ	1948-49 1978-81
35	05578200	North Fork Salt Creek near Farmer City, Ill. Lat 40°15'11", long 88°47'43", sec.30, T.21 N., R.4 E., De Witt County.	97.0	WQ	1981
36	05578500	Salt Creek near Rowell, Ill. Lat 40°06'54", long 89°02'57", sec.11, T.19 N., R.1 E., De Witt County.	335	D WQ	1943-81 1978-81
37	05579000	Salt Creek near Kenney, Ill. Lat 40°07'16", long 89°07'24", secs.7 & 8, T.19 N., R.1 E., De Witt County.	390	D	1908-12
38	05579500	Lake Fork near Cornland, Ill. Lat 39°57'00", long 89°23'10", sec.1, T.17 N., R.3 W., Logan County.	214	D WQ	1948-81 1978-81
39	05579750	Kickapoo Creek tributary at Heyworth, Ill. Lat 40°19'05", long 88°58'55", sec.34, T.22 N., R.2 E., McLean County.	3.06	C	1956-73
40	05580000	Kickapoo Creek at Waynesville, Ill. Lat 40°15'20", long 89°07'40", secs.19 & 20, T.21 N., R.1 E., De Witt County.	227	D WQ	1948-81 1978-81
41	05580500	Kickapoo Creek near Lincoln, Ill. Lat 40°11'30", long 89°21'40", sec.18, T.20 N., R.2 W., Logan County.	306	D C WQ	1944-71 1972-81 1978-81
42	05580700	Salt Creek tributary at Middletown, Ill. Lat 40°06'00", long 89°34'55", sec.18, T.19 N., R.4 W., Logan County.	.90	C	1961-76
43	05580730	Sugar Creek at Towanda Avenue at Normal, Ill. Lat 40°30'12", long 88°57'26", sec.26, T.24 N., R.2 E., McLean County.	6.34	WQ	1977

Map site number	USGS station number	Station name and location	Drainage area (mi^2)	Type of data	Years of record
44	05580740	Country Club Branch Sugar Creek at Bloomington, Ill. Lat 40°29'35", long 88°58'52", sec.34, T.24 N., R.2 E., McLean County.	1.45	WQ	1977
45	05580760	Sugar Creek below Franklin Avenue at Normal, Ill. Lat 40°29'46", long 88°59'29", sec.33, T.24 N., R.2 E., McLean County.	9.71	WQ	1975-78
46	05580770	North Branch Sugar Creek at Towanda Avenue at Normal, Ill. Lat 40°31'00", long 88°57'38", sec.26, T.24 N., R.2 E., McLean County.	2.68	WQ	1977
47	05580800	North Branch Sugar Creek tributary at R.R. at Normal, Ill. Lat 40°30'20", long 88°59'23", sec.28, T.24 N., R.2 E., McLean County.	0.56	C	1971-74
48	05580805	North Branch Sugar Creek tributary at Normal, Ill. Lat 40°30'06", long 88°59'25", sec.33, T.24 N., R.2 E., McLean County.	.63	WQ	1977
49	05580810	North Branch Sugar Creek at Normal, Ill. Lat 40°29'55", long 88°59'29", sec.33, T.24 N., R.2 E., McLean County.	5.52	WQ	1975-77
50	05580880	West Branch Sugar Creek at Normal, Ill. Lat 40°30'09", long 89°00'16", sec.32, T.24 N., R.2 E., McLean County.	4.28	WQ	1977
51	05580910	Sugar Creek at Market Street at Bloomington, Ill. Lat 40°29'02", long 89°01'10", sec.5, T.23 N., R.2 E., McLean County.	21.6	WQ	1977
52	05580920	Skunk Creek at Bloomington, Ill. Lat 40°29'02", long 89°01'18", sec.5, T.23 N., R.2 E., McLean County.	6.32	WQ	1977
53	05580930	West Slough at Bloomington, Ill. Lat 40°28'50", long 89°01'09", sec.5, T.23 N., R.2 E., McLean County.	3.22	WQ	1975-77

Map site number	USGS station number	Station name and location	Drainage area (mi^2)	Type of data	Years of record
54	05580945	Sugar Creek above Sewage Plant at Bloomington, Ill. Lat 40°28'21", long 89°01'36", sec.7, T.23 N., R.2 E., McLean County.	32.2	WQ	1976-77
55	05580948	Goose Creek above Sewage Plant at Bloomington, Ill. Lat 40°28'14", long 89°01'25", sec.7, T.23 N., R.2 E., McLean County.	2.19	WQ	1977
56	05580950	Sugar Creek near Bloomington, Ill. Lat 40°28'18", long 89°01'46", sec.7, T.23 N., R.2 E., McLean County.	34.6	D WQ	1975-81 1975-77
57	05581000	Sugar Creek near Armington, Ill. Lat 40°15'57", long 89°20'10", sec.21, T.21 N., R.2 W., Logan County.	314	D	1948-49
58	05581500	Sugar Creek near Hartsburg, Ill. Lat 40°13'20", long 89°24'12", sec.35, T.21 N., R.3 W., Logan County.	333	D C WQ	1945-71 1972-81 1978-81
59	05582000	Salt River near Greenview, Ill. Lat 40°08'01", long 89°44'08", sec.2, T.19 N., R.6 W., Mason County.	1,804	D WQ	1942-81 1978-81
60	05582200	Cabiness Creek tributary near Petersburg, Ill. Lat 40°02'00", long 89°46'35", sec.9, T.18 N., R.6 W., Menard County.	.94	C	1956-76
61	05582500	Crane Creek near Easton, Ill. Lat 40°14'46", long 89°51'40", sec.26, T.21 N., R.7 W., Mason County.	26.5	D C	1950-75 1976-81
62	05583000	Sangamon River near Oakford, Ill. Lat 40°07'25", long 89°59'05", sec.3, T.19 N., R.8 W., Mason County.	5,093	D D D D D WQ	1909-12 1914-19 1921-22 1928-33 1939-81 1976-81
63	05583580	Panther Creek near Chandlerville, Ill. Lat 40°01'45", long 90°07'38", sec.8, T.18 N., R.9 W., Cass County.	44.9	WQ	1981

14.0 LIST OF REFERENCES

American Public Health Association, 1976, Standard methods of the examination of water and wastewater: Washington, D.C., 1,193 p.

Andros, S. D., 1915, Coal mining in Illinois: Illinois State Geological Survey Coal Mining Investigation Bulletin 13, 250 p.

Curtis, G. W., 1977, Technique for estimating magnitude and frequency of floods in Illinois: U.S. Geological Survey Water-Resources Investigations 77–117, 70 p.

Dawes, J. H., and Terstriep, M. L., 1966, Potential surface water reservoirs of north-central Illinois: Illinois State Water Survey Report of Investigation 56, 144 p.

Durfor, C. N., and Becker, Edith, 1964, Public water supplies of the 100 largest cities in the United States, 1962: U.S. Geological Survey Water-Supply Paper 1812, 364 p.

Fehrenbacher, J. B., and Odell, R. T., 1953, Menard County soils: University of Illinois, Agricultural Experiment Station, Soil Report 76, Urbana, Ill., 56 p.

Fehrenbacher, J. B., Walker, G. O., and Wascher, H. L., 1967, Soils of Illinois: University of Illinois College of Agriculture, Agricultural Experiment Station, Urbana, Ill., Bulletin 725, 47 p.

Frederick, R. H., Myers, V. A., and Auciello, E. P., 1977, Five-to-sixty minute precipitation frequency for the eastern and central United States: National Oceanic and Atmospheric Administration Technical Memorandum NWS HYDRO-35, 36 p.

Gibb, J. P., 1973, Water quality and treatment of domestic ground water supplies: Illinois State Water Survey Circular 118, 17 p.

Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 1473, 363 p.

Herschfield, D. M., 1961, Rainfall frequency atlas of the United States, U.S. Illinois Conservation Needs Committee, 1970, Illinois soil and water conservation needs inventory: Cooperative Extension Service, College of Agriculture, University of Illinois, Urbana, Ill., 192 p.

Illinois Department of Mines and Minerals, 1982, 1981 Annual coal, oil, and gas report: 403 p.

Illinois Environmental Protection Agency, 1978, Assessment and classification of Illinois lakes, volume I: 173 p.

Kirk, J. R., Jarboe, Jacquelyn, Sanderson, E. W., Sasman, R. T., and Sinclair, R. H., 1979, Water withdrawals in Illinois, 1978: Illinois State Water Survey Circular 140, 34 p.

Krauskopf, Konrad B., 1967, Introduction to geochemistry: McGraw-Hill, Inc., New York, 721 p.

Larson, T. E., 1963, Mineral content of public ground water supplies in Illinois; Illinois State Water Survey Circular 90, 28 p.

Lewis, J. W., ed., 1971-72, Illinois blue book: 856 p.

Lineback, J. A., 1979, Quaternary deposits of Illinois map: Illinois State Geological Survey, scale 1:500,000.

Nawrot, J. R., Klimstra, W. D., Jenkusky, S. M., and Hickmann, T. J., 1980, Illinois State reclamation plan for abandoned mined land, resource document Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, Ill., 254 p.

Piskin, Kemal, and Bergstrom, R. E., 1975, Glacial drift in Illinois–thickness and character: Illinois State Geological Survey Circular 490, 35 p.

Rankama, Kalervo, and Sahama, T. G., 1950, Geochemistry: The University of Chicago Press, 912 p.

Rickert, D. A., Ulman, W. J., and Hampton, E. R., 1979, Synthetic fuels development–Earth science considerations: U.S. Geological Survey Special Report, 45 p.

Rockford Map Publishers, Inc., 1973, Illinois State atlas: Rockford, Ill., 260 p.

Samson, Irma, 1981, Illinois mineral industry in 1978 and a review of preliminary mineral production data for 1979: Illinois State Geological Survey, Illinois Minerals Note 79, 35 p.

Selkregg, L. F., and Kempton, J. P., 1958, Groundwater geology in east-central Illinois: Illinois State Geological Survey Circular 248, 36 p.

Sieber, C. R., 1970, A proposed streamflow data program for Illinois: U.S. Geological Survey open-file report, 73 p.

Smith, W. H., and Stall, J. B., 1975, updated 1977, Coal and water resources for coal conversion in Illinois: Illinois State Water Survey and Illinois State Geological Survey Cooperative Resources Report 4, 79 p.

Thornburn, T. H., 1963, Surface deposits of Illinois–a guide for soil engineers University of Illinois Engineering Experiment Station Circular No. 80, Urbana, Ill., 135 p.

Toler, L. G., 1982, Some chemical characteristics of mine drainage in Illinois: U.S. Geological Survey Water-Supply Paper 2078, 47 p.

U.S. Department of Agriculture, 1974, Soil survey of Logan County, Illinois: Soil Conservation Service in cooperation with Illinois Agricultural Experiment Station, 99 p.

________1980a, Land resources inventory by river basins of Illinois: Watershed-River Basin Planning Staff, Soil Conservation Service, Champaign, Ill., 53 p.

________1980b, Survey of Sangamon County, Illinois: Soil Conservation Service in cooperation with Illinois Agricultural Experiment Station, 87 p.

U.S. Environmental Protection Agency, 1976 [1978], Quality criteria for water: Washington, D.C., U.S. Government Printing Office, 56 p.

________1977, National secondary drinking water regulations: Federal Register, v. 42, no. 62, Thursday, March 31, 1977, Part I, p. 17143-17147.

Van Den Berg, Jacob, and Elyn, J. R., 1981, Petroleum industry in Illinois, 1979: Illinois State Geological Survey, Illinois petroleum 120, 132 p.

Willman, H. B., and Frye, J. C., 1970, Pleistocene stratigraphy of Illinois: Illinois State Geological Survey Bulletin 94, 204 p.

Willman, H. B., and others, 1967, Geologic map of Illinois: Illinois State Geological Survey, scale 1:500,000.

________1975, Illinois stratigraphy: Illinois State Geological Survey Bulletin 95, 261 p.

Wischmeier, W. H., and Smith, D. D., 1978, Predicting rainfall erosion losses–a guide to conservation planning: U.S. Department of Agriculture, Agriculture Handbook No. 537, 58 p.