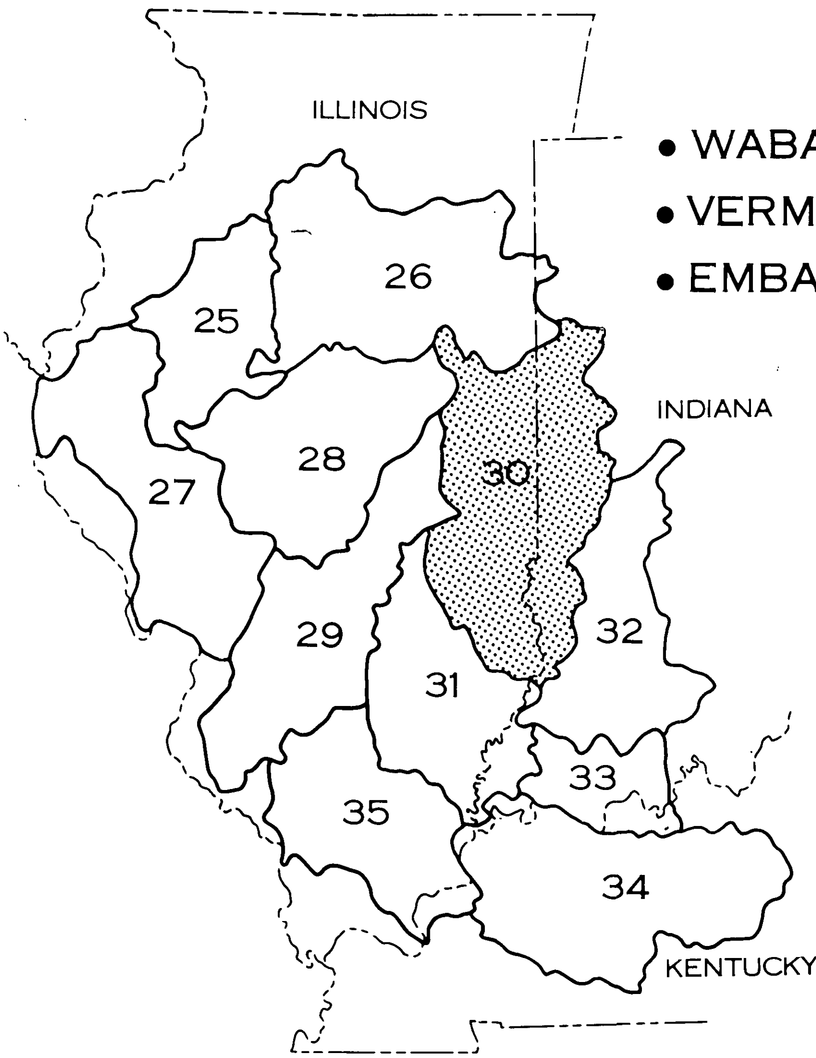
HYDROLOGY OF AREA 30, EASTERN REGION, INTERIOR COAL PROVINCE, ILLINOIS AND INDIANA



- WABASH RIVER
- VERMILLION RIVER
- EMBARRAS RIVER

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 82-1005

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BY
DAVID J. WANGSNESS AND OTHERS

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INDIANAPOLIS, INDIANA
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UNITED STATES DEPARTMENT OF THE INTERIOR

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CONTENTS

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)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
acres	0.4047	square hectometers (hm^2)
gallons per minute (gal/min)	0.06309	liters per second (L/s)
gallons per day per foot [(gal/d)/ft]	0.0124	square meters per day (m^2/d)
gallons per day per square foot [(gal/d)/ft^2]	0.0407	meters per day (m/d)
cubic feet per second (ft^3/s)	0.0283	cubic meters per second (m^3/s)
ton (short, 2,000 pounds)	0.0283	metric ton (t)
micromhos per centimeter (μmho/cm)	1.0	microsiemens (μS)

$$°C = 0.556\,(°F - 32)$$

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 30, EASTERN REGION, INTERIOR COAL PROVINCE, ILLINOIS AND INDIANA

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Abstract

The Eastern Coal Region is divided into 35 separate hydrologic reporting areas. The division is based on hydrologic factors, location, size, and mining activity. Hydrologic units (drainage basins), or parts of units, are combined to form each area. Area 30 includes about 8,600 square miles.

This report on hydrologic conditions and identification of sources of hydrologic information is designed particularly for use by mine owners, mine operators, and consulting engineers. The report format consists of brief texts and supporting illustrations or tables on a series of hydrologic topics that describe the hydrology of Area 30.

The physiography is characterized by lowland plains, except for small upland areas in the south and the east. Average elevation ranges from 400 feet in the south to 800 feet in the north.

At least three glaciers (the Kansan, Illinoian, and Wisconsin) advanced into what is now Indiana and neighboring States during the Pleistocene Epoch. All Area 30 was glaciated and is covered with drift. The underlying bedrock is predominantly of Pennsylvanian age, although Mississippian, Devonian, and Silurian rocks crop out at the north edge of the study area. Most of the coal has been mined from rocks of Pennsylvanian age. The major coal seam in Indiana is the Springfield coal member (Coal V), and the most productive Illinois unit is Herrin Coal (No. 6). As of 1978, about 860 million tons of coal had been mined from counties within the study area. During 1978, 6.8 million tons of coal was mined. Estimates of reserves for the Indiana part of the study area are more than 7 billion tons. Estimates of reserves for the Illinois part are not available.

The major rivers draining Area 30 are the Vermilion, Embarras, and Wabash. Records of stream and river discharge indicate that the dominant factor affecting average annual flow is size of drainage area. Low flow is highly variable, depending upon the physiography and the extent of the surficial aquifer. In the absence of surficial aquifers, low flow is minimal. Streams cutting thick till and outwash deposits may have sustained flows. In small rivers and streams, precipitation index (rainfall minus snowfall and evapotranspiration) controls flood magnitude. In the Wabash River, drainage area, channel slope, and stream length control flood magnitude, and precipitation index is insignificant. Flood magnitude for streams and rivers in Area 30 is medium to moderately high compared with that for the rest of the streams in Indiana and Illinois.

Most of the coal production in Area 30 has been in Vigo, Sullivan, and Knox, Counties, Indiana, and Vermilion County, Illinois. The exposure and the oxidation of pyrite and marcasite may cause specific conductance and concentrations of sulfate, iron, and manganese to be higher and pH and alkalinity to be lower in the surface water in the coal-mining regions than in areas unaffected by mining.

Yields from sand and gravel aquifers range from 5 to 3,000 gallons per minute and generally exceed those from bedrock aquifers. Yields are highest in the alluvial and outwash deposits along the Wabash and Embarras Rivers and in the Mahomet bedrock valley aquifer. Bedrock aquifers yield about 110 gallons per minute or less. The aquifers discharge by seepage into streams, evapotranspiration, springs, and pumping. The annual seepage rate during periods of normal precipitation is about 0.40 cubic foot per second per square mile of drainage area or less.

Median concentrations of dissolved solids, total iron, total manganese, and sulfate in glacial aquifers are 398, 0.5, 0.05, and 40 milligrams per liter, respectively. The median pH in glacial aquifers is 7.5. Median concentrations of dissolved solids, total iron, total manganese, and sulfate in bedrock aquifers are 467, 0.3, 0.02, and 15 milligrams per liter, respectively. The median pH in bedrock aquifers is 7.6. The dissolved-solids concentration of ground water generally increases with depth.

1.0 INTRODUCTION

Report Summarizes Hydrologic Data for Mine Permit Applications

This report summarizes available hydrologic information for a subbasin in Indiana and Illinois and documents the source of the information.

Coal is the most abundant fossil fuel in the United States, and the quantity mined will probably be increased to meet energy demands. Surface mining and reclamation have affected surface water in much of the continental United States. Hydrology has been altered by mining, and water quality has been affected by acid mine drainage.

A need for hydrologic data and analysis on a scale seldom required nationally resulted when the "Surface Mining Control and Reclamation Act of 1977" (Public Law 95-87) was enacted. The Act requires that extensive information about the probable hydrologic consequences of mining and reclamation be included in mining-permit applications so that the regulatory authority can determine the probable cumulative impact of mining on the hydrology. Hydrologic information on the general area is to be made available to applicants for mining permits from an appropriate Federal or State agency before mining permits are issued.

In this report and other reports on coal-mining areas, the U.S. Geological Survey is helping to provide the hydrologic data, particularly the water-quality data, required by Public Law 95-87. The report is a summary of several reports, maps, oral communications, written communications, and computer data files from Federal and State agencies in Indiana and Illinois. Much of the data has been summarized, but only some has been interpreted.

The area of study represents the hydrologic unit or drainage basin shown in figure 1.0-1. The unit boundary crosses political and hydrologic boundaries and therefore poses problems in nomenclature and data presentation. Adjoining States have slightly different names for the same geologic formations, soil types, and physiographic units. The authors have not standardized the nomenclature used by the various reporting agencies but instead have presented the information as it was reported. Much of the data is presented by State and county rather than by drainage areas--for example, coal production and land use. Where a part of any county is within the unit boundary, data for the whole county are generally presented. Where a total figure is presented, such as total coal production for the study unit, that figure represents the total for all counties contacted by the study-unit boundary and not just the total for the area within the unit boundaries. Therefore, some figures may be inflated because they represent a larger area than shown, and some county figures may be presented in adjacent coal-hydrology reports.

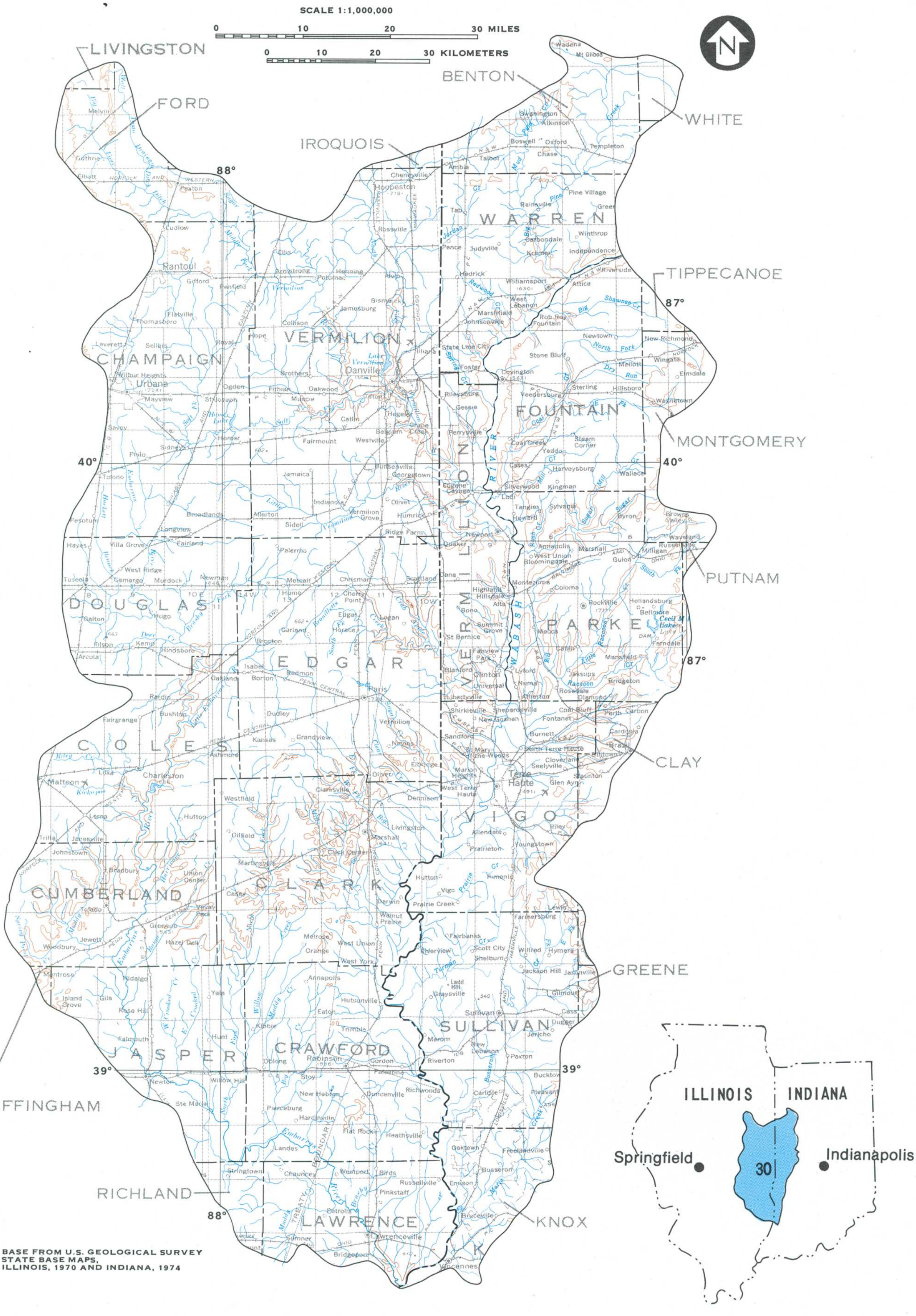


Figure 1.0-1.--Area 30 in Indiana and Illinois.

1.0 INTRODUCTION

Temperature in Area 30 is Representative of Middle-Latitude States

The interaction of tropical and polar air masses of contrasting temperatures and densities develops low-pressure centers that generally move east through, or near, Area 30.

Area 30 has warm summers and cool winters because of its location in the middle latitudes (38° to 39° north) in the interior of a large continent. Temperature can change significantly every few days, when surges of polar air or tropical air move into the area, but it changes more frequently during the winter. The mean annual temperature for 1941-70 was 52.0°F (fig. 2.1-1). The maximum mean monthly temperature at Terre Haute, Ind., is 76.0°F during July, and the minimum mean monthly temperature is 28.0°F during January. Mean maximum and minimum temperatures at Danville, Ill. are 2° and 4°F lower, respectively. The date of the first freeze is usually between October 15 and 20. The date of the last freeze is usually in mid- to late April. Data in this unit is from Albert Shipe, Indianapolis, Ind., National Oceanic and Atmospheric Administration, (written commun., January 1980).

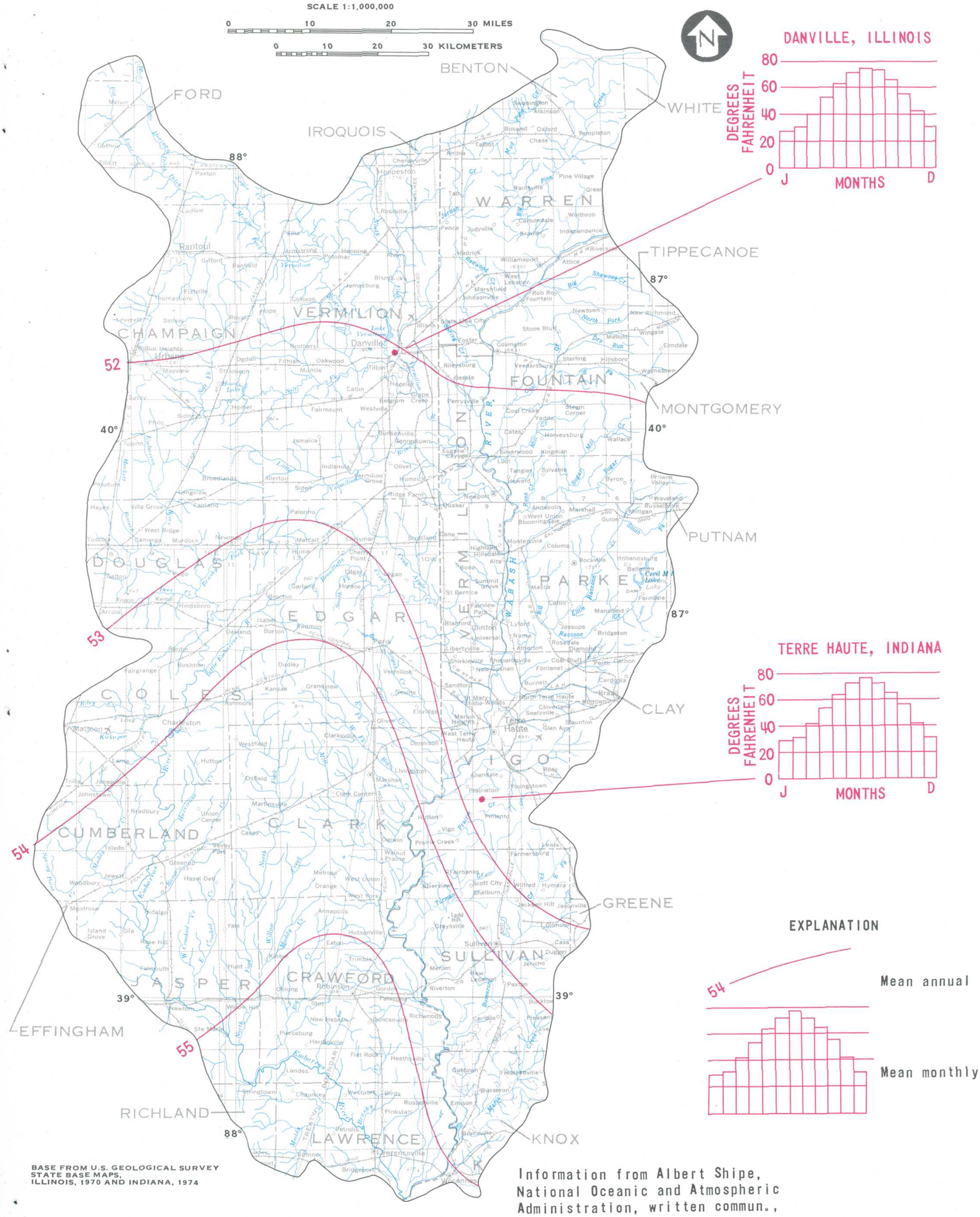


Figure 2.1-1--Mean annual temperatures and selected mean monthly temperature, 1941-70.

2.0 CLIMATE

2.1 Temperature

Most Precipitation in Area 30 is from Thunderstorms Typical of Middle-Latitude States

Thunderstorms in late spring generally produce the highest mean monthly precipitation.

Thunderstorms generated by storm fronts or locally by daytime, convective air currents, typify the precipitation in Area 30. Mean annual precipitation is 37 inches in the north and 42 inches in the south (fig. 2.2-1). Mean snowfall generally ranges from 10 inches in the south to 20 inches in the north. Maximum mean monthly precipitation (generally in late spring) ranges from 4.3 inches in the south to 4.6 inches in the north. Minimum mean monthly precipitation (usually in February) averages 2.1 inches.

Rates of pan evaporation are not available for the study area. However, mean monthly pan evaporation during July is 8 inches at Evansville, Ind., compared with 6.5 inches at Oaklandon, 12 miles northeast of Indianapolis. In October, mean monthly pan evaporation is about 2.5 inches at Evansville and Oaklandon. Humidity ranges from 40 to 90 percent. General information on climate is from Schaal (1959, and 1966, p. 156 to 170). Data in this unit is from Albert Shipe, Indianapolis, Ind., National Oceanic and Atmospheric Administration (written commun., January 1980).

Frequency analyses of rainfall data are used to compute hydrographs for the design of sewers, culverts, dams, reservoirs, and other hydrologic-control projects. Designing these projects for maximum runoff is seldom economical. Rather, they are designed for 10-, 25-, 100-year, or other floods on the basis of a regulation or an economic balance between the average cost of damages attributed to occasional floods and the cost of facilities for protection against larger floods.

Except in mountainous terrain, rainfall intensity is light and frequency variations are small over short distances. Thus, precipitation can be mapped for various frequencies and durations. A report by the Indiana Department of Natural Resources (1974) shows precipitation for frequencies of 1 to 100 years and durations of 1 to 24 hours. The adjacent maps (fig. 2.2-2) show precipitation for frequencies of 10-, 25-, and 100- years for a 24-hour duration. Only generalized rainfall-frequency data are available for Illinois (Herschfield, 1961); therefore, the nearly straight lines in Indiana have been extended into eastern Illinois.

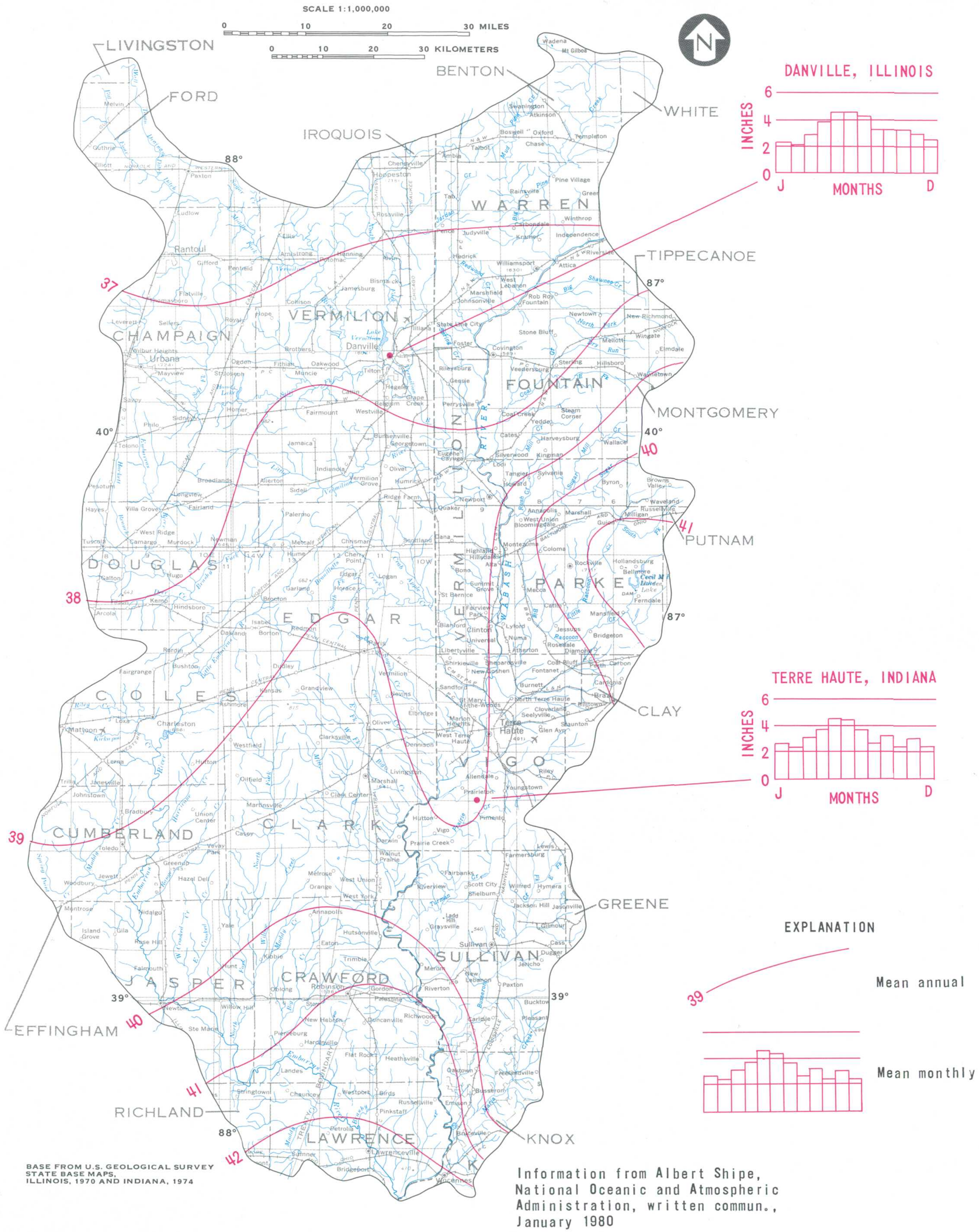


Figure 2.2-1--Mean annual precipitation and selected mean monthly precipitation, 1941-70.

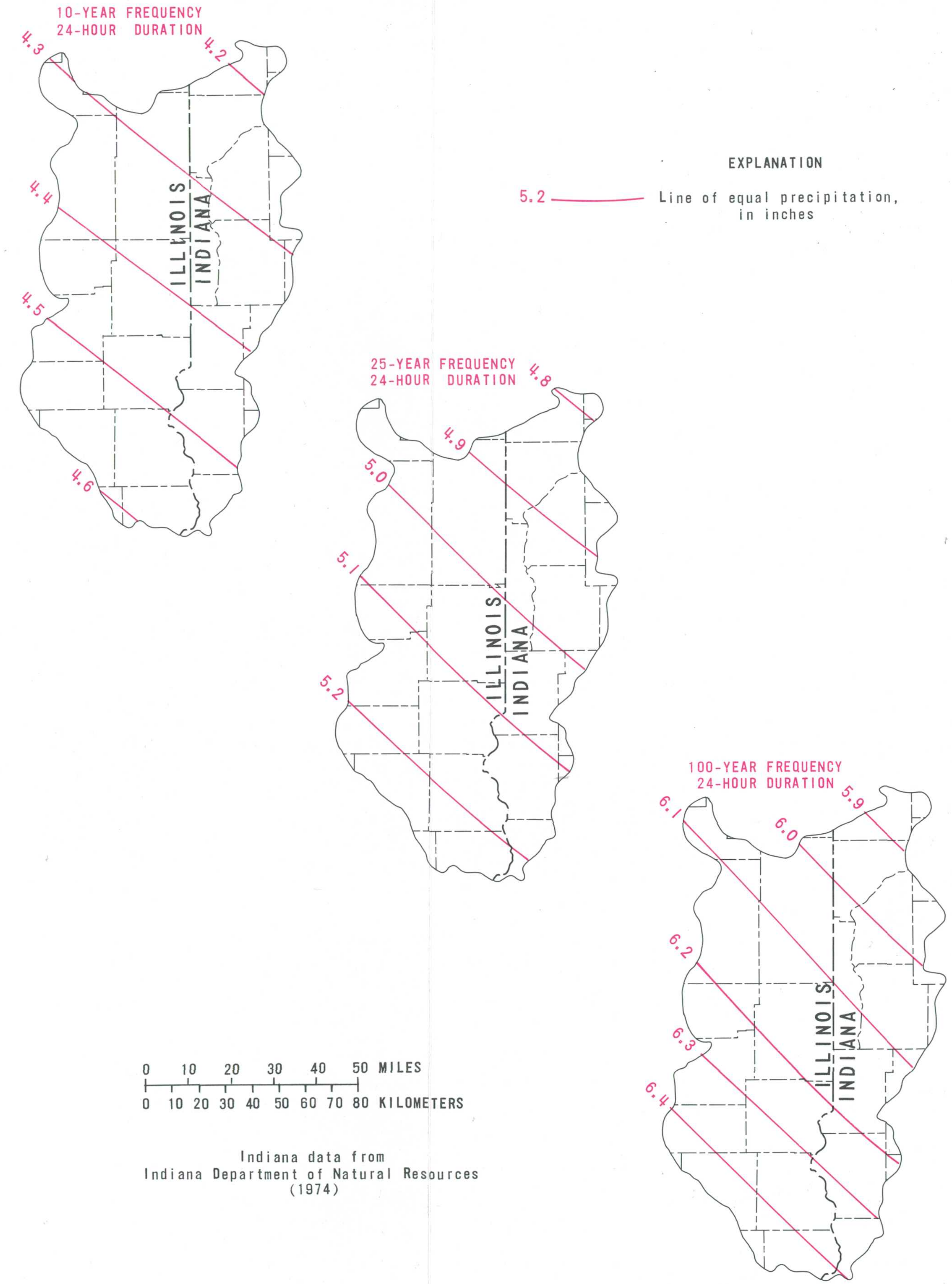


Figure 2.2-2--Magnitude of precipitation and frequency for 24-hour duration.

3.0 PHYSIOGRAPHY

Physiography is Predominantly Lowland Plains

Area 30 is characterized by lowland plains, except for small upland areas in the south and east. Average elevation ranges from 400 feet in the south to 800 feet in the north.

The land slopes generally south, and its average elevation ranges from about 400 feet (NGVD of 1929) in the south to 800 feet in the north. Area 30 was glaciated during the Kansan, Illinoian, and Wisconsin Glaciations. The north and much of the west parts of the study area were glaciated during the Illinoian advance. Three physiographic regions in the Indiana part of the study area (fig. 3.0-1) are described by Schneider (1966, p. 40-50): (1) the Tipton Till Plain, (2) the Wabash Lowland, and (3) the Crawford Upland. Three physiographic regions in the Illinois part of the study area are described by Walton (1965, p. 48-49): (1) the Bloomington Ridged Plain, (2) the Springfield Plain, and (3) the Mt. Vernon Hill Country.

The Tipton Till Plain and the Bloomington Ridged Plain are depositional plains of low relief underlain by thick till and modified only slightly by postglacial stream erosion. The plains are nearly flat to gently rolling and are crossed by several low and poorly developed end moraines. The flatness of the plains is broken by low eskers, esker troughs, and melt water drainways that trend southwest in Indiana and southeast in Illinois.

The Wabash Lowland and the Springfield Plain are underlain by lacustrine, outwash, and alluvial sediments and till and are characterized by extensively aggraded valleys. The lowlands are broad plains with low rolling hills. The north parts of the lowland and plain have less relief than the south parts.

The Crawford Upland is underlain by alternating layers of sandstone, shale, and limestone that have been eroded to produce a mature, dissected upland with diverse topographic features. The area has a well-developed drainage pattern. Drainage divides are generally flat but narrow, and the valley walls are steep. The bottoms of the large valleys are moderately wide flood plains and are generally the only level land in the area.

The Mt. Vernon Hill Country has gently rolling topographic features that are controlled chiefly by the underlying bedrock. The uplands are well dissected, and the lowlands are broad and have low-gradient alluvial river plains.

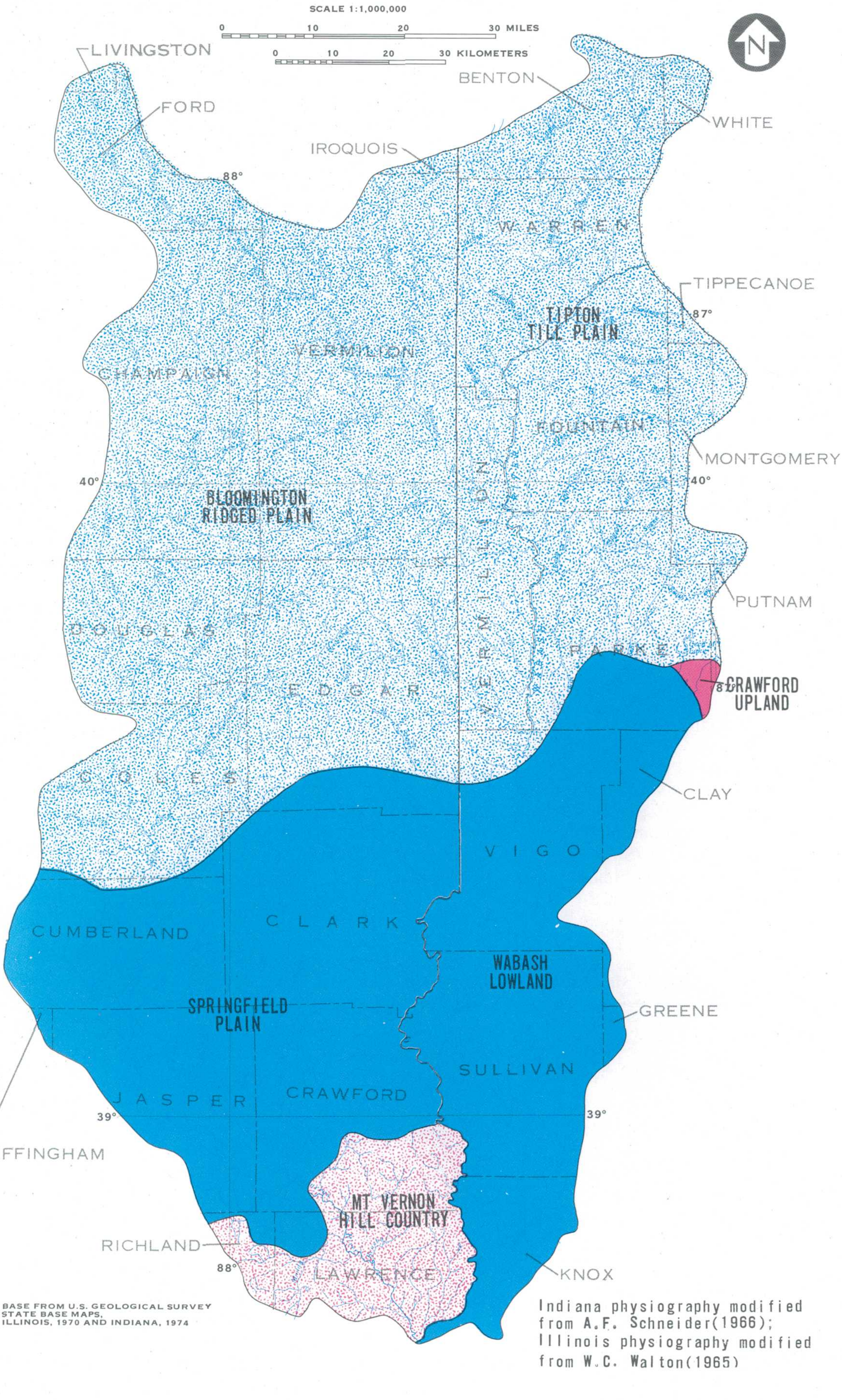


Figure 3.0-1--Physiography.

4.0 GEOLOGY

4.1 Bedrock Geology

Bedrock Composed of Pennsylvanian, Mississippian, Devonian, and Silurian Marine Deposits

Bedrock, predominantly Pennsylvanian, contains several extensive coal beds of commercial importance. Bedrock units dip into the Illinois Basin at generally less than 1°.

Area 30 is entirely within the Illinois Basin. Dip of the rock into the basin, generally less than 1°, ranges from 10 to 30 feet per mile (Gutschick, 1966, p. 10). The LaSalle Anticline, trending northwest to southeast, borders the west edge of the study area (Willman and others, 1975, p. 23). Pennsylvanian rocks (shale, siltstone, limestone, sandstone, and coal) are predominant. Mississippian, Devonian, and Silurian rocks crop out at the north edge of the study area (fig. 4.1-1).

Correlations between rock units in Illinois and Indiana are shown in the adjacent stratigraphic section (fig. 4.1-2). The Kewanee Group in Illinois contains 99 percent of the mapped coal reserves in Illinois. The principal economic coals are in the Carbondale Formation (Hopkins and Simon, 1975, p. 183 and 187). The principal economic coals in Indiana are in the Carbondale Group (Shaver and others, 1970, p. 32-33). Major commercial coal members and their importance to mining in the two States are listed in table 4.1.

The Upper and the Lower Block coals, mined in Clay and Owen Counties, provide 11 percent of Indiana's coal production (Powell, 1972, p. 6). The correlative coals in Illinois are only mined locally (Hopkins and Simon, 1975, p. 182-183). Springfield coal (V) provides 49 percent of Indiana's coal production. The comparable Illinois unit, Springfield-Harrisburg (No. 5), is the second most productive coal in Illinois (Powell, 1972, p. 6; Hopkins and Simon, 1975, p. 187). Herrin coal (No. 6) is the most productive Illinois unit, but the Herrin coal in Indiana is thin and discontinuous (Hopkins and Simon, 1975, p. 187).

Mississippian, Devonian, and Silurian rock units are in only a small part of the study area. For detailed information on all bedrock units in Area 30, refer to Shaver and others (1970) and Willman and others (1975).

Table 4.1 Major coal members in Indiana and Illinois

Indiana	Illinois
Danville (VII)[1]	Danville (No. 7)[1]
Hymera (VI)[1]	Jamestown
Herrin	Herrin (No. 6)[1]
Springfield[1]	Springfield-Harrisburg (No. 5)[1]
Survant (IV)[1]	Shawneetown
Colchester (IIIa)	Colchester (No.2)[1]
Seelyville (III)[1]	Seelyville[1]
Minshall[1]	----------------------------
Upper Block[1]	Delwood
Lower Block[1]	Willis

[1]Commercially important coal

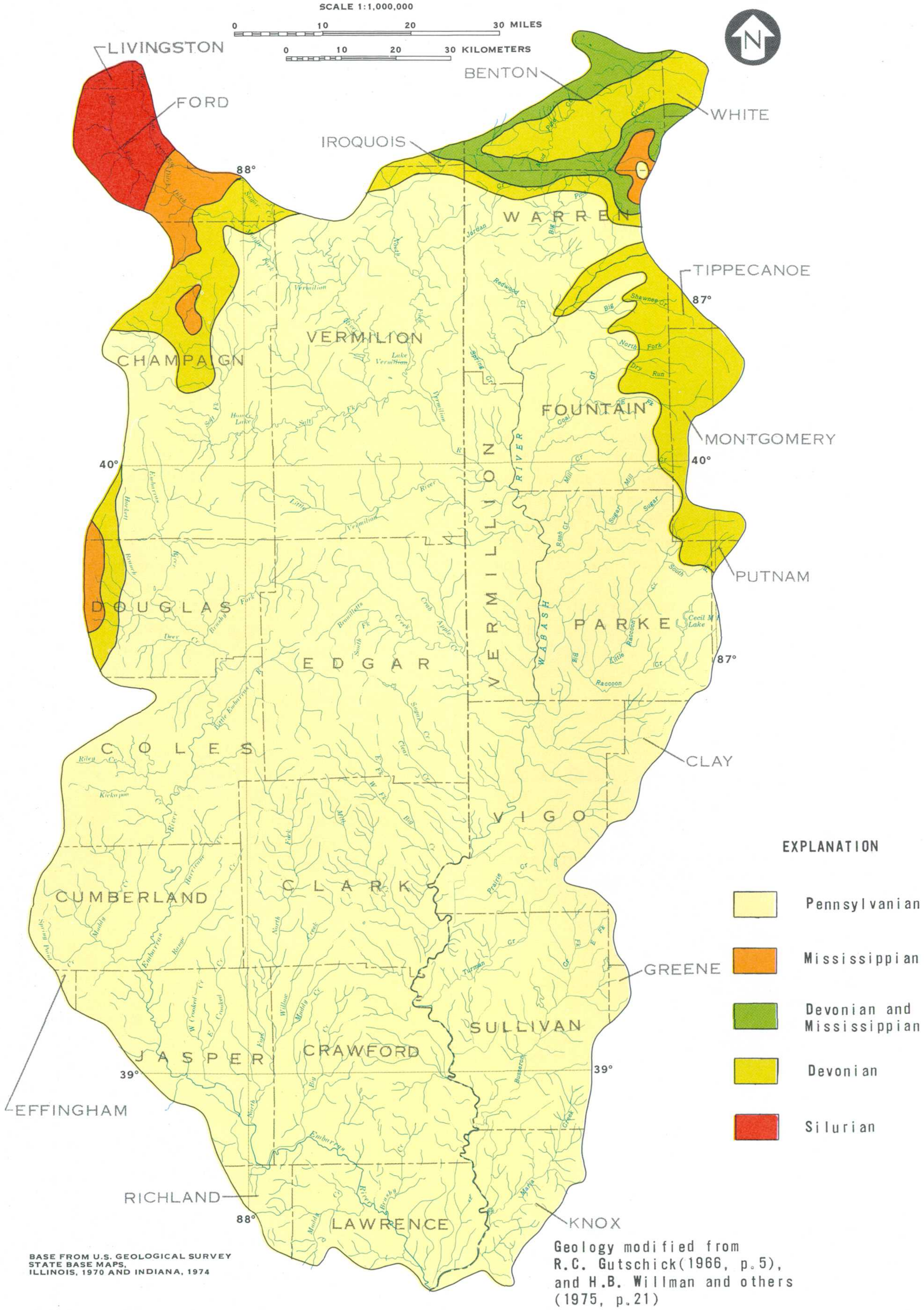
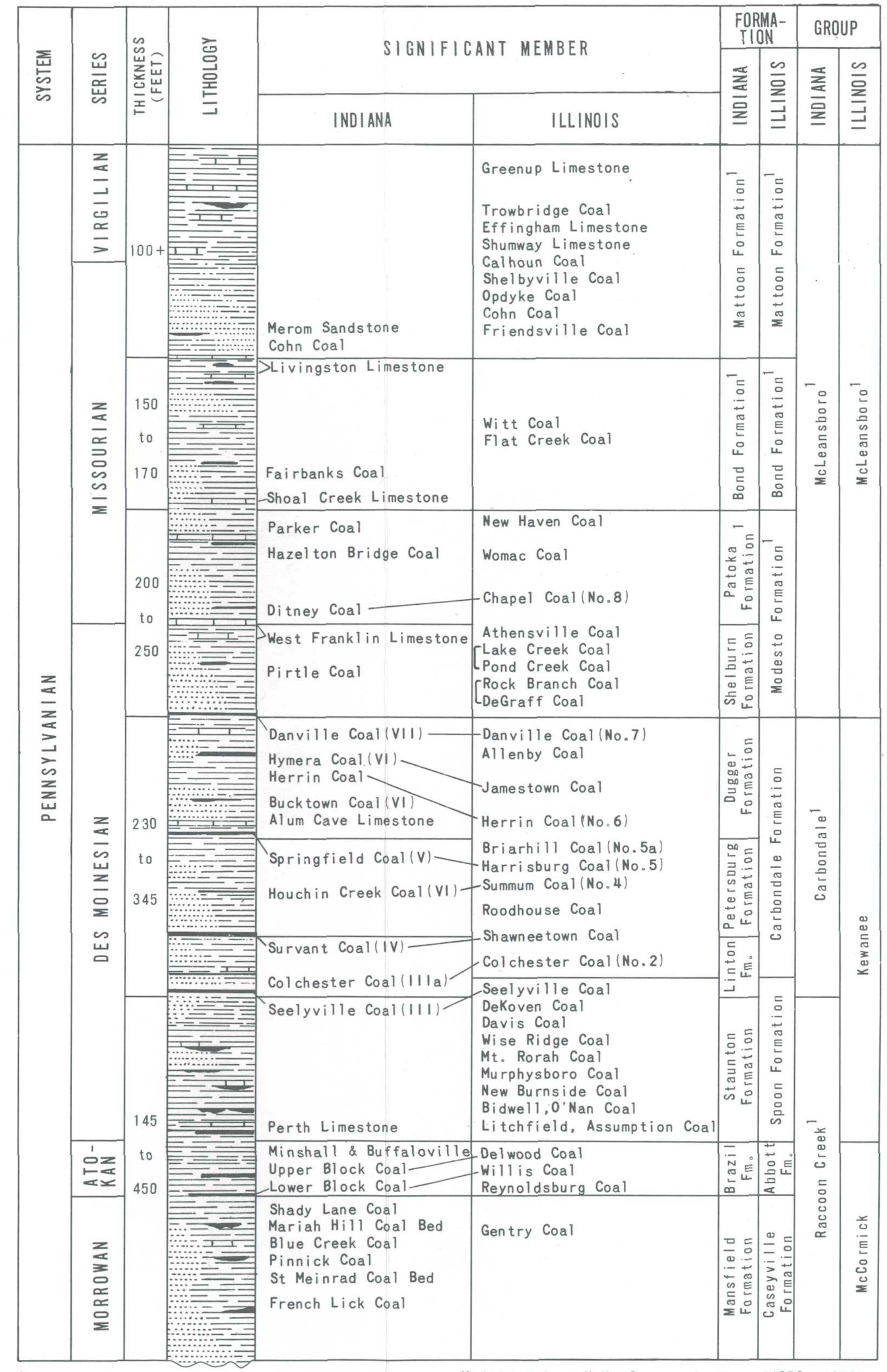


Figure 4.1-1.--Bedrock geology.



[1]Usage of Indiana Geological Survey

Modified from H.H. Gray and others(1970, 1979) and J.B. Patton(1956) and J.C. Frye and H.B. Willman (1975, p.167, 171)

The stratigraphic nomenclature follows the usage of the Illinois Geological Survey and the Indiana Geological Survey and differs somewhat from the usage of the U.S. Geological Survey

Figure 4.1-2.--Stratigraphic section.

Unconsolidated Materials in Area 30 are Glacial Deposits

The Kansan, Illinoian, and Wisconsin glacial advances left deposits of unsorted gravel, sorted sand and gravel, and loess. Thickness of unconsolidated material ranges from about 50 to 400 feet.

At least three glacial advances during the Pleistocene Epoch buried most of the bedrock surface under drift (Wayne, 1958). The first glacial advance into the area was the Kansan, followed by the Illinoian and then the Wisconsin. Each advance was followed by a warm interglacial period of plant growth, weathering, and erosion. The glacial and interglacial sequence is shown in the adjacent chart of the Pleistocene Epoch (figure 4.2-1). Extent of drift cover by the Illinoian and Wisconsin advances is shown in figure 4.2-2.

Deposits associated with the Kansan advance are buried under deposits of subsequent glacial advances. No surface deposits of Kansan drift are known; however, weathering zones commonly allow identification of the different ages of drift. Kansan deposits in buried valleys may be 150 feet thick (Piskin and Bergstrom, 1975, p. 210).

Illinoian deposits covering Area 30 obscure the Kansan drift. Thickness in the area covered by only Illinoian deposits ranges from about 50 to 200 feet (Frye and Willman, 1975, p. 213). Loess associated with the Illinoian Glaciation is thin because of interglacial weathering.

Wisconsin drift is the uppermost deposit in the northern two-thirds of Area 30, where glacial features shape the landscape. Thickness of the drift ranges from about 50 to 400 feet (Frye and Willman, 1975, p. 213). Wisconsin loess covers the remaining one-third of the area. A thickness of 4 feet is common in the Illinois part of Area 30 but is as much as 8 feet in areas adjacent to the Wabash River (Piskin and Bergstrom, 1975, p. 6).

Deposits since the Wisconsin Glaciation, have been assigned to the Holocene Epoch (Frye and Willman, 1975, p. 230). They include alluvium, colluvium, sand dunes, and lake sediments that are primarily reworked and redistributed glacial deposits.

QUATERNARY SYSTEM	PLEISTOCENE SERIES	
		HOLOCENE
		WISCONSIN GLACIAL ADVANCE
		SANGAMONIAN
		ILLINOIAN GLACIAL ADVANCE
		YARMOUTHIAN
		KANSAN GLACIAL ADVANCE

Modified from K. Piskin and R.E. Bergstrom (1975, p.4) and W.J. Wayne(1966,p.29)

Figure 4.2-1. --Pleistocene glaciation and interglaciation affecting Area 30.

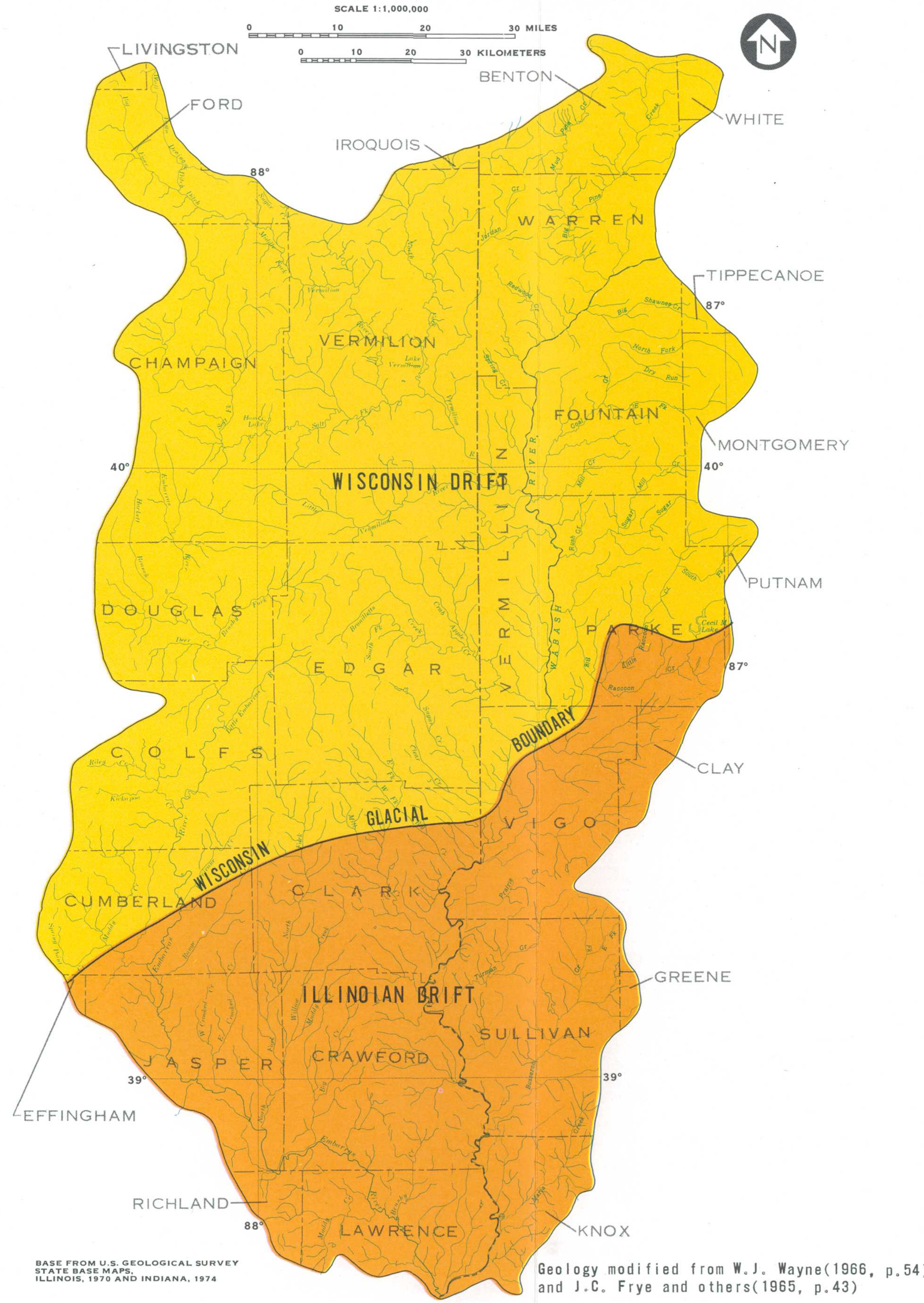


Figure 4.2-2. --Glacial geology.

Coal Production and Estimated Reserves

About 860 million tons of bituminous coal was produced in the counties in Area 30 from 1812 to 1978. Coal reserves were estimated to total 9 billion tons in the counties in Area 30 but these estimates are revised as mining technology advances.

None of the counties in Area 30 is a major coal producer. About 4.8 million tons of coal (20 percent of the State production) was produced in the counties in the Indiana part of Area 30 during 1978. About 2 million tons (4.2 percent of the State production) was produced in the counties in the Illinois part of Area 30. The coal-production data used in this report represent production by county and, therefore, should not be totaled to represent production in the study area. Several counties are represented in more than one study area, and their production figures appear in other study-area reports. Electrical utilities are the major consumers of this coal. In 1978, 98 percent of the coal produced in Indiana and 47 percent of the coal produced in Illinois came from surface mines (Indiana Bureau of Mines and Mining, 1979, and Illinois Department of Mines and Minerals, 1978, respectively).

Estimates of coal reserves are subject to revision because of advances in mining technology. The 1978 estimates were based on removing 90 feet of overburden. Technology in 1982 allows for removal of 120 feet of overburden; with some equipment, as much as 150 feet of overburden can be removed. As technology and equipment are improved, thickness of overburden removed and, therefore, the amount of strippable reserves, will increase. Also, the techniques for calculating coal reserves are improving, and the number and the depth of test wells are increasing.

Indiana coal production for 1812-1970 was summarized by Carter and others (1974, p. III-11) and Wier (1973, p. 21). Data for 1971-78 are from annual reports of the Indiana Bureau of Mines and Mining (1972-79). Maps showing locations of active surface and underground coal mines in some of the counties in southwestern Indiana are available from the Indiana Department of Natural Resources (1980). Maps showing locations of areas strip mined for coal (Powell, 1972 and 1976) and of active mines (Powell, 1977) are also available for Indiana. A series of maps showing the distribution, structure, and mined areas of coal (including abandoned surface and underground mines) as well as a series showing geology and coal deposits in the coal-producing counties of Indiana is available from the Indiana Geological Survey. Illinois coal-production figures are from the Illinois Department of Mines and Minerals (1978) and Treworgy and others (1978). A series of maps showing the strippable coal reserves in Illinois and two coal-resources maps showing locations and thicknesses of the Springfield and Herrin coal members are available from the Illinois Geological Survey. Coal-production figures and estimates of coal reserves by county for Area 30 from 1812 through 1978 are listed in table 5.

Table 5. Coal production and estimates of reserves.

[Sources of data: INDIANA--Estimates of reserves, from Donald L. Eggart, Indiana Geological Survey, written commun., March 1980; Coal production, from Carter and others, 1974, p. III-II; Wier, 1973, p. 21; Indiana Bureau of Mines and Mining, 1972-79. ILLINOIS--Estimates of reserves, from Treworgy and others, 1978; Coal production, from Illinois Department of Mines and Minerals, 1978; NA, data not available for publication]

Counties	Coal production[2] in Indiana 1812-1978 (tons)	Estimates of recoverable reserves in thousand tons[1]		
		Strippable	Underground	Total
Fountain	3,991,324	32,245	3,602	35,847
Knox	117,599,560	141,330	2,241,269	2,382,599
Parke	20,773,031	9,492	29,502	38,994
Sullivan	193,846,662	273,484	3,482,223	3,755,707
Vermillion	83,766,329	27,726	294,336	322,062
Vigo	247,820,597	253,780	1,448,432	1,702,212
Warren	35,005	Included in Franklin County		

Counties	Coal production[2] in Illinois 1882-1978 (tons)	Estimates of recoverable reserves in thousand tons[1]		
		Strippable	Underground	Total
Clark	4,482	-------	NA	NA
Coles	198,932	-------	NA	NA
Crawford	45,400	21,305	NA	NA
Douglas	26,487,279	-------	NA	NA
Edgar	915,698	64,051	NA	NA
Jasper	23,739	-------	NA	NA
Richland	154	-------	NA	NA
Vermilion	165,264,289	146,499	NA	NA

[1]These estimates are subject to revision as mining techniques advance. The estimates are based on removing 90 feet of overburden. Technology in 1982 allows for removal of 120 feet of overburden; with some equipment, as much as 150 feet of overburden can be removed. As technology and equipment are improved, thickness of overburden removed and, therefore, the amount of strippable reserves will increase. Also, the techniques for calculating coal reserves are improving, and the number and the depth of test wells are increasing.

[2]Data listed in the table represent coal production by county, and, therefore, should not be totaled to represent production within the study area. Several counties are represented within more than one study area, and their production figures appear in other study-area reports.

Soil Associations and Land Slope Vary Widely

Area 30 contains 30 soil associations that are subdivided into 81 major soil types.

The surface horizons of many of the soils in Area 30 are light- or dark-colored silty loams or silty-clay loams underlain by clay loams and silty clays. Factors affecting the usefulness of a soil include texture, soil depth, permiability, slope, fertility, and vegetative cover. Slopes of poor to well-drained soils generally range from zero (level terraces and plains) to 35 percent. Removal of vegetation during disruptive activities such as mining, road construction, and farming may cause erosion on the slopes. A report by Wischmeier and Smith (1978) contains useful information for predicting erosion losses due to rainfall.

Soil associations are shown in figure 6.0-1, and generalized descriptions of the associations are listed in section 13.1. Information is from an Indiana soils association map published by the U.S. Soil Conservation Service (1977a) and an Illinois soil survey by Fehrenbacher and others (1967). More detailed soils maps and information on the engineering properties of the soils in Area 30 are available in county soil surveys that are also published by the Soil Conservation Service.

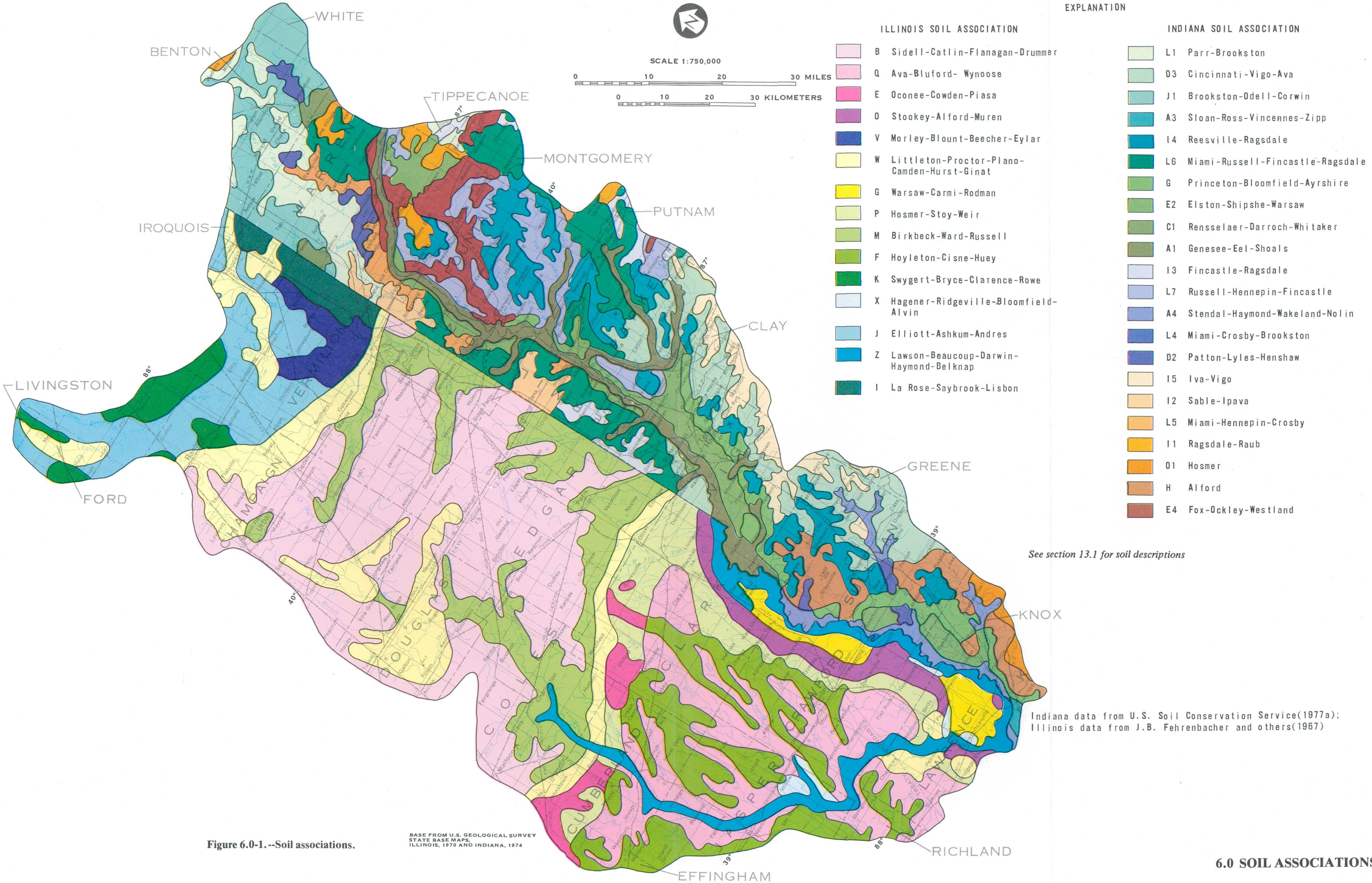


Figure 6.0-1.--Soil associations.

7.0 LAND USE AND PRIME FARMLAND

Most of Area 30 is Agriculture or Forest Land

Area 30 is 83 percent farmland, and 10-percent forest land. Less than 1 percent of the total land area is affected by mining.

General land-use categories by area and percentage of total area for the 20 counties in Area 30 are listed in table 7. Land use in this report is presented by county and, therefore, should not be totaled to represent production within the study area. Several counties are represented within more than one study area, and their land-use figures appear in other study-area reports. Land-use categories are described in the following list:

• Agriculture--row crop, pasture, small grains, and barren rural lands

• Urban--residential, commercial, industrial, institutions, and recreational

• Forest--commercial forest and wooded farm lots.

• Water--lakes, ponds, and rivers

• Wetland--marsh or bog areas

• Mine--surface area affected by strip or underground mines (In Illinois, "mined" is included in "other".)

• Other--miscellaneous land uses not generally categorized (In Illinois, "other" includes strip mines, road cuts, and borrow pits.)

Land-use maps for most of the counties in Indiana are available from the Indiana State Board of Health, Stream Pollution Control Board (1980), at a scale of 1:250,000.

Limits on the mining of prime farmland (land best suited for producing food, fiber, forage, and oil-seed crops) are given in the Surface Mining Control and Reclamation Act of 1977. The Soil Conservation Service is responsible for defining areas of prime farmland, which are shown in figure 7.0-1.

Table 7 Land use by county for Area 30.

County	Agri-culture	Urban	Forest	Water	Wet-land	Mine[1]	Other	Total (acres)
	(acres/percent)							
Indiana								
Benton[2]	249,133 95.2	1,919 0.7	4,078 1.5	120 <0.1	262 0.1	20 <0.1	6,228 2.4	261,760
Fountain[2]	213,000 83.9	2,750 1.1	29,205 11.5	1,242 .5	254 .1	520 .2	6,870 2.7	253,841
Knox[3]	266,500 80.7	15,814 4.8	38,000 11.5	2,091 .6	30 <.1	311 .1	7,494 2.3	330,240
Parke[3]	154,055 53.4	1,646 .6	126,435 43.8	3,172 1.1	0 0	3,290 1.1	0 0	288,598
Sullivan[2]	245,144 83.8	4,389 1.6	29,367 10.0	2,924 1.0	0 0	10,676 3.6	0 0	292,500
Vermillion[2]	121,579 72.2	2,744 1.6	38,810 23.1	1,649 1.0	0 0	3,517 2.1	0 0	168,299
Vigo[2]	191,816 72.2	22,601 8.5	42,151 15.9	3,055 1.2	0 0	5,976 2.2	0 0	265,599
Warren[2]	205,679 87.4	1,726 .7	21,065 9.0	915 .4	436 .2	260 .1	5,179 2.2	235,260
Illinois								
Champaign[4]	582,567 91.0	35,441 5.5	9,400 1.5	509 .1	-----	------	12,083 1.9	640,000
Clark[4]	260,299 80.5	12,232 3.8	48,000 14.9	448 .1	-----	------	2,221 .7	323,200
Coles[4]	273,275 84.2	26,161 8.1	24,084 7.4	532 .2	-----	------	428 .1	324,480
Crawford[4]	218,265 77.2	16,015 5.7	47,400 16.7	550 .2	-----	------	650 .2	282,880
Cumberland[4]	184,548 83.3	11,671 5.3	24,483 11.1	300 .1	-----	------	438 .2	221,440
Douglas[4]	252,071 93.9	9,488 3.5	4,700 1.7	310 .1	-----	------	2,171 .8	268,740
Edgar[4]	357,190 88.8	22,040 5.5	20,312 5.1	260 .1	-----	------	2,118 .5	401,920
Ford[4]	292,096 93.5	11,028 3.5	1,254 .4	140 <.1	-----	------	7,802 2.5	312,320
Jasper[4]	259,222 81.7	7,800 2.5	44,287 14.0	1,150 .4	-----	------	4,341 1.4	316,800
Lawrence[4]	185,951 77.6	9,950 4.2	34,000 14.2	945 .4	-----	------	8,514 3.6	239,360
Richland[4]	192,996 82.9	12,200 5.2	26,748 11.5	300 .1	-----	------	716 .3	232,960
Vermilion[4]	491,351 85.4	40,753 7.1	33,843 5.9	932 .2	-----	------	7,841 1.4	574,720
Total	5,196,737 83.3	268,368 4.3	647,622 10.4	21,544 .3	982 <.1	24,570 .4	75,094 1.2	6,234,917

[1]In Illinois, mined lands are combined with road cuts and borrow pits and the land use classified as "other."
[2]Mark Blade, West Central Indiana Economic Development District, Inc., written commun., December 1979.
[3]Kris Kothe, Indiana State Planning Services Agency, written commun., December 1979.
[4]Illinois Conservation Needs Committee, 1970.

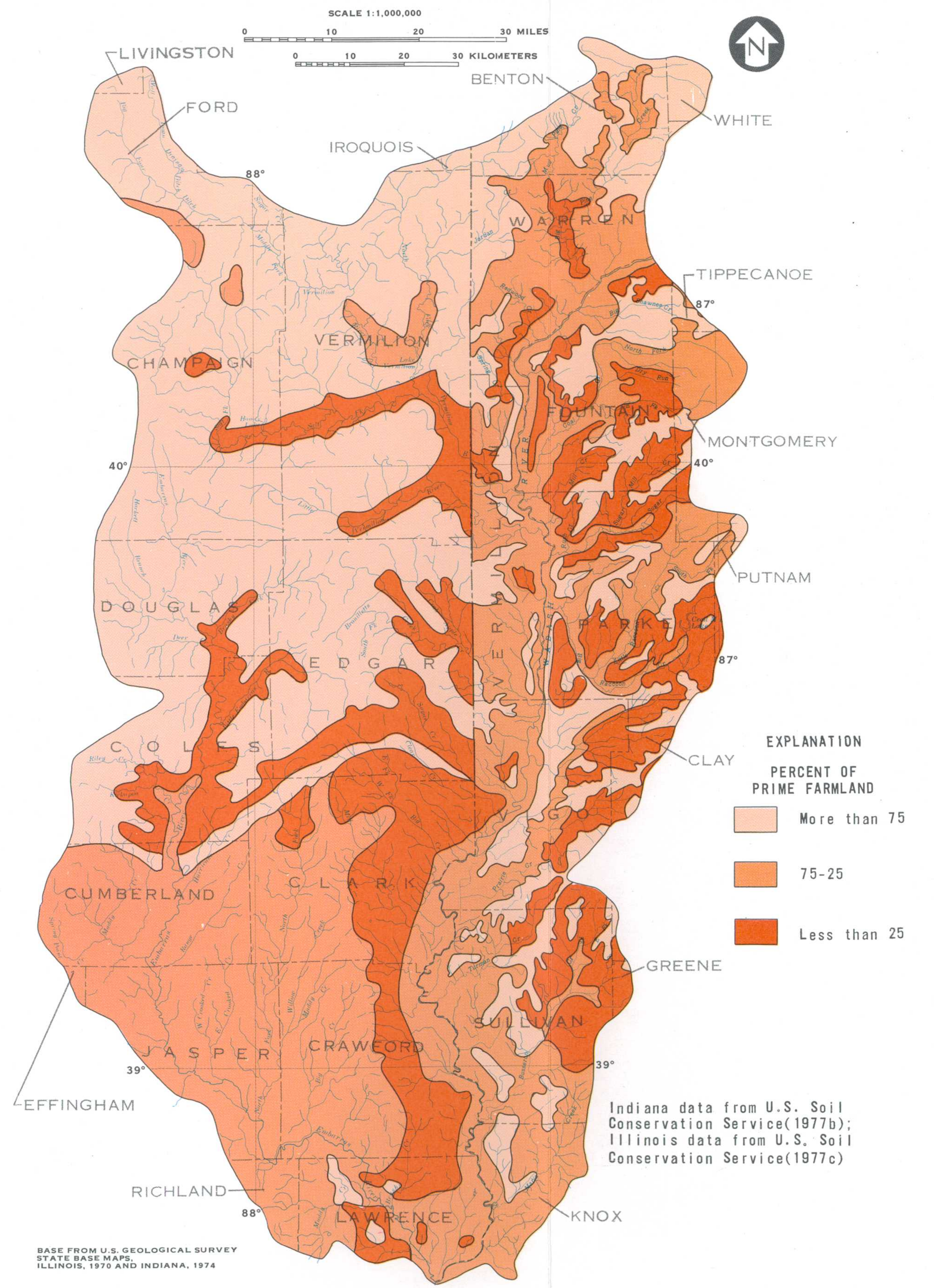


Figure 7.0-1.--Prime farmland.

Description of U.S. Geological Survey Network

Discharge data are available for 40 continuous-record stations, 9 low-flow stations, and 13 crest-stage partial-record stations.

Discharge data analyzed for this report have been collected at 40 continuous-record stations, 9 low-flow stations, 13 crest-stage partial-record stations, and at several miscellaneous measurement sites. Gaging stations are listed in section 13.4, and their locations are shown on figure 8.1-1.

Length and type of records available at gaging stations vary. The stream flow on Big Raccoon Creek at Ferndale, Ind., and at Coxville, Ind., has been controlled by the Cecil M. Harden Lake since December 1960. The analyses for these stations were computed for the period of record beginning with the 1960 water year, representing regulated conditions. The station on Big Raccoon Creek at Mansfield, Ind., was discontinued in September 1958. The analyses for this station represent the unregulated condition of Big Raccoon Creek.

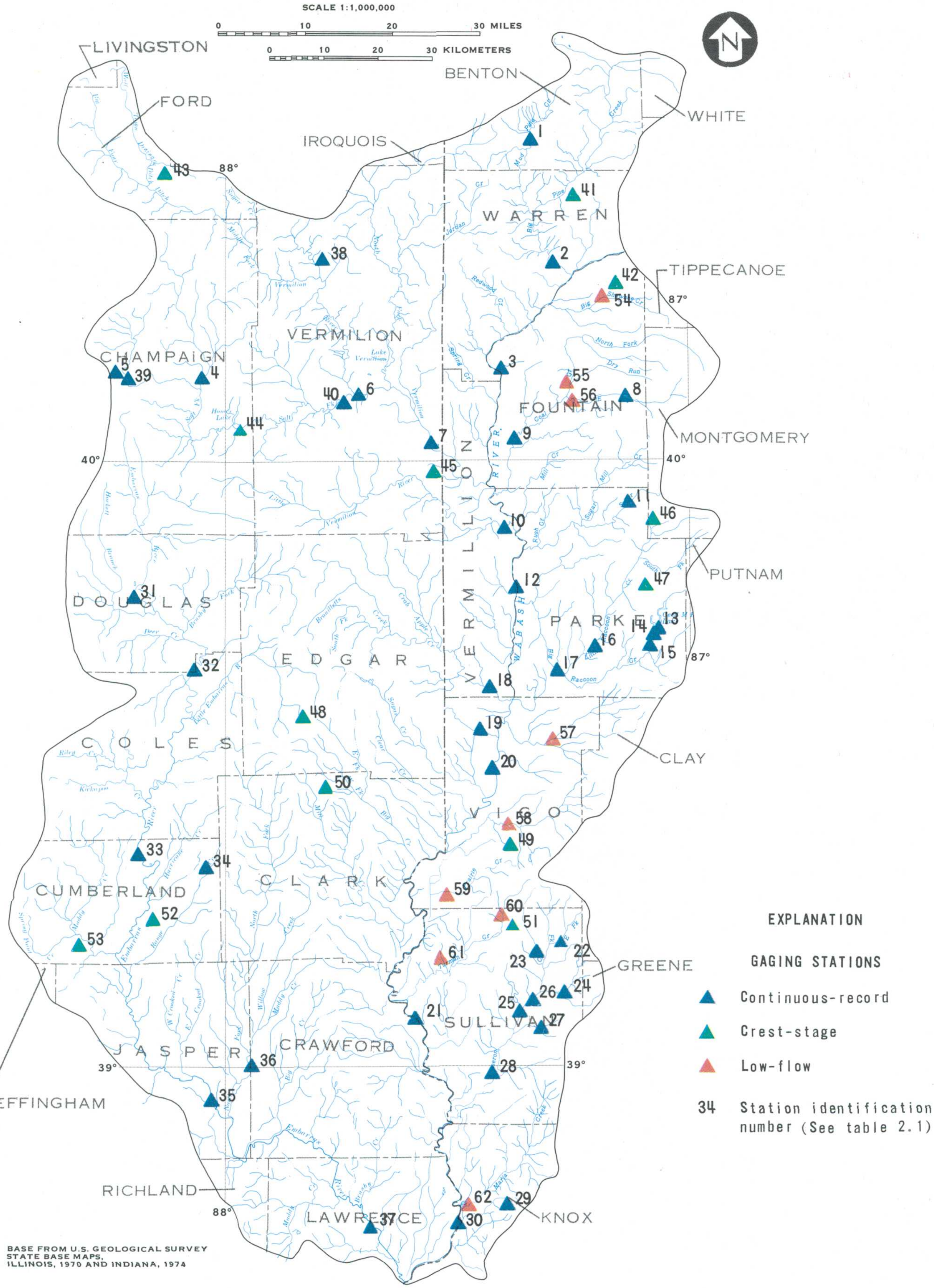


Figure 8.1-1. --Gaging stations.

Estimates of 7-Day, 10-Year Low Flow Presented for 45 Stations

Low-flow is highly variable in Area 30. Physiography plays a major role in determining the low-flow characteristics of an area.

The 7-day, 10-year low flow is the lowest average rate of flow for 7 consecutive days to which streamflow can be expected to decline in 1 year out of 10. For Indiana, where continuous record was sufficient, 7-day, 10-year low flow was estimated by fitting low-flow measurements to a log-Pearson type-III frequency distribution (Meeks, 1975). For partial-record stations, the frequency was estimated by correlating the measured flows with flows at a long-term, continuous-record index site, where the low-flow frequency has been defined. Streamflow at partial-record sites was measured during base flow, when flow is primarily contributed by ground-water discharge. For Illinois, estimates of 7-day, 10-year low flows are listed in a report by Singh and Stall (1973). Station locations are shown in the adjoining map (fig. 8.2-1). Estimates of 7-day, 10-year low flows are listed in table 8.2.

Physiography plays a major role in determining low-flow characteristics. The highly dissected Crawford Upland and the Mt. Vernon Hill Country represent diverse areas in terms of surface flow. Steep slopes result in rapid runoff and little sustained flow. However, where erosion has been severe enough to penetrate into the karst limestone, springs can be numerous (Schneider, 1966, and Walton, 1965).

The Wabash Lowland and the Springfield Plain are underlain by siltstone and shale beds and are capped by a layer of till (Schneider, 1966, and Walton, 1965). The 7-day, 10-year low flows for these lowlands are minimal because of the relative absence of surficial aquifers. An exception is the outwash areas along major streams, which store water during high flow and rainstorms and release it to the streams during low flow.

The Tipton Till Plain and the Bloomington Ridged Plain are deposited plains of low relief underlain by thick till and glacial outwash (Schneider, 1966 and Walton, 1965). Low flow is highly variable in these areas. Streams cut in outwash deposits may have sustained annual flows, whereas streams cut in clay till may have little or no sustained flow.

Table 8.2 Estimates of 7-day, 10-year low flow

ID (See fig. 8.2-1)	Station name	Station number	Drainage area (mi^2)	Q7, 10 (ft^3/s)
1	Mud Pine Creek nr Oxford, Ind.	03335690	39.4	[1]0.4
2	Big Pine Creek nr Williamsport, Ind.	03335700	323	[1]7.6
54	Big Shawnee Creek nr Attica, Ind.	03335800	42	[2]7.4
3	Wabash River at Covington, Ind.	03336000	8,218	[1,3]714
38	Bluegrass Creek at Potomac, Ill.	03336500	35	[4]0
4	Salt Fk nr St. Joseph, Ill.	03336900	134	[4,5]3.6
5	Boneyard Creek at Urbana, Ill.	03337000	4.46	[4,5].7
39	Saline Branch at Urbana, Ill.	03337500	68	[4]1.0
40	Salt Fk nr Homer, Ill.	03338000	340	[4]13.5
6	Vermilion River nr Catlin, Ill.	03338500	958	[4]19
7	Vermilion River nr Danville, Ind.	03339000	1,290	[3,4]33
55	Coal Creek nr Veedersburg, Ind.	03339100	77.6	[2]3.3
8	East Fk Coal Creek nr Hillsboro, Ind.	03339108	33.4	[1]3.6
56	East Fk Coal Creek nr Veedersburg, Ind.	03339111	60.1	[2]3.3
9	Coal Creek at Coal Creek, Ind.	03339120	214	[1]7.8
10	Little Vermilion R nr Newport, Ind.	03339150	237	[1].3
11	Sugar Creek nr Byron, Ind.	03340000	670	[1]22
12	Wabash River at Montezuma, Ind.	03340500	11,118	[1,3]851
14	Big Raccoon Creek at Ferndale, Ind.	03340900	222	[1,3]11
15	Big Raccoon Creek at Mansfield, Ind.	00341000	248	[1]2.7
16	Little Raccoon Creek nr Catlin, Ind.	00341200	134	[1]4.0
17	Big Raccoon Creek at Coxville, Ind.	03341300	448	[1,3]28
18	Brouilletts Creek nr Universal, Ind.	03341420	321	[4].6
57	Otter Creek at Burnett, Ind.	03341450	69	[2]2.7
20	Wabash River at Terre Haute, Ind.	03341500	12,265	[1,3]981
58	Honey Creek nr Terre Haute, Ind.	03341580	64	[2].5
59	Prairie Creek at Prairie Creek, Ind.	03341800	24	[2]0
60	Turman Creek nr Farmersburg, Ind.	03341920	77.6	[2]0
61	Turman Creek nr Fairbanks, Ind.	03341950	69	[2]0
21	Wabash River at Riverton, Ind.	03342000	13,161	[1,3]1,160
22	Busseron Creek nr Hymera, Ind.	03342100	16.7	[1,3]0
23	West Fk Busseron Creek nr Hymera, Ind.	03342150	14.4	[1]0
24	Mud Creek nr Dugger, Ind.	03342250	11.9	[1,6].7
25	Busseron Creek nr Sullivan, Ind.	03342300	138	[1,3,6]2.0
26	Buttermilk Creek nr Paxton, Ind.	03342350	16.5	[1,6]0
28	Busseron Creek nr Carlisle, Ind.	03342500	228	[1,3,6].5
62	Maria Creek nr Emison, Ind.	03342700	88	[2].4
30	Wabash River at Vincennes, Ind.	03343000	13,705	[1,3]1,180
31	Embarras River nr Camargo, Ill.	03343400	186	[4]0
32	Embarras River nr Oakland, Ill.	03343500	518	[4].08
33	Embarras River nr Diona, Ill.	03344000	919	[4]3.2
34	Range Creek nr Casey, Ill.	03344500	7.61	[4]0
35	Embarras River at Ste. Marie, Ill.	03345500	1,516	[4]16.6
36	North Fk Embarras R nr Oblong, Ill.	03346000	319	[4]0
37	Embarras R at Lawrenceville, Ill.	03346500	2,333	[4]35

[1]Calculated by log-Pearson type-III analysis.
[2]Calculated by correlation techniques.
[3]Source: Singh and Stall (1973).
[4]Flow partially regulated by upstream reservoir.
[5]Diurnal fluctuation caused by municipal and/or industrial effluent.
[6]Flow affected by surface-mined area.

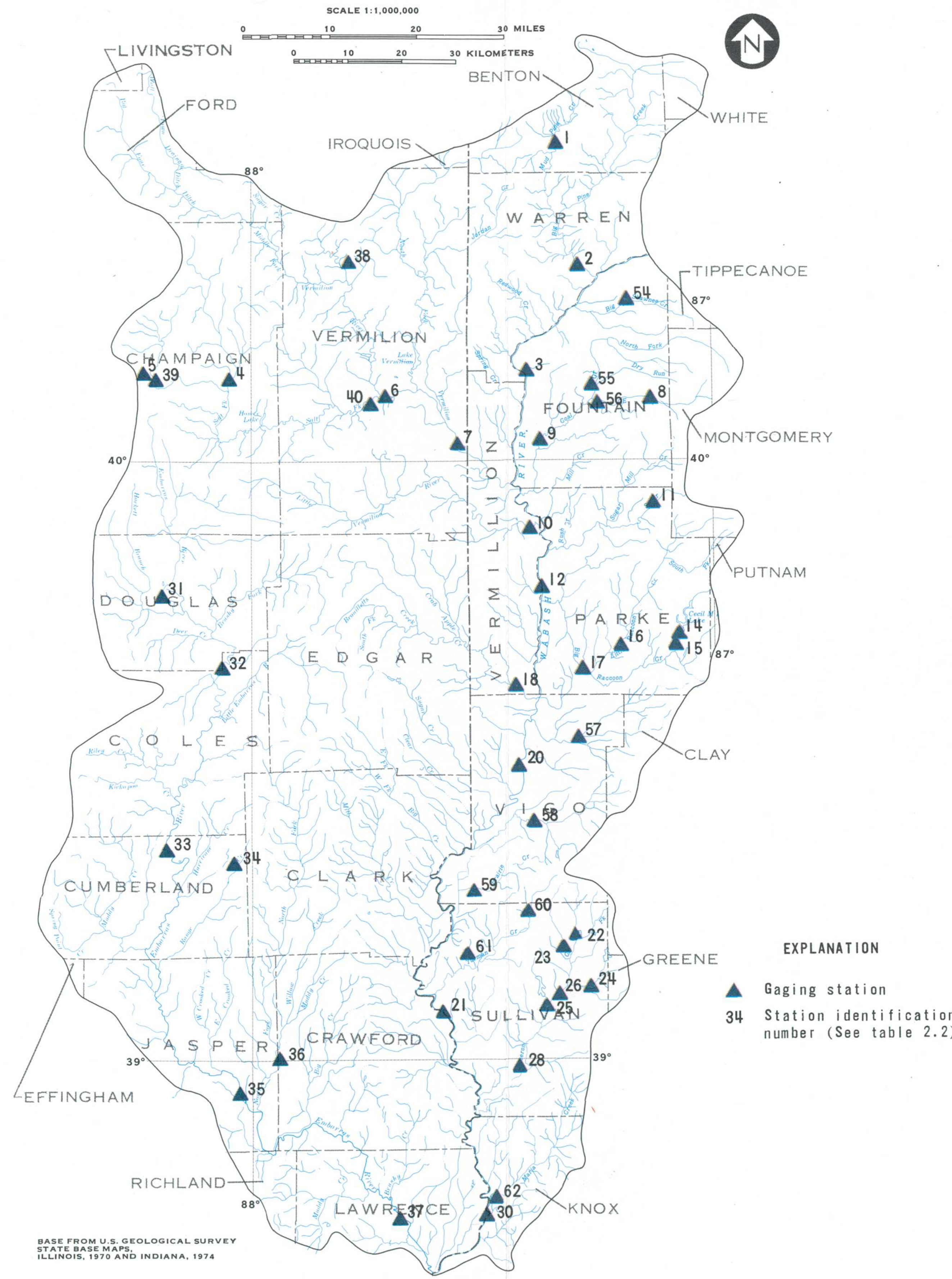


Figure 8.2-1.--Data sites for 7-day, 10-year low-flow calculations.

Flood Frequencies Estimated for Selected Gaging Stations

Precipitation index, drainage area, channel slope, and stream length are important factors controlling the magnitude of various flood frequencies.

The 10-, 25-, 50-, and 100-year floods are of magnitudes expected to be equaled or exceeded once during any 10-, 25-, 50-, or 100-year recurrence interval. These floods have a 10, 4, 2 or 1 percent chance, respectively, of being equaled or exceeded during any year. The recurrence interval represents the long-term average period between floods of a specific magnitude; however, floods of greater magnitude can occur at a shorter interval or even within a given year. Estimates of flood peaks are listed in table 8.3. Locations of the gaging stations used to compute flood peaks are shown in figure 8.3-1.

Discharge records of less than 10 years are insufficient to compute flood peaks. Where records for more than 10 years were available, flood frequencies of 10, 25, 50, and 100 years were computed.

Davis (1974) and Gold (1980), in Indiana, and Curtis (1977), in Illinois, prepared manuals that provide methods for estimating the magnitude and frequency of floods on unregulated and unurbanized streams. Additional methods are provided by the U.S. Soil Conservation Service (1975) for areas less than 2,000 acres. Davis (1974) and Gold (1980) found that precipitation index (precipitation minus snowfall and evapotranspiration) controls flood magnitude for most Indiana streams in the study area. Davis (1974) concluded that, for the Wabash River, drainage area, channel slope, and stream length are the dominant factors and that precipitation index is insignificant. Curtis (1977) found that drainage area, slope, rainfall intensity, and areal adjustment factor are the most significant variables.

The precipitation index and the areal adjustment factors indicate an average to moderately high flood magnitude in the study area compared with flood magnitudes for the rest of the streams in Indiana and Illinois. Therefore, drainage structures and channel alterations should be designed to compensate for this condition.

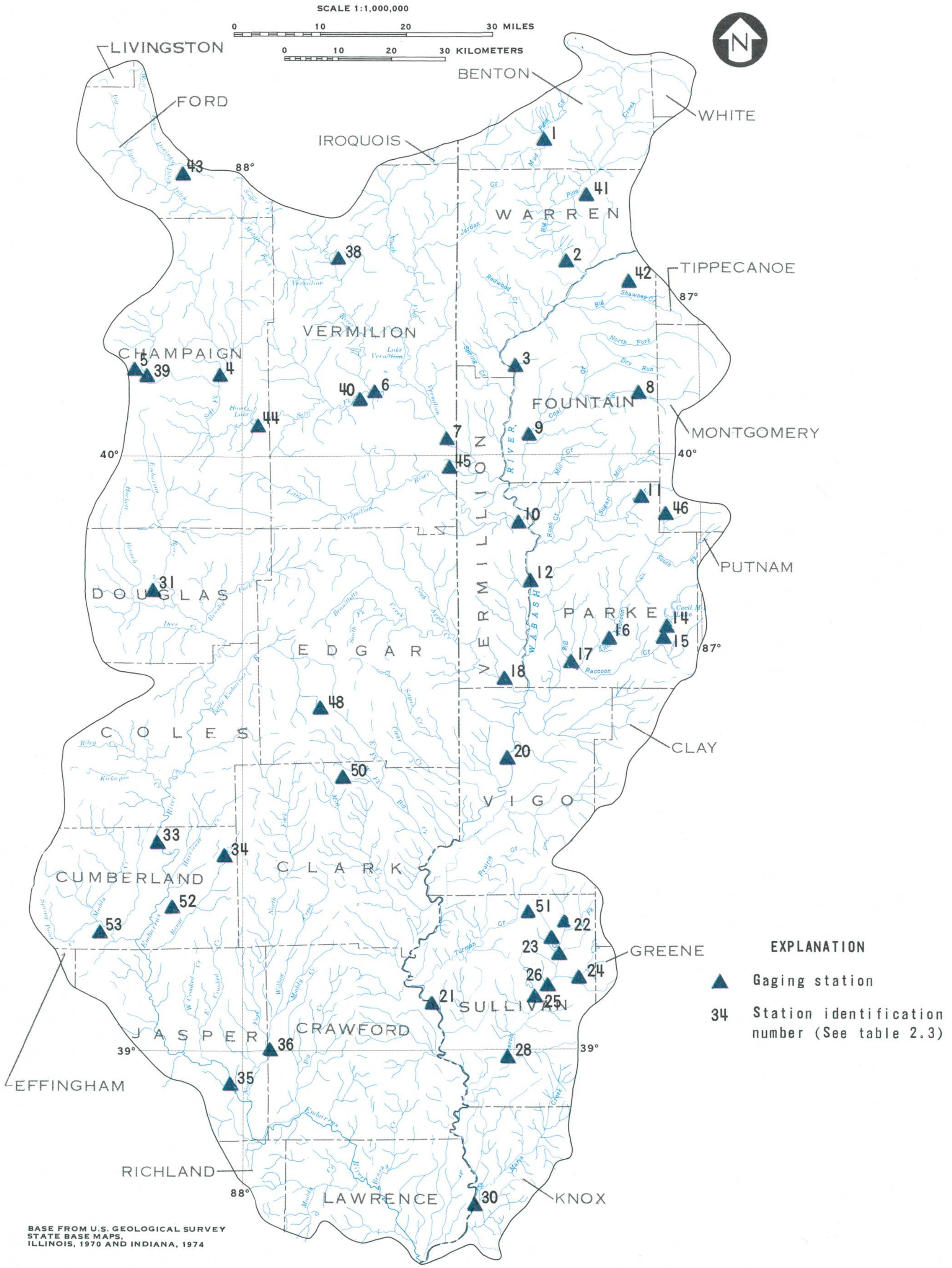


Figure 8.3-1. --Data sites for flood-frequency calculations.

Table 8.3 Estimates of flood peak at selected gaging stations.

ID (See fig. 8.3-1)	Station name	Station number	Drainage area (mi^2)	Years of record	Flood peaks (ft^3/s) 10 years	25 years	50 years	100 years
2	Big Pine Cr nr Williamsport, Ind.	[1]03335700	323	25	8,510	10,000	11,100	12,100
3	Wabash R at Covington, Ind.	[2,3]03336000	8,218	41	70,000	86,000	97,000	109,000
43	Big Four ditch Trib nr Paxton, Ill.	[4]03336100	1.05	25	262	343	406	467
38	Bluegrass Cr at Potomac, Ill.	[4]03336500	35	30	3,310	4,110	4,730	5,290
4	Salt Fk nr St. Joseph, Ill.	[4]03336900	134	22	5,050	6,250	7,120	8,000
39	Saline Br at Urbana, Ill.	[4]03337500	68	40	2,490	3,090	3,540	3,970
40	Salt Fk nr Homer, Ill.	[4]03338000	621	36	7,470	9,360	10,700	12,100
44	Salt Fk Trib nr Catlin, Ill.	[4]03338100	2.2	21	499	680	827	963
6	Vermilion R nr Catlin, Ill.	[4]03338500	958	20	18,600	23,700	27,500	31,200
45	N Fk Vermilion R Trib nr Danville, Ill.	[4]03338800	1.31	22	605	772	906	1,030
7	Vermilion R nr Danville, Ill.	[3,4]03339000	1,290	59	26,000	32,300	36,900	41,300
8	E Fk Coal Cr nr Hillsboro, Ind.	[1]03339108	33.4	12	2,160	2,400	2,570	2,710
11	Sugar Cr nr Byron, Ind.	[1]03340000	670	32	23,500	27,600	30,500	33,200
12	Wabash R at Montezuma, Ind.	[2,3]03340500	11,118	53	92,000	111,000	128,000	140,000
14	Big Raccoon Cr at Ferndale, Ind.	[1,3]03340900	222	24	2,730	3,190	3,500	3,790
15	Big Raccoon Cr at Mansfield, Ind.	[1]03341000	248	20	13,900	17,600	20,300	22,800
16	Little Raccoon Cr nr Catlin, Ind.	[1]03341200	134	16	15,100	21,400	26,800	32,800
17	Big Raccoon Cr at Coxville, Ind.	[1,3]03341300	448	24	19,800	26,400	31,500	36,600
20	Wabash R at Terre Haute, Ind.	[2,3]03341500	12,265	57	99,000	120,000	138,000	152,000
48	Big Cr Trib nr Dudley, Ill.	[4]03341700	1.08	17	385	487	560	639
50	Raccoon Cr Trib nr Annapolis, Ill.	[4]03341900	.04	25	45	61	73	84
21	Wabash R at Riverton, Ind.	[1,3]03342000	13,161	42	106,000	128,000	145,000	160,000
22	Busseron Cr nr Hymera, Ind.	[1,3]03342100	16.7	14	1,750	1,950	2,080	2,210
23	W Fk Busseron Cr nr Hymera, Ind.	[1]03342150	14.4	14	1,670	1,910	2,060	2,210
24	Mud Cr nr Dugger, Ind.	[1,5]03342250	11.9	14	1,110	1,300	1,430	1,550
25	Busseron Cr nr Sullivan, Ind.	[1,3,5]03342300	138	14	5,040	5,940	6,570	7,160
28	Busseron Cr nr Carlisle, Ind.	[1,3,5]03342500	228	37	6,090	7,460	8,470	9,460
30	Wabash R at Vincennes, Ind.	[2,3]03343000	13,706	51	93,000	118,000	132,000	150,000
31	Embarras R nr Camargo, Ill.	[4]03343400	186	20	5,630	6,960	7,930	8,910
33	Embarras R nr Diona, Ill.	[4]03344000	919	17	16,000	19,600	22,400	25,000
52	Embarras R Trib nr Greenup, Ill.	[4]03344250	.08	25	40	51	58	65
53	Muddy Cr Trib at Woodbury, Ill.	[4]03344225	.07	18	77	108	131	155
34	Range Cr nr Casey, Ill.	[4]03344500	7.61	30	2,020	2,650	3,150	3,610
35	Embarras R at Ste. Marie, Ill.	[4]03345500	1,516	69	29,500	38,100	44,700	51,400
36	N Fk Embarras R nr Oblong, Ill.	[4]03346000	319	40	19,300	26,100	31,500	36,400

[1]Calculations by log-Pearson type-III analysis.
[2]Coordinated discharges from Indiana Department of Natural Resources (1979).
[3]Flow partially regulated by upstream reservoir.
[4]Source: Curtis (1977).
[5]Flow affected by surface-mined area.

Flow Duration is Variable

Broad, gently sloping rivers have sustained flow. Steeply sloping streams have low recharge because of minimal surficial aquifers, and thus, have little sustained flow.

Flow-duration curves show the percentage of time that specified discharges were equaled or exceeded during a given period of record. Duration curves for four gaging stations are presented in figure 8.4-1. The 95-, 90-, 75-, 70-, 50-, 25-, and 10-percent flow durations for these and 29 additional stations are listed in table 8.4.

Flow duration was computed by a magnitude-frequency analysis of daily-discharge (Meeks, 1975). The computed discharges, listed in table 8.4, were used to construct the duration curves in figure 8.4-1. The duration curves indicate wide variation in streamflow. Broad rivers with low slopes have a sustained flow. Streams with steep slopes, and low recharge because of minimal surficial aquifers, sustain little flow. The steep slope at the lower end of the flow-duration curve in figure 8.4-1 indicates that streamflow is not sustained and that runoff is primarily a response to precipitation.

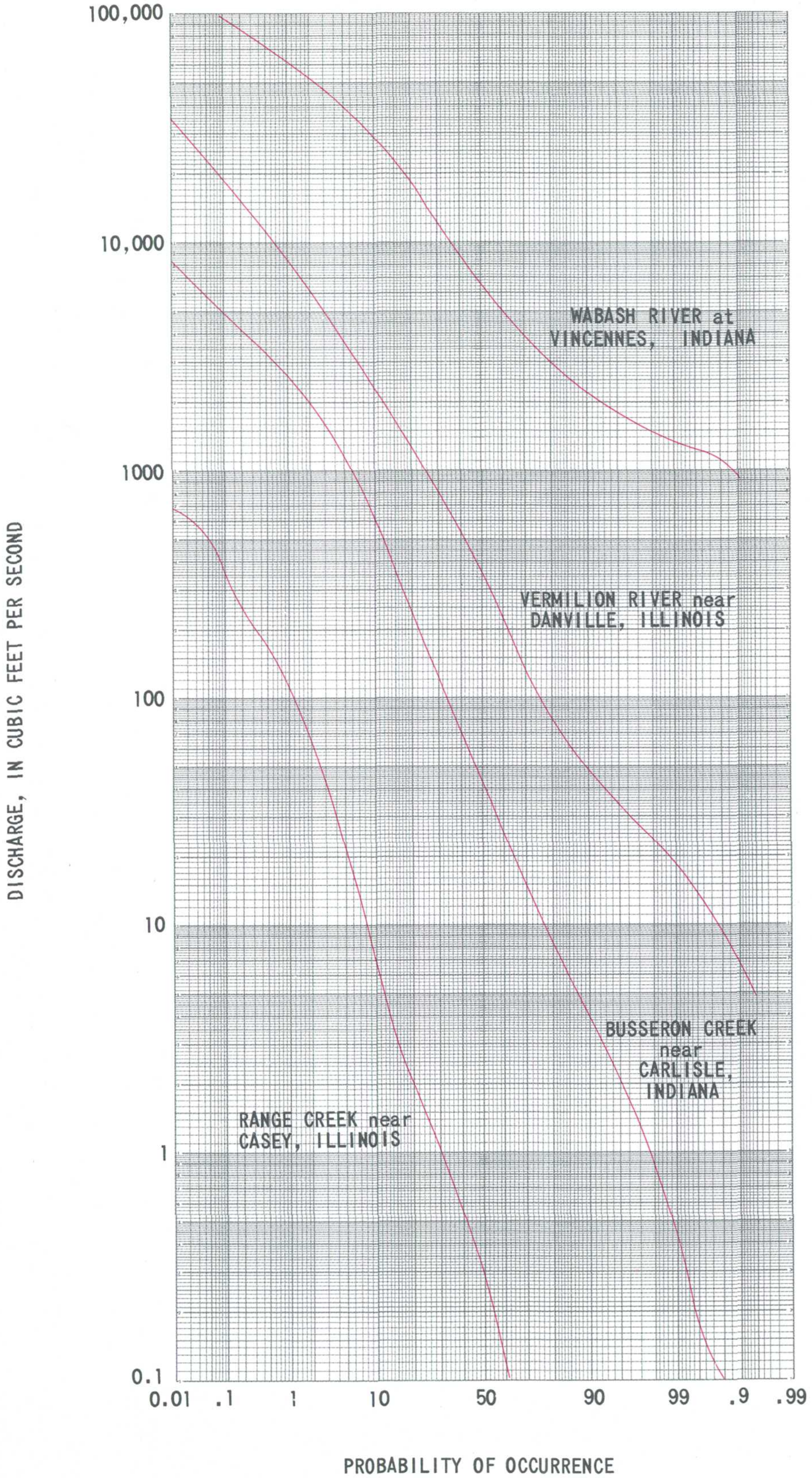


Figure 8.4-1. --Duration curves for selected sites.

Table 8.4 Flow duration at selected gaging stations, in cubic feet per second.

ID (See fig. 8.4-2.)	Station name	Station number	Percent of time flow is exceeded						
			95	90	75	70	50	25	10
1	Mud Pine Cr nr Oxford, Ind.	03335690	0.7	1.0	4.1	5.8	17	46	96
2	Big Pine Cr nr Williamsport, Ind.	03335700	14	18	38	50	120	280	600
3	Wabash R at Covington, Ind.	[1]03336000	990	1,300	2,100	2,400	4,000	8,600	18,000
38	Bluegrass Cr at Potomac, Ill.	03336500	0	.2	.7	1.3	6.8	21	54
4	Salt Fk nr St. Joseph, Ill.	[2]03336900	7.2	9.3	16	20	46	110	230
5	Boneyard Cr at Urbana, Ill.	[2,3]03337000	1.1	1.2	1.6	1.7	2.3	3.9	9.0
39	Saline Br at Ubrana, Ill.	03337500	3.4	4.1	6.5	8.1	21	57	130
40	S Fk nr Homer, Ill.	03338000	14	18	31	41	110	280	590
6	Vermilion R nr Catlin, Ill.	03338500	25	32	64	88	270	760	1,800
7	Vermilion R nr Danville, Ill.	[1]03339000	33	47	100	130	360	990	2,300
8	E Fk Coal Cr nr Hillsboro, Ind.	03339108	5.8	7.3	11	12	19	37	78
9	Coal Cr at Coal Creek, Ind.	03339120	14	22	37	43	80	170	350
10	Little Vermilion R nr Newport, Ind.	03339150	2.3	5.4	18	27	77	190	430
11	Sugar Cr nr Byron, Ind.	03340000	41	54	93	110	230	570	1,400
12	Wabash R at Montezuma, Ind.	[1]03340500	1,200	1,600	2,600	3,000	5,200	12,000	24,000
14	Big Raccoon Cr at Ferndale, Ind.	[1]03340900	19	25	43	49	100	240	590
15	Big Raccoon Cr at Mansfield, Ind.	03341000	7.2	13	26	34	85	210	460
16	Little Raccoon Cr nr Catlin, Ind.	03341200	3.0	6.1	13	17	39	100	230
17	Big Raccoon Cr at Coxville, Ind.	[1]03341300	61	77	130	160	260	590	1,200
20	Wabash R at Terre Haute, Ind.	[1]03341500	1,500	1,800	3,000	3,400	5,900	13,000	27,000
21	Wabash R at Riverton, Ind.	[1]03342000	1,600	2,000	3,300	3,800	6,600	14,000	29,000
22	Busseron Cr nr Hymera, Ind.	[1]03342100	.03	.06	.4	.6	3.1	17	50
23	W Fk Busseron Cr nr Hymera, Ind.	03342150	.06	.1	.4	.6	2.2	8.9	29
24	Mud Cr nr Dugger, Ind.	[4]03342250	1.3	1.6	2.8	3.3	6.5	14	27
25	Busseron Cr nr Sullivan, Ind.	[1,4]03342300	3.5	5.0	13	16	40	130	360
26	Buttermilk Cr nr Paxton, Ind.	[4]03342350	.3	.6	1.8	2.2	4.8	13	36
28	Busseron Cr nr Carlisle, Ind.	[1,4]03342500	1.9	3.8	12	15	44	170	630
30	Wasbash R at Vincennes, Ind.	[1]03343000	1,700	2,100	3,300	3,800	6,800	15,000	29,000
31	Embarras R nr Camargo, Ind.	03343400	.5	1.5	11	19	57	160	380
33	Embarras R nr Diona, Ind.	03344000	9.9	17	110	140	350	1000	2200
34	Range Cr nr Casey, Ind.	03344500	0	0	0	0	.30	1.40	6.90
35	Embarras R at Ste. Marie, Ind.	03345500	26	40	120	160	430	1,300	3,300
36	N Fk Embarras R nr Oblong, Ill.	03346000	1.0	2.3	9.2	13	41	150	560

[1]Flow partially regulated by upstream reservoir.
[2]Diurnal fluctuation caused by municipal and/or industrial effluent.
[3]Part of storm runoff from 1.12 mi^2 at headwater has been diverted.
[4]Flow affected by surface-mined area.

Average Flow is Proportional to Drainage Area

Average annual flow can be estimated from the drainage area.

The average annual streamflow is related to drainage area, soil characteristics, average annual precipitation, area of lakes and ponds, area of forest, elevation, and stream slope and length (Seiber, 1970). Average annual streamflow (Qa) in Area 30 can be estimated from the drainage area (A) by the equation $Qa = A^{0.98}$. The coefficient of determination (r^2) for the equation is 0.99, and the standard error is 5.9 percent. The average annual streamflow is in cubic feet per second, and the drainage area is in square miles. Drainage areas for most named rivers, streams, and ditches have been computed by Hoggatt (1975). Figure 8.5-1 shows the relation of discharge and drainage area based on data from 33 gaging stations. Drainage areas range from 4.46 to 13,706 square miles. Locations of four stations are shown in figure 8.5-2. Monthly and annual average flows were calculated from daily discharges (Price, 1975) and are listed in section 13.2. Maximum, minimum, and average monthly discharges, and average annual discharges for four of the stations listed in section 13.2 are shown in figure 8.5-3.

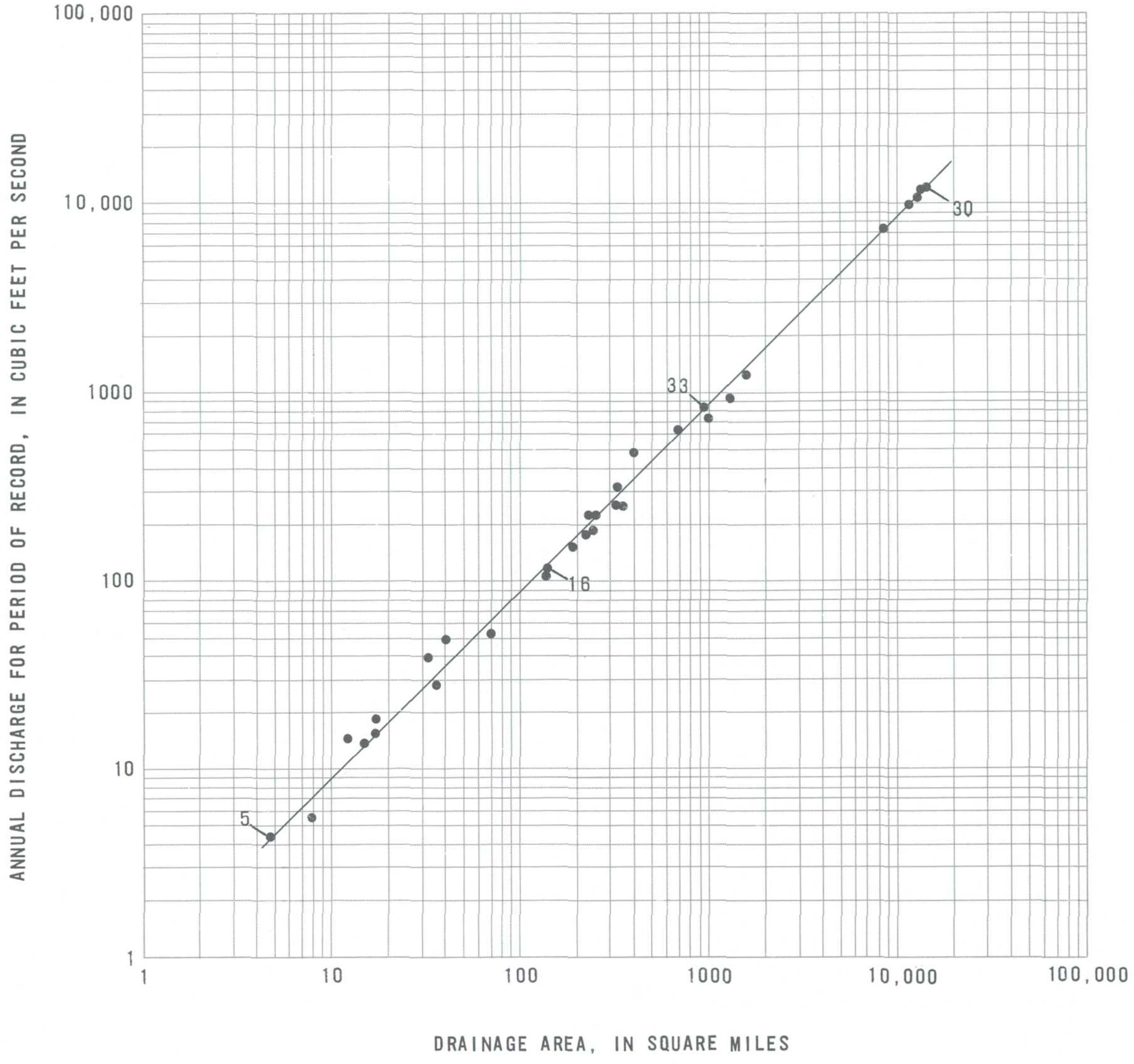


Figure 8.5-2.--Relation of drainage area to mean discharge.

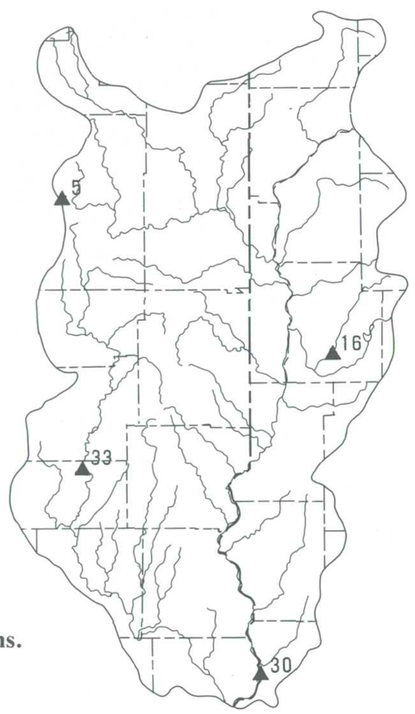


Figure 8.5-1.--Data sites for average flow calculations.

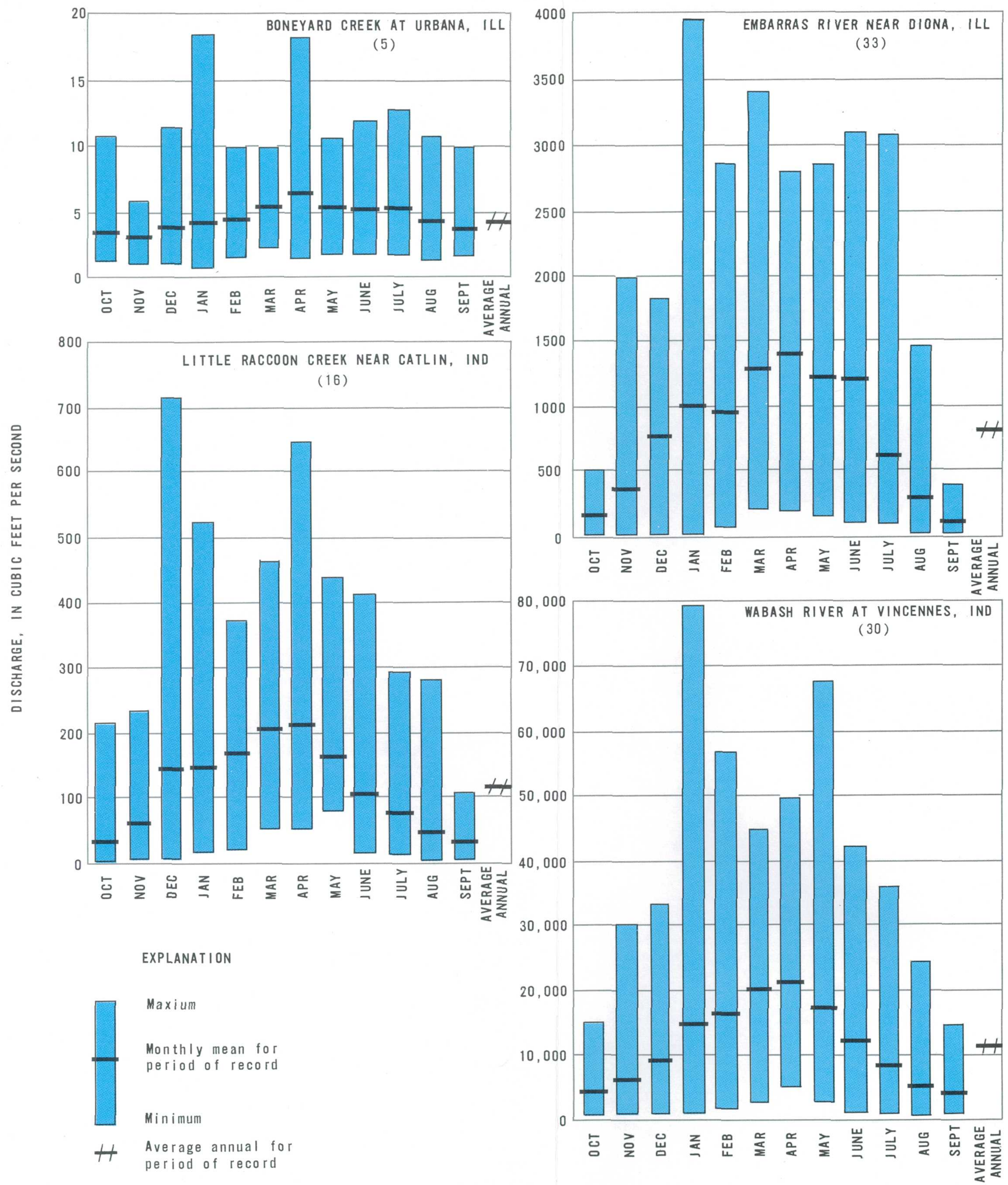


Figure 8.5-3. --Average flows.

8.0 SURFACE-WATER QUANTITY (Continued)

8.5 Average Flow

Surface Mining and Reclamation Affects Surface-Water Quality

Water-quality data for streams affected by surface mining indicate that pH is lower and dissolved- and suspended-solids concentrations are higher in these streams than in streams unaffected by surface mining.

Surface mining and reclamation have affected surface-water quality in the United States, and their impact, especially in coal-mining areas, is well documented (Dyer and Curtis, 1977; Hoehn and Sizemore, 1977; King and others, 1974; and Letterman and Mitsch, 1978). Because of the oxidation and the weathering of pyrite and marcasite exposed by mining operations, drainage in many old mining areas has an acidic pH (<7).

Acid mine drainage is not the only water-quality problem. Concentrations of many dissolved and suspended constituents, including iron and aluminum, are higher in streams in both old and new mining areas than in streams unaffected by mining. Erosion from unreclaimed areas of old mines or unvegetated areas of new mines can substantially increase sediment loads in streams (Dyer and Curtis, 1977).

The Surface Mining Control and Reclamation Act of 1977 provides little information on water-quality constituents and properties that should be monitored. Paragraph 779.16 of the Federal regulations concerning reclamation (Office of Surface Mining, 1979) states that, in general, local water-quality standards are applicable, but, as a minimum, monitoring should include: (1) dissolved solids, (2) suspended solids, (3) acidity, (4) pH, (5) total and dissolved iron, and (6) total manganese. Other water-quality properties or constituents that might be affected by surface mining include specific conductance, alkalinity, sulfate, and aluminum.

The water-quality data analyzed in this report include specific conductance and pH; concentrations of sulfate, alkalinity, and acidity; and concentrations of total and dissolved iron, manganese, and aluminum. Averages were determined for each sampling station, except for pH where the median was determined. Where only one measurement was available at a station, the measurement was assumed to represent the average or median. The averages and medians were used for regional comparisons. They were divided into six categories on the basis of a percentile distribution. Unusually high or low measurements are presented in the illustrations. The median of all station averages was used as a basin descriptor, except for pH where the median of medians was used.

Locations of the 167 stations where water samples were collected are shown on the adjoining map (fig. 9.1-1). Station identification (ID), name, the agency responsible for sample collection, latitude, longitude, and the number of measurements for each water-quality constituent or property are listed in section 13.3.

The coal-mining-area boundary shown in the illustration is a generalized boundary modified from Indiana Department of Natural Resources (1980), Powell (1976), and Treworgy and others (1978).

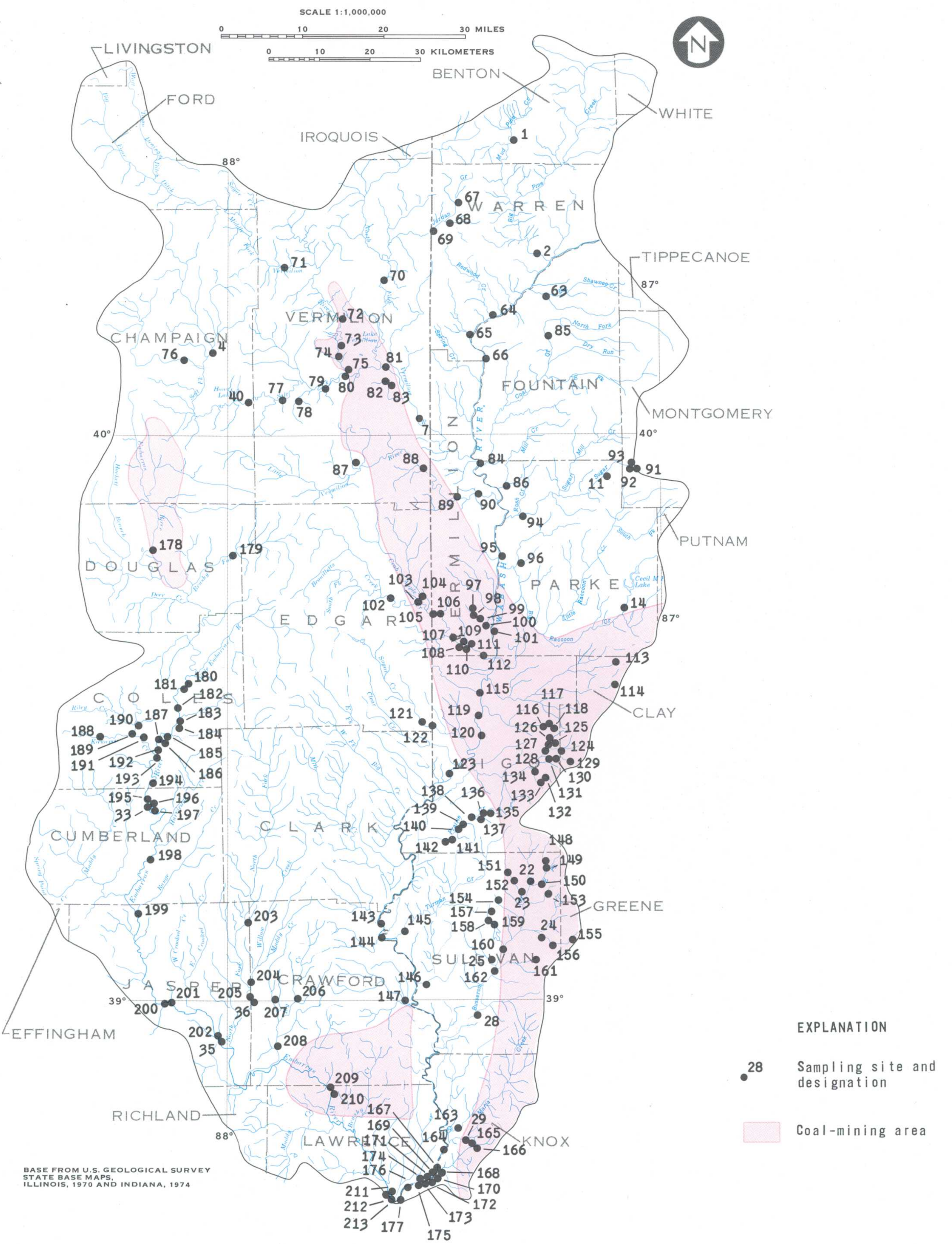


Figure 9.1-1.--Data sites used in water-quality comparisons.

pH Generally Lower in Coal-Mining Regions

Median pH was generally lower in the coal-mining regions, specifically in Vigo, Sullivan, and Knox Counties, Indiana, than in other parts of Area 30.

pH, a measure of the effective hydrogen ion activity, can affect the solubility of metals and the bonding of these metals to insoluble carriers (Hem, 1970, p. 88-95). pH's less than 4.5 may indicate the exposure and oxidation of pyrite and marcasite from mining, whereas pH's greater than 8 may indicate a carbonate strata.

A study of the water quality of streams in the coal-mining region of southwestern Indiana indicated that median pH of streams in mined watersheds was not significantly different from that of streams in forested and agricultural watersheds (Wilber and others, 1981, p. 222). However, the range of pH of streams in unreclaimed-mined watersheds was considerably greater than in watersheds of other land uses. The pH of several streams draining unreclaimed-mined areas was less than 4.0, whereas the pH of all streams from watersheds of other land use was greater than 6.2. The study also indicated that surface water in the Wisconsin glacial province are better buffered than those in the other areas studied. The median pH of streams in agricultural watersheds in the Wisconsin glacial province (8.2) was significantly greater than that of streams in agricultural watersheds in the Illinoian glacial province (7.7).

Median pH was generally lower in the coal-mining regions, specifically in Vigo, Sullivan, and Knox Counties, Indiana, than in other parts of Area 30. The median of the median pH's was 7.8, and the range was from 2.5 to 9 at 159 sites. The pH of the upper Wabash River, an unmined area in Wisconsin till, was greater than 7.0. pH in the Embarass River watershed was variable. The median pH's were grouped into six ranges by percentile and are presented in figure 9.1.1-1.

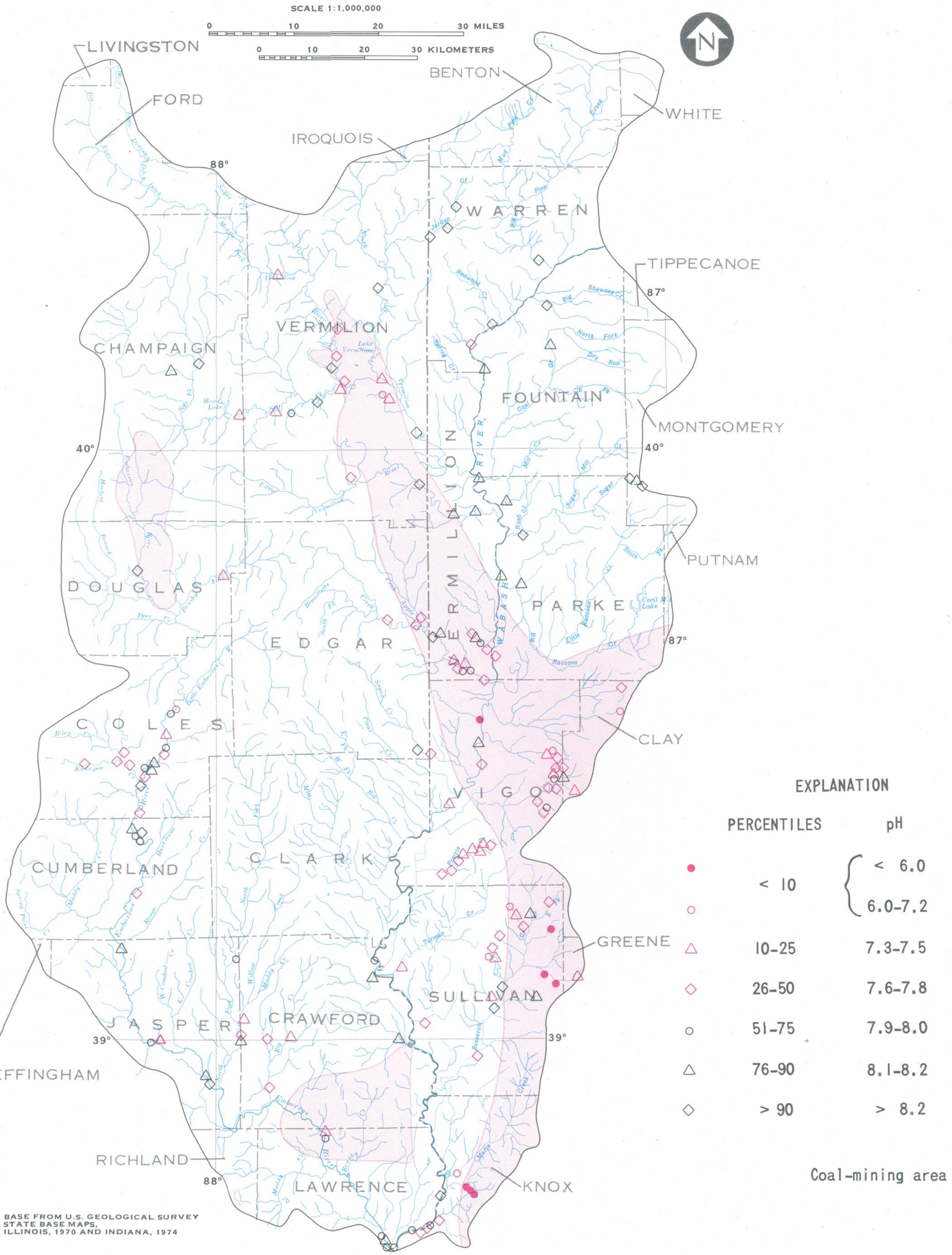


Figure 9.1.1-1.--Median pH.

9.0 SURFACE-WATER QUALITY (Continued)

9.1 Regional Water-Quality Comparisons (Continued)

9.1.1 pH

Acidity Concentrations Generally Higher in Coal-Mining Regions

Acidity concentrations within the coal-mining region of Area 30 were generally greater than 300 mg/L (milligrams per liter) as calcium carbonate.

Acidity is a measure of the concentration of solutes capable of reacting with hydroxyl ions. Solutes that contribute to acidity include certain hydrolyzable metal ions, such as iron, manganese, and aluminum as well as strong and weak acids (Brown and others, 1970 p. 39).

A study of the water quality of streams in the coal-mining region of southwestern Indiana indicated that the acidity of all samples collected from watersheds representing forested, agricultural, and reclaimed-mined land use was zero (Wilber and others, 1981, p. 223). The acidities of samples from several sites on unreclaimed-mine land were greater than zero.

The median of average acidity concentrations was 0 mg/L, and the range of average concentrations was from 0 to 3,052 mg/L at 81 sites in Area 30. Average concentrations of acidity were greater than 0 mg/L at 38 sites. Acidity concentration of the Embarras River watershed downstream from the coal-mining region were less than 100 mg/L, whereas concentrations within the coal-mining region were generally greater than 300 mg/L. The average acidity concentrations, grouped into four ranges by percentile, are presented in figure 9.1.2-1.

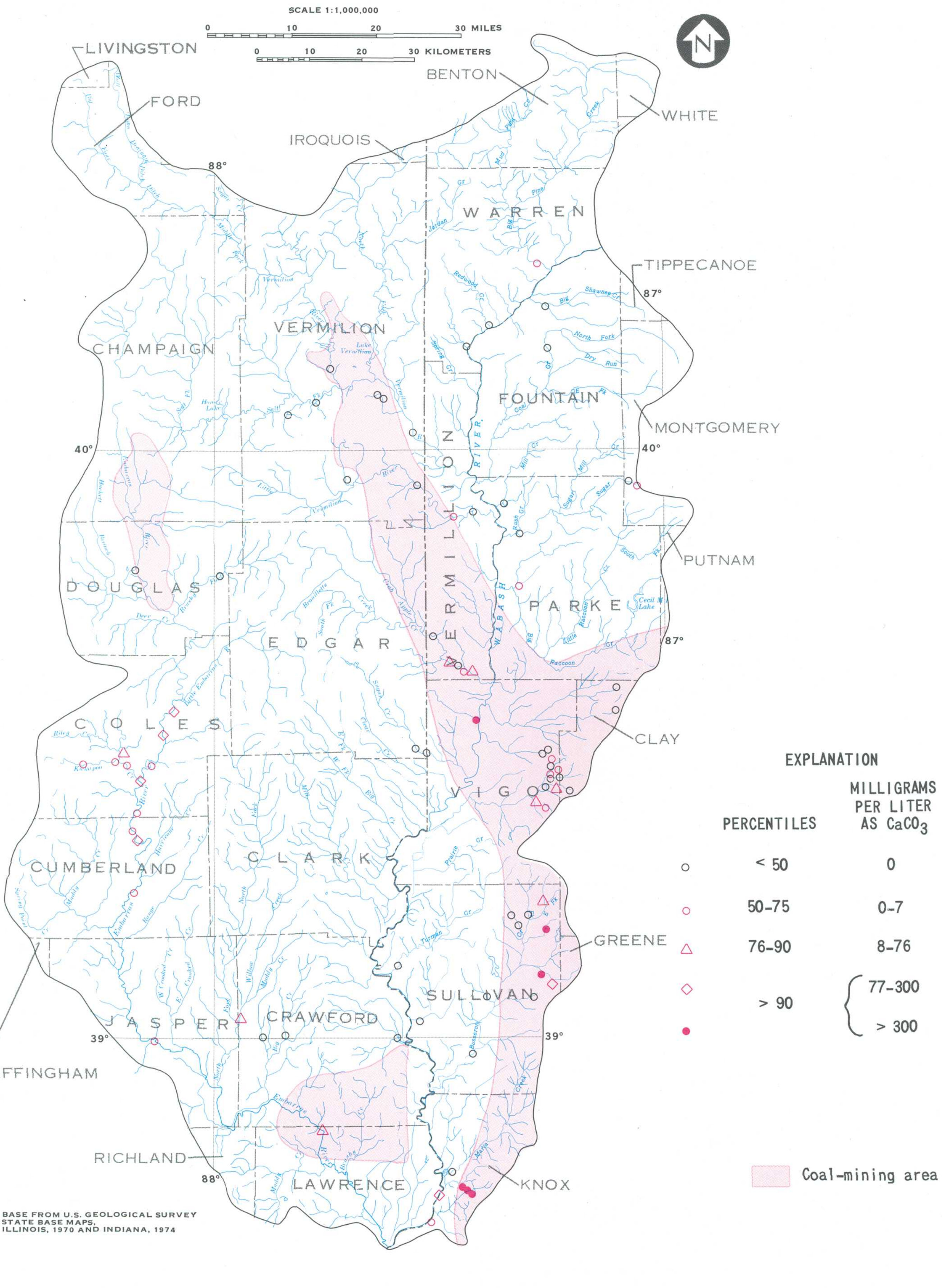


Figure 9.1.2-1.--Average acidity concentrations.

9.0 SURFACE-WATER QUALITY (Continued)

9.1 Regional Water-Quality Comparisons (Continued)

9.1.2 Acidity

Alkalinity Concentrations Generally Lower in Coal-Mining Regions

Average alkalinity concentrations were generally lower in the coal-mining region especially in Vigo, Sullivan, and Knox Counties, Ind., than in other parts of Area 30.

Alkalinity is the capacity of water to neutralize acid. It is normally perceived as an indication of carbonate and bicarbonate concentration and expressed as equivalents of calcium carbonate (Hem, 1970, p. 52).

A study of the water quality of streams in the coal-mining region of southwestern Indiana indicated that average alkalinity concentrations of streams in forested and reclaimed-mine watersheds (210 and 250 mg/L, respectively) were generally higher than those of streams in agricultural and unreclaimed-mine watersheds (180 and 140 mg/L, respectively), although the differences were not statistically significant (Wilber and others, 1981, p. 223). The study also indicated that the surficial geology of the Wisconsin glacial province may contain greater quantities of carbonate minerals than the Illinoian province because average alkalinities of streams in the Wisconsin glacial province were higher than those of streams in the Illinoian glacial province.

The median of average alkalinity concentrations was 196 mg/L as calcium carbonate, and the range of average concentrations was from 0 to 310 mg/L at 129 sites. Average alkalinity concentrations were generally lower in the coal- mining regions, especially in Vigo, Sullivan, and Knox Counties, Ind., than in other parts of Area 30. Average alkalinity concentrations were grouped into six ranges by percentile and are presented in figure 9.1.3-1.

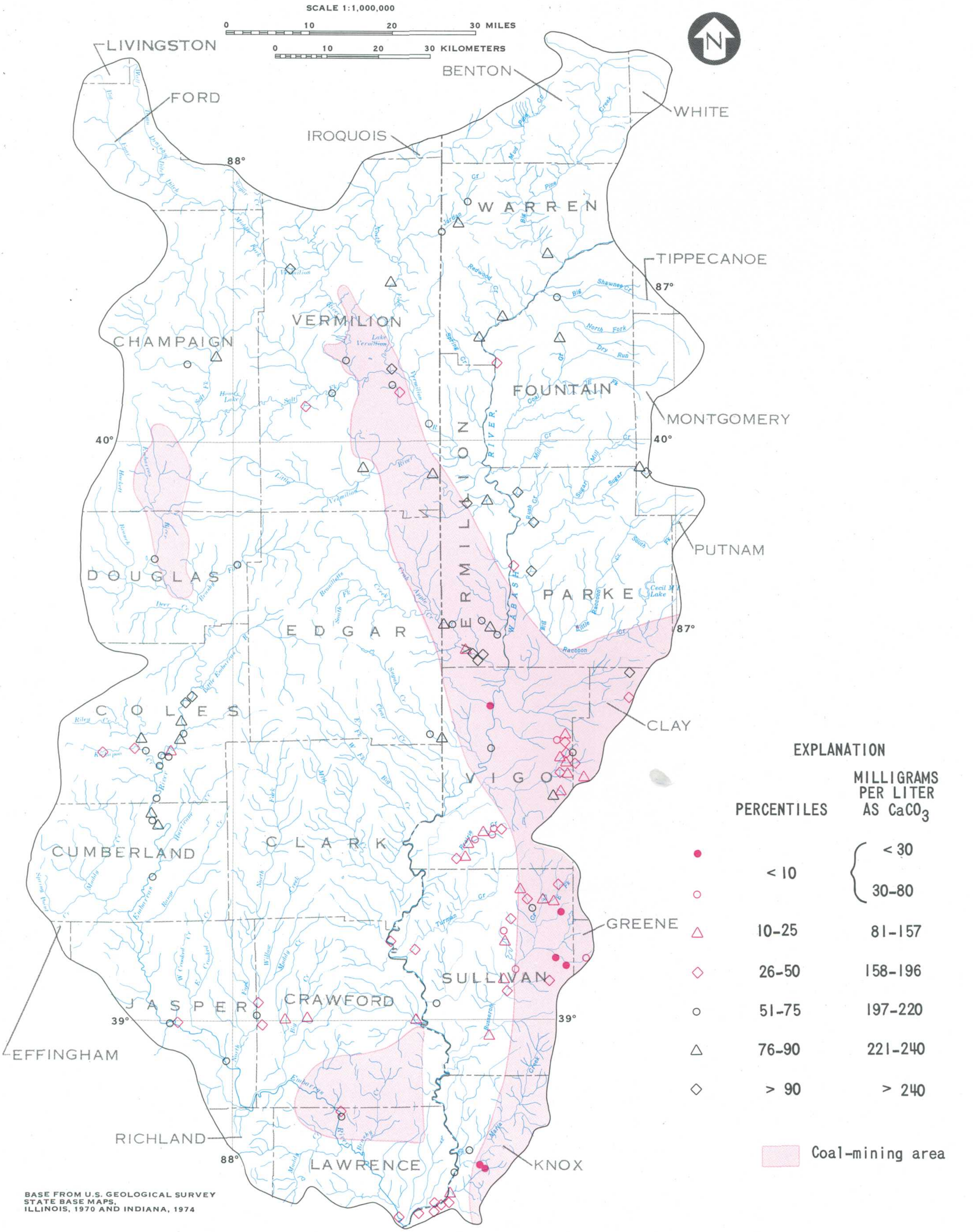


Figure 9.1.3-1. --Average alkalinity concentrations.

Specific Conductance Generally Higher in Coal-Mining Regions

Average specific conductance was highest in localized areas of Knox, Sullivan, and Vigo Counties, Indiana, where coal is surface mined.

Specific conductance is a measure of the ability of water to carry an electrical current. It is also used as an indicator of the ionic strength of a solution (Brown and others, 1970, p. 148) and, therefore, as an indicator of the dissolved-solids concentrations of water.

A study of the water quality of streams in the coal-mining region of southwestern Indiana indicated that average dissolved-solids concentrations of streams in both agricultural and mined watersheds were significantly greater than those of streams in forested watersheds (Wilber and others, 1981, p. 224). The study concluded that the greater dissolved-solids concentrations of streams in mined and agricultural areas were probably due to exposure and oxidation of pyrite and marcasite in mined areas and to dissolution of carbonate and clay minerals in agricultural areas. Dissolved-solids concentrations were also significantly greater in samples from agricultural watersheds in the Wisconsin glacial province than in samples from agricultural watersheds in the Illinoian glacial province.

The median of average specific conductance was 623 μmho/cm at 25°C (micromhos per centimeter at 25 degrees Celsius) and the average ranged from 90 to 4,920 μmho/cm at 25°C at 159 sites. Average specific conductance was highest in localized areas of Knox, Sullivan, and Vigo Counties, Indiana, where coal is surface mined. Average conductances were grouped into six ranges by percentile, and are presented in figure 9.1.4-1.

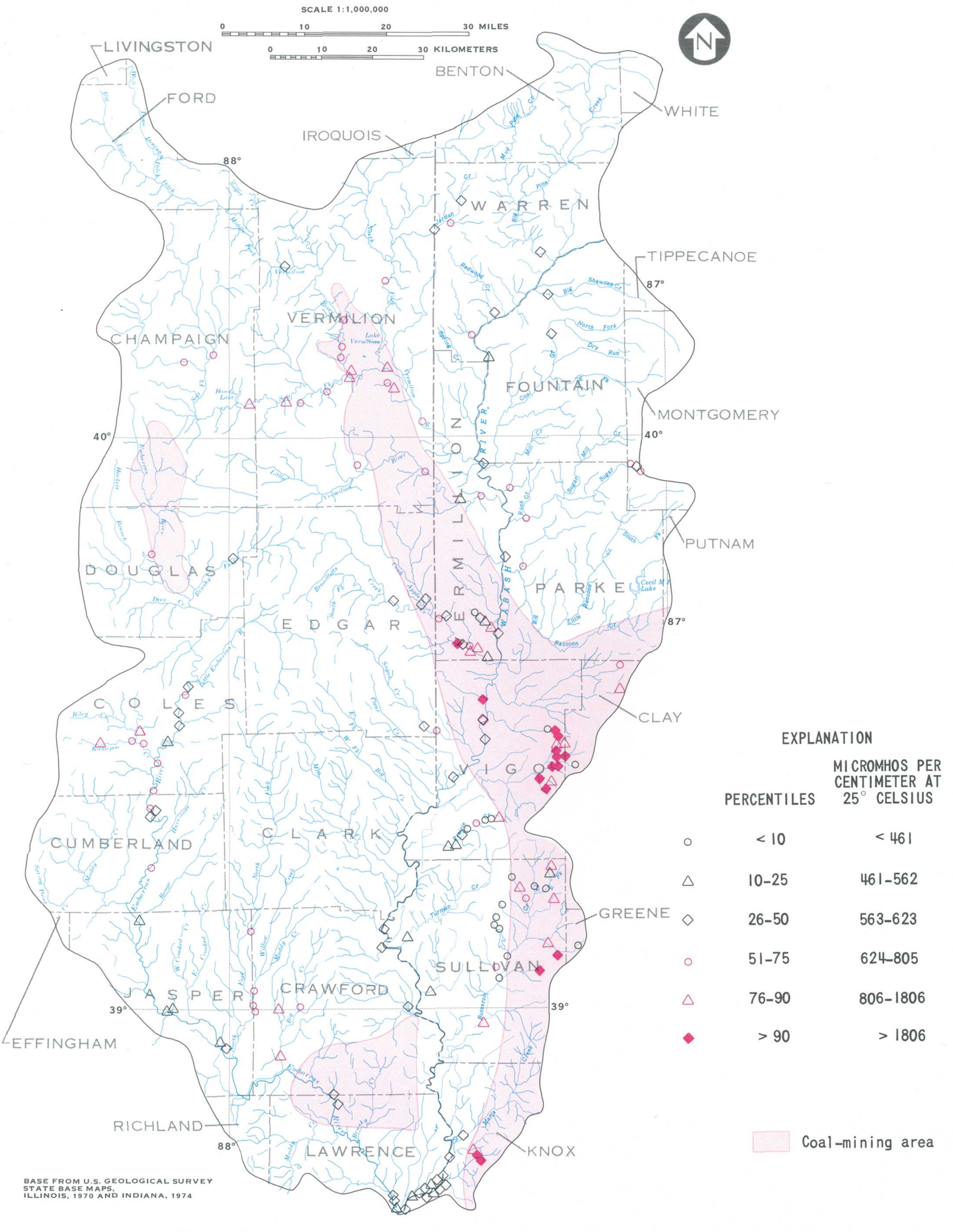


Figure 9.1.4-1. --Average specific conductance.

9.0 SURFACE-WATER QUALITY (Continued)

9.1 Regional Water-Quality Comparisons (Continued)

9.1.4 Specific Conductance

Sulfate Concentrations Generally Higher in Coal-Mining Regions

Concentrations of dissolved sulfate were generally higher in the coal-mining regions of Area 30.

Sulfide minerals such as pyrite and marcasite are weathered by oxidation and yield sulfate ions, iron, and considerable hydrogen ions (Hem, 1970, p. 161-166). The increase in hydrogen ions causes a decrease in pH and possibly an increase in metals loading.

A study of the water quality of streams in the coal-mining region of southwestern Indiana indicated that average sulfate concentrations of streams draining mined watersheds were significantly greater than the average for streams draining agricultural and forested watersheds (Wilber and others, 1981, p. 224). Average sulfate concentrations of streams in unreclaimed- and reclaimed- mine watersheds were 31 and 24 times, respectively, the average for streams in forested watersheds. Average concentrations of streams in agricultural watersheds were significantly higher in the Wisconsin glacial province than in the Illinoian glacial province.

The median of average sulfate concentrations was 69 mg/L and the range average concentrations was from 20 to 3,379 mg/L at 134 sites. Concentrations of dissolved sulfate were generally higher in the coal-mining regions of Area 30. Average sulfate concentrations, grouped into six ranges by percentile, are presented in figure 9.1.5-1.

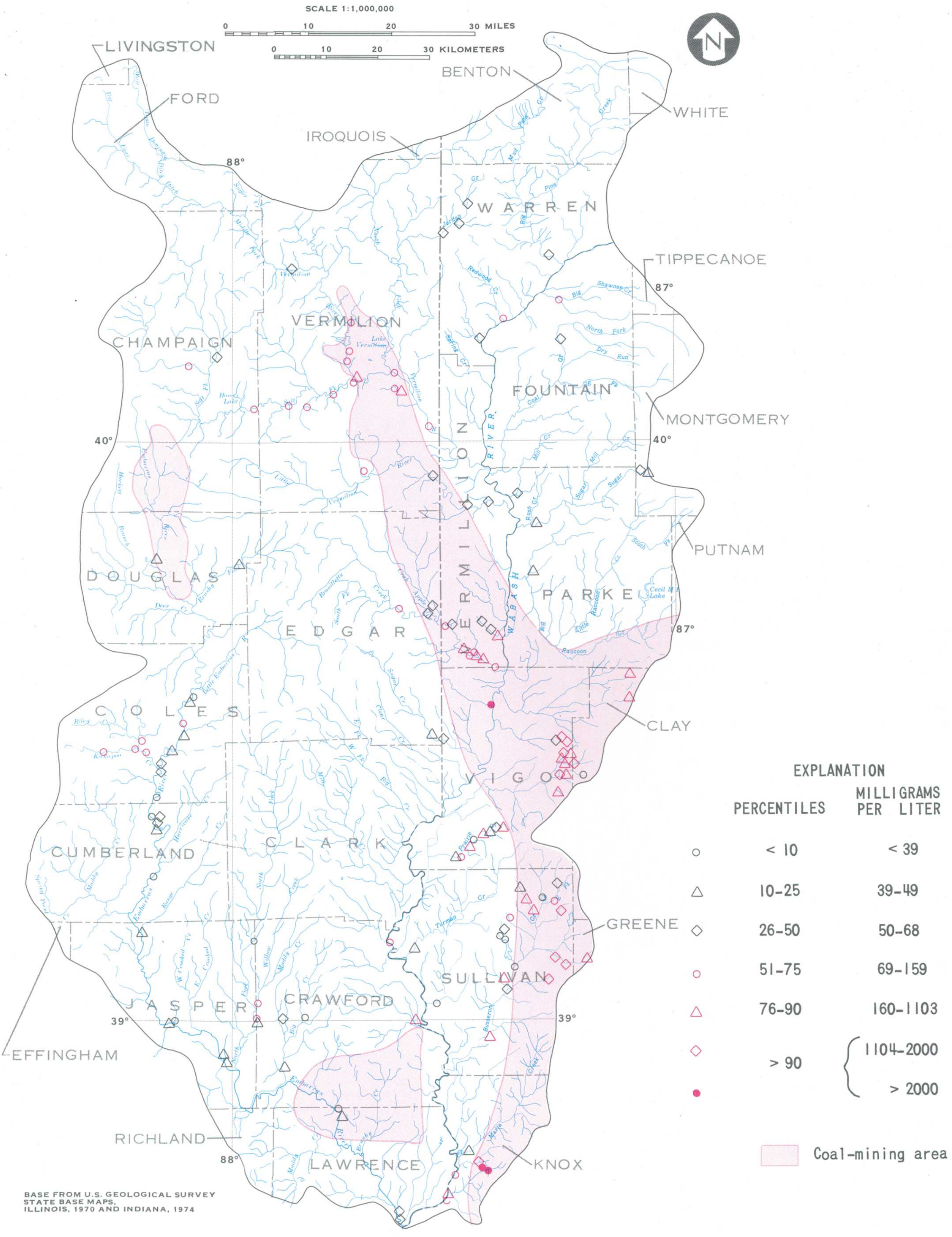


Figure 9.1.5-1.--Average sulfate concentrations.

9.0 SURFACE-WATER QUALITY (Continued)

9.1 Regional Water-Quality Comparisons (Continued)

9.1.5 Sulfate

Total- and Dissolved-Iron Concentrations Generally Higher in Coal-Mining Regions

Concentrations of total- and dissolved-iron were generally higher in the coal-mining regions of Area 30 than in the areas unaffected by mining.

Iron, one of the most abundant metals in the earth's crust, is readily precipitated as the hydroxide and sorbed on suspended particles. Thus, it is rarely a major dissolved constituent of surface water. When pyrite and marcasite are exposed to oxygenated water, iron tends to go into solution as the pH decreases (Hem, 1970, p. 122 and 162).

The average total-iron concentration of streams draining unreclaimed-mine watersheds in southwestern Indiana was significantly greater than the average of streams in agricultural and reclaimed-mine watersheds, whose concentrations were significantly greater than the average of streams in forested watersheds. Iron was generally in the suspended phase, except for streams in watersheds having unreclaimed mine land use. In several of these streams, particularly where the pH was less than 4, total iron was generally in the dissolved phase. (See Wilber and others, 1981, p. 225.)

The median of average total-iron concentrations was 0.95 mg/L, and the range of average concentrations was from 0.095 to 1,200 mg/L at 114 sites. The median of average dissolved-iron concentration was 0.06 mg/L, and the range of average concentrations was from 0.01 to 410 mg/L at 93 sites. Concentrations of total- and dissolved-iron were generally higher in the coal-mining regions of Area 30 than in the areas unaffected by mining. Average total- and dissolved-iron concentrations, grouped into six ranges by percentile, and presented in figures 9.1.6-1 and 9.1.6-2.

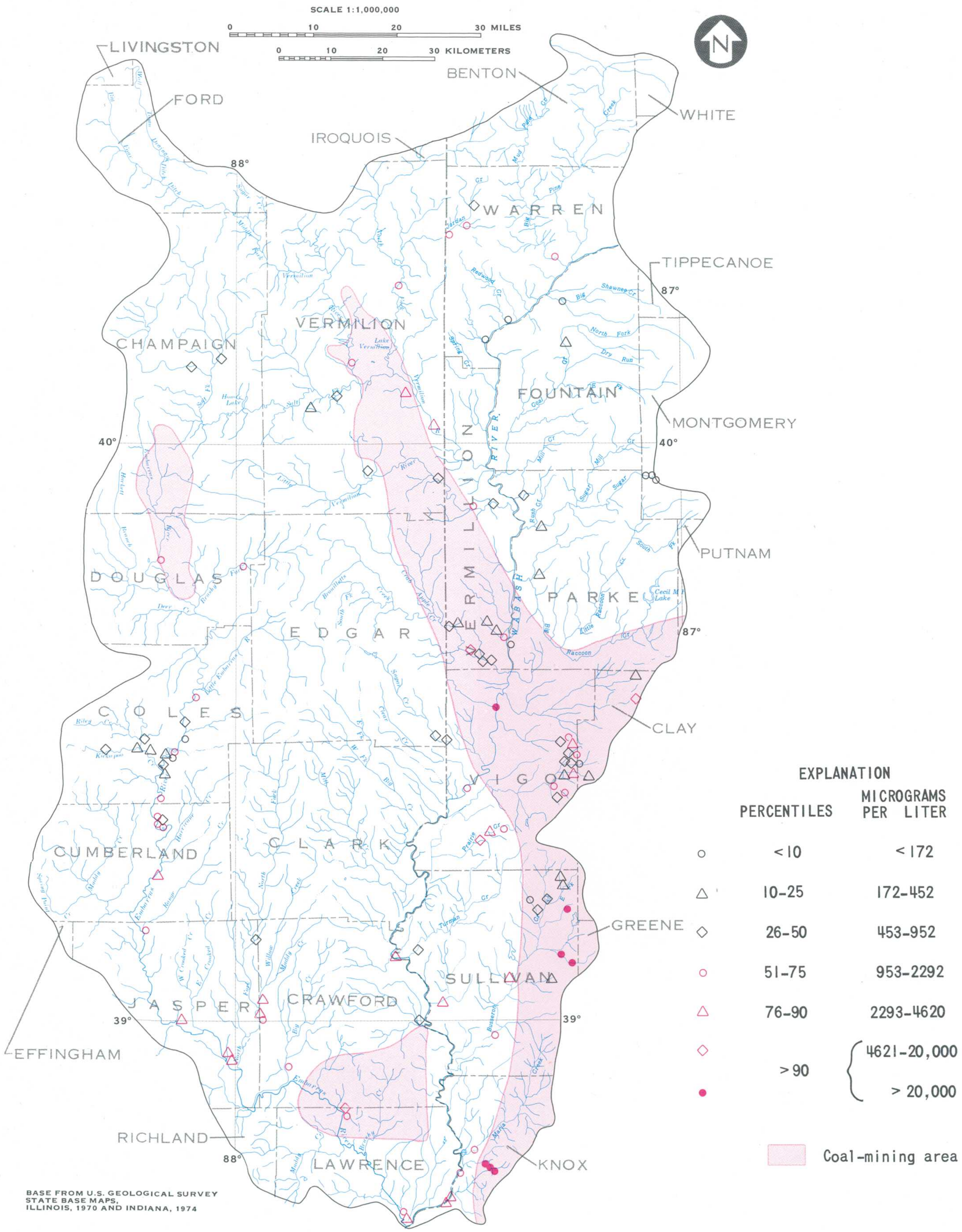


Figure 9.1.6-1. --Average total-iron concentrations.

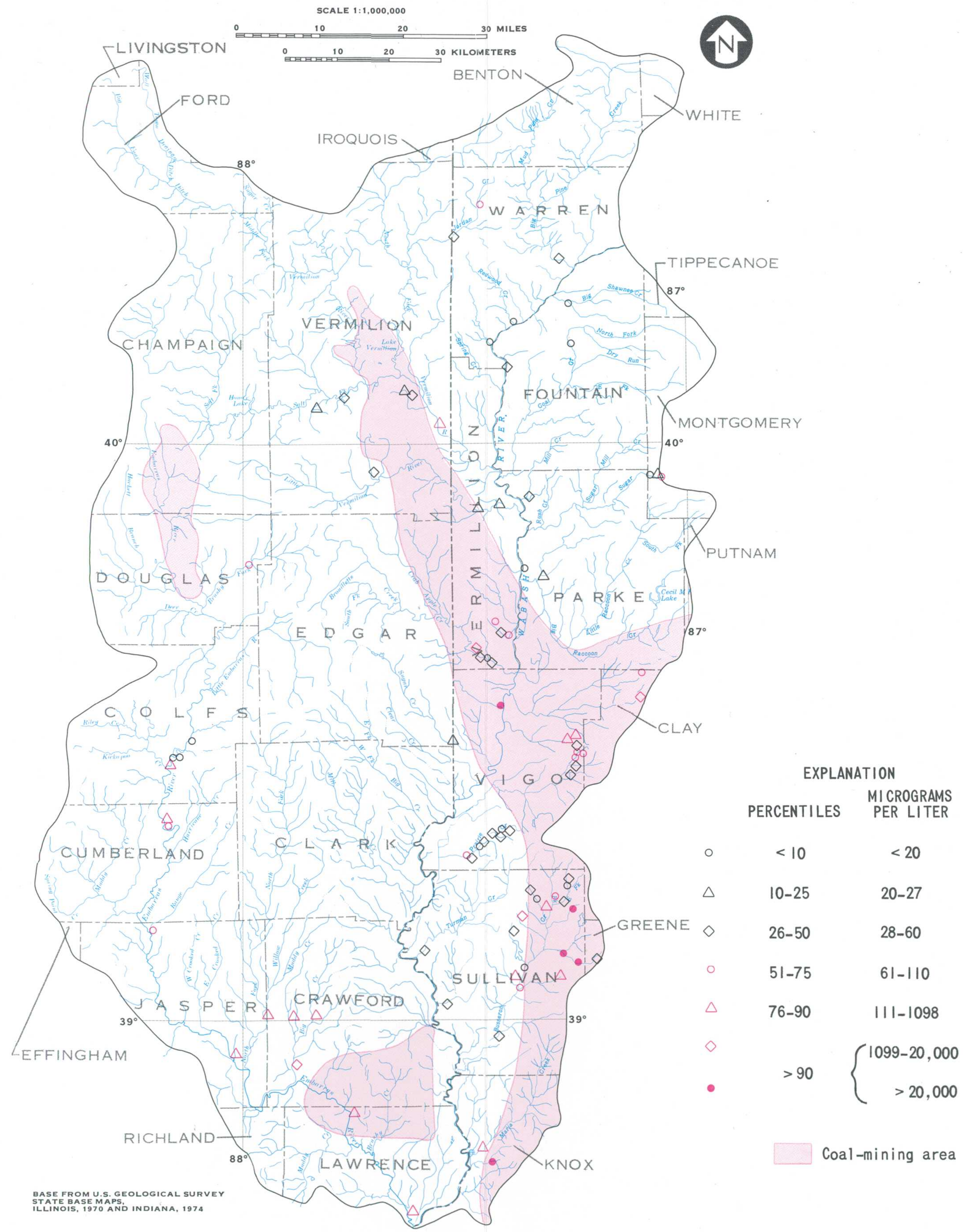


Figure 9.1.6-2. --Average dissolved-iron concentrations.

Total- and Dissolved-Manganese Concentrations Generally Higher in Coal-Mining Regions

Average concentrations of total and dissolved manganese were generally greater than 1.0 mg/L in the coal-mining regions of Area 30.

Manganese oxide and manganese hydroxide minerals are common in rocks and soils. The reduced form is soluble. Manganese concentrations greater than 1.0 mg/L are found in water having a low pH (Hem, 1970, p. 126 and 131).

A study of the water quality of streams in the coal-mining region of southwestern Indiana indicated that manganese in streams was generally in the dissolved phase, regardless of land use (Wilber and others, 1981, p. 226). Average dissolved-manganese concentrations of streams in unreclaimed-mine, reclaimed-mine, and agricultural watersheds were 92, 16, and 3 times, respectively, the average of streams in forested watersheds. The average totalmanganese concentrations in these same watersheds were 75, 13, and 5 times the average of streams in forested watersheds. Because average total- and dissolved-manganese concentrations for each land use were all significantly different, manganese, especially in the dissolved phase, may be a good indicator of the effect of land use on water quality in Indiana.

The median of average total-manganese concentrations was 0.20 mg/L, and the range of average concentrations was from 0.01 to 14.60 mg/L at 111 sites. The median of average dissolved manganese concentrations was 0.14 mg/L, and the range of average concentrations was from 0.005 to 10.60 mg/L at 84 sites. Average concentrations of total and dissolved manganese were generally greater than 1.0 mg/L in the coal-mining regions of Area 30. Average values were grouped into six ranges by percentile, and are presented in figure 9.1.7-1 and 9.1.7-2.

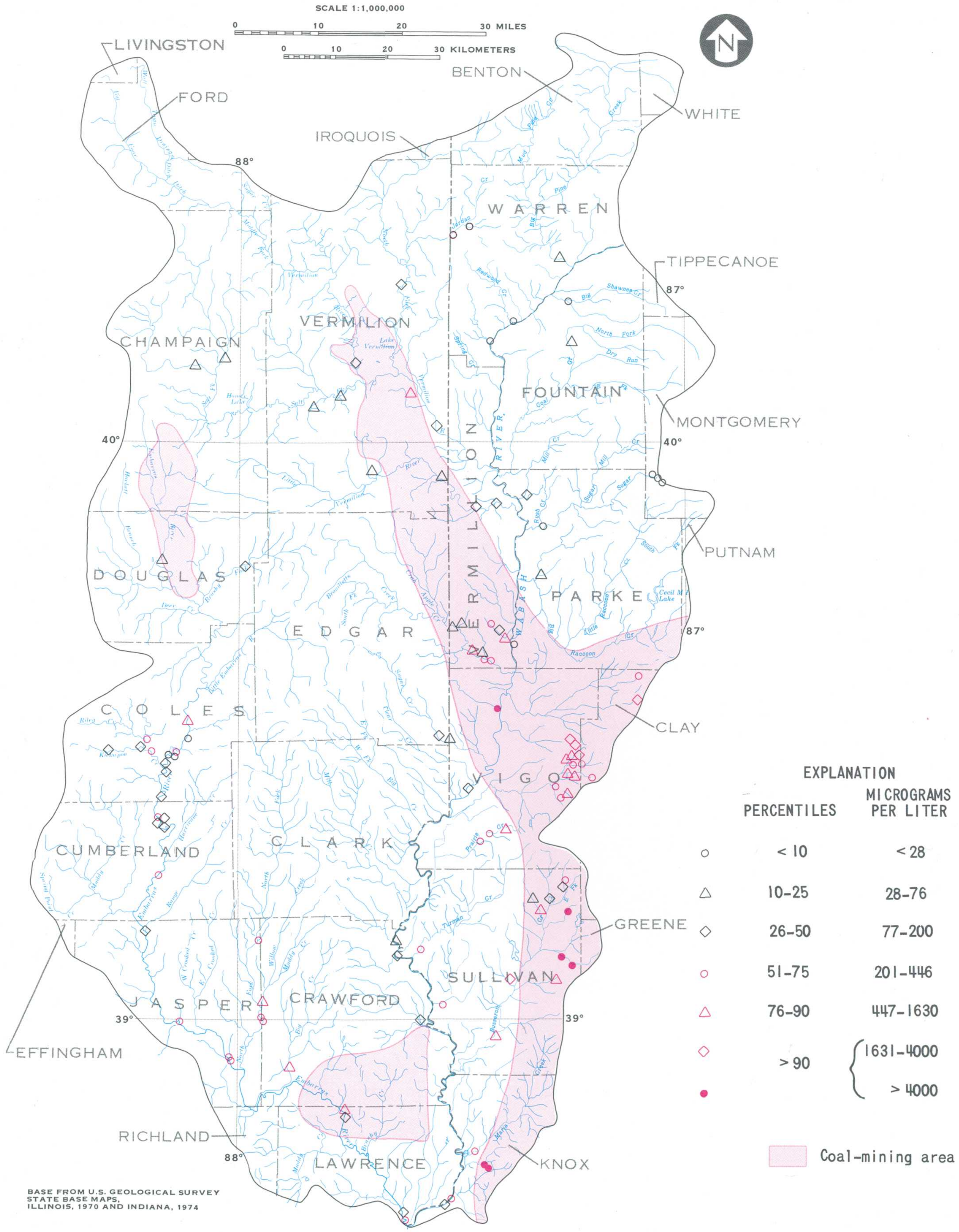


Figure 9.1.7-1. --Average total-manganese concentrations.

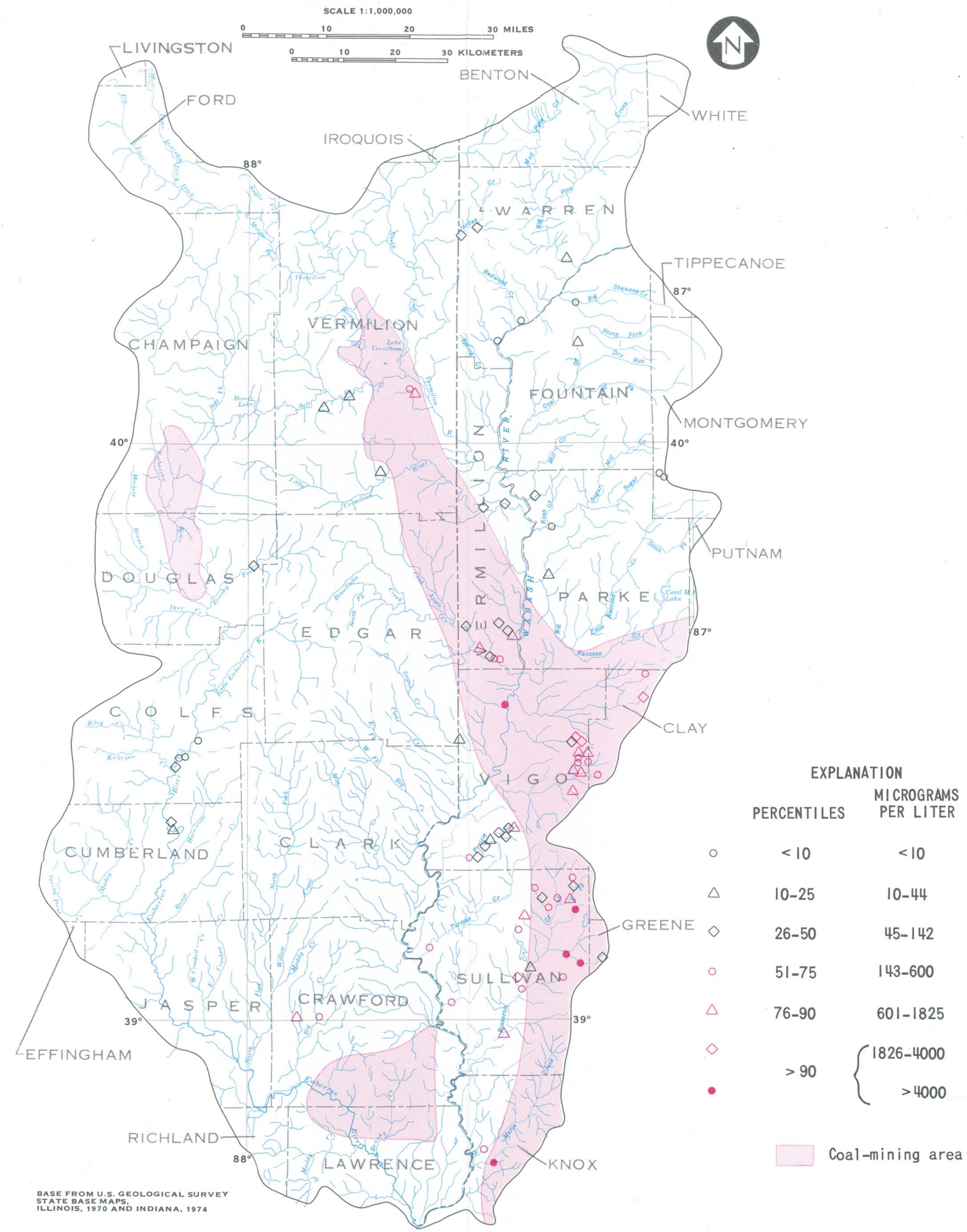


Figure 9.1.7-2. --Average dissolved-manganese concentrations.

Total- and Dissolved-Aluminum Concentrations Generally Higher than in Coal-Mining Regions

Concentrations of total and dissolved aluminum were variable within Area 30, although 12 sites in the coal-mining regions had concentrations greater than 1 mg/L.

Aluminum, the third most abundant element in the earth's outer crust, is rarely found in natural water in concentrations greater than a few tenths of a milligram per liter; however, concentrations as high as several thousand milligrams per liter occur at pH's below 4.0 because aluminum-bearing minerals dissolve and form soluble aluminum complexes (Hem, 1970, p. 110-111).

Concentrations of total and dissolved aluminum were variable within Area 30, although 12 sites in the coal-mining regions had concentrations greater than 1 mg/L. The median of average total-aluminum concentrations was 0.20 mg/L, and the range of average concentrations was from nondetectable to 170 mg/L at 58 sites. The median of average dissolved-aluminum concentrations was 0.038 mg/L, and the range of average concentrations was from 0.01 to 41 mg/L at 29 sites. Total-and dissolved-aluminum concentrations, grouped into six ranges by percentile, are presented in figure 9.1.8-1 and figure 9.1.8-2.

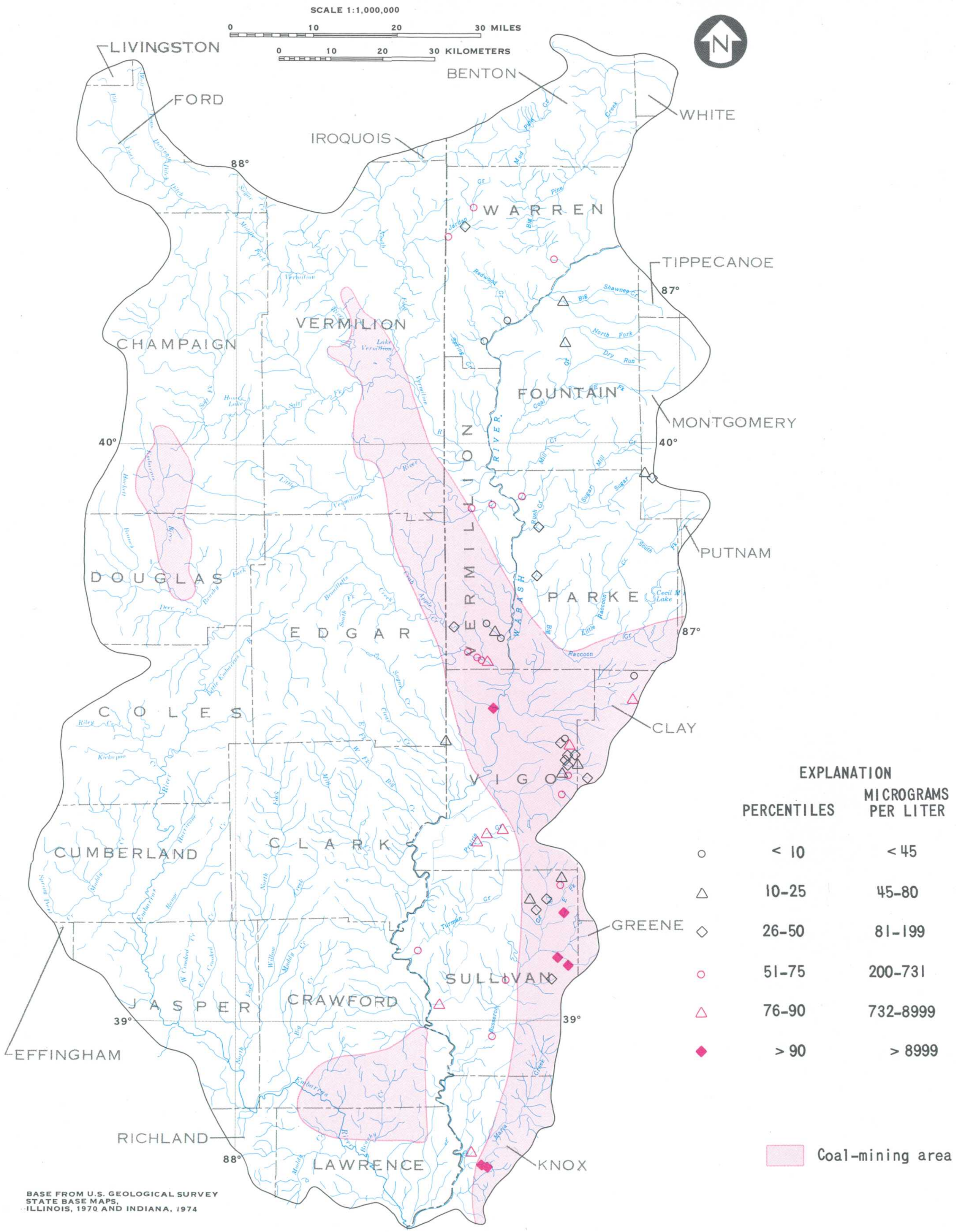


Figure 9.1.8-1.--Average tota1-aluminum concentrations.

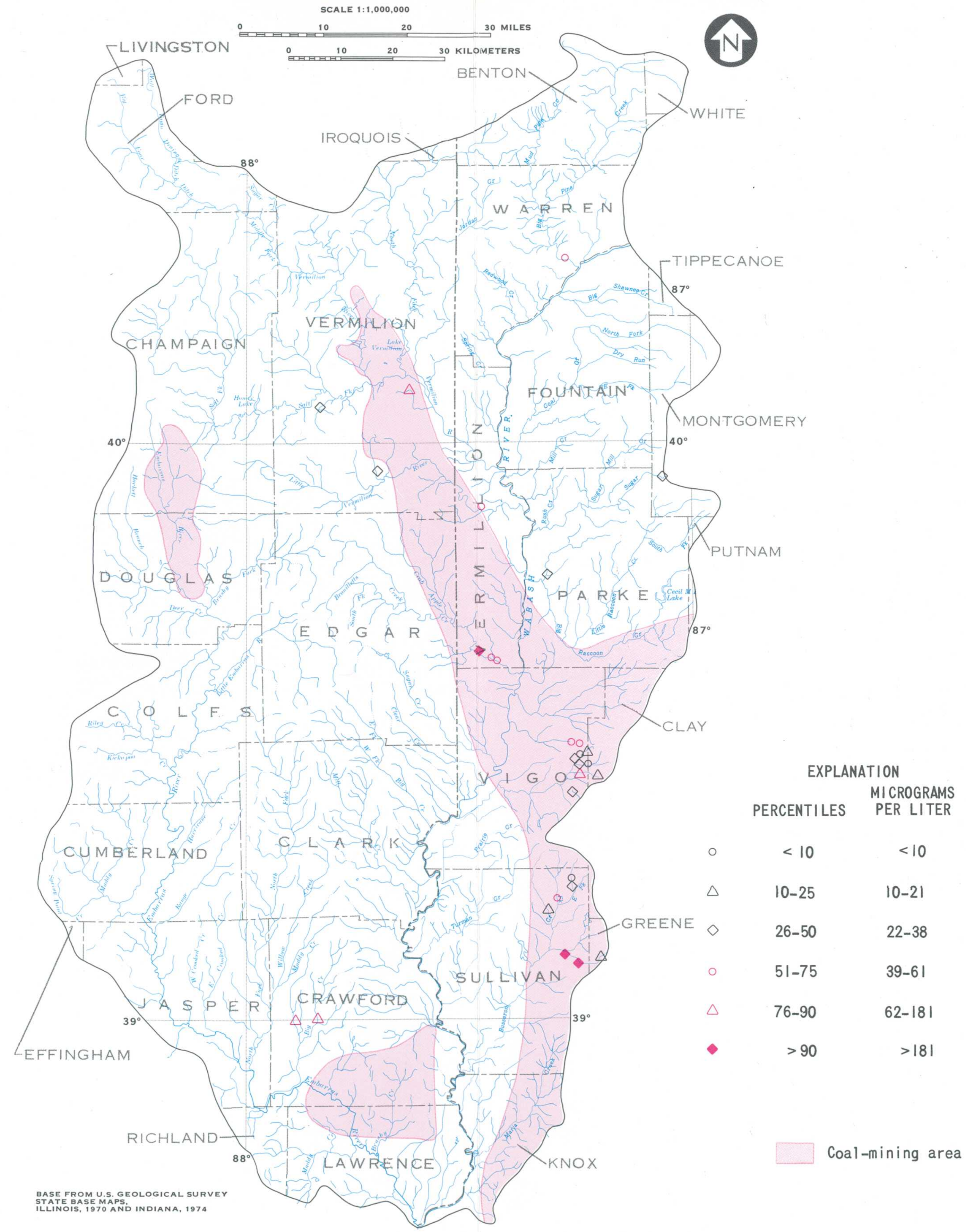


Figure 9.1.8-2. --Average dissolved-aluminum concentrations.

Suspended-Sediment Data are Limited for Area 30

Median suspended-sediment concentrations were generally higher at sites affected by coal-mine drainage than at unaffected sites.

Suspended-sediment data available at 24 sites within Area 30 are summarized in table 9.1.9, and their locations and range of median values are shown in figure 9.1.9-1. Factors such as streamflow, geology, physiography, stream slope, land use, precipitation intensity, and others cause suspended-sediment concentrations to vary. Higher median suspended-sediment concentrations are generally found at sites affected by coal-mine drainage than at sites unaffected by mining.

Streamflow and land use were found to be the most significant factors affecting suspended-sediment concentration of streams in the coal-mining region of southwestern Indiana (Wilber and others, 1981, p. 225). Average suspended-sediment concentrations were greater during high streamflow than during low flow and were greater in streams draining agricultural and mined watersheds than in streams draining forested watersheds. The study noted that the full effect of land use on suspended-sediment concentration could not be determined without additional data for adequately defining the relation of suspended-sediment concentration to flow.

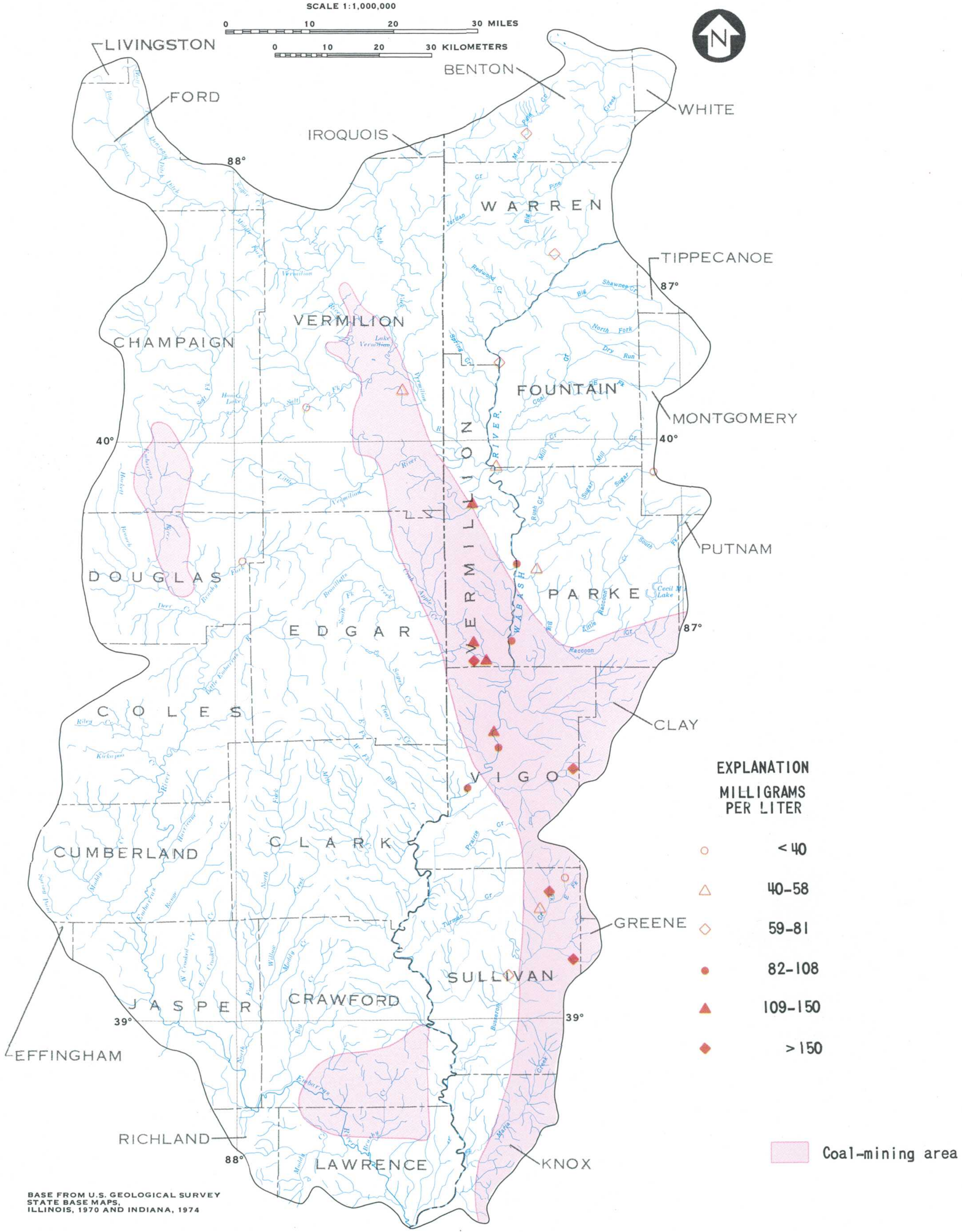


Figure 9.1.9-1. --Median suspended-sediment concentrations.

Table 9.1.9- Suspended sediment concentration and discharge at selected sites.

ID (See fig. 9.1.9-1)	Station name	Drainage area (mi^2)	Years of record	No. of samples	Discharge (ft^3/s) Minimum	Discharge Maximum	Discharge Median	Suspended sediment (mg/L) Minimum	Suspended sediment Maximum	Suspended sediment Median
1	Mud Pine Cr nr Oxford, Ind.	39	2	12	1.2	1,990	28.4	7	977	76
2	Big Pine Cr nr Williamsport, Ind.	323	1	8	24.3	748	201	14	204	78
66	Wabash R at Covington, Ind.	8,218	13	280	630	42,800	3,740	2	984	78
78	Jordan Cr at Fairmont, Ill.	18	2	3	2.8	59	4.3	11	43	36
83	Grape Cr at Hegeler, Ill.	13	2	3	.7	79	6.4	6	103	49
84	Wabash R at Cayuga, Ind.	9,729	3	32	--------	--------	--------	6	340	58
89	Trib to Little Vermilion R nr Cayuga, Ind.	.54	1	14	.03	4.21	.62	31	497	116
92	Trib to Sugar Cr nr Deer Mill, Ind.	.45	2	9	.02	.63	.23	.5	104	26
95	Wabash R at Montezuma, Ind.	11,118	18	378	901	69,200	5,400	4	1,520	100
96	Leatherwood Cr nr Midway, Ind.	26	2	6	2.6	38.3	7.8	10	50	44
101	Wabash R at Clinton, Ind.	11,708	3	34	--------	--------	--------	4	620	102
107	Trib to Brouilletts Cr nr Centenary, Ind.	2	2	19	.03	1.7	.8	25.5	1,210	137
110	Gin Cr nr Universal, Ind.[1]	8	2	9	.3	4.2	1.5	59	349	123
111	Trib draining Universal Mine nr Universal, Ind.	4.4	2	19	.1	1.6	.5	37	280	163
119	Wabash R above Terre Haute, Ind.	12,263	3	31	--------	--------	--------	8	630	114
120	Wabash R above Terre Haute, Ind.	12,265	14	287	1,100	88,000	5,720	2	1,200	84
123	Wabash R at Terre Haute, Ind.	12,267	6	77	--------	--------	--------	4	370	97
130	Trib to Stone Quarry Br nr Riley, Ind.[1]	2.8	1	7	.08	2.6	.6	46	260	206
149	Hooker Cr nr Lewis, Ind.	2.7	1	3	.4	1.4	.5	21	52	39
22	Busseron Cr nr Hymera, Ind.	16.7	1	3	.4	1,490	421	3.5	314	264
23	W Fk Busseron Cr nr Hymera, Ind.[1]	14.4	3	18	.3	1,850	2.6	0	780	47
156	Mud Cr nr Dugger, Ind.[1]	10	1	8	1.3	12.7	4.7	130	624	250
25	Busseron Cr nr Sullivan, Ind.[1]	138	3	37	10	5,960	42	7	319	60
179	Brushy Fk nr Newman, Ill.	108	2	3	4.3	393	348	17	120	36

[1]Affected by coal-mine drainage.

Coal-Mine Drainage has Affected the Water-Quality of Feather Creek and Busseron Creek Watersheds

In Feather and Busseron Creeks the specific conductance and concentration of dissolved solids and manganese were higher at sites affected by coal-mine drainage than at sites unaffected. In Busseron Creek alkalinity (as calcium carbonate) and pH were lower and concentrations of sulfate and dissolved iron were higher in streams affected by coal-mine drainage than in unaffected streams.

Water-quality of Feather Creek was assessed at eight stream sites by the Geological Survey from October 1975 to September 1976 (Eikenberry, 1977). Water-quality of Busseron Creek was assessed at 46 stream sites by the Geological Survey from November 1975 to July 1976 (Eikenberry, 1978). The purpose of the studies was to delineate water-quality problems and (or) potential problems in the watersheds, particularly in areas of potential development. Feather Creek watershed is located in Vermillion County near Clinton, Indiana. Busseron Creek watershed is located in the southeast part of the study area in Sullivan County, Indiana. Both creeks are tributary to the Wabash River.

According to Eikenberry (1977), chemical quality of the Feather Creek watershed was generally good. Surface water in the watershed is generally calcium bicarbonate type, except at one site where the water type was calcium sulfate because of coal-mine drainage from an abandoned deep mine. In the stream reach affected by coal-mine drainage, specific conductance was 1,540 μmho/cm at 25°C, dissolved-solids concentration was 1,080 mg/L (milligrams per liter), and the concentration of dissolved manganese was 1.2 mg/L. At sites unaffected by mining, specific conductance ranged from 380 to 720 μmho/cm at 25°C, dissolved-solids concentrations ranged from 290 to 386 mg/L, and concentrations of dissolved manganese ranged from 0.02 to 0.39 mg/L. The range of pH for all sites was from 7.3 to 8.6, and concentrations of dissolved iron were less than 0.14 mg/L.

The most significant water-quality problem in the Feather Creek watershed was the high concentrations of fecal coliform (6,700 colonies/100 ml) and fecal streptococci bacteria (18,000 colonies/100 ml) in the main stem of Feather Creek.

Chemical quality of the surface water in the Busseron Creek watershed is affected by coal-mine drainage. Surface water in the Busseron Creek watershed is generally calcium bicarbonate type, except in areas affected by coal-mine drainage where the water is a calcium and magnesium sulfate type. Ranges of measurements and concentrations for several properties and dissolved constituents of streams unaffected and affected by coal-mine drainage are listed in table 9.2.

Municipal wastes also affected the water quality of the Busseron Creek watershed. Concentrations of chloride, phosphate, and total organic carbon were higher at sites affected by municipal wastes than at unaffected sites. Numbers of fecal coliform bacteria and phytoplankton were also much greater in streams affected by municipal wastes (as much as 46,000 colonies per 100 milliliters and 190,000 cells per milliliter, respectively) than at unaffected sites.

Table 9.2 Chemical quality of Busseron Creek watershed November 1975 to July 1976.

Properties and constituents	Streams unaffected by coal-mine drainage	Streams affected by coal-mine drainage
pH	7.4-8.5	3.1-7.0
Alkalinity (mg/L as $CaCO_3$)	68-171	3-16
Specific conductance (μmho/cm at 25°C)	178-460	2,100-2,970
Dissolved solids (mg/L as residue on evaporation at 180°C)	104-228	1,120-2,610
Sulfate (mg/L)	14-45	800-1,900
Dissolved iron (mg/L)	0.02-0.13	12-150
Dissolved manganese (mg/L)	0.11-0.43	5-16

Predominant Aquifers are Sand and Gravel Units in Glacial and Alluvial Deposits

Sand and gravel aquifers of glacial and alluvial origin yield the most water. Glacial outwash is found in the Wabash and Embarras River valleys and in buried bedrock valleys. Aquifers of secondary importance are bedrock and thin, discontinuous units of sand and gravel in the till.

Sand and gravel units in the alluvial and glacial deposits are the predominant aquifers in Area 30. Alluvial deposits are associated with the Wabash and the Embarras River valleys. Glacial deposits are widely dispersed (fig. 10.1-1). The most common glacial deposit is till, consisting of clay, silt, sand, and gravel. The northern two-thirds of the study area is covered by both the Illinoian and Wisconsin tills, whereas the southern one-third is covered by only the Illinoian till. The sand and gravel units within the till generally form thin, discontinuous aquifers.

Glacial outwash is the second most common deposit in Area 30. The deposits are scattered throughout the area and may also be found in buried valleys. The outwash, consisting of well-sorted deposits of sand and gravel overlain by silt and clay, is an excellent water-bearing formation. Many places in preglacial valleys having well-sorted alluvial flood plains were eventually filled by glaciers. The combination of original sand and gravel deposits and the valley fill in some places resulted in extensive aquifers. An example is the Teays (named Mahamet in Illinois) bedrock valley aquifer, which extends across central Illinois and Indiana (Visocky and Schicht, 1969). This valley was filled during glacial and interglacial periods.

Aquifers in Pennsylvanian rock consist of sandstone formations and fractured limestone, shale, and coal. Aquifers also are found in Mississippian, Devonian, and Silurian bedrock. However, these aquifers are tapped only when more recent rock deposits are absent or cannot provide an adequate water supply. The areal extent and the stratigraphic relationships of bedrock in Area 30 are shown in the bedrock geology map (fig. 10.1-2) and in the geologic column (fig. 10.1-3), respectively.

Water is tapped from Mississippian rocks that crop out in the northeastern part of Fountain and Warren Counties, Ind. In the western part of the study area, particularly Douglas County, Ill., uplifted strata of Devonian and Silurian rocks along the LaSalle anticlinal belt yield water.

Specific information on aquifer type and extent is available from well logs and some observation well records. In Indiana, well logs are available from the Division of Water, Indiana Department of Natural Resources at Indianapolis. In Illinois, well logs are available from the Illinois State Water Survey in Urbana. Observation-well records are available from the U.S. Geological Survey in both States.

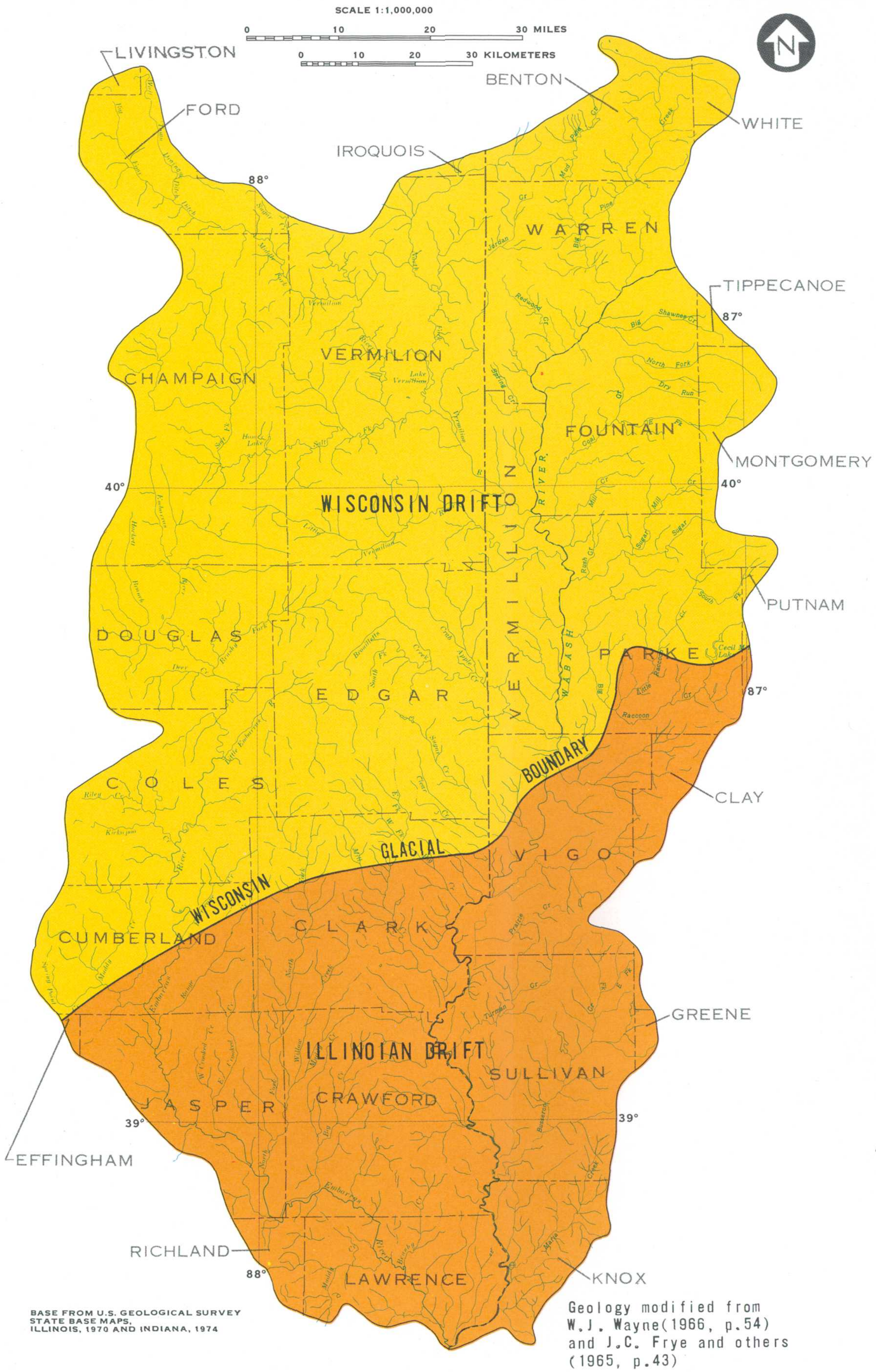


Figure 10.1-1. --Glacial geology.

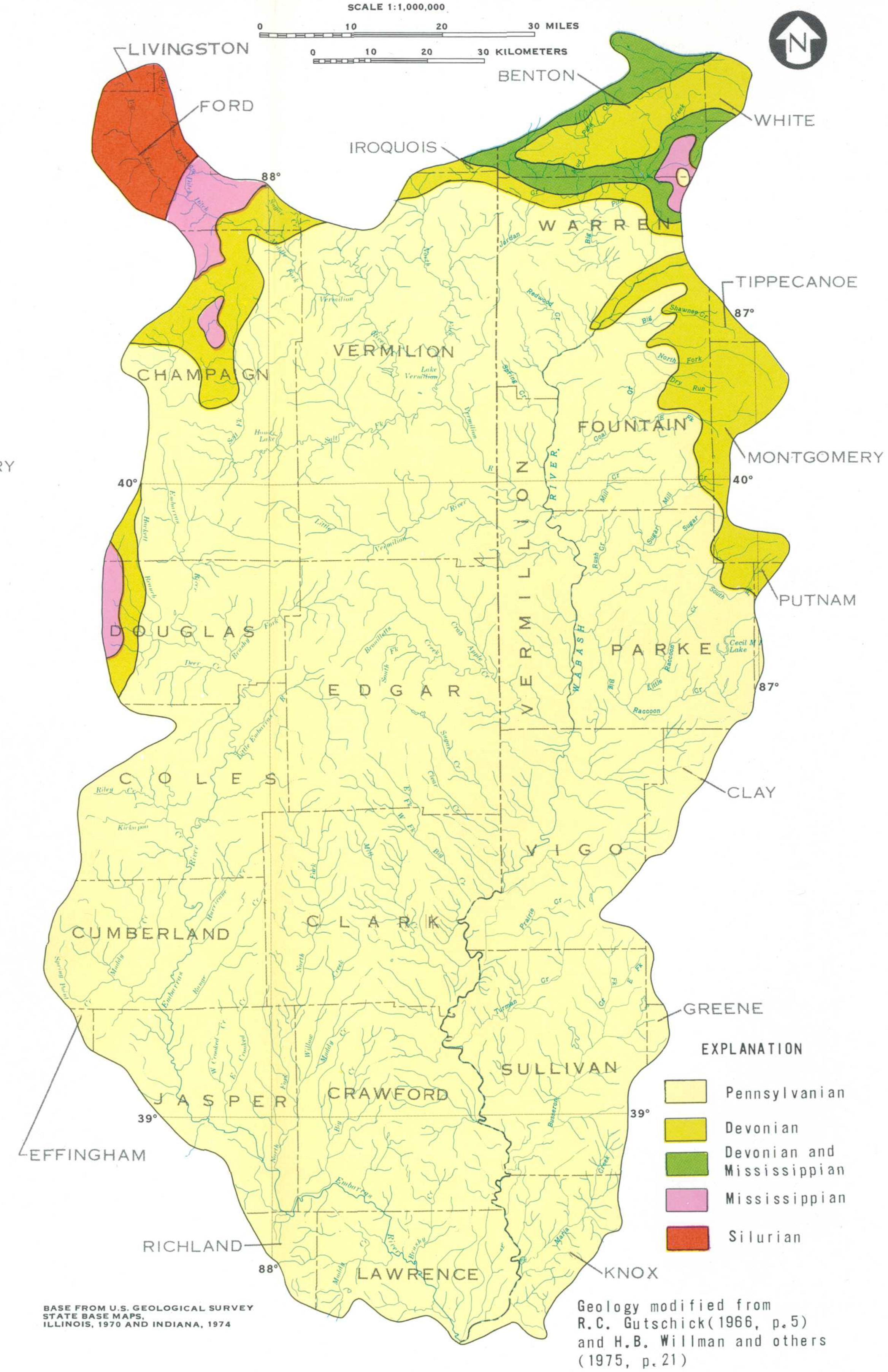


Figure 10.1-2. --Bedrock geology.

SYSTEM	SERIES	THICKNESS (FEET)	LITHOLOGY	SIGNIFICANT MEMBER: INDIANA	SIGNIFICANT MEMBER: ILLINOIS	FORMATION: INDIANA	FORMATION: ILLINOIS	GROUP: INDIANA	GROUP: ILLINOIS
PENNSYLVANIAN	VIRGILIAN / MISSOURIAN	100+		Merom Sandstone Cohn Coal	Greenup Limestone Trowbridge Coal Effingham Limestone Shumway Limestone Calhoun Coal Shelbyville Coal Opdyke Coal Cohn Coal Friendsville Coal	Mattoon Formation[1]	Mattoon Formation[1]	McLeansboro[1]	McLeansboro[1]
	MISSOURIAN	150 to 170		Livingston Limestone Fairbanks Coal Shoal Creek Limestone	Witt Coal Flat Creek Coal	Bond Formation[1]	Bond Formation[1]		
	MISSOURIAN	200 to 250		Parker Coal Hazelton Bridge Coal Ditney Coal	New Haven Coal Womac Coal Chapel Coal (No.8)	Patoka Formation[1]	Modesto Formation[1]		
	DES MOINESIAN			West Franklin Limestone Pirtle Coal	Athensville Coal Lake Creek Coal Pond Creek Coal Rock Branch Coal DeGraff Coal	Shelburn Formation			
	DES MOINESIAN	230 to 345		Danville Coal (VII) Hymera Coal (VI) Herrin Coal Bucktown Coal (VI) Alum Cave Limestone	Danville Coal (No.7) Allenby Coal Jamestown Coal Herrin Coal (No.6)	Dugger Formation	Carbondale Formation	Carbondale[1]	Kewanee
	DES MOINESIAN			Springfield Coal (V) Houchin Creek Coal (VI)	Briarhill Coal (No.5a) Harrisburg Coal (No.5) Summum Coal (No.4) Roodhouse Coal Shawneetown Coal	Petersburg Formation			
	DES MOINESIAN			Survant Coal (IV) Colchester Coal (IIIa)	Colchester Coal (No.2)	Linton Fm.			
	DES MOINESIAN	145 to 450		Seelyville Coal (III) Perth Limestone	Seelyville Coal DeKoven Coal Davis Coal Wise Ridge Coal Mt. Rorah Coal Murphysboro Coal New Burnside Coal Bidwell, O'Nan Coal Litchfield, Assumption Coal	Staunton Formation	Spoon Formation	Raccoon Creek[1]	
	ATOKAN			Minshall & Buffaloville Upper Block Coal Lower Block Coal	Delwood Coal Willis Coal Reynoldsburg Coal	Brazil Fm.	Abbott Fm.		McCormick
	MORROWAN			Shady Lane Coal Mariah Hill Coal Bed Blue Creek Coal Pinnick Coal St Meinrad Coal Bed French Lick Coal	Centry Coal	Mansfield Formation	Caseyville Formation		

[1]Usage of Indiana Geological Survey

Modified from H.H. Gray and others (1970, 1979) and J.B. Patton (1956) and J.C. Frye and H.B. Willman (1975, p.167, 171)

The stratigraphic nomenclature follows the usage of the Illinois Geological Survey and the Indiana Geological Survey and differs somewhat from the usage of the U.S. Geological Survey

Figure 10.1-3. --Stratigraphic section.

10.0 GROUND-WATER QUANTITY

10.1 Aquifers

Ground-Water Recharge and Discharge are Indicated by Water Levels

Well hydrographs in Area 30 show seasonal recharge and discharge but do not indicate long-term trends. Where pumpage is insignificant, recharge equals discharge.

Water levels are a function of recharge and discharge. Recharge from precipitation during late winter and early spring causes a rise in ground-water levels (fig. 10.2-1). During the growing season, loss of ground water to evapotranspiration and discharge to streams causes water-level decline. This seasonal trend is probably typical of water levels in glacial deposits.

In spite of seasonal trends, long-term water levels remain fairly constant. Neither hydrograph in figure 10.2-1 shows a significant long-term trend in water levels. Thus, ground-water discharge and recharge are in equilibrium.

Bedrock aquifers are recharged mainly by precipitation on outcrop areas and, to a lesser extent, by leakage from overlying material.

Recharge area, leakage rates, confining-bed thickness, permeability coefficients, and vertical head loss in the aquifer determine recharge rates. Walton (1965, p. 33-35) discusses theoretical application for determining recharge rates of aquifers in Illinois. Field testing of aquifers may be required to determine recharge rates in Area 30. However, an estimate of recharge is possible by equating it with the summation of discharge and pumpage. If pumpage is insignificant, recharge equals discharge.

Ground-water discharge can be estimated by hydrograph separation techniques. Walton (1965, p. 35) determined discharge for several drainage basins in Illinois by a separation technique described in Linsley and others (1958, p. 135). Groundwater discharge from basins in Area 30 were determined for years with below, near, and above average precipitation (table 10.2). Walton (1965) defined these precipitation classes only by the year of precipitation, not by the amount of precipitation.

Table 10.2 Ground-water discharge for below-, near-, and above-normal precipitation in Illinois

[Data from Walton, 1965, p.39. $(ft^3/s)/mi^2$, cubic foot per second per square mile]

Station	Annual ground water discharge $[(ft^3/s)/mi^2]$			Drainage area (mi^2)
	Below normal	Near normal	Above normal	
Salt Fk Vermilion R nr Homer, Ill.	0.14	0.39	0.58	344
Vermilion R nr Catlin, Ill.	.14	.32	.56	959
Vermilion R nr Danville, Ill.	.14	.35	.60	1,280
Embarras R nr Oakland, Ill.	.10	.28	.48	535
Embarras R nr Diona, Ill.	.15	.34	.60	903
Embarras R at Ste. Marie, Ill.	.18	.30	.42	1,540
N Fk Embarras R nr Oblong, Ill.	.09	.16	.22	304
Embarras R at Lawrenceville, Ill.	.28	.40	.62	2,260

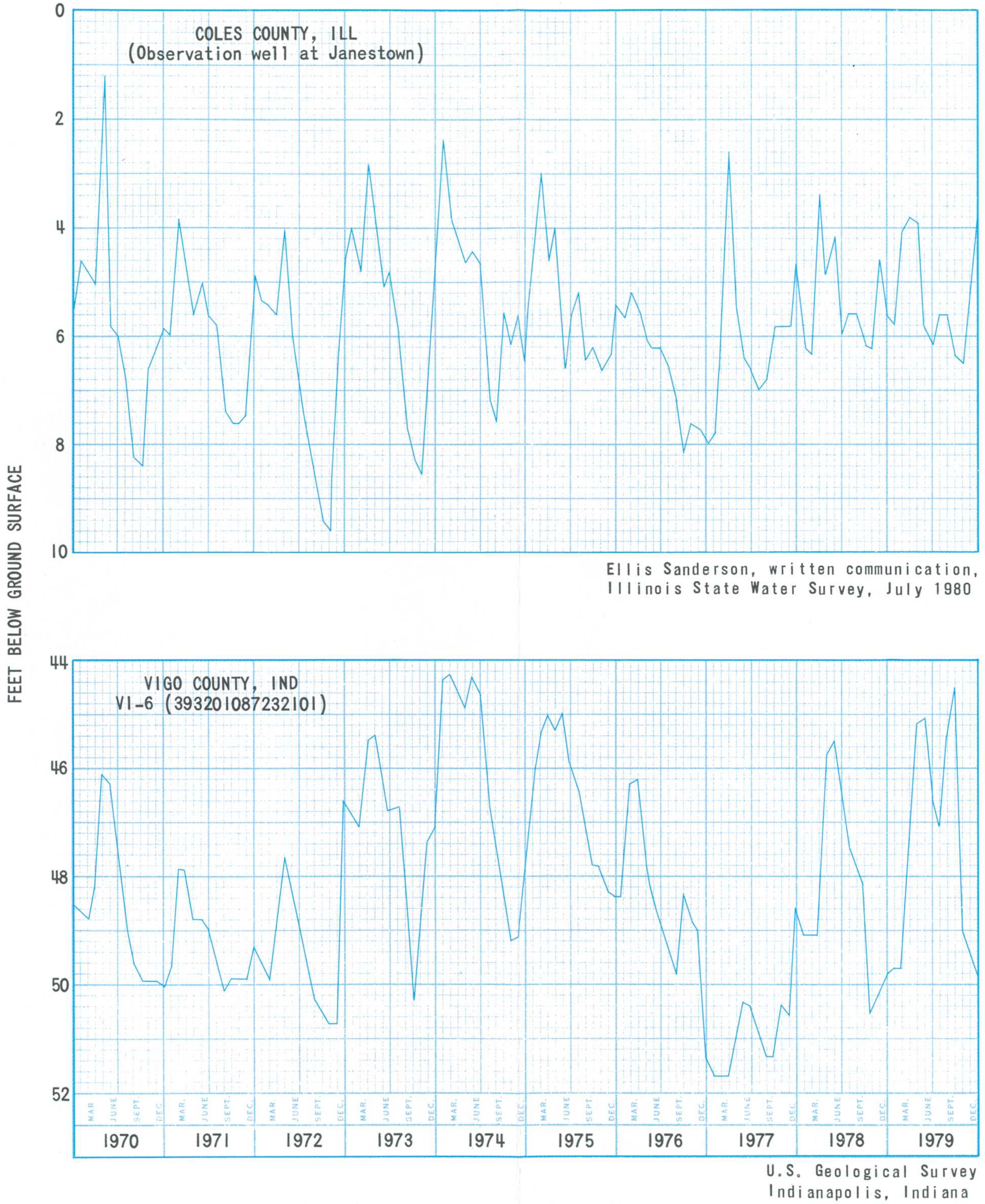


Figure 10.2-1. --Hydrographs of selected wells.

Sand and Gravel Aquifers Generally have Greater Yields than Bedrock Aquifers

Yields from sand and gravel aquifers ranged from 1 to 3,000 gallons per minute. Yields from bedrock aquifers ranged from 1 to 110 gallons per minute.

Sand and gravel aquifers generally provide more water than bedrock aquifers. Yields are highest in the alluvial and outwash deposits along the Wabash and Embarras Rivers (fig. 10.3-1) and in the Teays valley bedrock aquifer. Bechert and Heckard (1966, p. 108) indicated that wells in the Wabash alluvium commonly yield 700 gal/min (gallons per minute). Selkregg and Kempton (1958, p.21) report that a test well in the Teays valley bedrock aquifer yielded about 1,900 gal/min. In contrast, bedrock aquifers yield about 110 gal/min or less (table 10.3).

Table 10.3 Ranges of well depths and yields.

[Data from Woller, 1974 a, b, and c, and 1975; Watkins and Jordan, 1965 a and b]

Aquifer type	County	Well depth (ft)	Well yield (gal/min)
Sand and gravel	Champaign, Ill.	26-340	25-3,000
Do.	Ford, Ill.	56-340	74-1,900
Do.	Vermillion, Ind.	10-230	1-1,200
Do.	Fountain, Ind.	30-190	5-1,000
Do.	Crawford, Ill.	32-85	75-800
Do.	Edgar, Ill.	38-165	23-348
Mississippian bedrock	Fountain, Ind.	30-400	1-110
Pennsylvanian bedrock	Vermillion, Ind.	50-55	1-75
Pennsylvanian bedrock	Fountain, Ind.	40-300	1-50

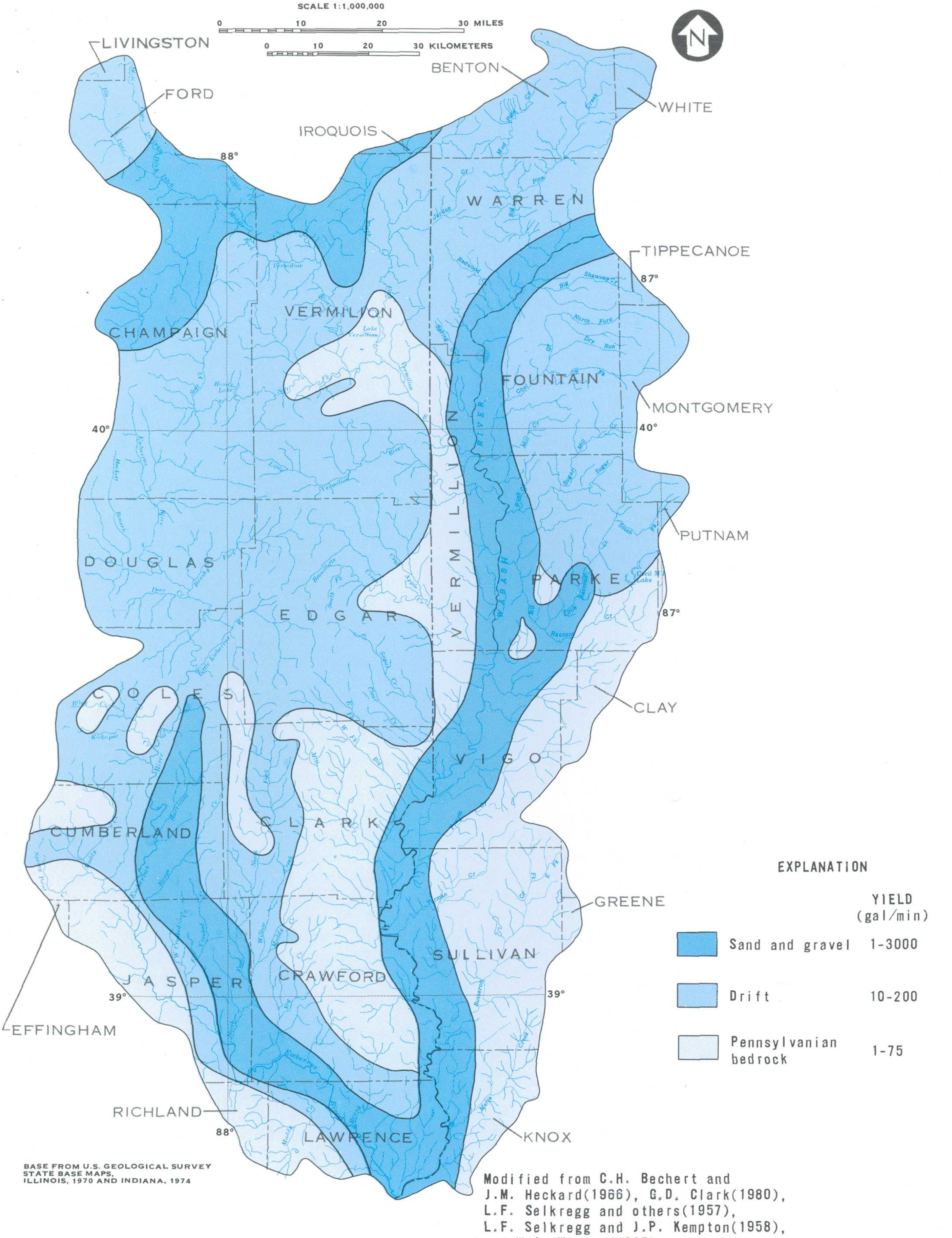


Figure 10.3-1. --Ground-water potentia1.

11.0 GROUND-WATER QUALITY

Greatest Variation in Ground-Water Quality is with Depth

Sulfate and manganese concentrations are higher in the glacial aquifers than in the bedrock aquifers, but sulfate concentration can be high locally in the bedrock. Also, dissolved-solids concentration generally increases with depth.

Chemical constituents in ground water are from several sources: (1) the surface materials through which water perculates, (2) minerals in the aquifer, and (3) seepage from surrounding formations (Nyman and Pettijohn, 1971, p. 7). Glacial aquifers and bedrock aquifers near their outcrop areas usually produce potable water. Deep bedrock aquifers that are confined by impervious layers usually produce poor-quality and sometimes nonpotable water (Harrell, 1935, p. 75-76). According to Nyman and Pettijohn (1971, p. 7), "Wells deeper than 300 feet (in the Wabash River basin) generally yield mineralized or saline water."

Concentrations of fluoride, bicarbonate, and dissolved solids increase with depth and the hardness and sulfate concentrations decrease (Cable and others, 1971; and Cable and Robison, 1973). Also, the water in shallow glacial aquifers (less than 100 feet deep) is generally calcium bicarbonate type that changes to sodium bicarbonate type in deeper bedrock aquifers. The decrease in hardness from an average of 300 mg/L in glacial aquifers to 150 mg/L in bedrock aquifers is attributed to the exchange of sodium for calcium and magnesium (Cable and Robison, 1973, p. 13). The increase in fluoride from an average of 0.2 mg/L in glacial aquifers to 3 mg/L in bedrock aquifers is attributed to dissolution of calcium and magnesium fluorides in the bedrock aquifers (Cable and others, 1971, p. 28). Bicarbonate increases with depth from an average of 250 mg/L in glacial aquifers to 450 mg/L in bedrock aquifers. The increase is from a series of reactions involving sodium, carbon dioxide, and carbonate minerals in the bedrock aquifers (Cable and Robison, 1973, p. 18). The greater availability of oxygen in the glacial aquifers and the shallow bedrock aquifers than in the bedrock probably causes more pyrite oxidation and, therefore, higher sulfate concentrations in the shallow aquifers than in the deep bedrock aquifers (Cable and others, 1971, p. 28).

Chloride and sulfate concentrations exceed 250 mg/L in ground water from 50 to 350 feet below land surface in isolated parts of Sullivan, Parke, and Fountain Counties, Ind. (Watkins and Jordan, 1962, 1964, 1965a). High chloride concentrations can result from natural upward seepage from deeper formations. This seepage can be increased by oil and gas wells that allow upward seepage of water through the borehole and into fractures in the upper bedrock layers. Shedlock (1980, p. 1) described a plume of saline water near Vincennes, Ind., that was entering the glacial aquifer through bedrock fractures near abandoned oil wells. The isolated high sulfate concentrations are generally found at depths from 50 to 100 feet and are probably associated with isolated areas of high-sulfur coal.

Medians and ranges of concentrations for constituents and properties of the water from glacial and combined bedrock aquifers for Area 30 are shown in the adjacent bar graphs (fig. 11.0-1). The more extensive Indiana data represents more deep bedrock aquifers than the Illinois data. The Illinois data are generally from glacial aquifers and shallow bedrock aquifers used primarily for drinking water. Although the data sources are not equally distributed areally, the generalized graphs are probably representative of the water-quality range in the study area. For convenience, the concentrations presented are compared to the National Secondary Drinking Water Standards of the U.S. Environmental Protection Agency (1979) and the National Academy of Sciences and the National Academy of Engineering (1972 1974), as a point of reference. The recommended standards are listed in table 11.

Water-quality data from wells in the study area but not summarized in this report are stored in the National Water Data Storage and Retrieval System by latitude and longitude and are available at the Indiana District Office of the Geological Survey, Indianapolis, Ind. However, for most samples, the aquifer has not been identified, and the information is of limited use.

Table 11 Recommended water-quality standards

Constituent or property	Recommended standard	Criteria for recommended standard
pH[1]	6.5 to 8.5	<6.5 can contribute to corrosive potential of of water; >8.5 can cause encrustation of pipes.
Dissolved solids[1]	500 mg/L	>500 mg/L can cause excessive hardness, mineral deposition, corrosion, and adverse taste.
Iron[2]	0.3 mg/L	>0.3 mg/L can cause taste and stain problems.
Manganese[2]	0.05 mg/L	>0.05 mg/L can cause taste and stain problems.
Sulfate[1]	250 mg/L	>250 mg/L can cause adverse taste and laxative effects.

[1]U.S. Environmental Protection Agency (1979).
[2]National Academy of Sciences and the National Academy of Engineering (1972 [1974]).

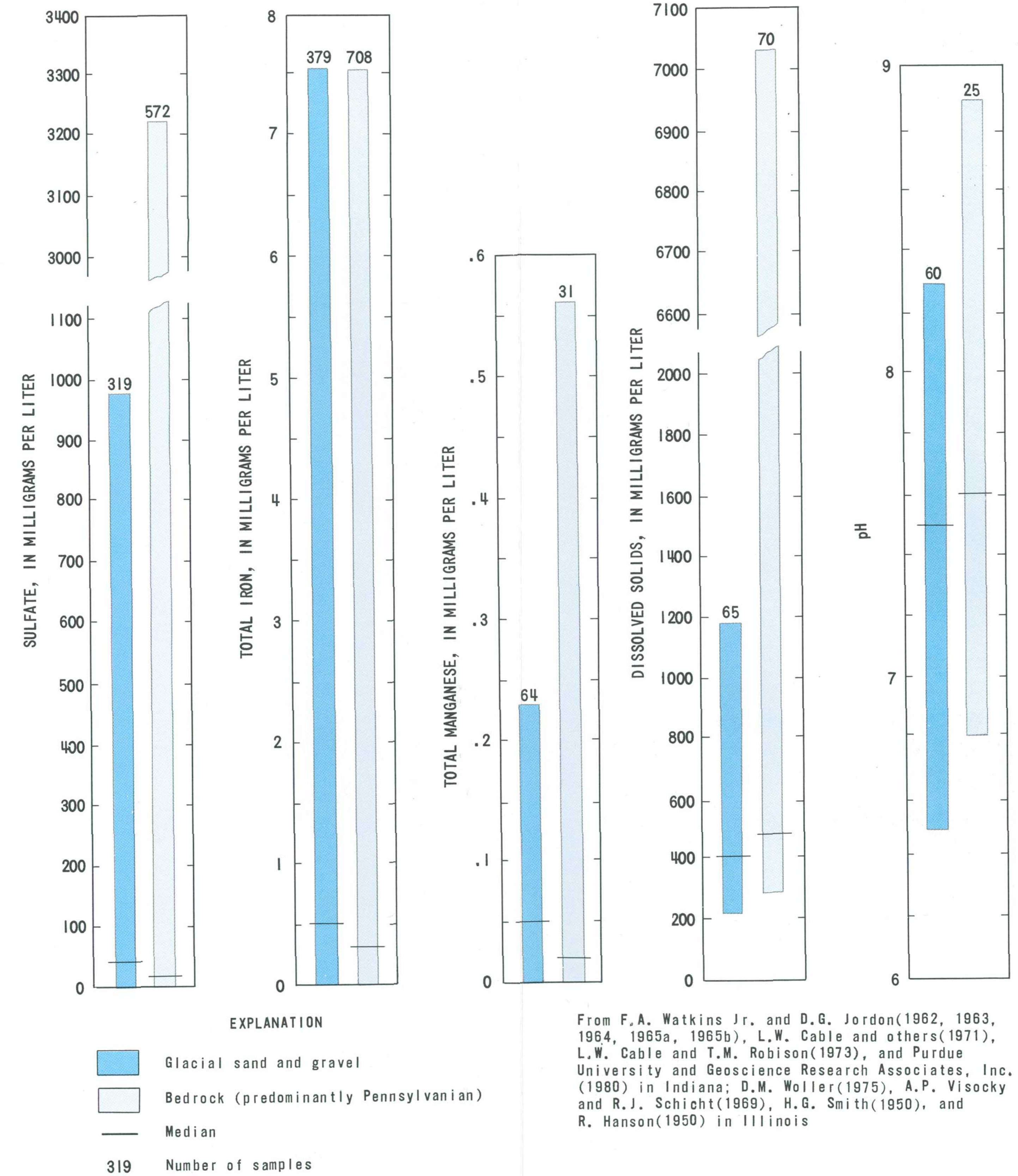


Figure 11.0-1.--Median concentrations and ranges in concentrations of selected ground-water-quality parameters in Indiana and Illinois.

NAWDEX, WATSTORE, and OWDC Help Users Obtain Water Data

Water data in coal areas are collected by many organizations in response to a wide variety of needs.

Three facilities within the Geological Survey help to identify and improve access to the vast quantity of water data:

(1) The National Water-Data Exchange (NAWDEX), which indexes water data available from more than 400 organizations and serves as a central focal point for determining what water data are available.

(2) The National Water-Data Storage and Retrieval System (WATSTORE), which serves as the central repository of water data collected by the Geological Survey, contains much data on the quantity and the quality of both surface water and ground water.

(3) The Office of Water Data coordinatlon (OWDC), which coordinates Federal water-data acquisition and maintains a "Catalog of Information on Water Data." Special indexes to the catalog, identifying water-data facilities in coal provinces of the United States, are being printed.

More detailed explanations of items 1, 2, and 3 are given in sections 12.2, 12.3, and 12.4.

NAWDEX Simplifies Access to Water Data

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

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

NAWDEX can assist any organization or individual in identifying and locating water data. For this service, NAWDEX maintains a computerized Master Water-Data Index, that identifies sites for which water data are available, the type of data available for each site, and the organization storing the data. NAWDEX also maintains a Water-Data Sources Directory identifying organizations from which data may be obtained. In addition, NAWDEX has direct access to some large water-data bases of its members and has reciprocal agreements for 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 time, extensive personnel time, duplicating services, or other costs to NAWDEX in 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 on 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

or

NAWDEX ASSISTANCE CENTER
Indiana
U.S. Geological Survey
Water Resources Division
6023 Guion Road, Suite 201
Indianapolis, IN 46254

Telephone: (317) 927-8640
FTS 336-8640

Hours: 7:30 to 4:00 eastern standard time

Illinois
U.S. Geological Survey
Champaign County Bank Plaza
102 East Main Street, 4th Floor
Urbana, Illinois 61801

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

Hours: 8:00 to 4:30 central standard time

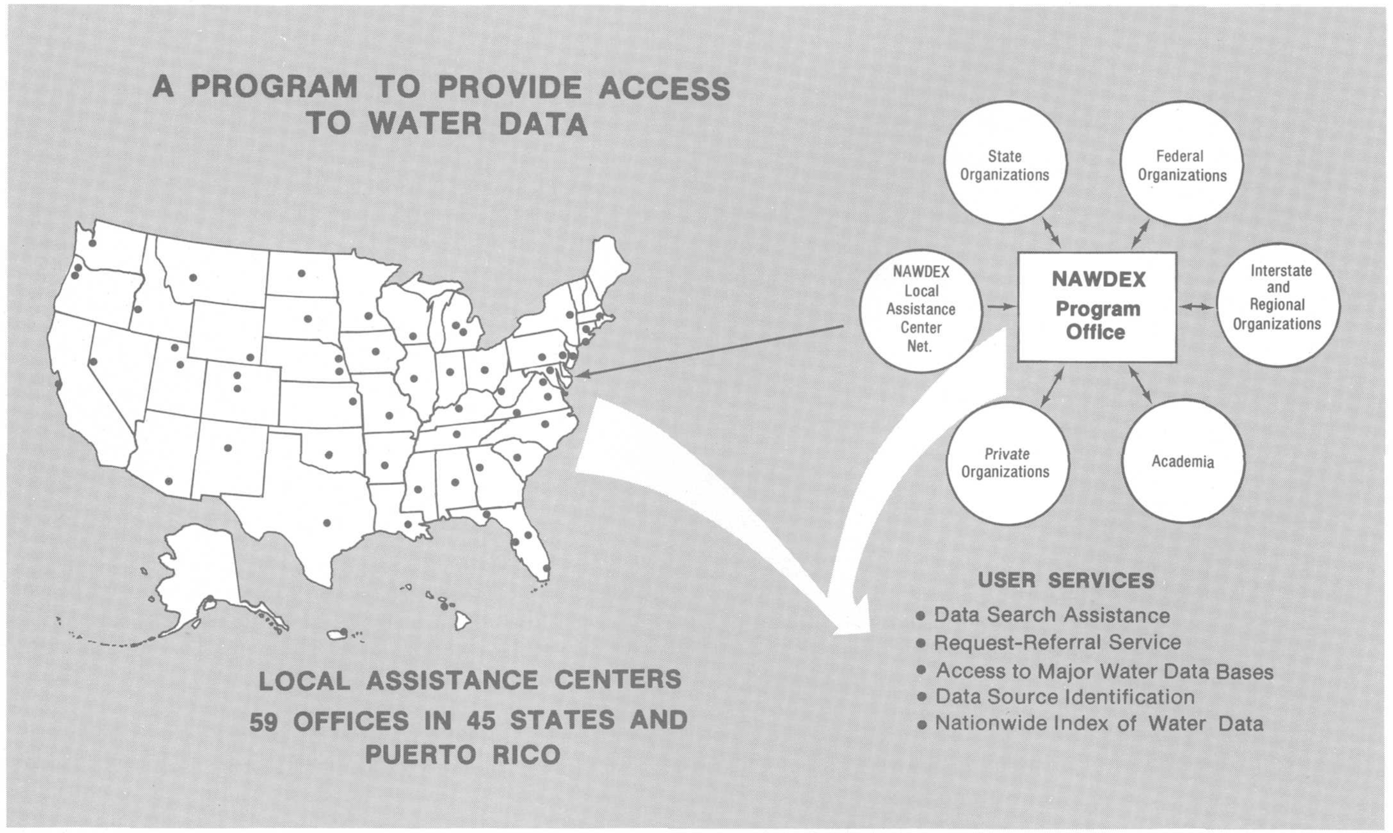


Figure 12.2-1 Access to water data.

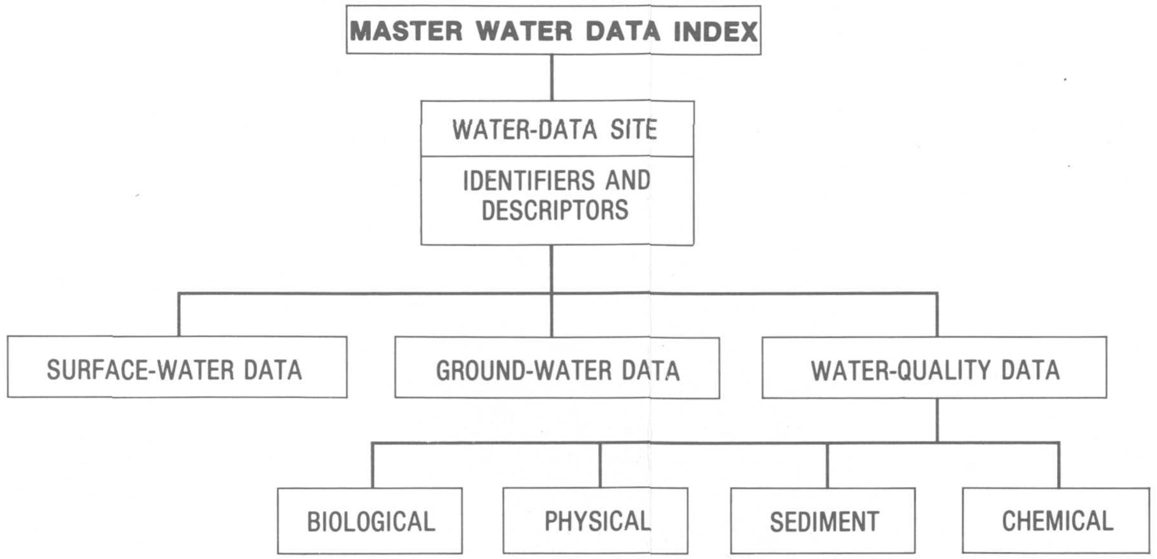


Figure 12.2-2 Master water-data index.

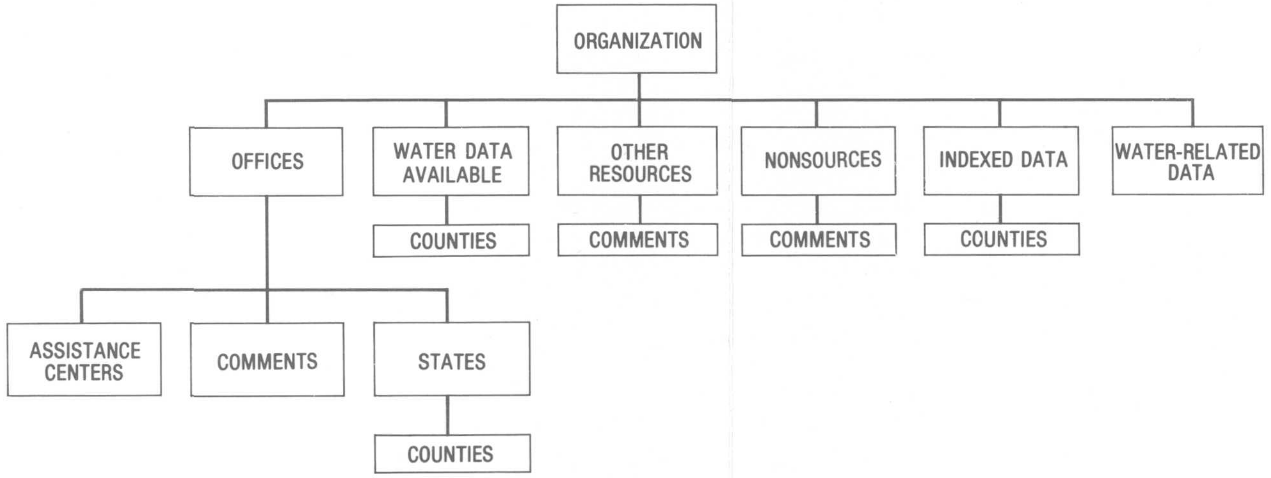


Figure 12.2-3 Water-data sources directory.

WATSTORE Automated Data System

The National Water-Data Storage and Retrieval System (WATSTORE) of the Geological Survey provides computerized procedures and techniques for processing water data.

The National Water-Data Storage and Retrieval System (WATSTORE) was established in November 1971 to computerize the water-data system of the Geological Survey and to provide for more effective and efficient management of data releasing. The system is operated and maintained on the central computer facilities of the Survey at its National Center in Reston, Va. Data may be obtained from WATSTORE through 46 District offices of the Geological Survey. General inquires concerning WATSTORE may be directed to:

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

or

U.S. Geological Survey
Water Resources Division
6023 Guion Road, Suite 201
Indianapolis, IN 46254

or

U.S. Geological Survey
Champaign County Bank Plaza
102 East Main Street, 4th Floor
Urbana, Illinois 61801

The Geological Survey currently (1982) collects data at approximately 16,000 stream-gaging stations, 1,000 lakes and reservoirs, 5,200 surface-water- quality stations, 1,020 sediment stations, 30,000 observation wells, and 12,500 ground-water quality wells. Each year many collection sites are added and others are discontinued. Thus, large quantities of diversified data, both current and historical, are amassed by the Geological Survey.

The WATSTORE system consists of several files in which data are grouped and stored by common characteristics and collection frequencies. The system is designed to allow for adding data files as needed. Files are maintained for storing (1) surface-water, quality-of-water, and ground-water data measured on a daily or continuous basis; (2) annual peak values for streamflow stations; (3) chemical analyses of surface water and ground water; (4) water characteristics 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 follows:

Station-Header 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. It contains information pertinent to identifying, locating, and describing nearly 220,000 sites.

Daily-Values File: All characteristics measured or observed, either daily or continuously, 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 may also be stored. The file contains more than 200 million daily measurements, including data on streamflow, river stage, reservoir content, water temperature, specific conductance, sediment concentration, sediment discharge, and ground-water level.

Peak-Flow File: Annual maximum (peak) streamflow (discharge) and gage height (stage) data at surface-water sites compose this file, which currently contains more than 400,000 peak measurements.

Water-Quality File: Analyses of more than 1.4 million water samples in this file indicate the chemical, physical, biological, and radiochemical characteristics of both surface water and ground water. These analyses include data for 185 constituents and properties.

Unit-Values File: Water properties and constituents measured more frequently than daily are stored in this file. Rainfall, stream-discharge, and water-temperature data are examples of the types of data stored.

Ground-Water Site-Inventory File: This file is maintained with WATSTORE independent of the preceding files, but it is cross referenced to the WaterQuality File and the Daily-Values File. The file contains inventory data on wells and springs. Examples of data are site location, site identification, geohydrologic characteristics, well-construction history, and one-time field measurements of water temperature. The file is designed to accomodate 255 data elements and currently contains data for nearly 700,000 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 or retrieved from WATSTORE at several locations that are part of a nationwide telecommunication network.

Remote Job-Entry Sites: Almost all District offices of the Geological Survey are equipped with high-speed computer terminals for remote access to the WATSTORE system. These terminals allow each site to put data into or retrieve data from the system within times ranging from several minutes to overnight, depending on the priority of 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 such values as river stage, specific conductance, water temperature, turbidity, wind direction, and chloride concentration. Data are recorded on 16-channel paper tape and are transmitted over telephone lines to the receiver at Reston, Va. The data are recorded on magnetic tape for use on the central computer. Extensive testing of satellite data-collection platforms indicates their feasibility for collecting real-time hydrologic data on a natsatellite. About 200 data-relay stations are being operated currently (1982).

Central-Laboratory System: The two water-quality laboratories of the Geological Survey, in Denver, Colo., and Atlanta, Ga., analyze more than 150,000 water samples per year. These laboratories are equiped to determine concentrations of dissolved constituents ranging from simple inorganic compounds, such as chlorides, to complex organic compounds, such as pesticides, and to measure various properties of water. After verification, results of each analysis are transmitted by a computer terminal to the central computer facilities for storing the Water-Quality File of WATSTORE.

Water data are used in many ways in managing, developing, and monitoring water resources. In addition to its data processing, storage, and retrieval capabilities, WATSTORE can provide a variety of useful products, ranging from simple data tables to complex statistical analyses. A minimal fee, plus the actual computer cost to produce a desired product, is charged to the requester.

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 data or condensed indexes that indicate availability of stored data. A variety of formats is available to display the many types of data.

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

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

Digital Plotting: WATSTORE also uses software systems that prepare data for digital plotting on peripheral off-line plotters available at the central computer site. Hydrographs, frequency-distribution curves, X-Y points, contours, and three-dimensional illustrations can be plotted.

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 userwritten computer programs. These data are available in the standard storage format of the WATSTORE system or in the form of punched cards or card images on magnetic tape.

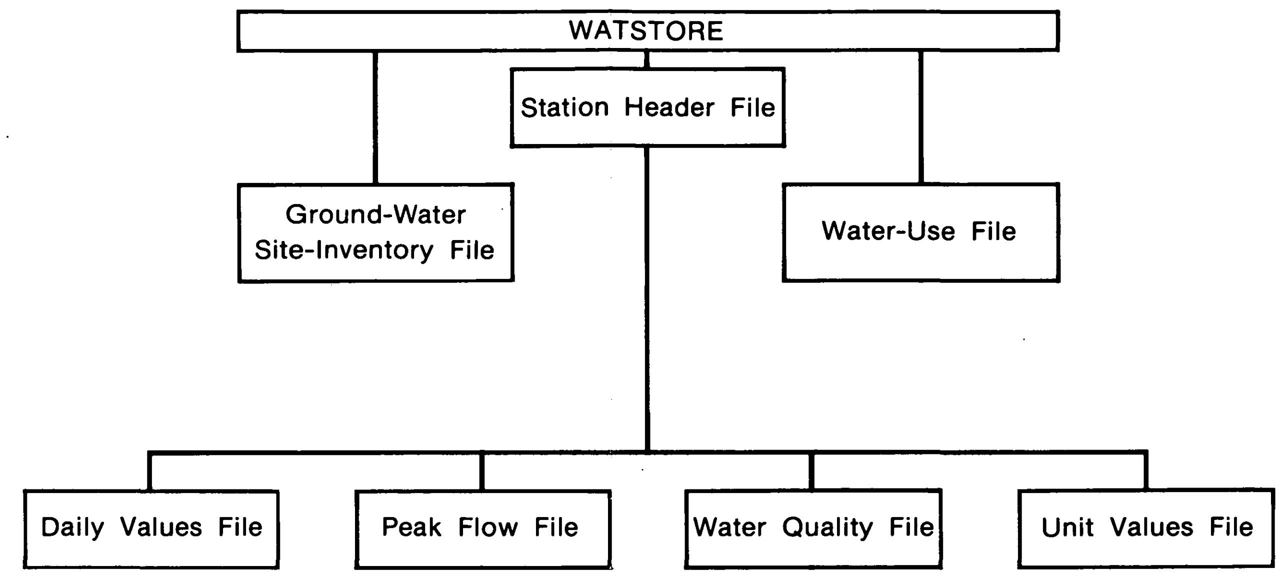


Figure 12.3-1 Index file stored data.

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 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 does not contain the data; rather, it provides information that will enable the user to determine if needed data are available. The index consists of five volumes: 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. These volumes aid the user in obtaining data for evaluating 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 data are stored, and (5) agency or organization reporting the activity. Part D summarizes areal hydrologic investigations and water-data activities not included in other parts of the index. Agencies that submitted the information, agency codes, and the number of activities reported by type are shown in a table.

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

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

U.S. Geological Survey
Water Resources Division
6023 Guion Road, Suite 201
Indianapolis, IN 46254

Telephone: (317) 927-8640
FTS 336-8640

or

Office of Surface Mining
U.S. Department of the Interior
46 E Ohio Street
Indianapolis, IN 46202

Telephone: (317) 269-2600
FTS 331-2636 or
FTS 331-2600

or

U.S. Geological Survey
Champaign County Bank Plaza
102 East Main, 4th Floor
Urbana, Illinois 61801

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

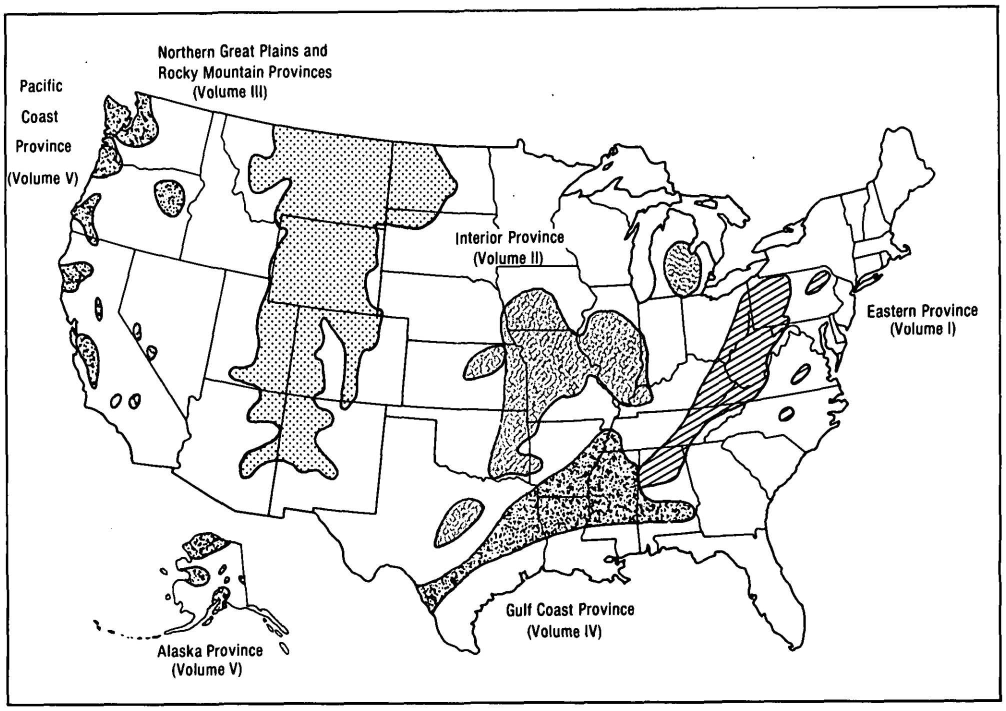


Figure 12.4-1 Index volumes and related provinces.

13.0 SUPPLEMENTAL INFORMATION FOR AREA 30

13.1 Description of Soil Associations

Illinois soil associations

[Source: Fehrenbacher and others (1967)]

Soil association		Soil description			Normal slope range (percent)	
Symbol	Major soil series	Surface horizons	Subsoils	Drainage		Remarks
B	Sidell	Dark-colored silty loam	Yellow-brown, silty clay loam	Moderately well drained	6-12	Parent materials are loess over loam to silty clay-loam till. Associated soils are Harpster, Pella, and Peotone.
	Catlin	do.	Brown, silty clay loam	do.	3-7	
	Flanagan	Black silty silty loam	Gray-brown, silty clay loam	do.	1-3	
	Drummmer	Black silty silty clay loam	Dark gray silty clay loam	do.	0-1	
E	Oconee	Dark-gray silty loam	Gray-brown, silty clay loam	Poorly drained	2-7	Parent materials are acidic; formed on loess over weathered Illinoian till. Associated soils are O'Fallon, Ebbert, Huey, Shiloh, Tamalco, Velma, and Walshville.
	Cowden	do.	Gray-brown, silty clay loam to silty clay	do.	1-3	
	Piasa	do.	Gray, silty clay loam to silty clay	do.	0-2	
F	Hoyleton	Dark, gray-brown, silty loam.	Gray-brown, silty clay	Poorly drained	1-4	Parent materials are acidic; formed on loess over weathered Illinoian till. Associated soils are Richview, Chauncey, Ebbert, Lukin, Newberry, Tamalco, and Walshville.
	Cisne	do.	do.	do.	0-2	
	Huey	do.	Gray silty clay	Very poorly drained	0-2	
G	Warsaw	Gray-brown, silty loam	Brown clay loam	Moderately well drained	1-8	Soils were developed under grass vegetation from thin, medium-textured material on gravel. Associated soils are Abington, Kane, Omaha, Will, Lorenzo, Palestine, Stockland, Stonington Troxel, and Volinia.
	Carmi	Gray-brown, sandy loam	Brown clay loam to gravely-clay loam	do.	1-5	
	Rodman	Dark-brown loam	Light- and dark-colored gravels	Very well drained	1-8	
I	LaRose	Gray-brown silty loam	Brown clay loam	Moderately well drained	7-15	Parent materials are thin loess on calcareous loam till. Associated soils are Corwin, Odell, Parr, Pella, Ayr, and Drummer.
	Saybrook	Dark-brown silty loam	Brown, silty clay loam to clay loam	do.	2-7	
	Lisbon	Dark-brown to black silty loam loam	Gray and brown silty clay loam to clay loam	do.	1-3	
J	Elliott	Dark-brown to black silty loam	Gray and brown, silty clay loam to silty clay	Poorly drained	1-3	Soils formed under grass vegetation from silty, clay-loam till. Associated soils are Rankin, Reddick, Symerton, Varna, Wesley, Houghton, Lena, Palms, and Peotone.
	Ashkum	Black, silty clay loam	Dark-gray, silty clay loam	do.	0-1	
	Andres	Black to dark brown silty loam	Gray and brown clay loam	Moderately well drained.	1-3	
K	Swygert	Dark-gray to black, silty, clay loam	Gray and brown silty clay	Poorly drained	1-6	Soils formed under grass vegetation from silty clay or clay till or drift. Associated soils are Mokena, Mona, Monee, Papineau, and Rantoul.
	Bryce	Black to dark-gray silty clay	Dark gray silty clay	do.	0-2	
	Clarence	Dark-gray to black, silty clay loam	Gray and brown clay	Very poorly drained	1-6	
	Rowe	Black to dark-gray silty clay	Gray silty clay to clay	do.	0-3	

Description of soil associations in Area 30.--Continued

Soil association		Soil description			Normal slope range (percent)	
Symbol	Major soil series	Surface horizons	Subsoils	Drainage		Remarks
M	Birkbeck	Dark, gray-brown silty loam	Brown, silty clay loam	Moderately well drained	2-8	Soils formed under forest or mixed forest and prairie vegetation from loess on loam to silty, clay-loam till. Associated soils are Fincastle, Mellott, Sabina, Sunbury, Toronto, Wingate, Xenia.
	Ward	do.	Dark-gray to gray-brown, silty clay loam	Poorly drained	0-1	
	Russell	do.	Brown, silty clay loam to clay loam	Moderately well drained	3-8	
P	Hosmer	Dark, gray-brown silty loam	Brown and gray, silty clay loam	Poorly drained	3-10	Soils formed under forest vegetation from loess on Illinoian drift or bedrock residium. Associated soils are Hickory, Negley, Parke, Pike, and Wartrace.
	Stoy	do.	do.	do.	1-4	
	Weir	do.	Gray, silty clay loam	do.	0-2	
Q	Ava	Dark, gray-brown silty clay loam	Brown and gray, silty clay loam	Poorly drained	3-7	Soils formed under forest vegetation from loess on Illinoin drift and till. Associated soils are Blair, Hichory, Creal, El Dara, Negley, Parke, Pike, and Racoon.
	Bluford	do.	do.	do.	1-4	
	Wynoose	do.	Gray, silty clay loam to silty clay	Very poorly drained	0-2	
W	Littleton	Dark-brown to dark-gray silty loam	Gray and brown silty loam	Poorly drained	0-2	Soils formed from water-deposited materials. Associated soils are Argo, Beardstown, Brooklyn, Dowagiac, Ellison, Emma, Harpster, Knight, Lomax, Montgomery, Niota, Oakford, Pittwood, Thorp, Troxel, Venedy, Wagner, and Zwingle.
	Proctor	Dark-brown silty loam	Brown, silty clay loam to clay loam	Moderately well drained	1-4	
	Plano	do.	Brown, silty clay loam	do.	1-4	
	Camden	Dark, gray-brown silty loam	Brown, silty clay loam to clay loam	do.	1-7	
	Hurst	do.	Gray-brown silty clay	Very poorly drained	1-4	
	Ginat	do.	Gray, silty clay loam to clay loam	Poorly drained	0-1	
Z	Lawson	Black silty loam	Black to dark-gray silty loam	Moderately well drained	0-1	Bottomland soils separated into three groups: (1) Calcareous soils (2) slightly acid to neutral soils and (3) acid soils. Associated soils are Ambraw, Burnside, Cairo, Calco, Elsah, McFain, Orion, and Sawmill.
	Beacoup	Dark-gray to black, gravely clay loam	Dark-gray, silty clay loam	do.	0-1	
	Darwin	Dark-gray silty clay	Gray silty clay to clay	Very poorly drained	0-1	
	Haymond	Dark, gray-brown silty loam.	Brown, silty loam	Moderately well drained	0-2	
	Belknap	do.	Gray and brown silty loam	Poorly drained	0-2	

Description of soil associations in Area 30.--Continued

Indiana soil associations

[Source: U.S. Soil Conservation Service (1977a)]

Soil association		Soil description			Normal slope range (percent)	
Symbol	Major soil series	Surface horizons	Subsoils	Drainage		Remarks
A1	Genesee	Light-colored loam	Light-colored loam with sand below 40 inches	Well drained	0-2	Parent materials are calcareous loamy alluvium, on wide flood plains of streams originating in glacial deposits of Wisconsin age. Fox soils are associated.
	Eel	do.	do.	Moderately well drained	0-2	
	Shoals	do.	do.	Poorly drained	0-2	
A4	Stendal	Light-colored, silty loam	Silty loam or silty, clay loam	Poorly drained	0-2	Parent materials neutral to acid, silty, alluvial deposits. Located on flood plains. Minor soils are Armiesburg, Cuba, Genesee, Petrolia, and Steff.
	Haymond	do.	do.	Well drained	0-2	
	Wakeland	do.	do.	Poorly drained	0-2	
	Nolin	do.	do.	Well drained	0-2	
C1	Rensselaer	Dark-colored silty loam	Dark-colored clay loam	Very poorly drained	0-2	Parent materials are stratified, loamy outwash and lacustrine deposits on nearly level lacustrine plains. Associated soils are Mahalasville and Sebewa.
	Darroch	Dark-colored loam or silt loam	Light-colored clay loam	Poorly drained	0-2	
	Whitaker	Light-colored loam or silt loam	do.	do.	0-2	
E2	Elston	Dark-colored sandy loam or loam	Dark-colored sandy loam	Well drained	0-6	Parent materials are loamy outwash over calcareous sand and gravel deposits. Soils formed on terraces and outwash plains. Associated soils are Volinia, Coupee, Fox, Sebewa, and Wea.
	Shipshe	do.	Dark-colored gravelly, sandy loam	do.	0-6	
	Warsaw	do.	Dark-colored sandy loam or sandy clay loam	do.	0-6	
E4	Fox	Light-colored loam or silt loam	Brown clay loam, or sandy, clay loam	Well drained	0-6	Parent materials are loamy outwash over calcareous sand and gravel. Soils formed on Wisconsin terraces and outwash plains. Associated soils are Genesee, Sleeth, Nineveh, and Martinsville.
	Ockley	do.	do.	do.	0-6	
	Westland	Dark-colored silty loam	Dark-colored clay loam	Very poorly drained	0-2	
G	Princeton	Light-colored, fine sandy loam	Sandy, clay loam	Well drained	0-12	Parent material is calcareous eolian sand of Wisconsin age. Found on dunes and swales along the Wabash River and its tributaries. Minor soils are Iva and Lyles.
	Bloomfield	Light-colored, loamy, fine sand	Bands of sandy loam	do.	2-18	
	Ayrshire	Light-colored, fine, sandy loam	Sandy, clay loam	Somewhat poorly drained	0-2	
H	Alford	Light-colored silty loam	Silty clay loam	Well drained	2-18	Parent material leached loess more than 5 feet thick. Found in loessial hills.
I1	Ragsdale	Dark-colored silty loam or silty, clay loam	Silty clay loam	Very poorly drained	0-2	Parent material is loess and other silty sediments over a Wisconsin age till plain. Associated soils are Dana and Sidell.
	Raub	do.	do.	Poorly drained	0-2	
I2	Sable	Dark-colored silty clay loam	Silty clay loam	Very poorly drained	0-2	Parent material is loess over a Wisconsin age till plain. Soils formed under grass vegetation. Associated soil is Raub.
	Ipava	Silt loam	do.	Poorly drained	0-2	
I3	Fincastle	Light-colored silt loam	Silty clay loam, clay loam, and compact till at 40-60 in	Poorly drained	0-2	Parent material loess over loam-textured till. Minor soils are Russell and Xenia.
	Ragsdale	Dark-colored silt loam or silty clay loam	Silty clay loam	Very poorly drained	0-2	

Description of soil associations in Area 30.--Continued

Soil association		Soil description			Normal slope range (percent)	
Symbol	Major soil series	Surface horizons	Subsoils	Drainage		Remarks
I4	Reesville	Light-colored silty loam	Silty clay loam	Somewhat poorly drained	0-2	Developed entirely in Wisconsin loess. Minor soils are Alford, Fincastle, and Iva.
	Ragsdale	Dark-colored silty loam or silty clay loam	do.	Very poorly drained	0-2	
I5	Iva	Light-colored silty loam	Silty clay loam	Somewhat poorly drained	0-2	Formed on leached loess deposits from 3 1/2 to 5 feet thick. Found on till plains.
	Vigo	do.	do.	do.	0-2	
J1	Brookston	Dark-colored silt loam or silty clay loam	Silty clay loam or clay loam	Very poorly drained	0-2	Parent material is loess and loamy till. Parr is an associated soil.
	Odell	Dark-colored silt loam	do.	Poorly drained	0-2	
	Corwin	do.	do.	Moderately well drained	2-6	
L1	Parr	Dark-colored silt loam	Silty clay loam or clay loam	Well drained	2-12	Soils formed in loess and loamy till. Found on end moraines and rolling areas near streams that dissect the till plain. Associated soils are Odell and Corwin.
	Brookston	Dark-colored silt loam or silty clay loam	do.	Very poorly drained	0-2	
L4	Miami	Light-colored silt loam	Clay loam over calcareous loam till	Well drained	2-12	Parent materials are calcareous loam till and overlying loess. Found on end moraines and rolling areas near streams that dissect till plains. Minor soil is Hennepin.
	Crosby	do.	Silty clay loam and clay loam	Somewhat poorly drained	0-2	
	Brookston	Dark-colored silt loam or silty clay loam	do.	Very poorly drained	0-2	
L6	Miami	Light-colored silt loam	Clay loam over calcareous loam till	Well drained	2-12	Parent materials loess and calcareous loam glacial till. Found on end moraines and rolling areas near streams that disect glacial till plain. Minor soil is Xenia.
	Russell	do.	do.	do.	2-12	
	Fincastle	do.	do.	Somewhat poorly drained	0-2	
	Ragsdale	Dark-colored silt loam or silty clay loam	Silty clay loam	Very poorly drained	0-2	
L7	Russell	Light-colored silt loam	Clay loam over calcareous loam till	Well drained	2-12	Parent materials are loess and till. Found on rolling areas and steep side slopes between tillplain uplands. Minor soil is Reesville.
	Hennnepin	Light-colored loam	Loam and loam till	do.	18->35	
	Fincastle	Light-colored silt loam.	Clay loam over calcareous loam till	Somewhat poorly drained	0-2	
O3	Cincinnati	Light-colored silt loam	Silty clay loam and buried clay	Well drained	6-25	Parent materials are Wisconsin loess and Illinoian till or buried soils formed from Illinoian till. Found on slopes of ravines and adjacent rolling areas. Minor soils are Hickory and Iva.
	Vigo	do.	do.	Poorly drained	0-2	
	Ava	do.	do.	Moderately well drained	2-6	

13.2 Average Monthly Discharge at Selected Gaging Stations

ID (See fig. 8.5-1.)	Station name	Station number		Average monthly discharge for period of record (ft^3/s) Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Average annual discharge (ft^3/s)
1	Mud Pine Cr nr	03335690	Min	0.96	0.84	0.98	0.47	3.41	17.6	17.2	8.49	3.22	0.96	1.48	0.71	
	Oxford, Ind.		Max	91.2	81.6	97.3	123	122	237	147	86.3	97.9	71.6	69.9	94.4	
			Ave	16.0	21.6	45.9	47.1	53.7	78.0	69.2	34.7	42.5	24.6	19.2	20.3	39.8
2	Big Pine Cr nr	03335700	Min	10.6	13.2	9.47	12.5	21.2	50.1	114	101	27.7	18.1	13.9	9.58	
	Williamsport, Ind.		Max	725	599	730	944	1,182	1,059	1,023	835	1,187	1,113	426	745	
			Ave	96.0	127	244	268	359	448	525	334	310	243	117	97.8	262
3	Wabash R at	03336000	Min	738	919	810	896	1,360	1,910	3,540	1,810	1,760	1,320	640	545	
	Covington, Ind.		Max	12,000	20,100	22,100	49,700	34,400	24,700	28,500	43,500	36,000	17,500	11,100	8,510	
			Ave	3,030	4,000	6,610	8,950	10,700	12,800	13,700	9,840	7,420	4,670	3,160	2,560	7,250
38	Bluegrass Cr at	03336500	Min	.03	.06	.12	.14	.39	4.67	5.95	9.89	2.19	.15	.03	.00	
	Potomac, Ill.		Max	32.5	52.0	148	164	156	105	151	117	123	148	64.7	56.0	
			Ave	7.6	10.5	26.1	35.7	43.2	41.7	56.9	37.3	37.5	31.6	8.2	6.6	28.4
4	Salt Fk nr St.	03336900	Min	7.18	8.69	4.43	3.57	10.5	57.2	36.6	37.6	23.5	13.2	8.50	6.60	
	Joseph, Ill.		Max	83.5	262	318	361	539	326	613	631	391	486	287	176	
			Ave	34.9	46.7	104	119	160	159	213	157	122	73.5	54.4	36.1	106
5	Boneyard Cr at	03337000	Min	1.25	1.08	1.04	.75	1.49	2.18	1.43	1.85	1.79	1.71	1.31	1.77	
	Urbana, Ill.		Max	10.8	5.77	11.5	18.6	9.94	10.0	18.3	10.6	11.8	12.8	10.8	9.97	
			Ave	3.40	3.07	3.71	4.05	4.24	5.15	6.40	5.21	5.18	5.34	4.31	3.75	4.38
39	Saline Br at	03337500	Min	3.76	3.53	3.43	4.18	4.58	5.68	21.3	9.87	13.6	8.44	3.53	3.21	
	Urbana, Ill.		Max	84.7	134	139	288	185	273	272	316	194	206	221	22.2	
			Ave	18.9	25.8	31.7	61.1	71.1	83.3	96.5	75.6	76.8	45.9	25.5	7.84	51.5
40	Salt Fk nr Homer,	03338000	Min	16.0	13.5	12.4	11.2	26.2	24.3	96.3	48.1	87.1	25.1	22.8	12.5	
	Ill.		Max	339	321	633	1,760	1,110	704	760	670	813	901	812	206	
			Ave	88.3	88.2	166	393	352	352	439	340	389	260	109	46.1	251
6	Vermilion R nr	03338500	Min	24.3	20.2	25.5	28.9	48.9	84.2	272	138	152	43.1	33.4	13.0	
	Catlin, Ill.		Max	1,220	1,800	1,820	5,020	2,940	2,240	3,485	5,772	2,368	2,233	1,750	706	
			Ave	233	340	481	876	966	1,010	1,280	1,250	1,040	651	235	99.8	704
7	Vermilion R nr	03339000	Min	12.8	22.8	27.3	27.8	39.6	59.6	190	83.7	43.3	26.6	17.9	14.4	
	Danville, Ill.		Max	3,350	2,960	2,840	6,930	4,540	5,200	4,940	7,620	3,730	3,300	2,460	1,880	
			Ave	290	438	744	1,160	1,340	1,520	1,780	1,490	1,150	702	341	232	930
8	E Fk Coal Cr nr	03339108	Min	7.34	6.35	5.93	4.04	8.28	16.2	10.7	10.5	6.25	12.6	12.1	5.95	
	Hillsboro, Ind.		Max	106	79.1	78.4	120	102	162	136	119	79.3	69.0	62.4	22.5	
			Ave	21.4	27.8	38.2	41.7	45.2	63.9	62.6	44.2	38.9	29.1	26.1	13.6	38.1
9	Coal Cr at Coal	03339120	Min	10.6	25.5	30.2	52.7	85.8	91.2	70.2	107	53.9	22.0	10.2	12.1	
	Creek, Ind.		Max	151	281	829	682	444	278	713	374	434	241	471	107	
			Ave	4[illegible]	93.0	288	234	257	176	379	222	184	115	93.0	53.8	178
10	Little Vermilion R	03339150	Min		7.02	10.9	40.1	77.2	81.6	58.2	146	60.4	16.8	1.89	1.83	
	nr Newport, Ind.		Max	241	305	954	775	544	293	919	457	379	168	387	250	
			Ave	40.7	60.8	315	252	299	176	435	275	186	860	63.3	48.1	186
11	Sugar Cr nr Byron,	03340000	Min	34.8	48.9	37.5	50.2	112	128	208	101	110	54.1	25.0	18.9	
	Ind.		Max	1,140	1,500	2,520	5,380	2,540	2,470	3,160	4,460	3,350	1,410	2,250	2,170	
			Ave	185	335	555	899	940	1,020	1,160	902	779	374	215	194	628
12	Wabash R at	03340500	Min	973	1,200	1,040	1,110	1,790	2,370	4,940	2,080	1,360	1,210	815	710	
	Montezuma, Ind.		Max	14,600	27,000	40,400	66,700	40,600	35,600	37,600	58,400	42,700	23,400	18,800	13,500	
			Ave	3,830	5,110	8,690	12,700	13,900	16,700	17,800	13,600	9,690	6,670	4,050	3,130	9,610
14	Big Raccoon Cr at	03340900	Min	95.6	197	9.90	17.0	18.1	23.0	21.3	17.5	14.3	16.0	14.8	15.2	
	Ferndale, Ind.		Max	549	669	721	645	1,160	606	598	751	716	535	120	386	
			Ave	263	338	267	273	350	263	185	208	153	129	74.0	162	221
15	Big Raccoon Cr at	03341000	Min	6.37	12.5	14.2	16.6	44.5	45.8	105	44.6	70.8	9.48	5.15	3.62	
	Mansfield, Ind.		Max	148	332	857	2,080	807	867	1,079	1,840	1,800	451	395	1,066	
			Ave	44.4	96.6	169	341	311	335	412	380	352	139	52.9	87.3	226

ID (See fig. 8.5-1.)	Station name	Station number		Average monthly discharge for period of record (ft³/s)												Average annual discharge (ft³/s)
				Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	
16	Little Raccoon Cr	03341200	Min	5.05	8.35	6.07	19.5	21.9	52.8	53.4	81.0	18.9	14.5	7.58	5.32	
	nr Catlin, Ind.		Max	218	235	714	525	373	463	645	440	413	294	283	109	
			Ave	30.7	62.3	148	149	170	208	213	165	105	79.3	48.4	31.2	117
17	Big Raccoon Cr at	03341300	Min	105	220	48.2	25.9	91.3	176	146	107	85.2	80.3	34.4	34.6	
	Coxville, Ind.		Max	799	1,320	2,070	1,570	1,650	1,420	1,450	1,231	1,205	982	1,061	682	
			Ave	330	499	621	614	665	767	657	525	337	305	211	245	480
20	Wabash R at Terre	03341500	Min	1,100	1,400	1,140	1,220	2,000	2,640	5,250	2,400	1,490	1,290	1,000	966	
	Haute, Ind.		Max	16,100	29,900	44,500	77,500	48,000	39,800	41,900	64,800	44,100	27,800	21,300	14,800	
			Ave	4,270	5,600	9,470	14,000	15,500	18,200	19,300	15,300	10,900	7,540	4,650	3,530	10,600
21	Wabash R at	03342000	Min	1,400	1,440	1,210	1,320	2,060	2,760	6,360	3,440	2,600	2,460	1,220	1,260	
	Riverton, Ind.		Max	15,200	31,200	37,400	80,200	54,500	44,300	41,800	68,000	45,600	36,200	23,700	14,600	
			Ave	4,400	5,850	9,520	13,300	17,400	20,600	21,800	16,800	12,600	8,460	5,380	3,850	11,600
22	Busseron Cr nr	03342100	Min	.07	.06	.03	.01	1.63	7.23	1.48	1.23	.16	.17	.09	.02	
	Hymera, Ind.		Max	14.7	72.5	63.5	105	67.4	112	72.5	66.7	28.6	79.3	25.4	54.4	
			Ave	2.91	13.7	24.8	28.6	26.7	40.9	32.5	19.1	8.51	12.9	5.39	6.56	18.7
23	W Fk Busseron Cr	03342150	Min	.09	.12	.20	.09	2.26	6.29	2.66	1.12	.24	.15	.08	.05	
	nr Hymera, Ind.		Max	10.6	46.8	52.2	52.4	50.9	66.3	59.7	67.7	23.1	39.5	13.5	50.9	
			Ave	1.92	10.4	18.5	17.1	18.7	31.1	23.9	14.8	7.86	10.6	3.71	5.35	13.9
24	Mud Cr nr	03342250	Min	1.65	1.74	1.26	.59	4.69	7.18	5.46	5.15	3.03	1.81	1.15	1.44	
	Dugger, Ind.		Max	9.94	28.1	35.7	79.2	37.2	79.9	48.8	45.7	19.0	38.4	17.8	26.8	
			Ave	4.33	10.8	19.5	19.7	18.9	30.7	25.2	16.5	9.14	7.36	4.74	4.87	14.4
25	Busseron Cr nr	03342300	Min	3.23	6.17	4.96	2.52	18.6	79.9	28.3	24.1	7.21	2.67	1.69	3.59	
	Sullivan, Ind.		Max	80.0	453	460	530	537	736	510	417	368	760	249	402	
			Ave	31.4	100	177	190	225	331	276	153	86.0	91.7	38.4	43.8	148
26	Buttermilk Cr nr	03342350	Min	.35	.96	4.89	4.85	4.87	7.31	4.99	7.07	2.10	.58	.08	.65	
	Paxton, Ind.		Max	9.84	50.1	42.1	61.7	44.2	67.4	57.7	38.4	29.8	5.56	6.48	4.60	
			Ave	3.89	14.6	22.7	23.7	22.0	26.8	34.1	18.8	9.28	2.71	2.33	1.90	15.5
28	Busseron Cr nr	03342500	Min	1.39	.94	2.87	3.64	11.3	12.8	35.6	31.6	8.88	.04	1.89	.88	
	Carlisle, Ind.		Max	263	756	1,220	2,380	1,320	1,280	1,100	1,200	988	1,100	633	627	
			Ave	39.5	135	237	329	353	482	418	278	186	110	55.4	56.4	223
30	Wabash R at	03343000	Min	1,240	1,500	1,350	1,410	2,040	3,000	5,250	3,080	1,610	1,470	1,300	1,500	
	Vincennes, Ind.		Max	15,300	30,600	33,700	79,800	57,000	44,800	50,000	67,800	42,400	36,100	24,500	15,000	
			Ave	4,480	6,220	9,480	15,100	16,700	20,400	21,600	17,600	12,200	8,700	5,500	4,030	11,800
31	Embarras R nr	03343400	Min	.00	.92	1.05	.63	4.11	76.8	35.6	36.5	28.3	11.0	.12	.02	
	Camargo, Ill.		Max	268	507	618	684	495	485	650	631	773	454	191	288	
			Ave	54.0	66.7	176	189	207	230	289	234	180	99.2	47.8	39.3	151
33	Embarras R nr	03344000	Min	15.9	13.1	8.60	7.11	78.0	237	205	158	121	120	24.7	9.65	
	Diona, Ill.		Max	533	2,000	1,850	3,970	2,860	3,410	2,820	2,860	3,110	3,100	1,480	412	
			Ave	176	374	788	1,020	970	1,300	1,410	1,230	1,220	641	321	130	829
34	Range Cr nr	03344500	Min	.00	.00	.00	.00	.02	.29	.29	.08	.00	.00	.00	.00	
	Casey, Ill.		Max	8.80	12.2	36.3	38.7	41.4	56.2	30.1	53.5	39.8	23.0	24.5	12.1	
			Ave	.87	3.17	7.67	7.91	9.17	11.1	7.98	6.99	4.75	3.19	2.56	.84	5.51
35	Embarras R at	03345500	Min	14.6	4.37	4.84	13.4	21.6	23.4	120	78.3	65.9	18.8	11.6	7.68	
	Ste. Marie, Ill		Max	3,890	2,880	7,500	11,500	5,730	5,770	7,680	10,600	5,750	3,840	4,440	3,810	
			Ave	430	609	1,180	1,700	1,840	2,100	2,110	1,790	1,270	728	391	330	1,200
36	N Fk Embarras R	03346000	Min	.01	.13	.56	.92	4.82	2.37	10.4	19.0	4.07	.46	.26	.10	
	nr Oblong, Ill.		Max	565	575	1,755	2,800	1,280	1,470	1,300	2,820	1,350	1,010	431	841	
			Ave	39.7	128	277	414	408	485	433	347	258	113	66.1	47.1	250

Number of water-quality measurements, 1956-81.

[COE, U.S. Army Corps of Engineers; EPA, Environmental Protection Agency; IDPH, Illinois Department of Public Health; ISBH, Indiana State Board of Health; ISWS, Illinois State Water Survey]

ID (See fig. 9.1.)	Station name	Agency	Lati-tude	Longi-tude	Spec cond	pH	Alka-linity	Acidity	SO4	Total Fe	Diss Fe	Total Mn	Diss Mn	Total Al	Diss Al
1	Mud Pine Cr nr Oxford, Ind. (03335690)[1]	USGS	403124	0872030	0	0	0	0	0	0	0	0	0	0	0
2	Big Pine Cr nr Williamsport, Ind. (03335700)[1]	USGS	401903	0871726	80	80	78	7	75	79	64	79	61	11	7
63	Big Shawnee Cr nr Fountain, Ind.	USGS	401448	0871628	2	2	2	2	2	2	2	2	2	2	0
64	Redwood Cr nr Covington, Ind.	USGS	401242	0872339	2	2	2	2	17	2	2	2	2	2	0
65	Opossum Run nr Covington, Ind.	USGS	401018	0872627	2	2	2	2	2	2	2	2	2	2	0
66	Wabash R at Covington, Ind.	ISBH	400823	0872419	269	280	279	0	0	0	0	0	0	0	0
67	Jordan Cr at Tab, Ind.	USGS	402440	0872801	1	1	1	0	1	1	1	1	1	1	0
68	Little Creek nr Stewart, Ind.	USGS	402218	0872928	1	1	1	0	1	1	1	1	1	1	0
69	Jordan Creek nr Pence, Ind.	USGS	402121	0873141	1	1	1	0	1	1	1	1	1	1	0
70	N Fk Vermilion R nr Bismark, Ill.	USGS	401613	0873834	38	34	4	0	0	18	0	15	0	0	0
71	Middle Fk Vermilion R at Armstrong, Ill.	USGS	401754	0875239	1	1	1	0	1	0	0	0	0	0	0
72	Middle Fk Vermilion R nr Collison, Ill.	USGS	401209	0874403	1	1	0	0	1	0	0	0	0	0	0
73	Middle Fk Vermilion R nr Glenburn, Ill.	USGS	400936	0874424	1	1	0	0	1	0	0	0	0	0	0
74	Middle Fk Vermilion R above Oakwood, Ill.	USGS	400812	0874445	37	35	38	23	24	39	0	39	0	0	0
75	Middle Fk Vermilion R above Catlin, Ill.	USGS	400627	0874327	1	1	0	0	1	0	0	0	0	0	0
4	Salt Fk nr St. Joseph, Ill. (03336900)[1]	USGS	400855	0880200	41	40	16	0	12	17	0	17	0	0	0
76	Saline Br nr Mayview, Ill.	USGS	400759	0880615	39	38	4	0	40	15	0	15	0	0	0
40	Salt Fk nr Homer, Ill.(03338000)[1]	USGS	400320	0875730	1	1	0	0	1	0	0	0	0	0	0
77	Salt Fk nr Fairmount, Ill.	USGS	400352	0875250	1	1	0	0	1	0	0	0	0	0	0
78	Jordan Cr at Fairmount, Ill.	USGS	400326	0875011	7	8	7	4	7	5	7	5	6	0	2
79	Salt Fk nr Oakwood, Ill.	USGS	400456	0874653	44	42	42	26	43	42	4	41	3	0	0
80	Salt Fork nr Catlin, Ill.	USGS	400626	0874335	1	1	0	0	1	0	0	0	0	0	0
81	Vermilion R nr Vermilion Heights, Ill.	USGS	400705	0873832	2	2	1	0	1	0	0	0	0	0	0
7	Vermilion R nr Danville, Ill. (03339000)[1]	USGS	400553	0873537	41	42	40	26	41	41	4	41	5	0	0
82	Grape Cr at Tilton, Ill.	USGS	400542	0873808	2	2	2	2	2	0	2	0	2	0	2
83	Grape Cr at Hegeler, Ill.	USGS	400514	0873723	5	6	5	2	5	5	5	5	5	0	0
84	Wabash R at Cayuga, Ind.	ISBH	395709	0872515	35	61	0	0	0	0	0	0	0	0	0
85	Coal Cr at Stone Bluff, Ind.	USGS	401014	0871541	2	2	2	2	2	2	2	2	2	2	0
86	Mill Cr nr Howard, Ind.	USGS	395429	0872138	2	2	2	2	2	2	2	2	2	2	0
87	Fayette Drain nr Indianola, Ill.	USGS	395700	0874230	7	8	6	4	7	5	6	5	7	0	2
88	Little Vermilion R nr Georgetown, Ill.	USGS	395629	0873305	29	28	28	13	28	29	0	28	0	0	0
89	Trib to Little Vermilion nr Cayuga, Ind.	USGS	395316	0872810	14	14	14	10	14	14	14	14	14	14	13
90	Little Vermilion R nr Newport, Ind.	USGS	395335	0872541	2	2	2	2	2	2	2	2	2	2	0
91	Trib to Sugar Cr nr Deer Mill, Ind.	USGS	395657	0870328	1	1	0	0	0	1	1	1	0	0	0
92	Trib to Sugar Cr nr Deer Mill, Ind.	USGS	395649	0870319	12	12	11	5	9	12	10	12	9	11	8
93	Sugar Cr nr Alamo, Ind.	USGS	395648	0870337	2	2	2	2	2	2	2	2	2	2	0
11	Sugar Cr nr Byron, Ind. (03340000)[1]	USGS	395552	0870733	0	0	0	0	0	0	0	0	0	0	0
94	Rush Cr nr West Union, Ind.	USGS	395156	0871932	2	2	2	2	2	2	2	2	2	2	0
95	Wabash R at Montezuma, Ind.	ISBH	394733	0872230	370	420	346	0	0	0	0	0	0	0	0
14	Big Raccoon Cr at Ferndale, Ind. (03340900)[1]	USGS	394144	0870501	0	0	0	0	0	0	0	0	0	0	0
96	Leatherwood Cr nr Midway, Ind.	USGS	394631	0871945	7	7	7	3	7	7	7	7	7	7	5
97	Feather Cr No 1 at Clinton, Ind.	USGS	394103	0872623	3	3	3	0	3	1	3	1	3	1	0
98	Feather Cr Tile Drain at Clinton, Ind.	USGS	394100	0872552	1	1	0	0	0	0	0	0	0	0	0
99	Feather Cr Site 2 nr Clinton, Ind.	USGS	394039	0872552	8	9	8	0	8	1	8	1	8	1	0
100	Feather Cr No 3 at Clinton, Ind.	USGS	393943	0872452	1	1	1	0	1	1	1	1	1	1	0

ID (See fig. 9.1.)	Station name	Agency	Lati-tude	Longi-tude	Spec cond	pH	Alka-linity	Acidity	SO4	Total Fe	Diss Fe	Total Mn	Diss Mn	Total Al	Diss Al
101	Wabash R at Clinton, Ind.	ISBH	393926.3	0872341.1	34	34	0	0	8	12	0	1	0	0	0
102	Brouilletts Cr nr Paris, Ill.	USGS	394243	0873757	1	1	0	0	1	0	0	0	0	0	0
103	Brouilletts Cr nr Scottland, Ill.	USGS	394219	0873316	1	1	0	0	1	0	0	0	0	0	0
104	Crab Apple Cr nr Scottland, Ill.	USGS	394238	0873310	1	1	0	0	1	0	0	0	0	0	0
105	Brouilletts Cr nr St. Bernice, Ind.	USGS	394053	0873116	38	37	4	0	1	13	0	14	0	0	0
106	Brouilletts Cr nr St. Bernice, Ind.	USGS	394053	0873114	2	2	1	2	2	2	2	2	2	2	0
107	Trib to Brouilletts Cr nr Centenary, Ind.	USGS	393845	0872847	21	21	20	17	20	22	20	22	20	22	18
108	Brouilletts Cr at Universal, Ind.	USGS	393748	0872748	1	1	0	0	1	0	0	0	0	0	0
109	Brouilletts Cr nr Universal, Ind.	USGS	393748	0872746	3	2	3	3	3	3	3	3	3	3	0
110	Gin Cr nr Universal, Ind.	USGS	393703	0872633	10	10	10	4	10	10	10	10	10	10	8
111	Trib Draining Universal Mine nr Universal, Ind.	USGS	393649	0872752	16	16	9	10	14	16	14	16	14	16	13
112	Brouilletts Cr at Sheperdsville, Ind.	USGS	393616	0872457	1	1	0	0	1	0	0	0	0	0	0
113	N Br Otter Cr nr Carbon, Ind.	USGS	393652	0870625	2	2	2	2	2	2	2	2	2	2	0
114	Benwood Run nr Brazil, Ind.	USGS	393307	0870628	2	2	2	2	2	2	2	2	2	2	0
115	Coal Cr nr Tecumseh, Ind.	USGS	393240	0872533	1	1	1	1	1	1	1	1	1	1	0
116	Lost Cr nr Seelyville, Ind.	USGS	392840	0871525	1	1	1	1	1	1	1	0	1	1	1
117	Lost Cr nr Staunton, Ind.	USGS	392933	0871402	2	2	2	2	2	2	2	2	2	2	0
118	Sulphur Cr Trib nr Seelyville, Ind.	USGS	392828	0871445	4	4	4	4	4	4	4	2	4	4	4
119	Wabash R above Terre Haute, Ind.	ISBH	393033	0872447	33	58	0	0	0	0	0	0	0	0	0
120	Wabash R above Terre Haute, Ind.	ISBH	392801	0872515	269	287	287	0	0	0	0	0	0	0	0
121	Sugar Cr nr Elbridge, Ill.	USGS	392953	0873311	33	32	5	1	1	15	0	15	0	0	0
122	Sugar Cr at State Line, Ind.	USGS	392905	0873159	2	2	2	2	2	2	2	2	2	2	0
123	Wabash R at Terre Haute, Ind.	ISBH	392407	0872939	77	77	0	0	0	11	0	12	0	0	0
124	Honey Cr Trib nr Staunton, Ind.	USGS	392642	0871308	1	1	1	1	0	1	1	1	1	1	1
125	Honey Cr nr Staunton, Ind.	USGS	392744	0871456	9	9	9	9	9	9	9	8	9	9	9
126	N Br Honey Cr nr Seelyville, Ind.	USGS	392744	0871457	2	2	2	2	2	2	2	2	2	2	2
127	N Br Honey Cr nr Staunton, Ind.	USGS	392711	0871531	10	10	10	10	10	10	10	8	10	10	10
128	Honey Cr nr Staunton, Ind.	USGS	392632	0871509	9	9	9	9	9	9	9	7	9	9	9
129	Unnamed Trib nr Staunton, Ind.	USGS	392516	0871252	1	1	1	1	1	1	1	1	1	1	1
130	Trib to Stone Quarry Br nr Riley, Ind.	USGS	392535	0871525	7	7	7	3	7	7	7	7	7	7	7
131	Honey Cr Trib nr Riley, Ind.	USGS	392538	0871527	2	2	2	2	2	2	2	2	2	2	0
132	Stone Quarry Br nr Staunton, Ind.	USGS	392450	0871531	11	11	11	11	11	11	11	9	11	11	11
133	Honey Cr nr Staunton, Ind.	USGS	392325	0871535	1	1	1	0	0	1	1	1	0	0	0
134	Honey Cr nr Riley, Ind.	USGS	392427	0871745	2	2	0	1	0	2	2	2	0	0	0
135	Prairie Cr above N Reservoir nr Pimento, Ind.	USGS	391957	0872425	1	1	1	0	1	1	1	1	1	1	0
136	Trib to Prairie Cr Trib nr Pimento, Ind.	USGS	391903	0872428	1	1	1	0	1	0	1	0	1	0	0
137	Trib to Prairie Cr nr Pimento, Ind.	USGS	391900	0872430	1	1	1	0	1	0	1	0	1	0	0
138	Prairie Cr below N Reservoir nr Pimento, Ind.	USGS	391929	0872627	1	1	1	0	1	1	1	1	1	1	0
139	Trib to Prairie Cr below Middle Reservoir nr Pimento, Ind.	USGS	391824	0872738	1	1	1	0	1	1	1	1	1	1	0
140	Prairie Cr below confluence with Middle Reservoir Trib nr Pimento, Ind.	USGS	391810	0872810	1	1	1	0	1	0	1	0	1	0	0

Number of water-quality measurements, 1956-81.--Continued

ID (See fig. 9.1.)	Station name	Agency	Lati-tude	Longi-tude	Spec cond	pH	Alka-linity	Acidity	SO4	Total Fe	Diss Fe	Total Mn	Diss Mn	Total Al	Diss Al
141	Prairie Cr on SR 63 at Prairie Creek, Ind.	USGS	391650	0872953	1	1	1	0	1	0	1	0	1	0	0
142	Trib to Prairie Cr on SR 63 at Prairie Creek,Ind.	USGS	391639	0872953	1	1	1	0	1	0	1	0	1	0	0
143	Wabash R nr Hutsonville, Ill.	USGS	390803	0873918	164	163	62	0	163	0	0	69	0	0	0
144	Wabash R at Hutsonville, Ill.	USGS	390637	0873918	59	54	0	0	0	17	0	8	0	0	0
145	Turman Cr nr Graysville, Ind.	USGS	390714	0873542	2	2	2	2	2	2	2	2	2	2	0
146	Turtle Cr nr Merom, Ind.	USGS	390158	0873222	2	2	2	2	1	2	2	2	2	2	0
147	Sugar Cr at Palestine, Ill.	USGS	390016	0873550	16	11	11	3	17	17	0	11	0	0	0
148	Hooker Cr nr Lewis, Ind.	USGS	391439	0871640	1	0	0	0	0	1	1	1	1	1	1
149	Hooker Cr nr Lewis, Ind.	USGS	391440	0871639	3	3	3	1	3	3	3	3	3	3	3
150	E Fk Cr nr Farmersburg, Ind.	USGS	391242	0871651	1	0	1	0	1	0	1	0	1	0	0
22	Busseron Cr nr Hymera, Ind. (03342100)[1]	USGS	391254	0871841	6	6	7	2	7	2	7	2	7	2	1
151	W Fk Busseron Cr nr Shelburn, Ind.	USGS	391331	0872133	1	1	1	0	1	0	1	0	1	0	0
152	W Fk Busseron Cr Trib nr Hymera, Ind.	USGS	391256	0872036	2	2	2	2	2	2	2	2	2	2	0
23	W Fk Busseron Cr nr Hymera, Ind. (03342150)[1]	USGS	391110	0871944	6	7	7	2	7	2	7	2	7	2	1
153	Sulphur Cr nr Hymera, Ind.	USGS	391136	0871555	2	2	2	2	2	2	2	2	2	2	0
154	Kettle Cr at Shelburn, Ind.	USGS	391033	0872307	5	6	4	0	4	0	4	0	4	0	0
155	Mud Cr nr Vicksburg, Ind.	USGS	390631	0871211	3	3	3	0	3	0	3	0	3	0	1
156	Mud Cr nr Dugger, Ind.	USGS	390556	0871545	9	9	8	9	9	9	9	9	9	9	8
24	Mud Cr nr Dugger, Ind. (03342250)[1]	USGS	390628	0871642	6	6	6	3	6	1	6	1	6	1	1
157	Kettle Cr nr Shelburn, Ind.	USGS	390922	0872333	6	6	4	0	4	0	4	0	4	0	0
158	Morrison Cr nr Sullivan, Ind.	USGS	390834	0872418	1	1	0	0	1	0	0	0	0	0	0
159	Morrison Cr nr Sullivan, Ind.	USGS	390834	0872418	1	1	1	0	1	0	0	0	0	0	0
160	Morrison Cr at Sullivan, Ind.	USGS	390553	0872238	2	2	1	1	0	0	1	0	1	0	0
25	Busseron Cr nr Sullivan, Ind. (03342300)[1]	USGS	390433	0872311	7	7	7	7	2	2	7	2	7	2	0
161	Buttermilk Cr nr Dugger, Ind.	USGS	390413	0871749	2	2	2	2	2	2	2	2	2	2	0
162	Buck Cr nr Sullivan, Ind.	USGS	390314	0872355	4	6	4	4	0	0	4	0	4	0	0
28	Busseron Cr nr Carlisle, Ind. (03342500)[1]	USGS	385826	0872533	3	3	4	3	2	2	3	2	3	2	0
163	Maria Cr nr Bruceville, Ind.	USGS	384624	0872803	2	2	2	2	2	2	2	2	2	2	0
164	Wabash R at Billet, Ill.	EPA	384411	0873000	9	7	5	2	6	8	0	0	0	0	0
29	S Fk Smalls Cr at Bruceville, Ind. (03342800)[1]	USGS	384449	0872544	42	42	13	42	39	40	1	12	1	13	0
165	Outlet of dam nr Bruceville, Ind.	USGS	384421	0872523	56	56	52	18	56	56	0	52	0	52	0
166	Drainage ditch at mine nr Bruceville, Ind.	USGS	384400	0872500	1	1	0	1	1	1	0	0	0	0	0
167	Wabash R at Vincennes, Ind.	EPA	384152.5	0873109.5	7	0	1	1	0	0	0	0	0	0	0
168	Wabash R at Vincennes, Ind.	EPA	384118	0873200	25	22	14	8	4	4	0	3	0	0	0
169	Wabash R at Vincennes, Ind.	EPA	384109	0873111.5	1	0	0	0	0	0	0	0	0	0	0
170	Wabash R at Vincennes, Ind.	EPA	384105	0873150	12	12	0	0	0	0	0	0	0	0	0
171	Wabash R at Vincennes, Ind.	ISBH	384053	0873205	340	145	292	0	0	53	0	7	0	0	0
172	Wabash R nr Vincennes, Ind.	EPA	384052	0873207	8	0	2	0	0	0	0	0	0	0	0
173	Wabash R nr Vincennes, Ind.	EPA	384043.5	0873228	16	16	0	0	0	0	0	0	0	0	0
174	Wabash R nr Vincennes, Ind.	EPA	384039.5	0873239.5	8	0	2	0	0	0	0	0	0	0	0
175	Wabash R nr Vincennes, Ind.	EPA	384032	0873326	12	12	0	0	0	0	0	0	0	0	0
176	Wabash R nr Vincennes, Ind.	EPA	384020.5	0873448	3	0	1	0	0	0	0	0	0	0	0
177	Wabash R at mile point 112, Ind.	EPA	383838.5	0873635	12	12	0	0	0	0	0	0	0	0	0
178	Embarras R at Camargo, Ill.	USGS	394759	0881013	28	25	26	12	26	26	0	26	0	0	0
179	Brushy Fk nr Newman, Ill.	USGS	394707	0875952	5	6	5	2	5	5	5	5	4	0	0

ID (See fig. 9.1.)	Station name	Agency	Lati- tude	Longi- tude	Spec cond	pH	Alka- linity	Acidity	SO4	Total Fe	Diss Fe	Total Mn	Diss Mn	Total Al	Diss Al
180	Embarras R nr Rardin, Ill.	EPA	393351	0880600	10	9	9	4	1	1	0	0	0	0	0
181	Embarras R nr Ashmore, Ill.	USGS	393317	0880522	1	1	1	0	1	0	0	0	0	0	0
182	Embarras R nr Chesterton, Ill.	EPA	393103	0880718	25	24	14	6	2	4	0	4	0	0	0
183	Embarras R nr Charleston, Ill.	IDPH	392921	0880648	56	56	27	0	25	0	0	0	0	0	0
184	Embarras R nr Charleston, Ill.	COE	392920	0880647	0	45	45	0	0	45	38	45	43	0	0
185	Embarras R above Kickapoo Cr, Ill.	EPA	392812	0880854	4	4	2	2	1	2	0	1	0	0	0
186	Embarras R below Lake Charleston, Ill.	COE	392740	0880847	0	44	44	0	0	44	44	44	44	0	0
187	Embarras R below Lake Charleston, Ill.	COE	392733	0880847	0	45	44	0	0	45	45	45	44	0	0
188	Kickapoo Cr nr Mattoon, Ill.	EPA	392812	0881800	4	4	2	2	1	2	0	1	0	0	0
189	Kickapoo Cr nr Loxa, Ill.	EPA	392833	0881344	4	4	2	2	1	2	0	1	0	0	0
190	Riley Cr nr Charleston, Ill.	EPA	392936	0881226	4	4	2	2	1	2	0	1	0	0	0
191	Kickapoo Cr nr Charleston, Ill.	EPA	392854	0881200	4	4	2	2	1	2	0	1	0	0	0
192	Kickapoo Cr at mouth, nr Charleston, Ill.	COE	392636	0881021	0	71	65	4	20	71	71	71	69	0	0
193	Embarras R nr Charleston, Ill.	IDPH	392605	0881020	48	42	0	0	8	3	0	3	0	0	0
194	Embarras R nr Charleston, Ill.	EPA	392336	0881046	13	13	9	5	3	6	0	4	0	0	0
195	Embarras R nr Diona, Ill.	EPA	392109	0881046	5	5	2	2	1	2	0	1	0	0	0
196	Embarras R nr Diona, Ill.	IDPH	392040	0881015	43	36	0	0	7	2	0	2	0	0	0
33	Embarras R nr Diona, Ill. (03344000)[1]	USGS	392040	0881015	112	107	79	0	76	86	72	85	72	0	0
197	Embarras R nr Diona, Ill.	COE	392039	0881014	0	70	65	4	19	71	71	71	71	0	0
198	Embarras R nr Greenup, Ill.	EPA	391530	0881200	14	14	10	6	3	6	0	4	0	0	0
199	Embarras R nr Hidalgo, Ill.	IDPH	390925	0881206	57	47	0	0	10	2	1	2	0	0	0
200	Embarras R nr Newton, Ill.	IDPH	385946.5	0880845	61	61	32	0	29	0	0	0	0	0	0
201	Embarras R at Newton, Ill.	EPA	390000	0880810	10	8	8	4	2	2	0	1	0	0	0
202	Embarras R nr Ste. Marie, Ill.	IDPH	385612	0880106	61	48	0	0	15	5	1	5	0	0	0
35	Embarras R at Ste. Marie, Ill. (03345500)[1]	ISWS and USGS	385610	0880110	30	27	63	0	62	75	0	74	0	0	0
203	N Fk Embarras R nr Bellair, Ill.	IDPH	3908	0875855	55	47	0	0	8	2	0	2	0	0	0
204	N Fk Embarras R nr Oblong, Ill.	EPA	3902[illegible]	0875702	11	10	8	4	3	4	0	4	0	0	0
205	N Fk Embarras nr Oblong, Ill.	IDPH	390036	0875645	115	108	36	0	48	5	1	5	0	0	0
36	N Fk Embarras R nr Oblong, Ill. (03346000)[1]	ISWS and USGS	390001	0875642	28	26	59	0	59	69	0	69	0	0	0
206	Big Cr nr Oblong, Ill.	USGS	390012	0875028	2	2	2	2	2	0	2	0	2	0	2
207	Dogwood Cr at Oblong, Ill.	USGS	390007	0875338	2	2	2	2	2	0	2	0	2	0	2
208	Big Cr nr Hardinville, Ill.	IDPH	385500	0875303	48	43	0	0	13	2	1	2	0	0	0
209	Embarras R nr Westport, Ill.	EPA	385109	0874502	11	10	8	4	2	2	0	2	0	0	0
210	Embarras R at Westport, Ill.	IDPH	385006	0874525.5	116	104	31	0	40	3	1	3	0	0	0
211	Embarras R nr Billet, Ill.	IDPH	383954	0873734.5	162	154	46	0	47	8	2	8	0	0	0
212	Embarras River nr Billet, Ill.	USGS	383954	0873735	29	30	0	0	1	10	0	10	0	0	0
213	Embarras R 0.8 mile from Mouth, Ill.	EPA	383914.5	0873712	4	4	0	0	0	0	0	0	0	0	0

[1]For surface-water flow stations see table 2.1.

Table 13.4 Gaging stations

Station ID (See fig. 8.1-1)	Station name	Station number	Drainage area (mi^2)	Period of record	Station type
1	Mud Pine Creek nr Oxford, Ind.	03335690	39.4	1971-	Continuous
2	Big Pine Creek nr Williamsport, Ind.	03335700	323	1955-	Do.
3	Wabash River at Covington, Ind.	[1]03336000	8,218	1939-	Do.
4	Salt Fk nr St. Joseph, Ill.	[2]03336900	134	1958-	Do.
5	Boneyard Creek at Urbana, Ill.	[2,3]03337000	4.46	1948-	Do.
6	Vermilion River nr Catlin, Ill.	03338500	958	1939 to 1958	Do.
7	Vermilion River nr Danville, Ill.	[1]03339000	1,290	1914 to 1921 1928-	Do.
8	East Fk Coal Creek nr Hillsboro, Ind.	03339108	33.4	1968-	Do.
9	Coal Creek at Coal Creek, Ind.	03339120	214	1964 to 1972	Do.
10	Little Vermilion River nr Newport, Ind.	03339150	237	1964 to 1972	Do.
11	Sugar Creek nr Byron, Ind.	03340000	670	1940 to 1971	Do.
12	Wabash River at Montezuma, Ind.	[1]03340500	11,118	1927-	Do.
13	Cecil M. Harden Lake at Ferndale, Ind.	03340870	216	1960-	Do.
14	Big Raccoon Creek at Ferndale, Ind.	[1]03340900	222	1956-	Do.
15	Big Raccoon Creek at Mansfield, Ind.	03341000	248	1939 to 1958	Do.
16	Little Raccoon Creek nr Catlin, Ind.	03341200	134	1956 to 1971	Do.
17	Big Raccoon Creek at Coxville, Ind.	[1]03341300	448	1956-	Do.
18	Brouilletts Creek nr Universal, Ind.	03341420	321	1966 to 1971	Do.
19	North Coal Creek nr Terre Haute, Ind.	03341470	1.91	1974 to 1976	Do.
20	Wabash River at Terre Haute, Ind.	[1]03341500	12,265	1902 to 1903 1905 to 1906 1927-	Do. Do. Do.
21	Wabash River at Riverton, Ind.	[1]03342000	13,161	1938-	Do.

Table 13.4 Gaging stations--Continued

Station ID (See fig. 8.1-1)	Station name	Station number	Drainage area (mi^2)	Period of record	Station type
22	Busseron Creek nr Hymera, Ind.	[1]03342100	16.7	1966-	Do.
23	West Fk Busseron Creek nr Hymera, Ind.	03342150	14.4	1966-	Do.
24	Mud Creek nr Dugger, Ind.	[4]03342250	11.9	1966-	Do.
25	Busseron Creek nr Sullivan, Ind.	[1,4]03342300	138	1966-	Do.
26	Buttermilk Creek nr Paxton, Ind.	[4]03342350	16.5	1966 to 1973	Do.
27	Buttermilk Creek nr Sullivan, Ind.	03342360	17.6	1974 to 1978	Do.
28	Busseron Creek nr Carlisle, Ind.	[1,4]03342500	228	1943-	Do.
29	South Fk Smalls Creek at Bruceville, Ind.	03342800	4.94	1972 to 1975	Do.
30	Wabash River at Vincennes, Ind.	[1]03343000	13,706	1929-	Do.
31	Embarras River nr Camargo, Ill.	03343400	186	1960-	Do.
32	Embarras River nr Oakland, Ill.	03343500	518	1909 to 1912 1914 to 1915	Do. Do.
33	Embarras River nr Diona, Ill.	03344000	919	1938 to 1940 1944 to 1947 1970-	Do. Do. Do.
34	Range Creek nr Casey, Ill.	03344500	7.61	1950-	Do.
35	Embarras River at Ste. Marie, Ill.	03345500	1,516	1909 to 1912 1914-	Do. Do.
36	N Fk Embarras River nr Oblong, Ill.	03346000	319	1940-	Do.
37	Embarras River at Lawrenceville, Ill.	03346500	2,333	1930 to 1933	Do.
38	Bluegrass Creek at Potomac, Ill.	03336500	35	1949 to 1971 1971-	Do. Crest stage
39	Saline Branch at Urbana, Ill.	03337500	68	1936 to 1958 1958 to 1975	Continuous Crest stage
40	Salt Fork nr Homer, Ill.	03338000	340	1944 to 1958 1958-	Continuous Crest stage
41	Big Pine Creek Trib nr Pine Village, Ind.	03335685	.21	1972-	Do.
42	Big Shawnee Creek Trib nr Attica, Ind.	03335790	1.22	1972-	Do.

Table 13.4 Gaging stations--Continued

Station ID (See fig. 8.1-1)	Station name	Station number	Drainage area (mi^2)	Period of record	Station type
43	Big Four Ditch Trib nr Paxton, Ill.	03336100	1.05	1955-	Do.
44	Salt Fk Trib nr Catlin, Ill.	03338100	2.20	1959-	Do.
45	N. Fk Vermilion R Trib nr Danville, Ill.	03338800	1.31	1955 to 1976	Do.
46	Demeree Creek Trib nr Byron, Ind.	03341150	.15	1972-	Do.
47	Little Raccoon Creek Trib nr Bellmore, Ind.	03341180	.50	1974 to 1978	Do.
48	Big Creek Trib nr Dudley, Ill.	03341700	1.08	1960 to 1976	Do.
49	Prairie Creek Trib nr Pimento, Ind.	03341770	.50	1974 to 1978	Do.
50	Raccoon Creek Trib nr Annapolis, Ill.	03341900	.04	1955-	Do.
51	Kettle Creek Trib nr Shelburn, Ind.	03342180	.48	1972-	Do.
52	Embarras River Trib nr Greenup, Ill.	03344250	.08	1955-	Do.
53	Muddy Creek Trib at Woodbury, Ill.	03344425	.07	1959 to 1976	Do.
54	Big Shawnee Creek nr Attica, Ind.	03335800	42	1968 to 1975	Low flow
55	Coal Creek nr Veedersburg, Ind.	03339100	77.6	1961 to 1967	Do.
56	East Fk Coal Creek nr Veedersburg, Ind.	03339111	60.1	1968 to 1973	Do.
57	Otter Creek at Burnett, Ind.	03341450	69	1960 to 1967	Do.
58	Honey Creek nr Terre Haute, Ind.	03341580	64	1964 to 1972	Do.
59	Prairie Creek at Prairie Creek, Ind.	03341800	24	1960 to 1967	Do.
60	Turman Creek nr Farmersburg, Ind.	03341920	77.6	1963 to 1971	Do.
61	Turman Creek nr Fairbanks, Ind.	03341950	69	1960 to 1967	Do.
62	Maria Creek nr Emison, Ind.	03342700	88	1954 to 1967	Do.

[1]Flow partially regulated by upstream reservoir.
[2]Diurnal fluctuation caused by municipal and/or industrial effluent.
[3]Part of storm runoff from 1.12 mi^2 at head water has been diverted.
[4]Flow affected by surface-mined area.

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