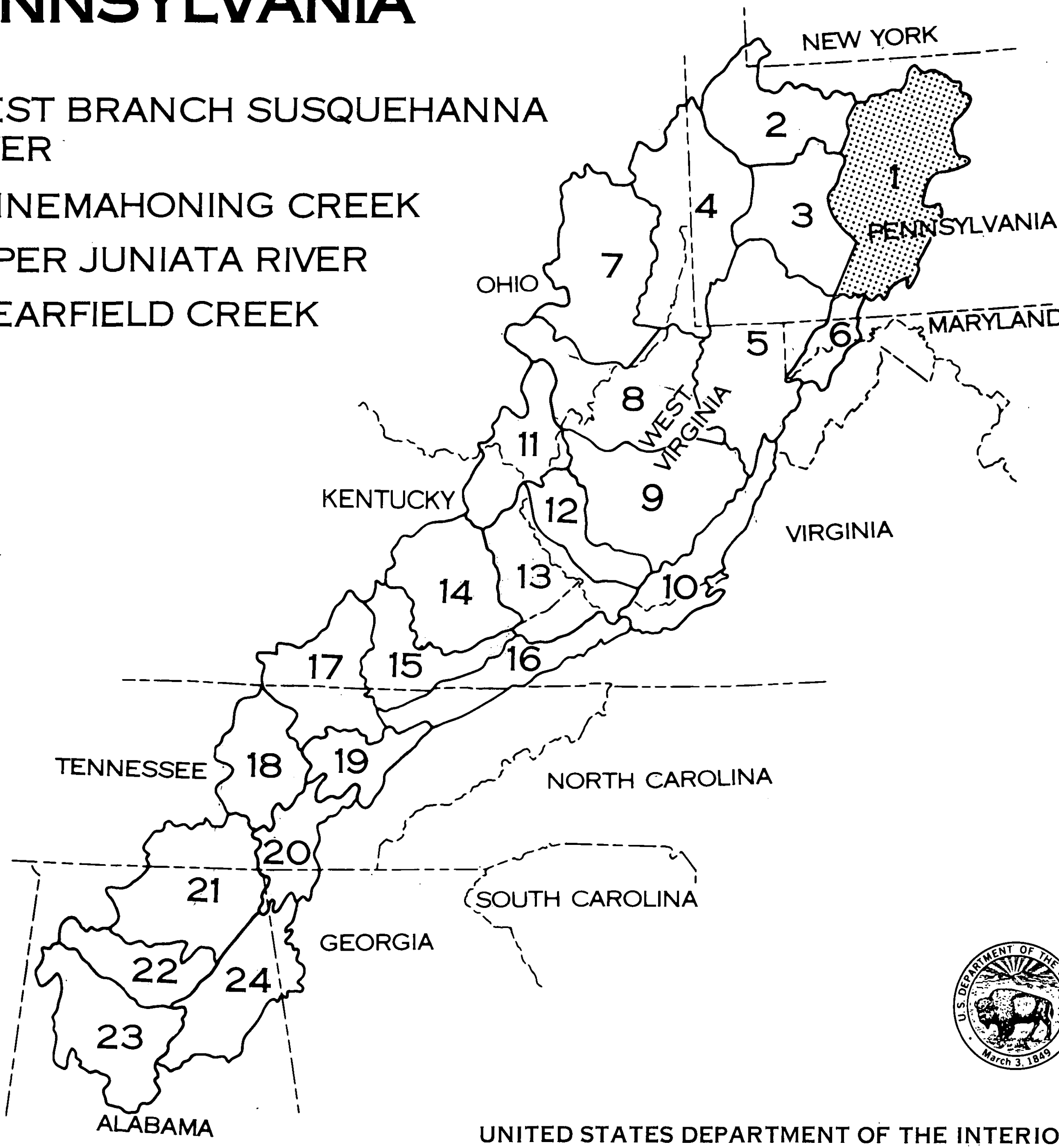
HYDROLOGY OF AREA 1, EASTERN COAL PROVINCE, PENNSYLVANIA

- WEST BRANCH SUSQUEHANNA RIVER
- SINNEMAHONING CREEK
- UPPER JUNIATA RIVER
- CLEARFIELD CREEK



UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER RESOURCES INVESTIGATIONS
OPEN FILE REPORT 82-223

HYDROLOGY OF AREA 1, EASTERN COAL PROVINCE, PENNSYLVANIA

BY
WILLIAM J. HERB, DEBORAH E. BROWN, LEWIS C. SHAW, AND
ALBERT E. BECHER

U. S. GEOLOGICAL SURVEY

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HARRISBURG, PENNSYLVANIA
SEPTEMBER, 1983

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, *SECRETARY*

GEOLOGICAL SURVEY

Dallas L. Peck, *Director*

For additional information write to:

U.S. Geological Survey
Federal Building, 4th Floor
P.O. Box 1107
228 Walnut Street
Harrisburg, Pennsylvania 17108

CONTENTS

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

For the 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)	25.4	millimeters (mm)
inches per hour (in/h)	25.4	millimeters per hour (mm/h)
	2.54	centimeters per hour (cm/h)
feet (ft)	0.3048	meters (m)
feet per mile (ft/mi)	0.1894	meters per kilometer (m/km)
miles (mi)	1.609	kilometers (km)
square miles (mi^2)	2.590	square kilometers (km^2)
gallons per minute (gal/min)	0.06309	liters per second (L/s)
million gallons per day (mgal/d)	0.04381	cubic meters per second (m^3/s)
	3,785.	cubic meters per day (m^3/d)
cubic feet per second (ft^3/s)	0.02832	cubic meters per second (m^3/s)
cubic feet per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meters per second per square kilometer [$(m^3/s)/km^2$]
tons	0.9072	metric tons (t)
tons per square mile ($tons/mi^2$)	0.3503	megagrams per square kilometer (Mg/km^2)
micromhos (μmho)	1	microsiemens (μS)

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.

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Abstract

Provisions of the Surface Mining Control and Reclamation Act of 1977 recognized a nationwide need for hydrologic information in mined and potentially mined areas. This report is designed to be useful to mine owners, operators, regulatory authorities, citizens groups, and others by presenting information on existing hydrologic conditions and by identifying additional sources of hydrologic information. General hydrologic information is presented in a brief text accompanied by a map, chart, graph, or other illustration for each of a series of water-resources-related topics. The summation of the topical discussions provides a description of the hydrology of the area.

The Eastern Coal Province has been divided into 24 hydrologic study areas which are shown on the cover of this report. The divisions are based on hydrologic factors, location, and size. Hydrologic units (surface drainage basins) or parts of units are combined to form each study area.

Area 1 covers 7,400 square miles of the Eastern Coal Province in part or all of 18 counties in west-central Pennsylvania. The major streams in the area are the West Branch Susquehanna and Juniata Rivers. Area 1 counties produced more than 20,000,000 tons of coal during 1979. About 66,000 acres of disturbed coal land in Area 1 counties are in need of reclamation.

Streamflow data have been collected at 146 locations in the area, and water-quality data have been collected at 123 locations. Interpretations of water quality in this report are generally based on a series of four water-quality samples collected at each of 113 locations during the 1979-80 water years. Water-quality data collected at these sites included: specific conductance; dissolved solids; pH; acidity; alkalinty; total and dissolved iron; total and dissolved manganese; sulfate; and bed-material iron, manganese, coal, and organic carbon. Most sites had benthic invertebrate populations sampled and analyses of bed-material constituents. A smaller set of sites was sampled for common constituents and minor elements.

Streams in Clearfield and Cambria Counties, the two leading coal producers in the area, had median specific conductances and dissolved-solids concentrations three to five times greater than those from other area counties. Clearfield County streams had the lowest median stream pH in the area. Most streams sampled in the area had acidity in excess of alkalinity. Streams in the three major coal producing counties in the area had median total-iron concentrations two to three times higher than those for other area counties, and the same general pattern was found for total manganese. The median sulfate concentration of a county's streams showed a close positive correlation with the amount of coal mined in the county. Iron and coal concentrations in bed material were higher in coal-producing counties, but manganese concentrations in bed material were not higher. Twenty-eight streams did not have a benthic biological community as defined by the Office of Surface Mining. Three-fourths of the sites with no biological community had levels of pH, acidity, iron, manganese, and sulfate indicative of acid mine drainage.

Statistics on low flow, mean flow, peak flow, and flow-duration can be computed from gaging station records for gaged streams. The same statistics can be estimated for ungaged streams through the use of regression or graphical techniques. This information may be useful in preparing and evaluating mine-permit applications.

Aquifers in the area receive most recharge from precipitation on outcrop areas. Highest ground-water levels generally occur in spring, decline during the summer, and begin to rise again during the fall. Water levels in valleys generally show less fluctuation than on hills. Median well yields in the area range from 5 to 50 gallons per minute. Ground-water supplies are obtained from more than 40 formations. Ground-water quality is generally suitable for most uses.

1.0 INTRODUCTION

1.1 Objective

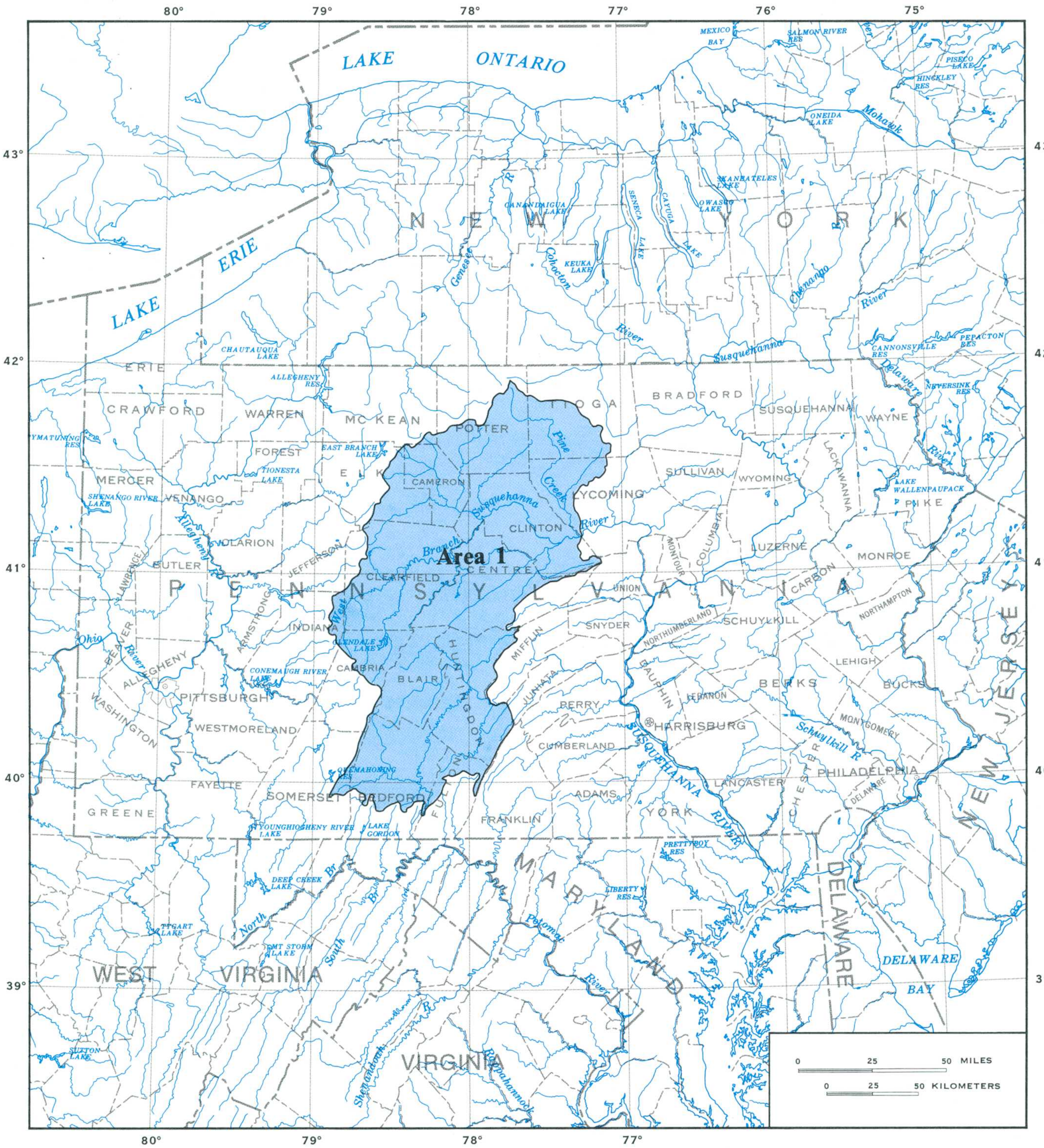
Area 1 Report to Aid Permitting

Existing hydrologic conditions and identification of sources of hydrologic information are described.

A need for hydrologic information and analysis on a scale never before required nationwide was initiated when the "Surface Mining Control and Reclamation Act of 1977" was enacted as Public Law 95-87, August 3, 1977. This need is partly met by this report which broadly characterizes the hydrology of two large subbasins in the coal areas of central Pennsylvania (see figure 1.1-1). This report, which is for Area 1, is one of a series that covers the coal provinces nationwide. The report contains a brief text with an accompanying map, chart, graph, or other illustration for each of a number of water-resources-related topics. The summation of the topical discussions provides a description of the hydrology of the area.

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

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



BASE FROM U.S. GEOLOGICAL SURVEY
UNITED STATES BASE MAP, 1980

Figure 1.1-1 Report area.

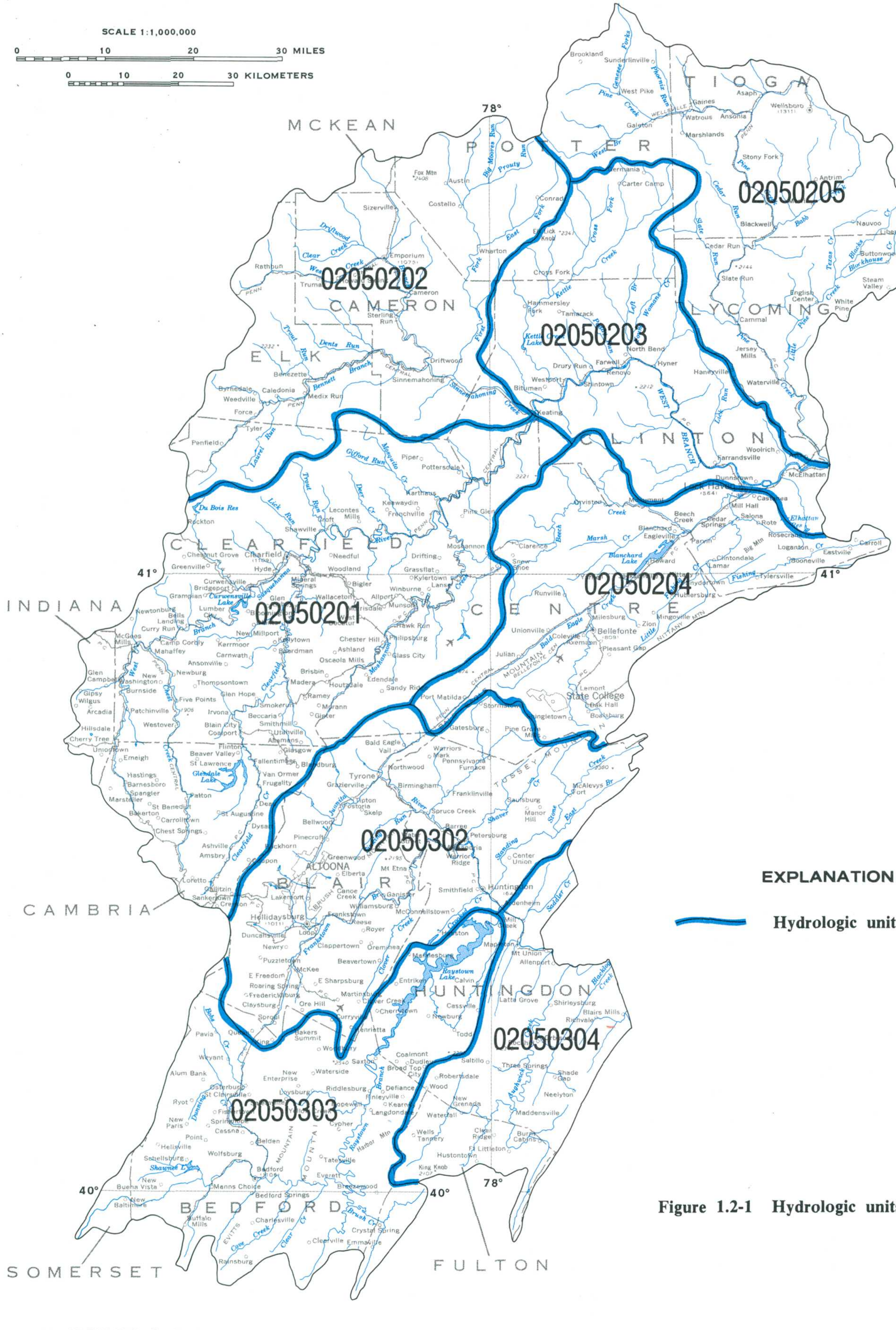
Hydrology and Water Resources Summarized for Area 1 in Pennsylvania

This report summarizes the hydrology and water resources of Area 1 in the northern part of the Eastern Coal Province in Pennsylvania.

The Eastern Coal Province is divided into 24 hydrologic reporting units. The divisions are based on hydrologic factors, location, size, and mining activity (see front cover for areas in the Eastern Coal Province). Hydrologic units (drainage basins) or parts of units are combined to form each area (fig. 1.2-1).

Area 1 is in the northeastern part of the Eastern Coal Province in west-central Pennsylvania. The area includes all or part of Elk, Cameron, Potter, Tioga, Clearfield, Clinton, Lycoming, Centre, Indiana, Cambria, Blair, Huntingdon, Bedford, McKean, Somerset, Mifflin, Juniata, and Fulton Counties.

Area 1 comprises the West Branch Susquehanna River basin upstream from, and including, Pine Creek and the Juniata River basin upstream from Ryde. Major tributaries in the area include Raystown and Frankstown Branches Juniata River; Clearfield, Pine, Bald Eagle, Kettle, and Sinnemahoning Creeks. The surface area of Area 1 is 7,400 square miles.



EXPLANATION

Hydrologic unit boundary

BASE FROM U.S. GEOLOGICAL SURVEY
1975; 1:500,000

Figure 1.2-1 Hydrologic units in Area 1.

2.0 DEFINITION OF TERMS

Terms Used in Hydrologic Reports Defined

Technical terms that occur in this Hydrologic Report are defined.

Bed material is the unconsolidated material of which a streambed, lake, pond, reservoir, or estuary bottom is composed.

Benthic invertebrate for this study, is an animal without a backbone, living on or near the bottom of an aquatic environment. It is retained on a 210 μm mesh sieve.

Bottom material specifically includes anthropogenic matter in addition to natural solid material in bed material.

Cubic feet per second per square mile $[(ft^3/s)/mi^2]$ is the average number of cubic feet of water flowing per second from each square mile of area drained, assuming that the runoff is distributed uniformly in time and area.

Cubic foot per second (ft^3/s) is the rate of discharge representing a volume of 1 cubic foot passing a given point during 1 second and is equivalent to approximately 7.48 gallons per second or 448.8 gallons per minute or 0.02832 cubic meters per second.

Discharge is the volume of water (or more broadly, volume of fluid plus suspended material) that passes a given point within a given period of time.

Mean discharge is the arithmetic mean of individual daily mean discharges during a specific period.

Instantaneous discharge is the discharge at a particular instant of time.

Dissolved refers to the amount of substance present in true chemical solution. In practice, however, the term includes all forms of substance that will pass through a 0.45-micrometer membrane filter, and thus may include some very small (colloidal) suspended particles. Analyses are performed on filtered samples.

Diversity index is a numerical expression of evenness of distribution of aquatic organisms, the formula for diversity index is:

$$\bar{d} = \sum_{i=1}^{s} \frac{n_i}{n} \log 2 \frac{n_i}{n}$$

Where n_i is the number of individuals per taxon, n is the total number of individuals, and s is the total number of taxa in the sample of the community. Diversity index values range from zero, when all the organisms in the sample are the same, to some positive number, when some or all of the organisms in the sample are different.

Drainage area of a stream at a specific location is that area, measured in a horizontal plane, enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into the river above the specified point. Figures of drainage area given herein include all closed basins, or noncontribution areas, within the area unless otherwise noted.

Drainage basin is a part of the surface of the Earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

Gage height (G.H.) is the water-surface elevation referred to some arbitrary gage datum. Gage height is often used interchangeably with the more general term "stage", although gage height is more appropriate when used with a reading on a gage.

Gaging station is a particular site on a stream, canal, lake, or reservoir where systematic observations of hydrologic data are obtained.

Hydrologic unit is a geographic area representing part or all of a surface drainage basin or distinct hydrologic feature as delineated by the Office of Water Data Coordination on the State Hydrologic Unit Maps; each hydrologic unit is identified by an 8-digit number.

Micrograms per gram (μg/g) is a unit expressing the concentration of a chemical element as the mass (micrograms) of the element per unit mass (gram) of sediment.

Micrograms per liter (μg/L) is a unit expressing the concentration of chemical constituents in solution as mass (micrograms) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter.

Milligrams per liter (mg/L) is a unit for expressing the concentration of chemical constituents in solution. Milligrams per liter represent the mass of solute per unit volume (liter) of water. Concentration of suspended sediment also is expressed in mg/L, and is based on the mass (dry weight) of sediment per liter of water-sediment mixture.

Partial-record station is a particular site where limited streamflow and(or) water-quality data are collected systematically over a period of years for use in hydrologic analyses.

Reference station is a streamflow and water-quality station operated as part of the State coal-hydrology network to monitor hydrologic characteristics in a watershed unaffected by mining.

Regression line is a line fitted to a set of data points by a least-squares statistical analysis. The same data set will always provide the same line of relation.

Sediment is solid material that originates mostly from disintegrated rocks and is transported by, suspended in, or deposited from water; it includes chemical and biochemical precipitates and decomposed organic material, such as humus. The quantity, characteristics, and cause of the occurrence of sediment in streams are influenced by environmental factors. Some major factors are degree of slope, length of slope, soil characteristics, land usage, and quantity and intensity of precipitation.

Suspended sediment is the sediment that at any given time is maintained in suspension by the upward components of turbulent currents or that exists in suspension as a colloid.

Suspended-sediment concentration is the velocity-weighted concentration of suspended sediment in the sampled zone (from the water surface to a point approximately 0.3 ft above the bed) expressed as milligrams of dry sediment per liter of water-sediment mixture (mg/L).

Specific conductance is a measure of the ability of a water to conduct an electrical current. It is expressed in micromhos per centimeter (μmho/cm) at 25°C. Specific conductance is related to the type and concentration of ions in solution and can be used for approximating the dissolved-solids concentration of the water. Commonly, the concentration of dissolved solids (in milligrams per liter) is about 65 percent of the specific conductance (in micromhos). This relation is not constant from stream to stream, and it may vary in the same stream with changes in the composition of the water.

Stage-discharge relation is the relation between gage height (stage) and volume of water per unit of time, flowing in a channel.

Streamflow is the discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than "runoff" as streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

Substrate is the physical surface upon which an organism lived.

Natural substrate refers to any naturally occurring emersed or submersed solid surface such as a rock or tree, upon which an organism lived.

Synoptic site is a stream location where periodic measurements are made of streamflow and water quality. If a group of such sites is measured at about the same time, the hydrologic conditions over a wide area can be seen.

Taxonomy is the division of biology concerned with the classification and naming of organisms. The classification of organisms is based upon a heirarchical scheme beginning with Kingdon and ending with Species at the base. The higher the classification level, the fewer features the organisms have in common. For example, the taxonomy of a particular mayfly, *Hexagenia limbata* is the following:

Kingdom	Animal
Phylum	Arthropoda
Class	Insecta
Order	Ephemeroptera
Family	Ephemeridae
Genus	*Hexagenia*
Species	*Hexagenia limbata*

Trend station is a streamflow and water-quality station operated as part of the State coal-hydrology network to monitor hydrologic characteristics in a watershed undergoing coal mining.

Water year is, for this report, the 12-month period beginning October 1 of one year and ending September 30 of the following year. Water year 1979 begins on October 1, 1978, and ends on September 30, 1979.

New Regulations Set Effluent Limitations for Iron, Manganese, pH, and Suspended Solids

Standards have been set for iron, manganese, pH, and suspended solids in water discharged from areas disturbed by surface mining.

The Permanent Regulatory Program of the Office of Surface Mining Reclamation and Enforcement (1979) sets specific standards for water leaving a mine site. Section 816.42 (a) (7) of the Permanent Regulatory Program states that "discharges of water from areas disturbed by surface mining shall be made in compliance with all Federal and State laws and regulations . . . ." This same section also sets certain specific numerical effluent limitations. The specific effluent limitations are for total iron, total manganese, total suspended solids, and pH. Table 3.0-1 lists these numerical standards.

The effluent limitations for iron and manganese are considerably higher than those recommended for drinking water by the U.S. Environmental Protection Agency which sets limits of 300 μg/L (micrograms per liter) iron and 50 μg/L manganese.

Table 3.0-1 Mine effluent limitations.

Effluent limitations in milligrams per liter (mg/L) except for pH[1]

Effluent characteristics	Maximum allowable	Average of daily values for 30 consecutive discharge days
Iron, total	7.0	3.5
Manganese, total[2]	4.0	2.0
Total suspended solids	70.0	35.0
pH[3]	Within range of 6.0 to 9.0	

[1] Office of Surface Mining, Reclamation, and Enforcement, 1979.

[2] Shall not apply to untreated alkaline discharges.

[3] pH may exceed 9.0, to a small extent, if needed to achieve manganese limit.

Different Rock Units and Contrasting Structural Features in Area 1

The Appalachian Plateaus province comprises gently folded shales, siltstones, and sandstones. The Valley and Ridge province comprises narrow steep, thrust-faulted folds in limestone, quartzite, shale, siltstones, and sandstones.

The Appalachian Plateaus province (Fenneman, 1938), the northwestern part of Area 1, consists of intricately dissected plateaus and broad ridges underlain by shale, siltstone, and sandstone layers (fig. 4.1-1). These layers are slightly warped into broad folds that plunge very gently to the southwest. The southeastern part of Area 1, the Valley and Ridge province (Fenneman, 1938), is a series of alternating ridges formed on resistant quartzite and sandstone, and valleys eroded from less resistant siltstone, shale, limestone, and dolomite (fig. 4.1-1). The rocks dip steeply on the flanks of major folds that are commonly disrupted by deep-seated extensive thrust faults.

Coal-bearing rocks of Pennsylvanian age in the Conemaugh, Allegheny, and Pottsville Formations or Groups crop out throughout the southern part of the Appalachian Plateau, but they are supplanted by older rocks to the north. These older rocks, in descending stratigraphic order are; Missippian sandstone interbedded with some shale, and Devonian shale, siltstone, and sandstone. The maximum thickness of the coal-bearing rocks is about 1,300 feet in the southern part of the Appalachian Plateaus and about 500 feet in the northern part. As many as 50 beds of coal have been reported, but many are discontinuous or of little commercial value. The Clearfield and Tioga County sections in figure 4.1-2 show the generalized stratigraphy in different parts of the Appalachian Plateaus.

Coal-bearing rocks of the Conemaugh, Allegheny, and Pottsville occur in the Broad Top coal field. The Broad Top field is a dissected tableland in the southeastern corner of Area 1. Eight major coal beds in the Broad Top field, seven of which are in the Allegheny, are shown in the Broad Top section in figure 4.1-2. Several other beds of impure, thin, or discontinuous coal are also present.

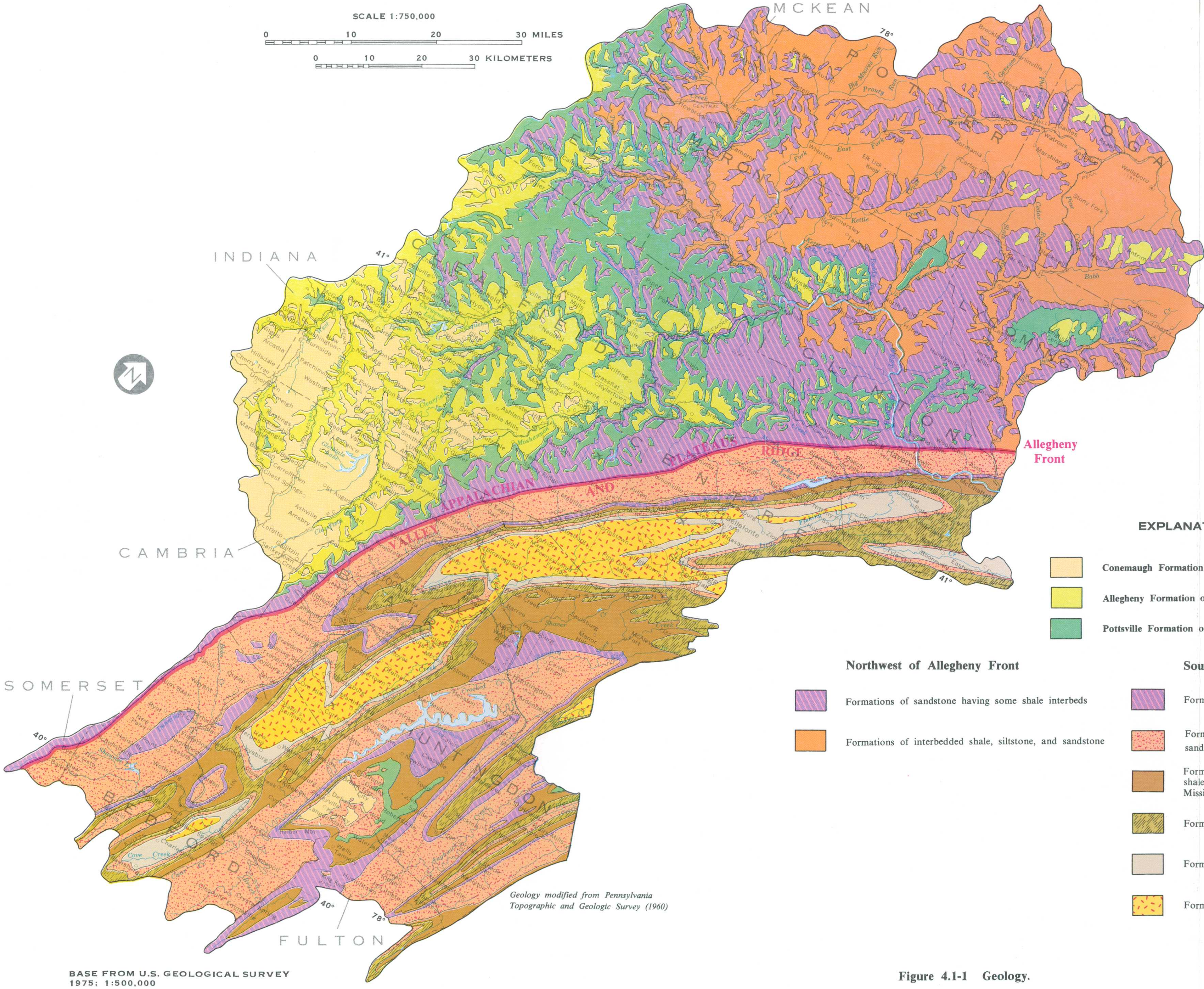


Figure 4.1-1 Geology.

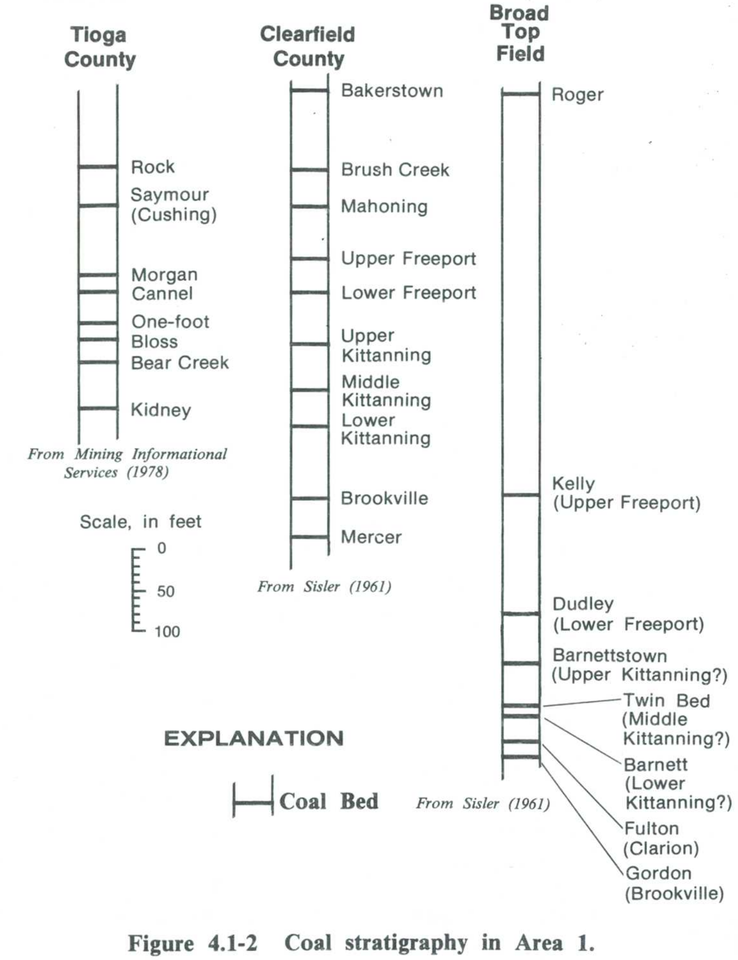


Figure 4.1-2 Coal stratigraphy in Area 1.

Area 1 Lies Entirely Within the Susquehanna River Basin

Area 1 is drained by the West Branch Susquehanna River and the Juniata River. Both rivers are tributary to the Susquehanna River.

Area 1 is entirely within the Susquehanna River basin and is drained by the West Branch Susquehanna River and the Juniata River. There are 10 major basins within Area 1 (fig. 4.2-1). These basins drain 5,720 of Area 1's 7,400 square miles (table 4.2-1). The remaining area is drained by West Branch Susquehanna River, Juniata River, or their minor tributaries. Drainage pattern (fig. 4.2-2) and channel pattern (fig. 4.2-3) characteristics for the 10 major basins are presented in table 4.2-1. The drainage and channel patterns are generally dependent upon the physiographic province in which the streams are located.

Area 1 is in the Appalachian Plateaus and Valley and Ridge provinces (Fenneman, 1938) (fig. 4.2-1). The provinces are separated by a topographic and geologic feature, the Allegheny Front, which trends from the southwest to the northeast (fig. 4.2-1). North of the Front, in the Appalachian Plateaus province, streams have a dendritic drainage pattern, whereas south of the Front, in the Valley and Ridge province, streams have a trellised drainage pattern (fig. 4.2-2). Appalachian Plateaus streams tend to have channels that are straight to tortuous whereas Valley and Ridge streams tend to have channels that are transitional to tortuous.

Table 4.2-1 Characteristics of major drainage basins in Area 1.

Basin	Drainage area (square miles)	Length (miles)	Channel slope (feet per mile)	Drainage pattern[1]	Channel pattern[2]
Clearfield Creek	393	70.9	8.7	Dendritic	Tortuous.
Moshannon Creek	274	55.6	13.8	Do.	Do.
Sinnemahoning Creek	1,035	15.7	5.9	Do.	Regular.
Kettle Creek	246	46.5	20.3	Do.	Tortuous.
Bald Eagle Creek	771	56.1	10.0	Trellised	Transitional.
Pine Creek	979	86.5	12.3	Dendritic	Irregular.
Little Juniata River	343	31.2	16.0	Trellised	Regular.
Frankstown Branch	396	53.3	11.3	Do.	Irregular.
Raystown Branch	961	126	5.7	Do.	Tortuous
Aughwick Creek	322	30.2	6.9	Do.	Do.

[1]Howard (1967).
[2]Schumm (1963).

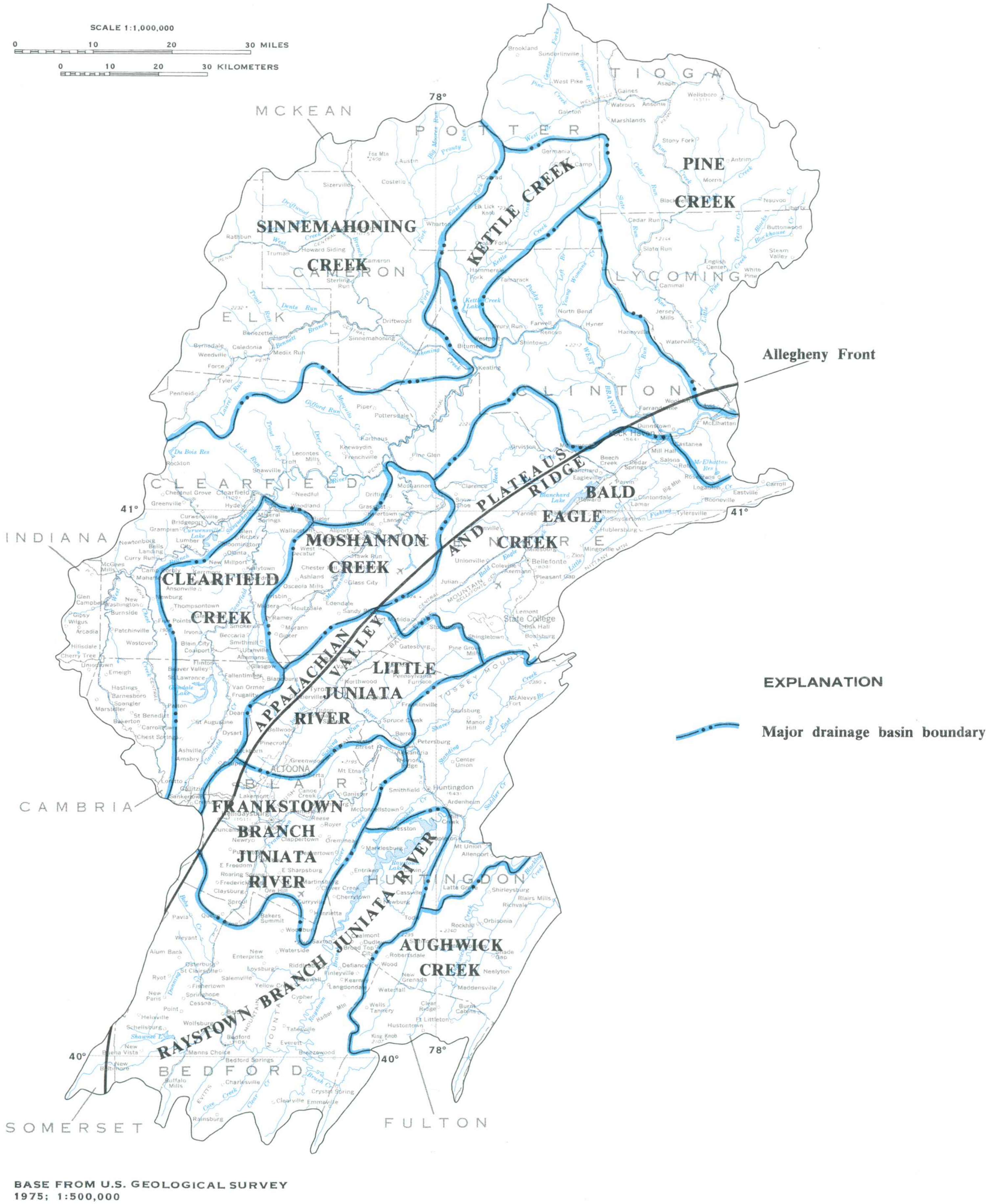
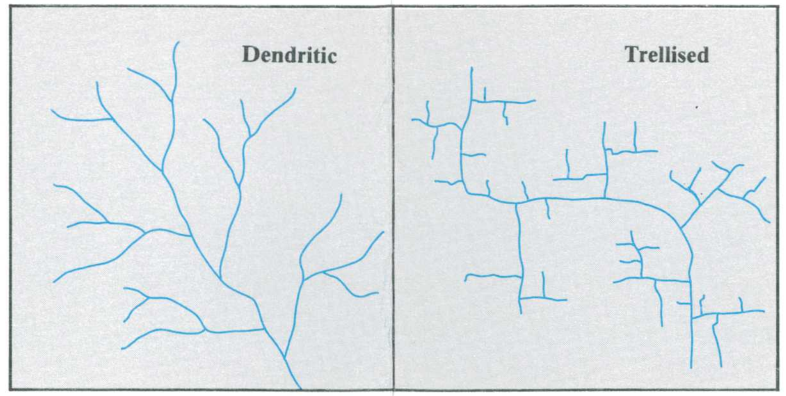
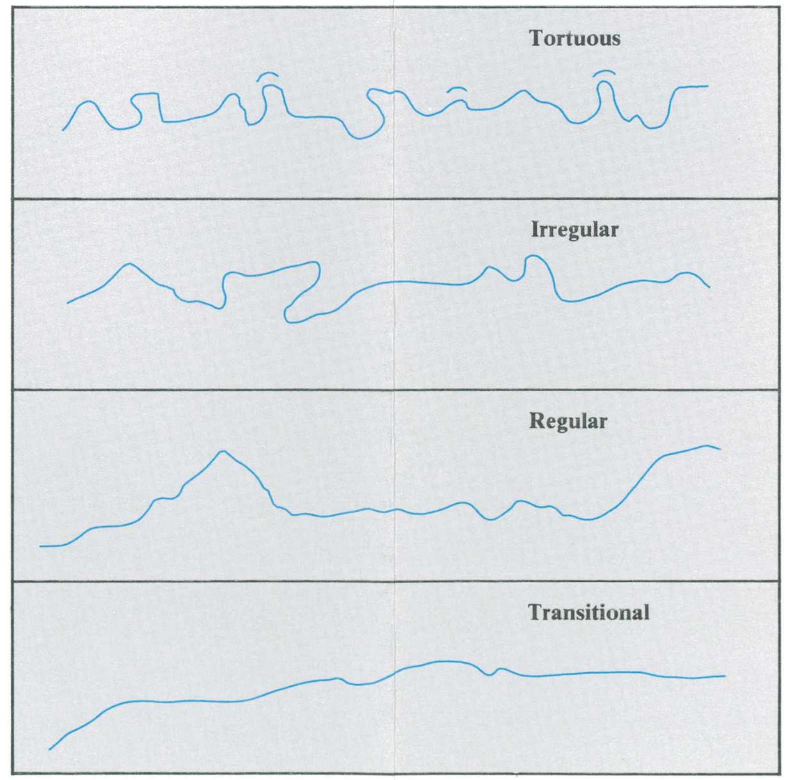


Figure 4.2-1 Major drainage basins in Area 1.



From Howard (1967)

Figure 4.2-2 Morphological classifications of drainage patterns.



From Schumm (1963)

Figure 4.2-3 Channel patterns.

Soils in Area Formed from Four General Parent Materials

Soils in Area 1 are formed from carbonate sedimentary rocks, noncarbonate sedimentary rocks, glacial till, or unconsolidated water-sorted materials.

Most soils in Area 2 are formed from noncarbonate sedimentary rocks, but some soils are derived from carbonate sedimentary rocks (fig. 4.3-1). Other soils in the area are formed from either glacial till or unconsolidated water-sorted materials. The locations of soils groups A, B, D, and E are shown in a generalized soils map (fig. 4.3-1). The groups can be further subdivided into 20 soil associations based on combinations of 35 major soils (Soil Conservation Service, 1972). Generalized soil characteristics for Area 1 are shown in table 4.3-1.

Soils in the Glaciated Low Plateaus (fig. 4.3-2) are formed from glacial till (fig. 4.3-1). The soils range from 30 to 50 inches thick, and are underlain by shales, sandstones, conglomerates, and coal. The area is mountainous, and slopes range from 3 to 45 percent.

The Allegheny High Plateaus (fig. 4.3-2) are covered by soils formed from noncarbonate sedimentary rocks (fig. 4.3-1). Soil depths in the area range from 50 to 70 inches and slopes range from 3 to 25 percent.

Soils north of the Allegheny Front (fig. 4.3-2) are generally formed from non-carbonate sedimentary rocks, but near Lock Haven (fig. 4.3-1) a small amount of soil is formed from unconsolidated water-sorted materials. The soils are underlain by a combination of shales, sandstones, and coal. Soil depths are commonly 50 to 70 inches and slopes range from 3 to 25 percent.

Southeast of the Allegheny Front (fig. 4.3-2), soils are formed from carbonate and noncarbonate sedimentary rocks (fig. 4.3-1). The underlying rocks are sandstones, shales, conglomerates, dolomites, and impure limestones. The soils range from 30 to 72 inches deep and slopes range from 3 to 40 percent.

Table 4.3-1 Soil characteristics in Area 1.

Physiographic area[1]	Soil depth (inches)	Slope (percent)	Infiltration rates	Drainage
Appalachian Plateau Province				
Allegheny Mountain Section	30-72	3-20	Well to medium well	Good.
Pittsburgh Plateaus Section	30-72	3-20	Do.	Do.
Allegheny High Plateaus Section	30-70	3-25	Moderate to slow	Fair.
Glaciated Low Plateaus Section	30-50	3-45	Slow when throughly wet	Poor.
Valley and Ridge Province				
Appalachian Mountain Section				
A Western area	as much as 60	3-40	Moderate when thoroughly wet	Fair to poor.
B Eastern area	30-70	3-40	Slow to very slow	Poor.
C Southwestern area	as much as 72	3-40	Moderate to high	Good
D Central area	as much as 60	3-40	Do.	Do.

[1]See figure 4.3-2. Usage of Commonwealth of Pennsylvania (no date).

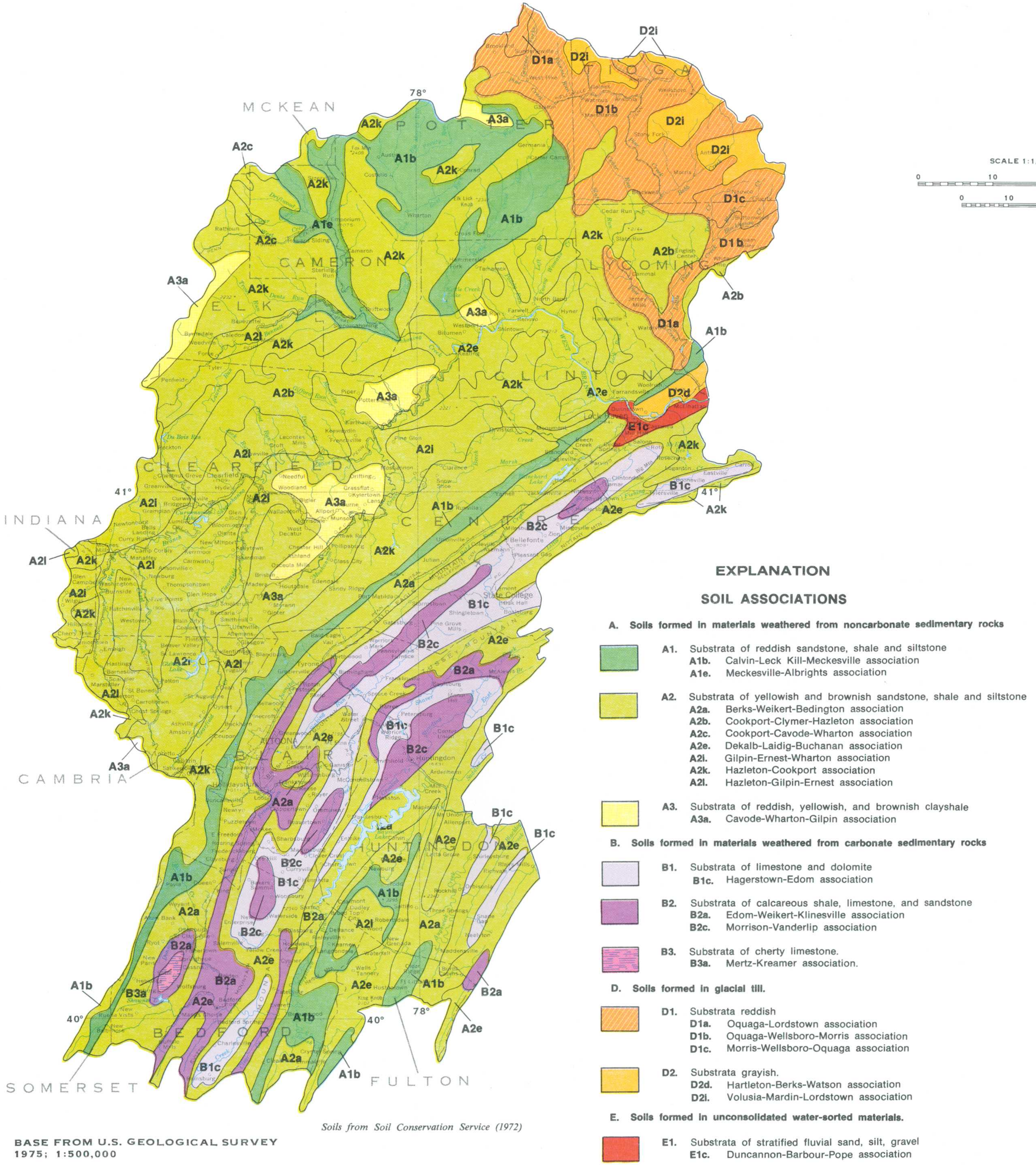


Figure 4.3-1 Soil associations in Area 1.

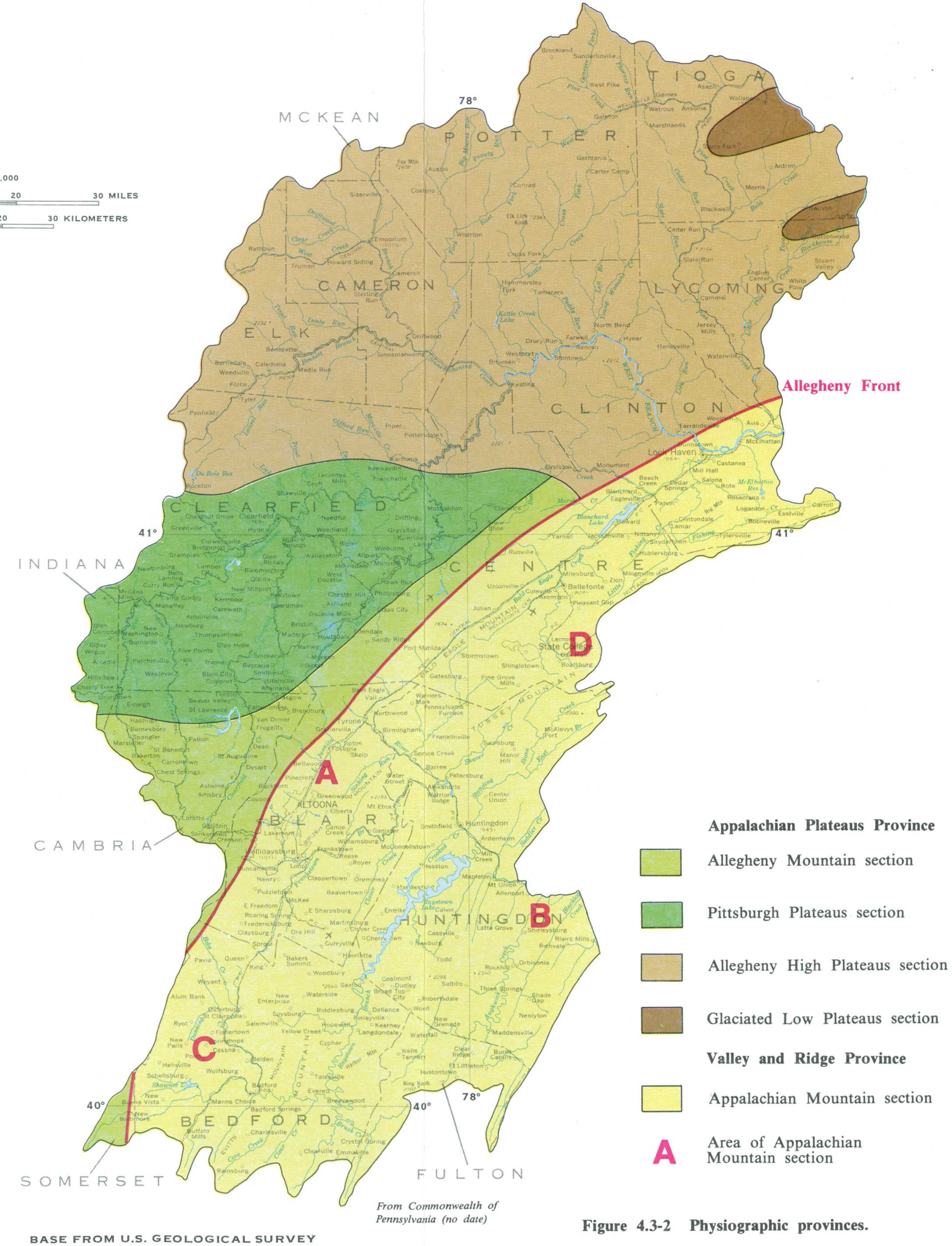


Figure 4.3-2 Physiographic provinces.

Area Has Humid Continental Climate

The humid continental climate of Area 1 is greatly influenced by the large number of storm tracks that cross the area from Polar Canada, the Rocky Mountains, Central Plains, Gulf of Mexico, and Atlantic Ocean.

Area 1 is located in the upper and central West Branch Susquehanna River and upper Juniata River subbasins of the Susquehanna River basin. Storm tracks frequently cross the area from the north, west, and south. Storms from the east are less frequent. Canada and the Central Plains govern the area's humid continental climate. The Gulf of Mexico is one of the primary sources of moisture; the Atlantic Ocean moderates the climate more than provides moisture.

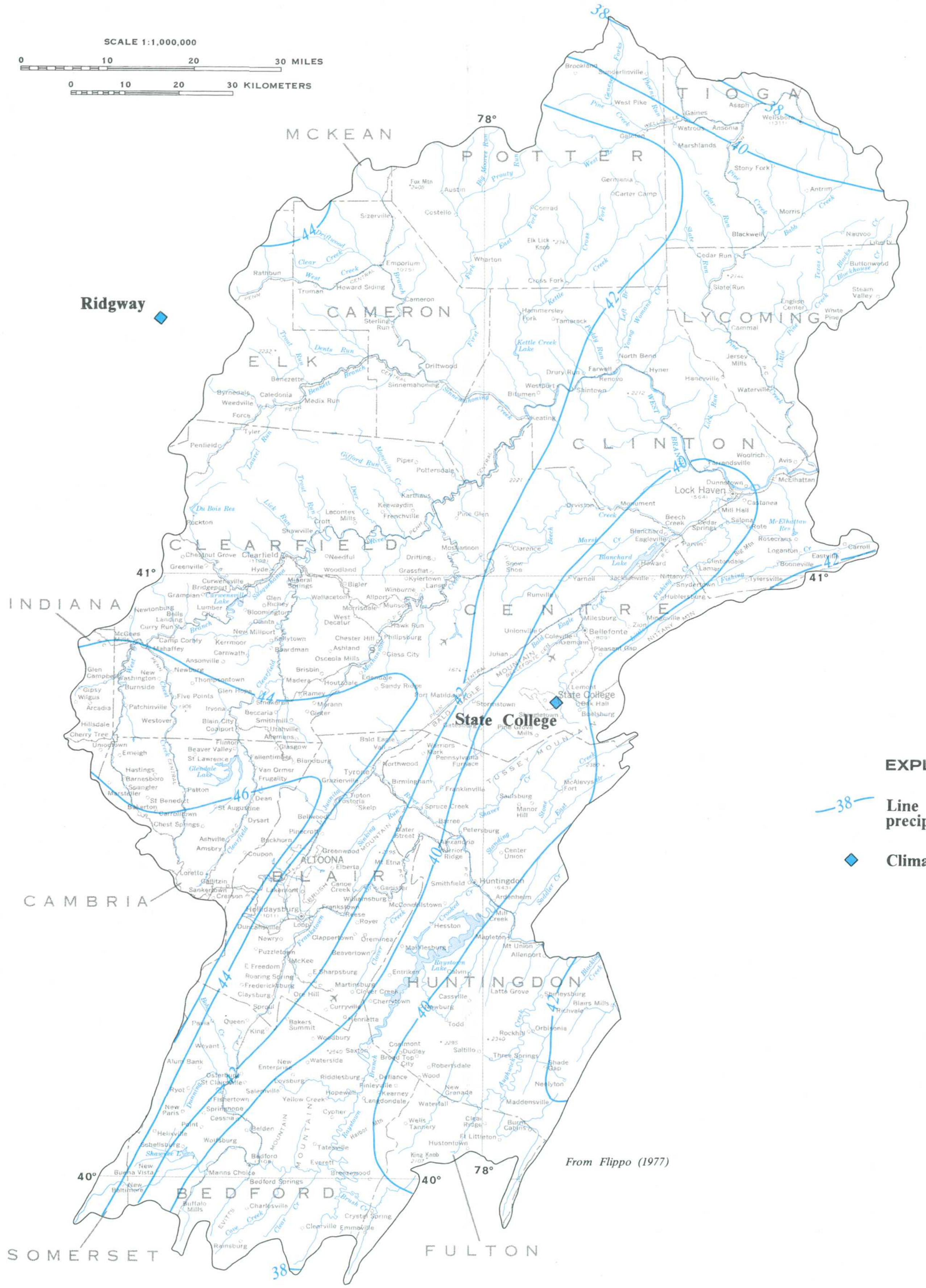
Area 1's winters are controlled by storms that originate in Canada and travel south from the Hudson Bay or east from the Rocky Mountains. Cold Canadian air, clear skies, and snow cover may cause sub-zero weather. At times, warm air from the Gulf of Mexico travels north causing alternate thawing and freezing. The Atlantic Ocean has less effect on winter weather than does Canada, but when it controls the weather, storms are severe with high winds, heavy rains, and heavy snows. Winter weather changes every few days and extended periods of extreme cold are rare.

Summer weather systems usually originate from the southwest. Summer storms bring heavy rains or hot, humid weather. Temperatures peak during July. Thunderstorms increase after the winter months, peak in mid-summer, and become less frequent as the colder months begin.

Mean annual precipitation for the area is shown by the lines of equal precipitation in figure 4.4-1; the base period is 1941-70. The monthly normal and extreme precipitation at two weather stations are shown in figure 4.4-2. Monthly extremes of snowfall and ice pellets are illustrated in figure 4.4-3.

Average annual temperatures in the study area range from 45°F to 50°F. Temperatures as high as 105°F have been recorded during August and as low as -31°F in January. Because of the variable topography, the mean annual freeze-free period ranges from 130 days to 165 days. The recorded normal and extreme temperatures at the Ridgway and State College weather stations are shown in figure 4.4-4.

Daily precipitation data are published monthly as "Local Climatological Data for Pennsylvania" by the National Oceanic and Atmospheric Administration, National Climatic Center, Ashville, North Carolina. Statistical information concerning analysis and data are presented by the U.S. Department of Commerce (1973).



EXPLANATION

—38— Line of equal mean annual precipitation, in inches

◆ Climate station and name

BASE FROM U.S. GEOLOGICAL SURVEY
1975; 1:500,000

Figure 4.4-1 Mean annual precipitation in Area 1

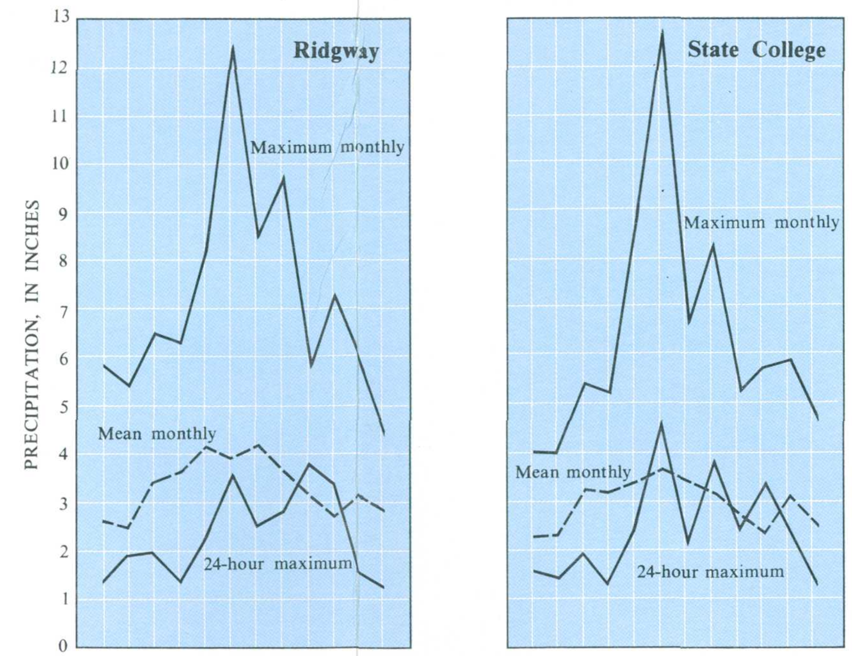


Figure 4.4-2 Precipitation in Area 1.

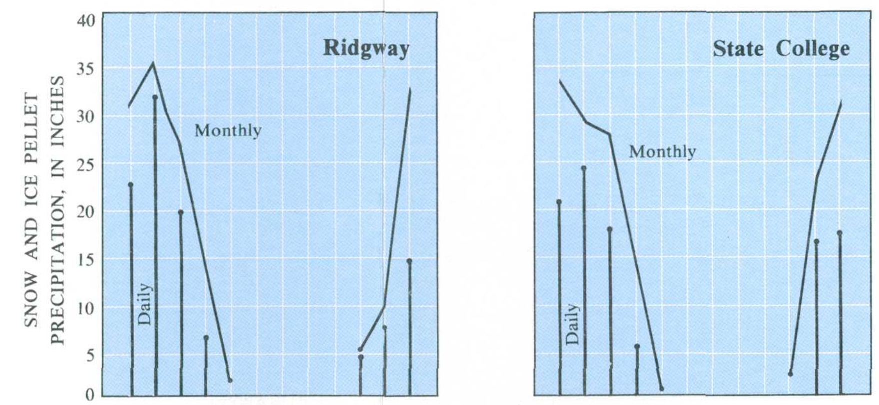


Figure 4.4-3 Maximum snow and ice pellet precipitation in Area 1.

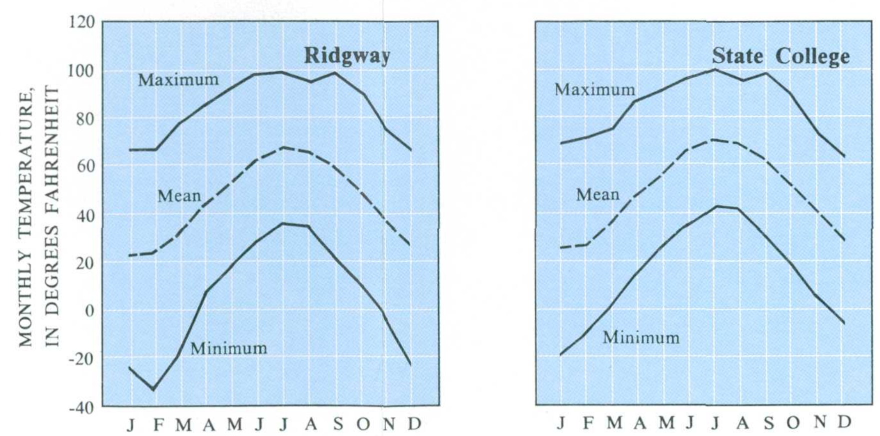


Figure 4.4-4 Temperature in Area 1.

5.0 COAL

Clearfield County Leads Area in Coal Production

Coal production in Area 1 counties during 1979 totaled more than 20 million tons. Clearfield County produced 47 percent of the total.

Most coal in Area 1 is produced by strip and deep mining with smaller amounts produced by auger mining and recovery from refuse piles. Strip mining is the overall leading producer (table 5.0-1). During 1979, 456 mines in Area 1 counties produced 20,570,663 tons of bituminous coal. Clearfield County alone produced 9,708,465 tons, or about 47 percent of the total (Commonwealth of Pennsylvania, 1980). If Clearfield, Cambria, and Centre Counties are combined, they produce 94 percent of the coal mined in the Area. Area 1 counties produced about 23 percent of the State's bituminous coal during 1979. Elk, Indiana, and Somerset Counties' coal production was not included in the Area 1 figures. Most of the coal produced in these counties is in Areas 2, 3, and 5, respectively. Because coal production figures are available only on a county basis, the production within Area 1 will differ somewhat from the production within Area 1 counties.

Although coal production in Area 1 counties has shown considerable year-to-year variation, there has been a general upward trend in production during 1970-1979 (fig. 5.0-1). Coal production in Area 1 counties has risen from about 15 million tons in 1970 to over 20 million tons in 1979. This rise is closely related to the change in Clearfield County production which rose from about 6 million tons annually to almost 10 million tons annually during the same period (Commonwealth of Pennsylvania, 1980). Increases in coal mining are accompanied by increases in the amount of land disturbed by mining. The U.S. Department of Agriculture (1977) indicates that about 300,000 acres of coal lands in Pennsylvania are in need of reclamation. Only 60,000 of these acres have a legal requirement for reclamation. Pennsylvania leads the nation in disturbed coal lands having no legal requirement for reclamation. More than 66,000 acres (103 square miles) in Area 1 counties are in need of reclamation (U.S. Dept. of Agriculture, 1977), but only about 18,000 of these acres have a legal requirement for reclamation (table 5.0-2).

The Eastern Coal Province extends from southwest Alabama to north-central Pennsylvania and follows a southwest to northeast trend which is evident in Area 1 (fig. 5.0-2). The major coal deposits in the area are generally found northwest of the Allegheny Front; however, the Broad Top coal field, Pennsylvania's smallest, is southeast of the Front and is located entirely in the upper Juniata River basin (fig. 5.0-2).

Table 5.0-1 Bituminous coal production in Area 1 counties during 1979.

[Elk, Indiana, and Somerset Counties' production included with Areas 2, 3, and 5, respectively.]

[All production values are in tons]

County	Production by method: Strip mining	Deep mining	Auger mining	Refuse recovery	Total production
West Branch Susquehanna River basin					
Cambria	3,310,768	4,407,109	8,803	144,848	7,871,528
Centre	1,137,824	535,188	---	---	1,673,012
Clearfield	9,081,407	585,108	41,950	---	9,708,465
Clinton	465,777	---	---	---	465,777
Lycoming	259,625	---	---	---	259,625
Tioga	406,163	---	---	---	406,163
Juniata River basin					
Bedford	84,118	---	---	8,601	92,719
Fulton	30,000	---	---	---	30,000
Huntingdon	63,374	---	---	---	63,374
Area total	14,839,056	5,527,405	50,753	153,449	20,570,663
State total	45,116,917	43,350,852	351,333	347,792	89,166,894

From Commonwealth of Pennsylvania (1980)

Table 5.0-2 Disturbed coal land in Area 1 counties in need of reclamation as of July 1977.

[Elk, Indiana, and Somerset Counties' acreage included in areas 2, 3, and 5, respectively]

[All land area in acres]

County	Reclamation required by law	Reclamation not required by law	Total
West Branch Susquehanna River Basin			
Cambria	3,100	12,000	15,100
Centre	2,000	12,000	14,000
Clearfield	12,000	20,000	32,000
Clinton	500	1,000	1,500
Lycoming	300	500	800
Tioga	200	1,000	1,200
Juniata River basin			
Bedford	100	700	800
Fulton	50	100	150
Huntingdon	100	800	900
Area total	18,350	48,100	66,450
State total	60,000	240,000	300,000

From U.S. Department of Agriculture (1977)

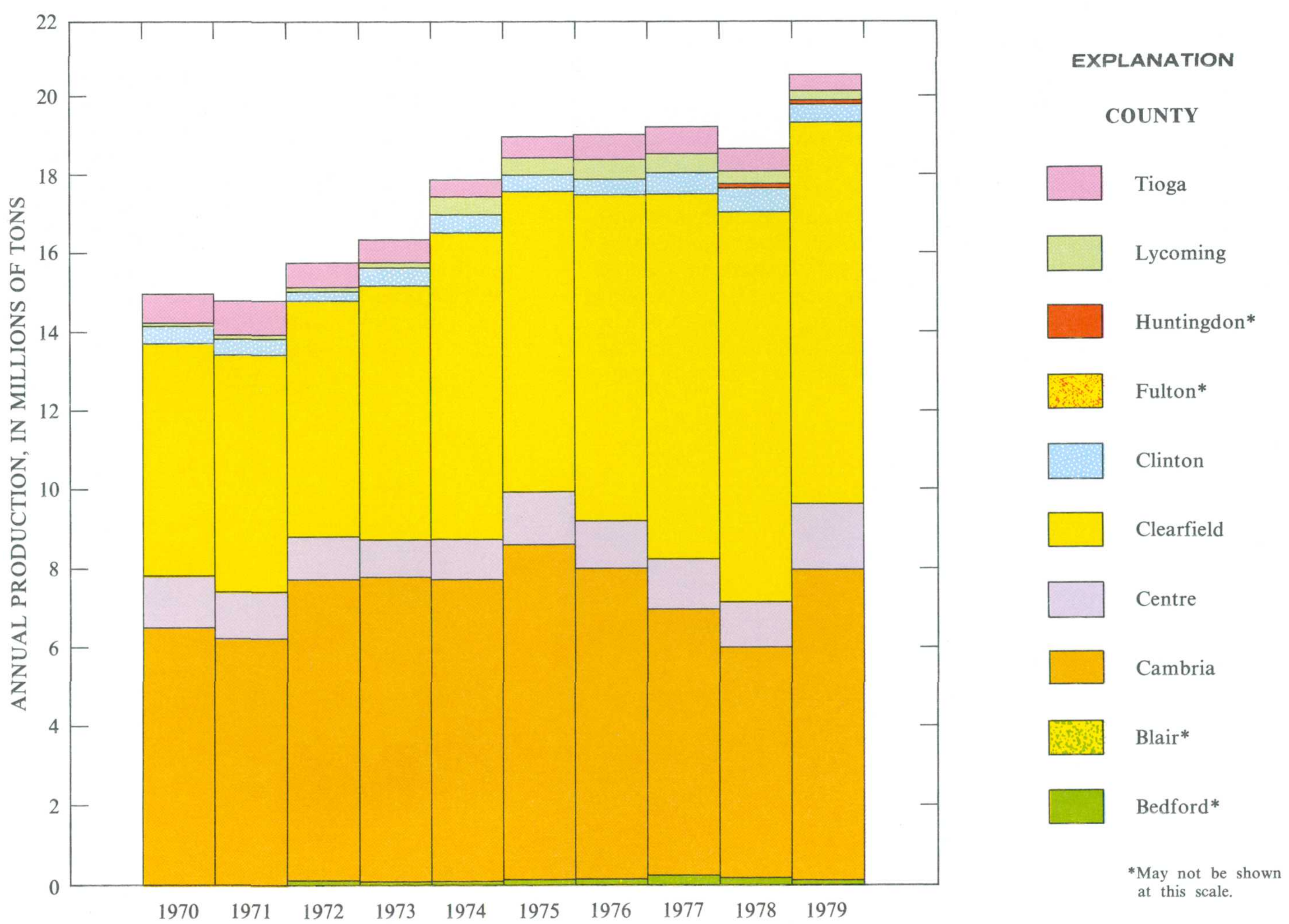


Figure 5.0-1 Coal production in Area 1, 1970-79.

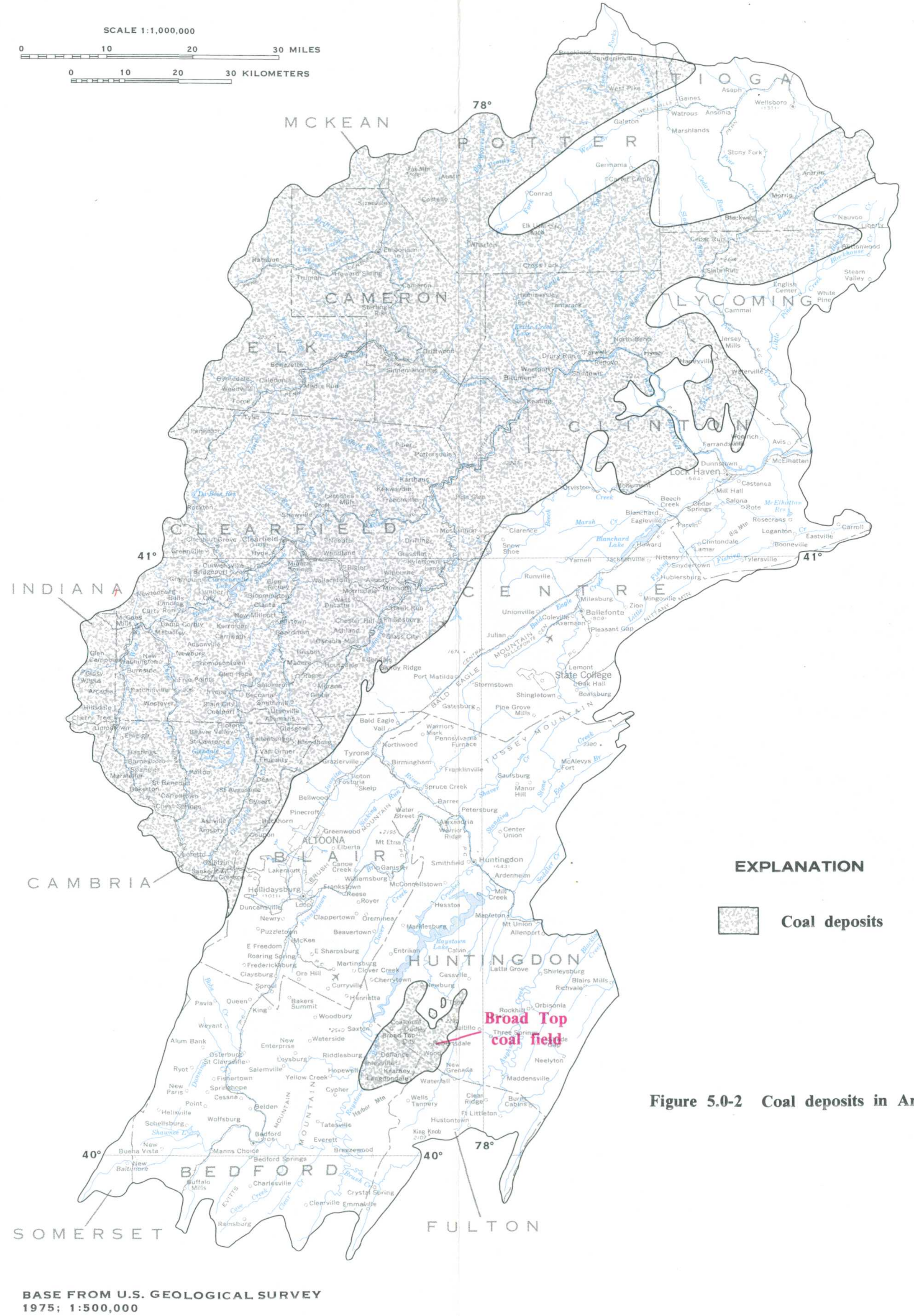


Figure 5.0-2 Coal deposits in Area 1.

Streamflow Data Collected at 146 Locations in Area

Streamflow data have been collected at 40 continuous-record gaging stations, 1 low-flow partial-record station, and 105 miscellaneous sites in Area 1.

Systematic collection of streamflow data at an established network of stations is a key ingredient in the description of the hydrology of any area. If streamflow data are collected over a period of time, it is possible to make estimates of streamflow characteristics such as peak discharge, low flow, mean flow, and flow duration at the gaging stations.

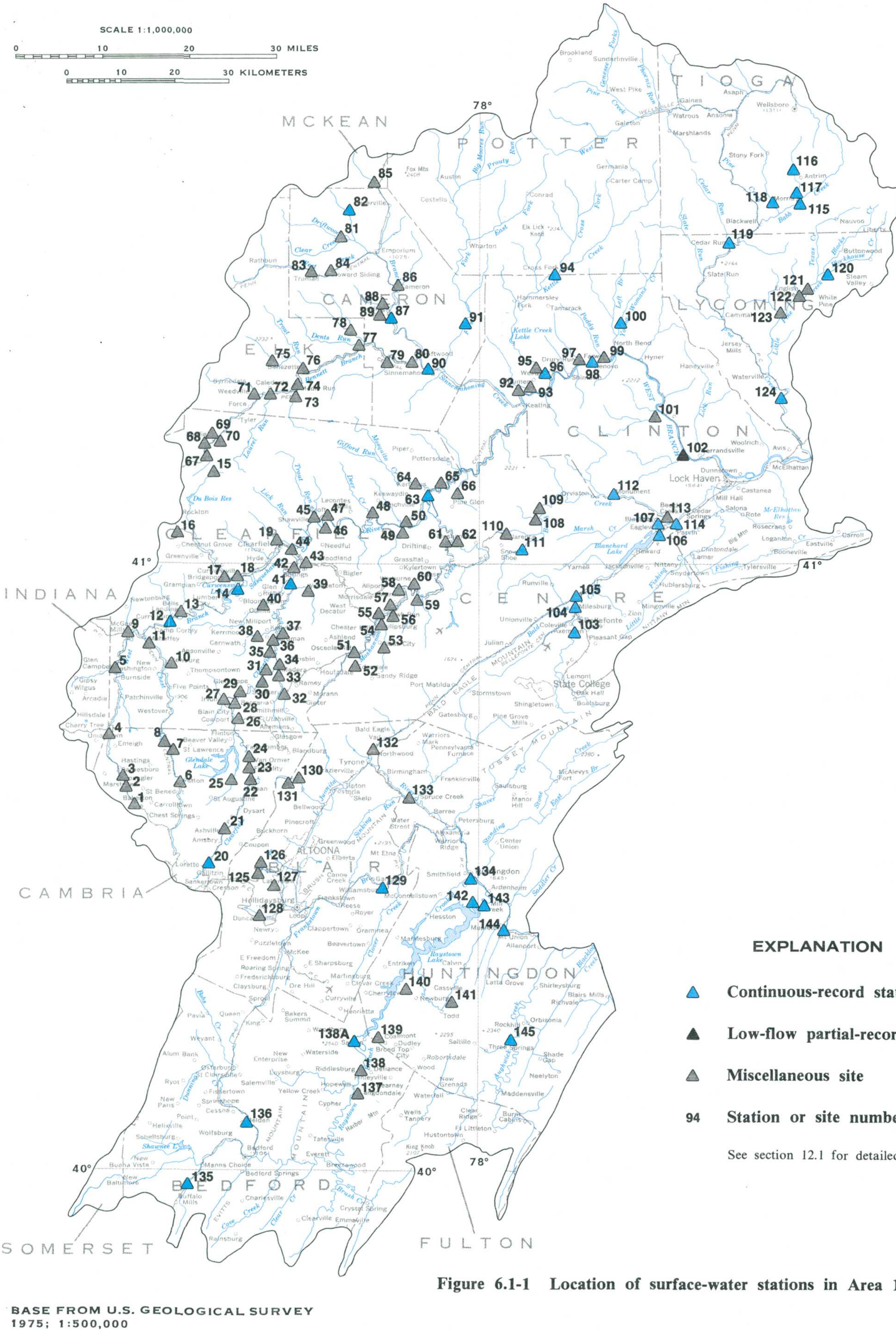
Systematic data collection also provides hydrologists with the necessary data to make estimates of streamflow characteristics for sites where data are not collected. Section 12.1 lists the types of surface-water data collected at 40 continuous-record gaging stations, 1 low-flow partial-record station, and 105 miscellaneous sites. Figure 6.1-1 shows the site locations.

Continuous-record stations are locations where a continuous record of stream gage height (stage) is collected on a daily basis. The gage height information is generally collected and recorded by a variety of automatic recorders. Periodic measurements of actual streamflow and indirect determinations of flood flow relate specific gage heights to specific discharges. The continuous record of gage height, combined with the stage-discharge relation, provides a continuous record of streamflow. Such continuous streamflow data are usually presented as daily mean discharges, although instantaneous discharges at specific times during the day can also be determined. Continuous-record stations provide the most detailed streamflow data.

Partial-record stations provide less detailed data at a much lower cost than data provided by a continuous-record station. Area 1 has only one partial-record station. Low-flow partial-record stations have no recording devices, but are occasionally measured during low flow. Data from concurrent flows at partial-record and continuous-record stations may be used indirectly to supplement the data available at the low-flow partial-record sites.

Miscellaneous sites are locations at which occasional discharge measurements are made. Discharge data at miscellaneous sites can be combined with water-quality data to compute instantaneous loads of various dissolved or suspended constituents. Area 1 has 105 miscellaneous sites.

The U.S. Geological Survey publishes Area 1 streamflow data on an annual basis in the report, "Water Resources Data for Pennsylvania, Volume 2, Susquehanna and Potomac River Basins."



EXPLANATION

- Continuous-record station (blue triangle)
- Low-flow partial-record station (black triangle)
- Miscellaneous site (grey triangle)
- 94 Station or site number

See section 12.1 for detailed site description.

Figure 6.1-1 Location of surface-water stations in Area 1.

Water-Quality Data Available for 123 Sites in Area

Water-quality data have recently been collected at 123 sites in Area 1. Data were collected at 119 of these sites as part of the coal-hydrology program.

The locations of 123 sites where surface-water quality data have recently been collected are shown in figure 6.2-1. The sites are identified by reference number, downstream order number, and name in section 12.1.

One-hundred twelve sites, designated as synoptic sites, had water-quality data collected in spring and summer. These sites were sampled to obtain a general overview of water quality in Area 1. Four sites were operated as coal-hydrology partial-record stations to obtain more detailed information on water quality.

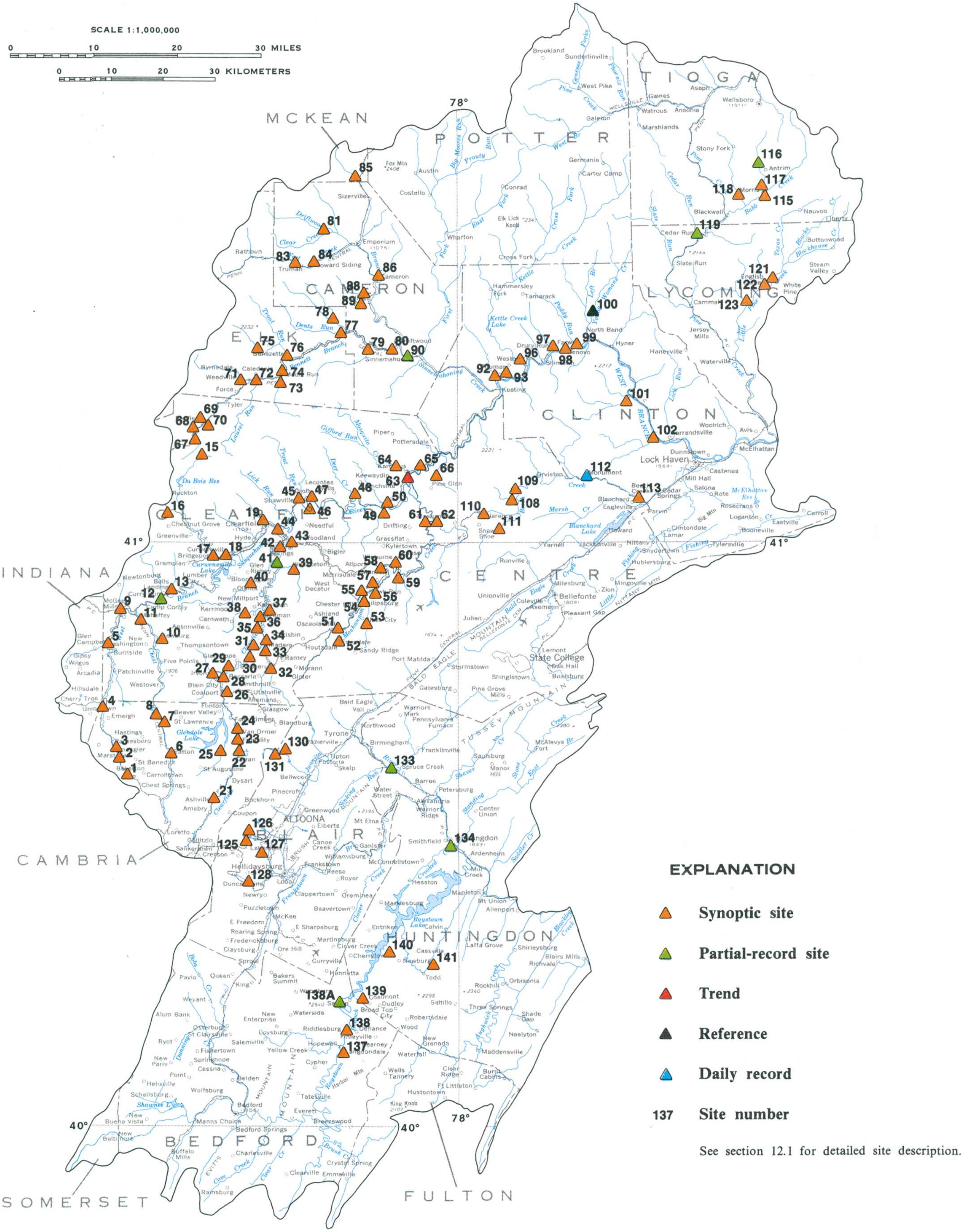
Historic water-quality data were available for the partial-record stations. One of the partial-record sites, 112, was equipped with a water-quality monitor to sample pH, temperature, and specific conductance at predetermined time intervals throughout the day. Site 63, designated as the trend station, was sampled for additional constituents to examine general changes in water quality over time. The data obtained from reference site 100 was used to determine water quality in an area having no coal mining. Five partial-record sites from other projects were incorporated into the coal-hydrology program, which is why some sites have more than one sampling classification in section 12.1.

Seasonal variations in streamflow can concentrate or dilute contaminants in the water. Changes in water quality are more readily detected with frequent long-term sampling of a small area, but a general overview can be obtained through synoptic sampling.

All first order streams in coal-bearing sections of Area 1 were initially considered for a synoptic site. First order streams were defined as those unbranched streams appearing on a 1:500,000 scale Hydrologic Unit Map. A subset of these first order streams was selected for actual synoptic site location. The final site selection was designed to provide broad areal coverage.

The 112 synoptic sites had drainage areas ranging from 0.53 to 2,975 mi^2 (square miles). The median drainage area for these streams was about 13.9 mi^2. Almost 60 percent of the streams have drainage areas less than 20 mi^2.

The U.S. Geological Survey publishes water-quality data for Area 1 annually in the report, "Water Resources Data for Pennsylvnia, Volume 2, Susquehanna and Potomac River Basins."



BASE FROM U.S. GEOLOGICAL SURVEY
1975; 1:500,000

Figure 6.2-1 Location of surface-water quality stations in Area 1.

Sampling Network Designed to Define Coal-Related Water Quality in Area

A network of 112 synoptic sites and 6 gaging stations was sampled to collect water-quality data which could be related to the presence of coal or coal mining.

The sampling program utilized two types of sampling stations, each having a distinct purpose. A large network of synoptic sites provided broad areal coverage; and a smaller network of gaging stations, provided detailed information on changes in water quality over time. The gaging stations were designated as partial-record, trend, or reference stations.

Water-quality and streamflow data were generally collected at synoptic sites under low, medium, and high base flow during the sample period. Table 6.3-1 lists the types and frequencies of data collection at the 112 synoptic sites. These data were selected to be useful in assessing the impact of coal mining. Many of the water-quality constituents listed in table 6.3-1 are specifically mentioned in the surface mining regulations. These water-quality data are published by U.S. Geological Survey (1980, 1981).

Similar data were collected at the six gaging stations in Area 1's coal hydrology network. Samples were collected more frequently than at the synoptic sites. Table 6.3-2 lists the types and frequencies of sampling at the gaging stations. The data collected at these sites have been published by U.S. Geological Survey (1980, 1981).

Table 6.3-1 Types and frequency of water-data collection at synoptic sites in Area 1.

Each visit (low, medium, and high flows)	
Discharge	Dissolved iron
Temperature	Total manganese
Specific conductance	Dissolved manganese
pH	Sulfate
Alkalinity	Residue, dissolved
Acidity	Suspended sediment
Total iron	
Annually (low flow)	
Field identification of benthic invertebrates	
One time only (low flow) Bottom materials	
Arsenic	Manganese
Cadmium	Mercury
Chromium	Selenium
Cobalt	Zinc
Copper	Organic carbon
Iron	Inorganic carbon
Lead	Coal
Storm events (high flow) selected sites	
Suspended sediment and discharge	

Table 6.3-2 Types and frequency of water-data collection at continuous gaging stations in Area 1.

Each visit (six to nine times annually)	
Discharge	Dissolved iron
Temperature	Total manganese
Specific conductance	Dissolved manganese
pH	Sulfate
Alkalinity	Residue, dissolved
Acidity	Suspended sediment
Total iron	
Annually (low flow)	
Field identification of benthic invertebrates	
One time only (low flow)[1] Bottom materials	
Arsenic	Manganese
Cadmium	Mercury
Chromium	Selenium
Cobalt	Zinc
Copper	Organic carbon
Iron	Inorganic carbon
Lead	Coal
Common constituents[1]	
Sodium absorption ratio	Dissolved fluoride
Sodium percent	Residue, dissolved
Dissolved calcium	Dissolved silica
Dissolved manganese	Dissolved sulfate
Dissolved potassium	Nitrite plus nitrate
Dissolved sodium	Total phosphorus
Dissolved chloride	Total alkalinity
Minor elements[1]	
Total barium	Total manganese
Total cadmium	Total silver
Total chromium	Total zinc
Total copper	Total arsenic
Total iron	Total selenium
Total lead	Cyanide
	Total mercury

[1]At gaging stations designated as trend or reference, collection is annually at low flow. Storm sediment data are also collected at trend and reference sites.

Streams in Leading Coal-Producing Counties Have High Specific Conductances

Streams in Clearfield and Cambria Counties, the leading coal producers in the area, have median specific conductances about 3 times greater than those for other area counties.

Table 7.1-1 shows median stream specific conductances and mean coal production for 7 counties in the area for which sufficient samples were available. Clearfield and Cambria Counties, which produce most of the coal in the area, had median stream specific conductances of 350 and 366 μmho/cm at 25° C (micromhos per centimeter at 25 degrees Celsius), respectively. These conductances are about 3 times greater than the medians for the other mining counties shown in table 7.1-1, and 5 times greater than the median for Cameron County, which produces no coal. Median stream conductance for a county is related to coal production, as shown in figure 7.1-1. Streams in counties having low coal production tend to have lower specific conductances than do streams in counties having high coal production.

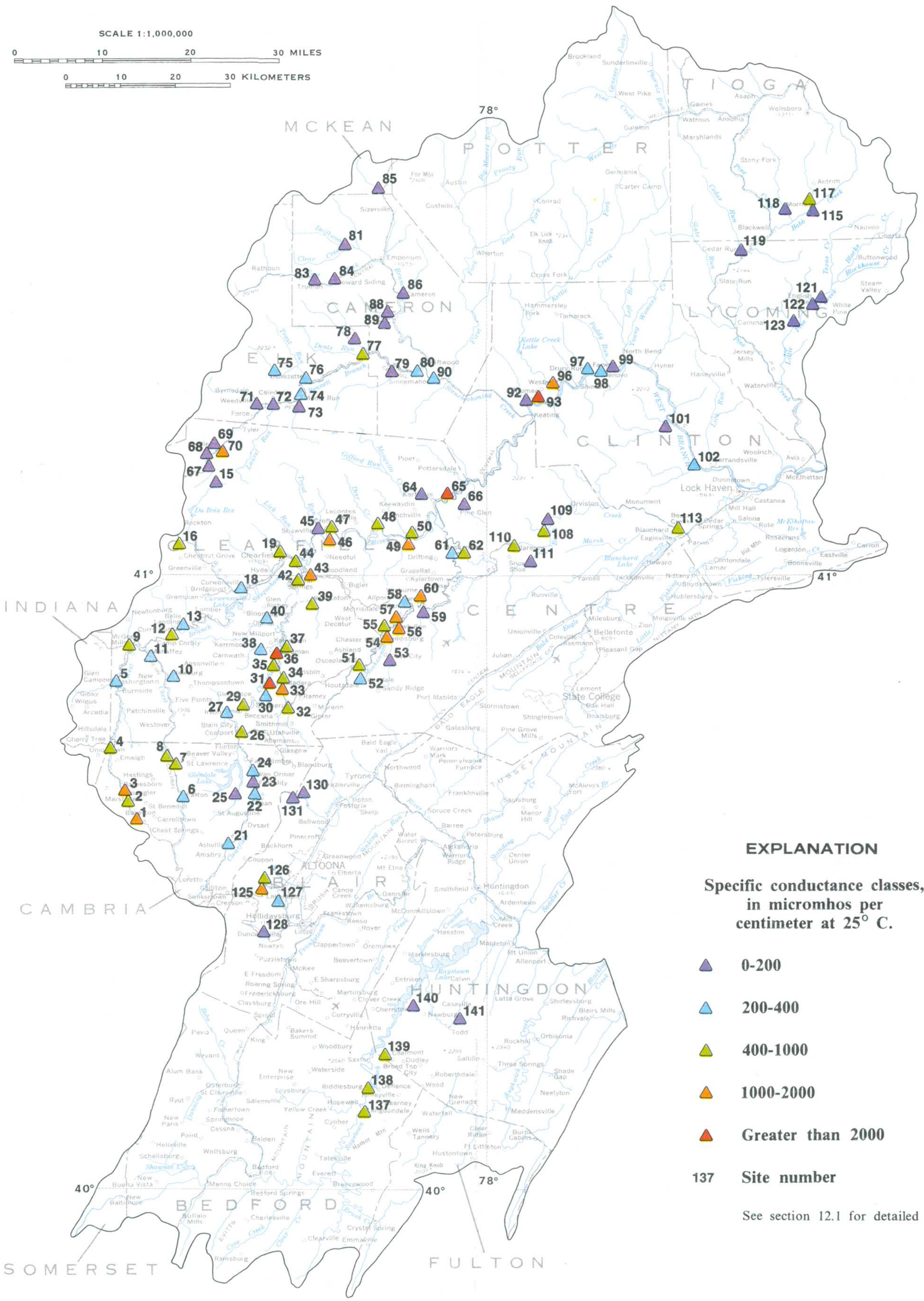
Streams having maximum observed specific conductances in excess of 400 μmho/cm are common in Clearfield County in the west-central part of Area 1 (fig. 7.1-2). Figure 7.1-2 also indicates that many of the streams in the vicinity of Clearfield County have maximum specific conductances in excess of 1000 μmho/cm. Most of the streams sampled in the Sinnemahoning and Pine Creek basins had maximum specific conductances less than 200 μmho/cm.

Sixty-four (56 percent) of the 115 streams measured in Area 1 had maximum specific conductances less than 400 μmho/cm (fig. 7.1-3); whereas only 11 streams (10 percent) had maximum specific conductances of 1,200 μmho/cm or greater. Maximum specific conductances in the area ranged from 50 to 5,000 μmho/cm. The mean maximum specific conductance was 550 μmho/cm and the median maximum specific conductance was 350 μmho/cm. The difference between the mean and median is a result of the effect of several high specific conductances on the mean.

Specific conductance was determined in the field according to procedures outlined by Skougstad and others (1979), generally on each of four visits to the synoptic sites in Area 1 during the 1979 and 1980 water years. The determinations were made during periods of low, medium, and high base flows. Specific conductance data for the 1979 and 1980 water years are published by the U.S. Geological Survey (1980, 1981).

Table 7.1-1 Median stream specific conductance, 1979-80, and mean coal production, 1976-80, for selected area counties.

County	Number of streams	Specific conductance (μmho/cm)	Coal production (tons)
Clearfield	47	350	9,481,000
Cambria	12	366	7,059,000
Centre	12	112	1,424,000
Elk	8	102	733,000
Clinton	8	148	450,000
Blair	6	128	13,000
Cameron	9	66	0



EXPLANATION

Specific conductance classes, in micromhos per centimeter at 25° C.

- 0-200
- 200-400
- 400-1000
- 1000-2000
- Greater than 2000

137 Site number

See section 12.1 for detailed site description.

BASE FROM U.S. GEOLOGICAL SURVEY 1975; 1:500,000

Figure 7.1-2 Maximum observed specific conductance for selected Area 1 streams.

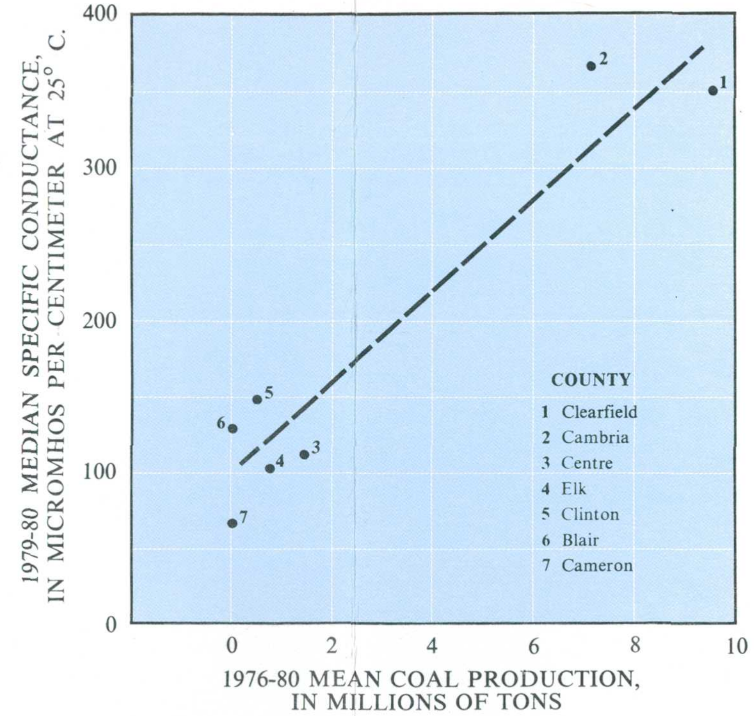


Figure 7.1-1 Specific conductance and coal production, by county.

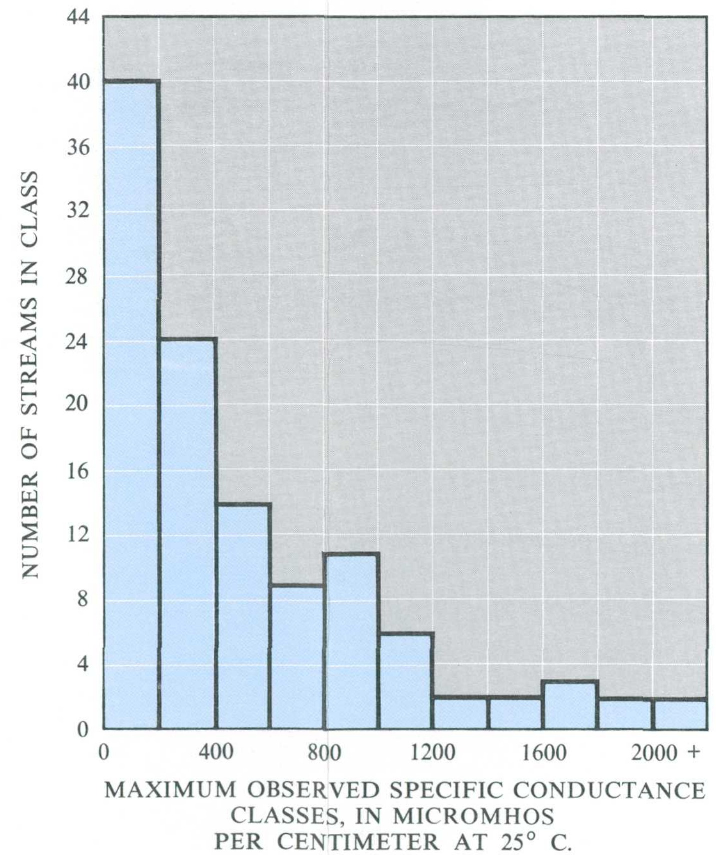


Figure 7.1-3 Histogram of maximum observed specific conductance for selected Area 1 streams.

High Dissolved-Solids Concentrations in Top Coal-Producing Counties

Clearfield and Cambria Counties, area leaders in coal production, have streams whose median dissolved-solids concentrations are more than twice as great as those for other area counties.

Median dissolved-solids concentrations for Clearfield and Cambria Counties, the top coal producers in the area, are 222 and 286 mg/L (milligrams per liter), respectively. Table 7.2-1 shows that these are more than twice as great as the median concentration in any other area county, and more than five times greater than the median for Cameron County, which has no coal mining. There is a positive correlation between the median stream dissolved-solids concentration for a county and the amount of coal mined in the county (fig. 7.2-1).

The geographic distribution of maximum observed dissolved-solids concentrations for Area 1 streams is shown in figure 7.2-2. Eleven of 47 streams (23 percent) sampled in Clearfield County had maximum dissolved-solids concentrations of 1,000 mg/L or greater. Only 4 of the 67 Area 1 streams outside Clearfield County had maximum dissolved-solids concentrations greater than or equal to 1,000 mg/L. Low maximum dissolved-solids concentrations were commonly found in the Sinnemahoning Creek basin, where 15 of 20 streams had maximum concentrations less than 100 mg/L.

Sixty-six of the 114 streams sampled for dissolved solids had maximum concentrations less than 300 mg/L, and 52 streams' maximum concentrations were less than 200 mg/L (fig. 7.2-3). Only 13 streams (11 percent) had maximum concentrations greater than 1,000 mg/L. Maximum dissolved solids in streams sampled in Area 1 ranged from 22 to 5,420 mg/L. The mean maximum concentration was 470 mg/L and the median maximum concentration was 226 mg/L. The large difference between the mean and median values is a reflection of the effect of several high concentrations on the mean.

Samples for dissolved-solids concentration were analyzed by procedures described by Skougstad and others (1979), and were generally collected four times during the 1979 and 1980 water years. Samples were collected during periods of low, medium, and high base flow. Dissolved-solids data for the 1979 and 1980 water years are published by the U.S. Geological Survey (1980, 1981).

Owing to the fact that dissolved solids have the ability to conduct electrical currents, there is a relation between dissolved-solids concentration and specific conductance. The relation is shown in figure 7.2-4. The relatively low scatter of the data indicates a close relation between the two water-quality measures. The graph is based upon 330 sets of concurrent dissolved-solids samples and specific-conductance determinations at 114 Area 1 streams. The slope of the line (0.76) falls well within the range of 0.55 to 0.96 given by Hem (1970) for most waters. Hem (1970) indicates that slopes greater than 0.75 are commonly associated with waters high in dissolved sulfate.

The relation between dissolved solids and dissolved sulfate is shown in figure 7.2-5. The graph is based upon 348 concurrent samples for dissolved solids and dissolved sulfate. The mean dissolved-solids concentration for the 348 samples was 315 mg/L and the mean dissolved-sulfate concentration was 177 mg/L. This indicates that about 55 percent of the dissolved solids are contributed by dissolved sulfate.

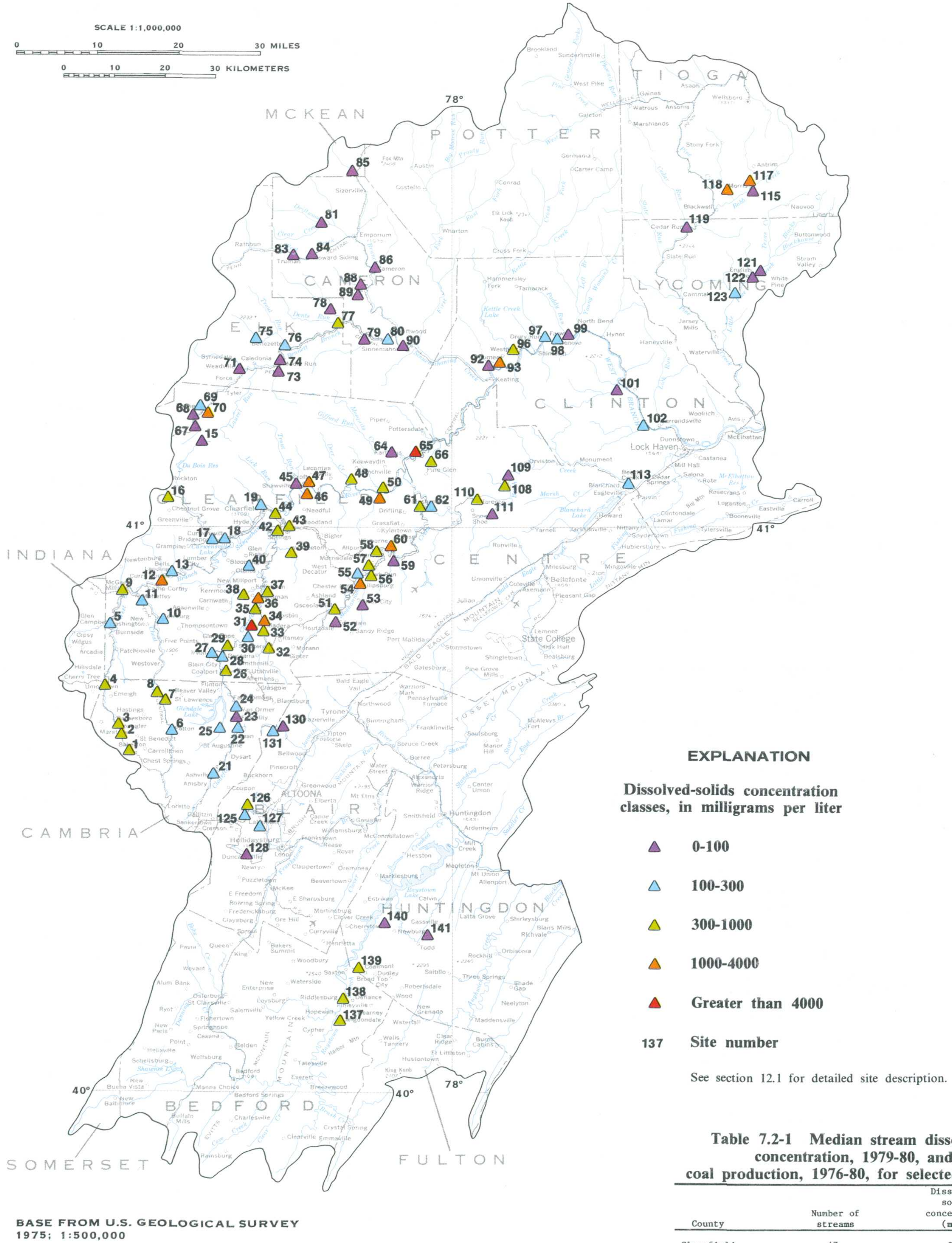


Figure 7.2-2 Maximum observed dissolved-solids concentrations for selected Area 1 streams.

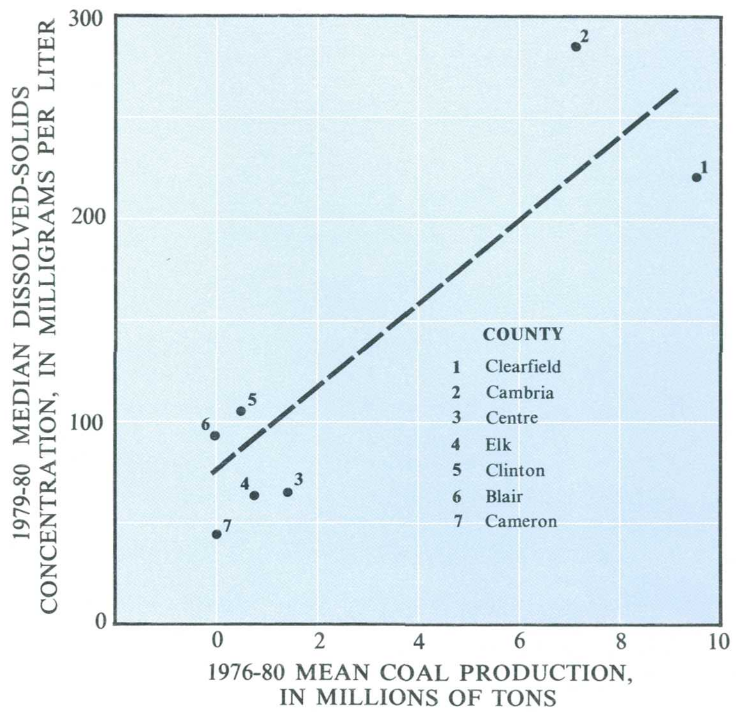


Figure 7.2-1 Dissolved-solids concentration and coal production, by county.

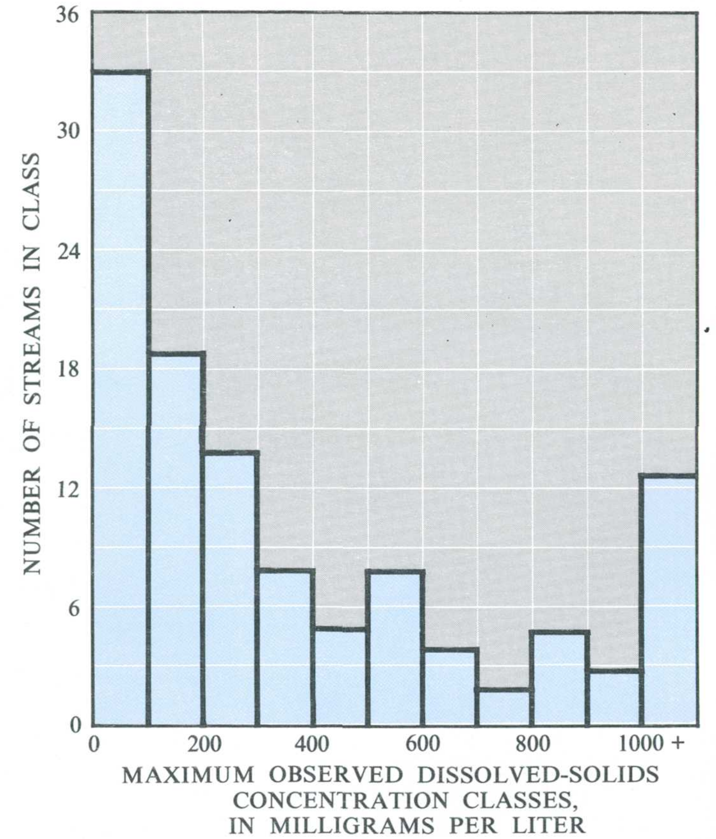


Figure 7.2-3 Histogram of maximum observed dissolved-solids concentration for selected Area 1 streams.

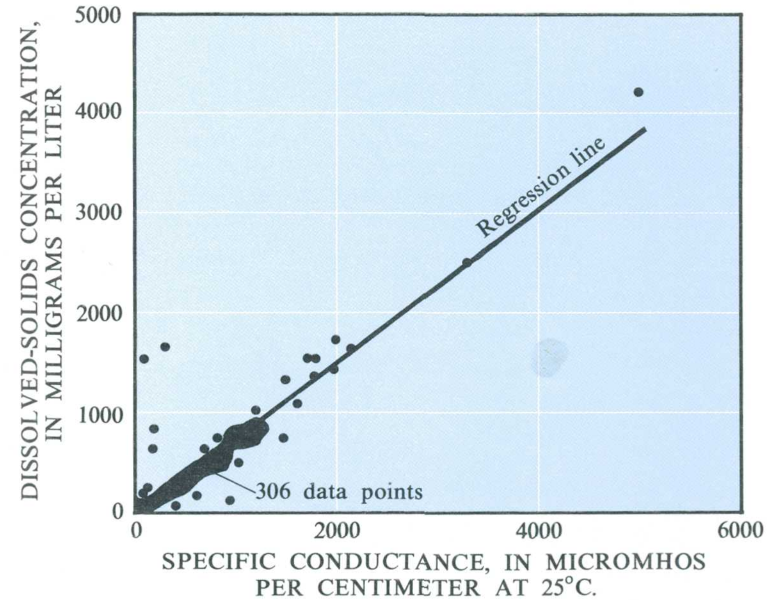


Figure 7.2-4 Relation between dissolved-solids concentration and specific conductance for selected Area 1 streams.

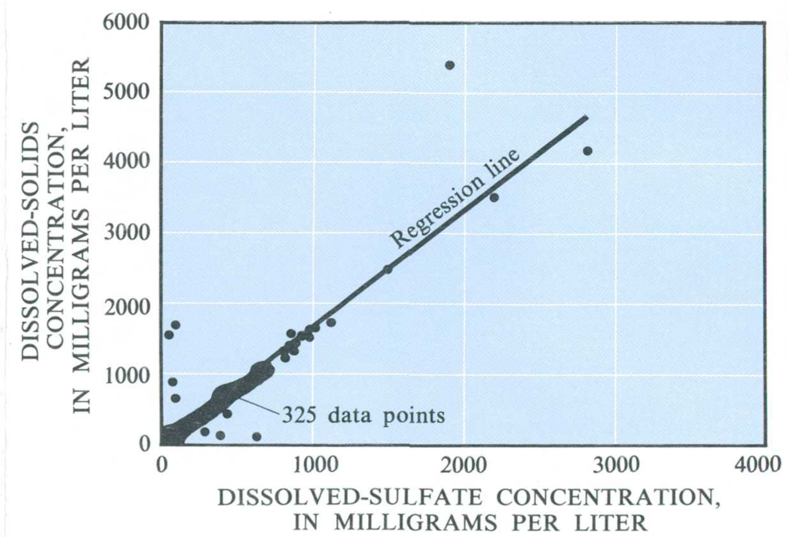


Figure 7.2-5 Relation between dissolved-solids and dissolved-sulfate concentrations for selected Area 1 streams.

Table 7.2-1 Median stream dissolved-solids concentration, 1979-80, and mean coal production, 1976-80, for selected area counties.

County	Number of streams	Dissolved solids concentration (mg/L)	Coal production (tons)
Clearfield	47	222	9,481,000
Cambria	12	286	7,059,000
Centre	12	66	1,424,000
Elk	8	64	733,000
Clinton	8	107	450,000
Blair	6	93	13,000
Cameron	9	44	0

Stream pH Values Generally Related to Amount of Coal Mining

For six of seven counties examined, there was a negative relation between coal production and stream pH.

Figure 7.3-1 shows the relation between median stream pH and mean coal production for seven counties in the area. Except for Cambria County, the graph shows that the median stream pH in a county is inversely related to coal production. That is, streams in counties having more coal production tend to have lower pH values. The wide departure of the Cambria County data from this general relation cannot be explained on the basis of existing data. Table 7.3-1 shows that the counties having coal production have median stream pH values at least 1.0 unit lower than the median stream pH for Cameron County, where no coal is mined. A pH value 1.0 unit lower corresponds to a 10-fold increase in hydrogen-ion activity.

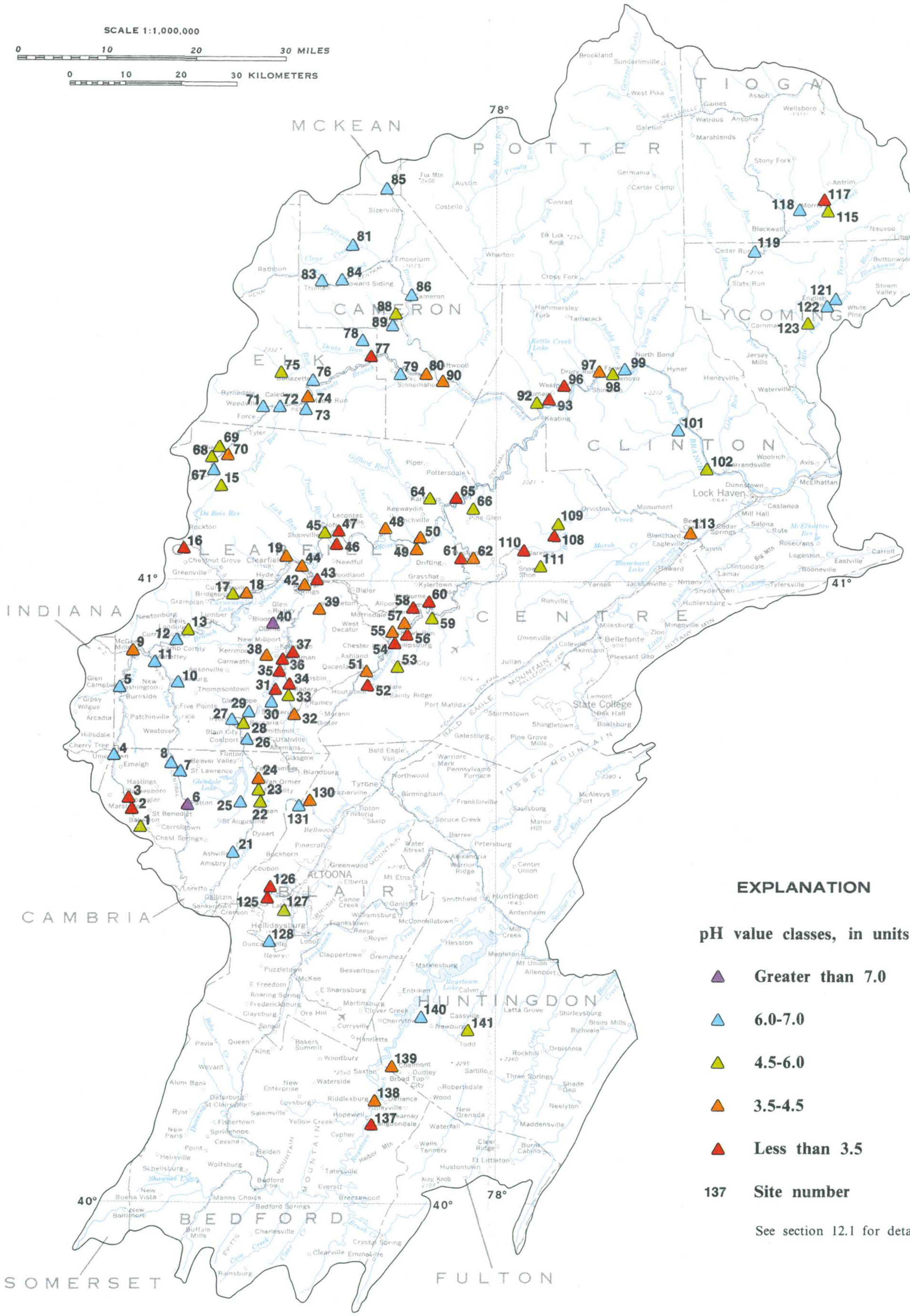
Streams in all parts of Area 1 were found to have minimum observed pH values less than 4.5 (fig. 7.3-2). Clearfield County contains the most concentrated collection of low-pH streams. In spite of the ubiquitous low pH values in Clearfield County, numerous streams had minimum pH values of 6.0 or greater. Minimum pH values of 6.0 or greater were common in the Sinnemahoning Creek basin.

The minimum pH values measured at 115 streams in Area 1 had a mean of 4.9 and a median of 4.6. Minimum pH values ranged from a low of 2.3 to a high of 7.1. Figure 7.3-3 shows that 55 streams (48 percent) had minimum pH values of 4.5 or less, 30 streams (26 percent) had minimum pH values of 3.5 or less, and 4 streams (3 percent) had minimum pH values of 2.5 or less. Only 35 streams (30 percent) had a minimum pH value within one pH unit of neutral (7.0).

Field determinations of pH, following procedures of Skougstad and others (1979), were generally made four times during the 1979 and 1980 water years. Determinations were made during periods of low, medium, and high base flow. The U.S. Geological Survey (1980, 1981) has published the pH data for the 1979 and 1980 water years.

Table 7.3-1 Median stream pH, 1979-80, and mean coal production, 1976-80, for selected area counties.

County	Number of streams	pH (units)	Coal production (tons)
Clearfield	47	4.4	9,481,000
Cambria	12	6.7	7,059,000
Centre	12	4.6	1,424,000
Elk	8	6.5	733,000
Clinton	8	5.2	450,000
Blair	6	5.6	13,000
Cameron	9	6.8	0



EXPLANATION

pH value classes, in units

- Greater than 7.0
- 6.0-7.0
- 4.5-6.0
- 3.5-4.5
- Less than 3.5

137 Site number

See section 12.1 for detailed site description.

BASE FROM U.S. GEOLOGICAL SURVEY 1975; 1:500,000

Figure 7.3-2 Minimum observed pH values for selected Area 1 streams.

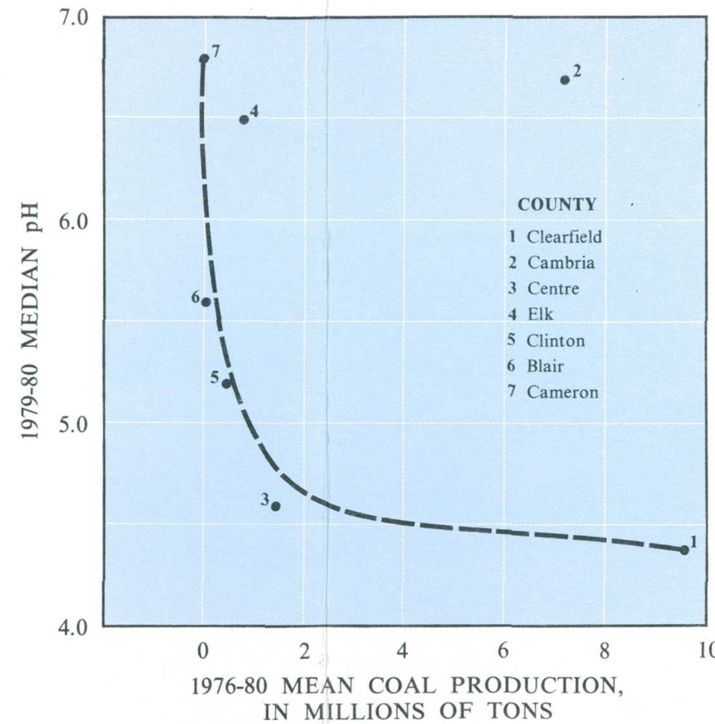


Figure 7.3-1 pH and coal production, by county.

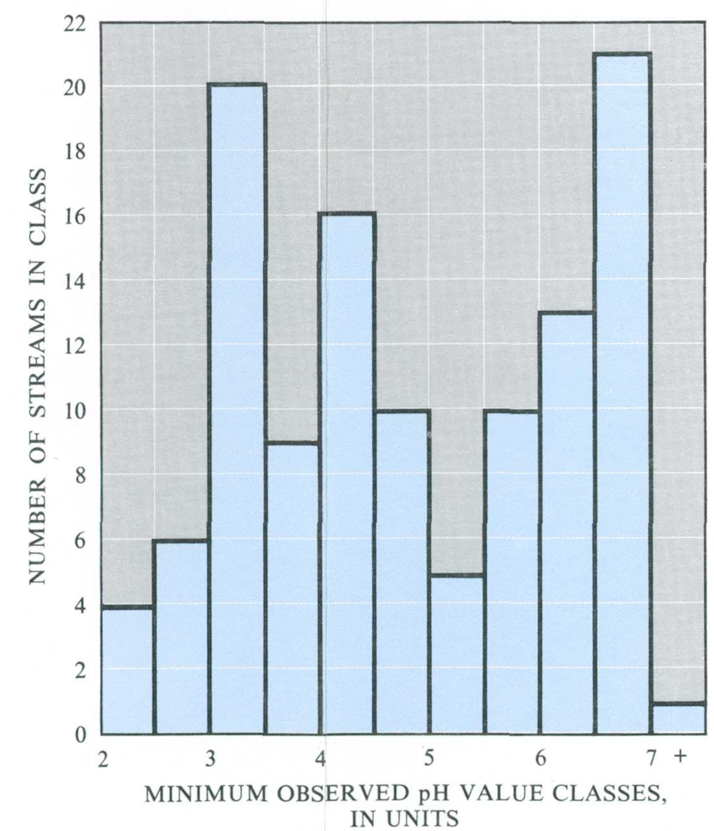


Figure 7.3-3 Histogram of minimum observed pH values for selected Area 1 streams.

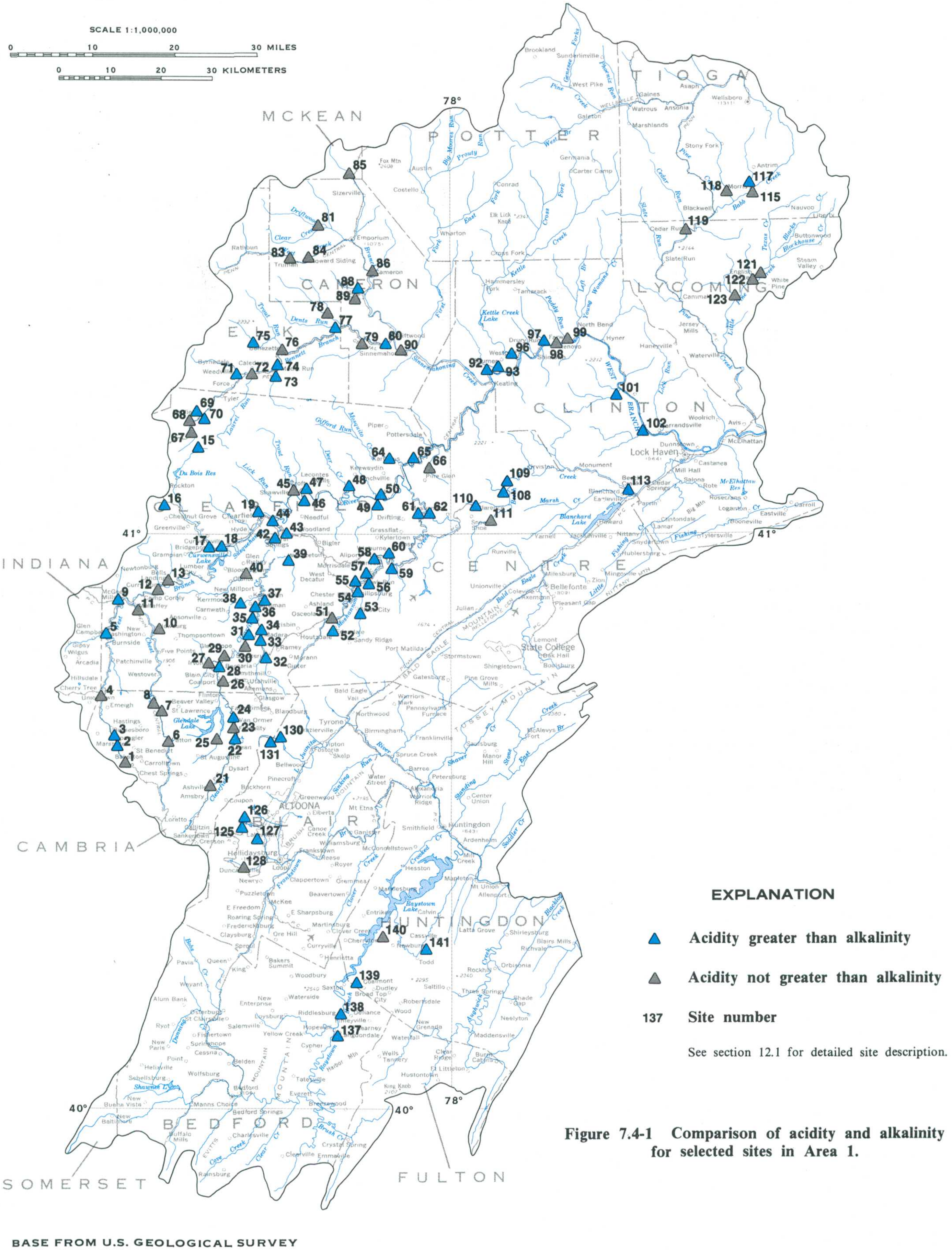
Most Streams Sampled in Area Have Acidity in Excess of Alkalinity

More than 60 percent of the 115 streams sampled during the 1979 and 1980 water years had acidity in excess of alkalinity.

Acidity, expressed in milligrams per liter of calcium carbonate, exceeded alkalinity, expressed in the same units, at 71 of 115 streams (62 percent) sampled during the 1979 and 1980 water years. Streams in which acidity exceeded alkalinity were found throughout Area 1 (fig. 7.4-1). The only basins where acidity did not commonly exceed alkalinity were Chest Creek, Driftwood Branch Sinnemahoning Creek, and Pine Creek (fig. 7.4-1).

Streams were generally tested for acidity and alkalinity four times during the 1979 and 1980 water years. Samples were collected during low, medium, and high base flow. Alkalinities were determined by field electrometric titration (Skougstad and others, 1979); 1979 acidities were laboratory determinations, but 1980 acidities were field electrometric titrations (Skougstad and others, 1979). If a stream's acidity exceeded its alkalinity at least once, the stream was classified as having excess acidity. Acidity and alkalinity data for the 1979 and 1980 water years are published by the U.S. Geological Survey (1980, 1981).

Hem (1970) defines acidity as "the quantitative capacity of aqueous media to react with hydroxyl ions," and alkalinity as "the quantitative capacity of aqueous media to react with hydrogen ions." Acidity and alkalinity are measures of a solution's buffering capacity, or ability to resist a pH change upon the addition of a base (acidity) or an acid (alkalinity). The concentration of hydrogen ions in a stream's water is measured by its pH. The acidity of a stream is dependent upon pH and the concentration of dissolved metals, mostly iron and aluminum. The alkalinity of a stream is dependent upon pH and the concentration of salts of weak acids or bases. Acidity can be measured by titrating a water sample to a pH of 8.3 with sodium hydroxide. Alkalinity can be measured by titrating a water sample to a pH of 4.5. If the pH of a stream is between 4.5 and 8.3, the stream will have both acidity and alkalinity. If the acidity is greater than the alkalinity, the stream is said to be acid; whereas, if alkalinity exceeds acidity, the stream is said to be alkaline.



EXPLANATION

▲ Acidity greater than alkalinity

▲ Acidity not greater than alkalinity

137 Site number

See section 12.1 for detailed site description.

Figure 7.4-1 Comparison of acidity and alkalinity for selected sites in Area 1.

Streams in Leading Coal-Producing Counties Have High Iron Concentrations

Streams in Clearfield, Cambria, and Centre Counties, producers of most of Area 1's coal, have iron concentrations two to three times higher than found in other counties.

The median toal-iron concentrations for streams in Clearfield, Cambria, and Centre counties were 1,500; 1,300; and 1,100 μg/L (micrograms per liter), respectively (table 7.5-1). These three counties are by far the largest coal producers in the area. The median concentrations in those three counties were generally two-three times greater than the medians for the other coal-producing counties in the area, and more than seven times the median for Cameron County, which produces no coal. Figure 7.5-1 shows a positive correlation between the amount of coal produced in a county and the median total-iron concentration of that county's streams.

Clearfield County had a higher percentage of sampled streams having maximum observed total-iron concentrations greater than or equal to 10,000 μg/L than did other counties in Area 1. Of the 47 streams sampled in Clearfield County, 11 streams (23 percent) had maximum total-iron concentrations of 10,000 μg/L or greater (fig. 7.5-2). A maximum total-iron concentration of 10,000 μg/L or more was found in only 7 of the remaining 68 streams (10 percent) sampled in the area. Streams sampled in the Sinnemahoning Creek basin generally had maximum total-iron concentrations less than 2,000 μg/L.

Maximum total-iron concentrations in 115 sampled streams ranged from 80 to 730,000 μg/L (4 orders of magnitude); dissolved-iron concentrations followed a similar pattern. The mean and median maximum total-iron concentrations were 14,400 and 1,900 μg/L, respectively. The large differences between the mean and median values resulted from the effect of several very high concentrations on the mean. Figure 7.5-3 shows that 42 of the 115 streams sampled in Area 1 had maximum total-iron concentrations of 1,000 μg/L or less, and 76 streams had a maximum concentration of 4,000 μg/L or less. Only 19 streams had maximum total-iron concentrations in excess of 10,000 μg/L.

Samples for the laboratory analysis of total- and dissolved-iron concentrations (Skougstad and others, 1979) were generally collected at all synoptic sites four times during the 1979 and 1980 water years. Samples were collected during low, medium, and high base flow. Total- and dissolved-iron data for the 1979 and 1980 water years are published by the U.S. Geological Survey (1980, 1981).

Total- and dissolved-iron concentrations for Area 1 streams are related as shown in figure 7.5-4, based upon 473 concurrent samples for total and dissolved iron. The mean total-iron concentration for the 473 data sets was 10,000 μg/L and the mean dissolved-iron concentration was 9,140 μg/L.

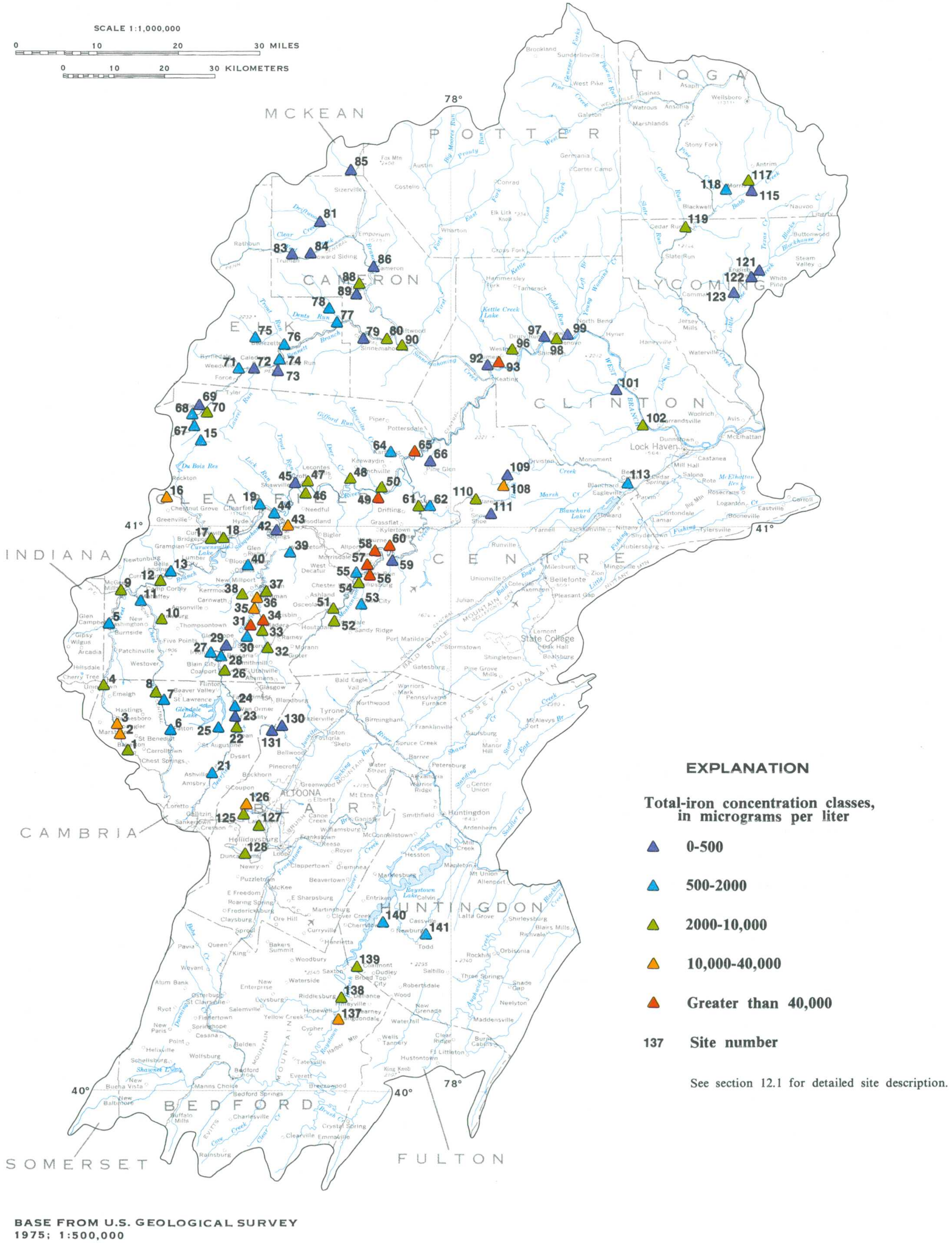


Figure 7.5-2 Maximum observed total-iron concentrations for selected Area 1 streams.

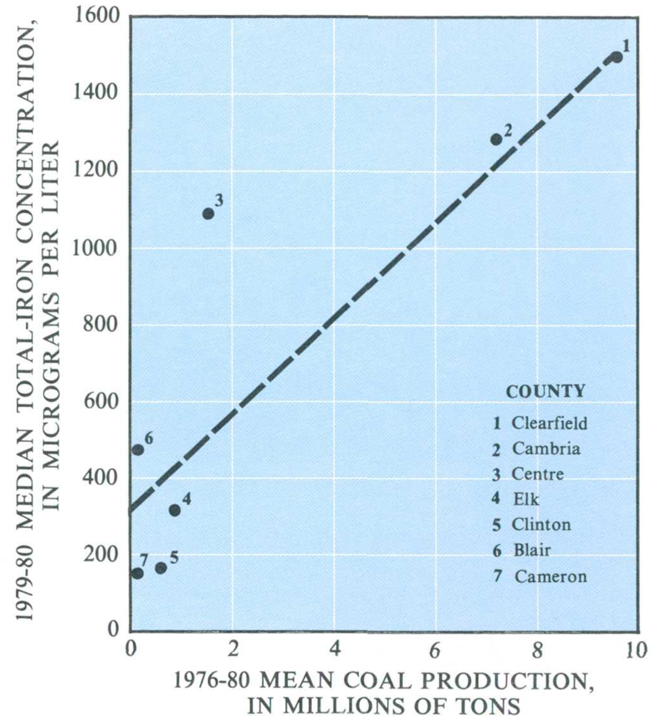


Figure 7.5-1 Total-iron concentration and coal production, by country.

Table 7.5-1 Median stream total-iron concentration, 1979-80, and mean coal production, 1976-80, for selected area counties.

County	Number of streams	Total-iron concentration (µg/L)	Coal production (tons)
Clearfield	47	1,500	9,481,000
Cambria	12	1,300	7,059,000
Centre	11	1,100	1,424,000
Elk	8	320	733,000
Clinton	8	170	450,000
Blair	6	475	13,000
Cameron	9	150	0

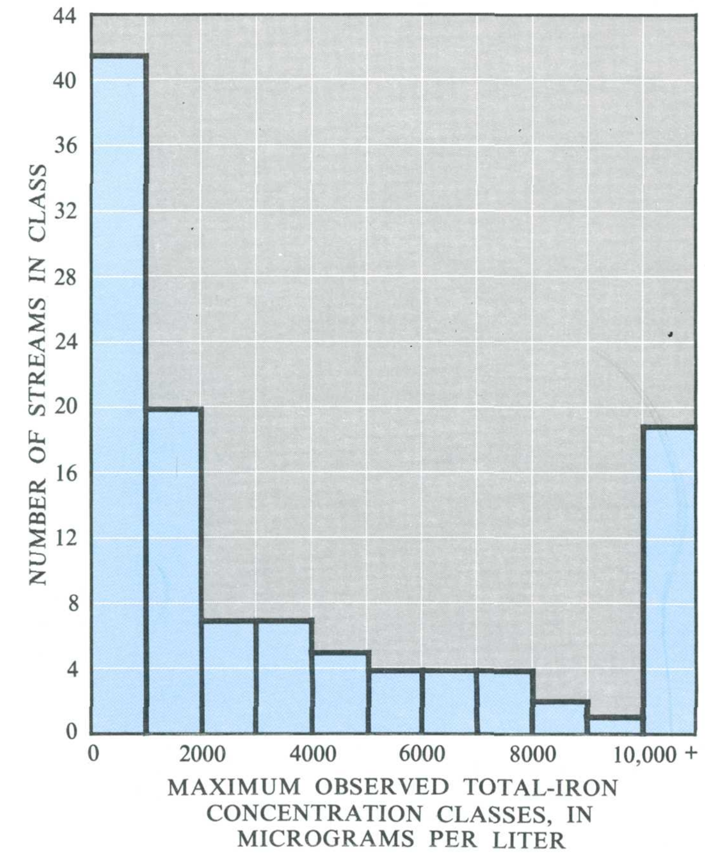


Figure 7.5-3 Histogram of maximum observed total-iron concentration for selected Area 1 streams.

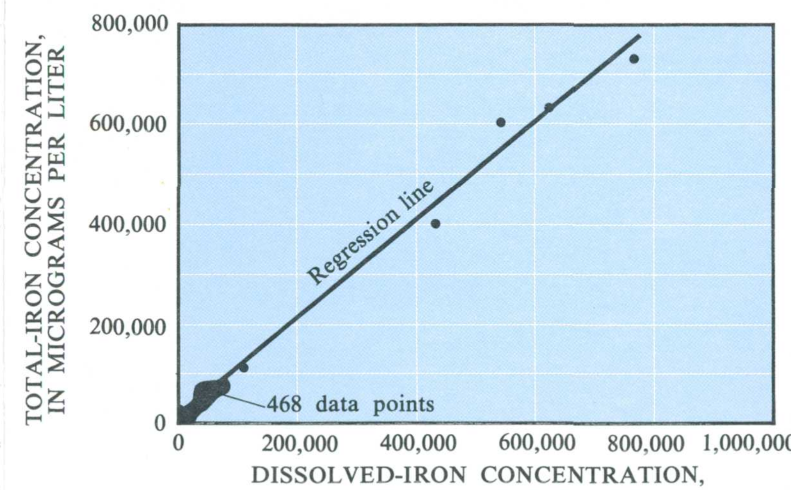


Figure 7.5-4 Relation between total- and dissolved-iron concentration for selected Area 1 streams.

Total-Manganese Concentrations High in Coal-Producing Counties

Median total-manganese concentrations for streams in coal-producing counties were 10 to 80 times greater than that for a non-producing county.

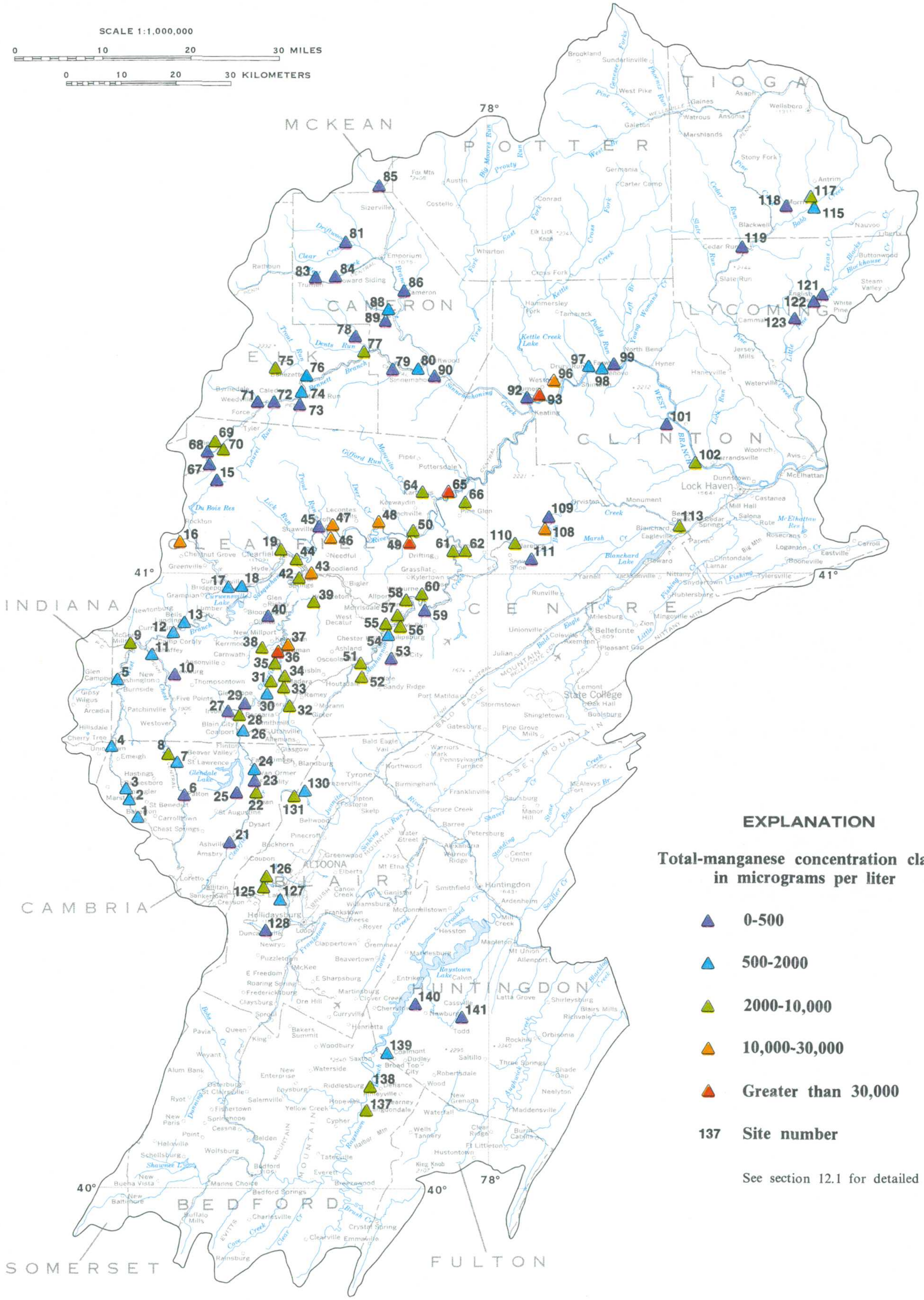
Median total-manganese concentrations for six coal-producing counties in Area 1 ranged from 310 to 2,400 μg/L (micrograms per liter) (table 7.6-1). These median concentrations were 10 to 80 times greater than the median concentration of 30 μg/L for streams in Cameron County, which produces no coal. Figure 7.6-1 shows the general positive correlation between median total-manganese concentration and coal production on a county-by-county basis.

Total-manganese concentrations of 10,000 μg/L or greater were found in 9 of 47 streams (19 percent) sampled in Clearfield County (fig. 7.6-2). Similarly high concentrations were found in only 3 of the remaining 68 streams (4 percent) sampled in Area 1. The geographical distribution of observed maximum total-manganese concentrations is illustrated in figure 7.6-2, which shows that maximum total-manganese concentrations less than 500 μg/L were commonly found in the Sinnemahoning Creek basin in the northwestern part of the area. Similarly low concentrations were found throughout Area 1, indicating that the background level for the area should be something less than 500 μg/L total manganese.

Fifty streams in the area had maximum total-manganese concentrations of 1,000 μg/L or less (fig. 7.6-3), and only 11 streams had maximum concentrations in excess of 10,000 μg/L. Maximum total-manganese concentrations in Area 1 streams ranged from 20 to 160,000 μg/L and averaged 6,080 μg/L. The mean maximum total-manganese concentration was 6,100 μg/L, but the median maximum total-manganese concentration was only 1,700 μg/L. The difference between the mean and median concentrations is the result of the effect of several very high concentrations on the mean. Dissolved-manganese concentrations followed the same pattern; the low maximum concentration was 20 μg/L, the high maximum concentration was 140,000 μg/L, and the mean and median maximum concentrations were 4,790 and 1,500 μg/L, respectively.

Samples for laboratory analysis of dissolved- and total-manganese concentrations were generally collected four times during the 1979 and 1980 water years and analyzed according to procedures described by Skougstad and others (1979). The samples were collected during periods of low, medium, and high base flow. Manganese data for the 1979 and 1980 water years are published by the U.S. Geological Survey (1980, 1981).

The total-manganese concentration is closely related to the dissolved-manganese concentration as shown by figure 7.6-4. The total-manganese concentration is mainly composed of dissolved manganese. The 446 data pairs used in developing the graph had a mean total-manganese concentration of 2,870 μg/L and a mean dissolved-manganese concentration of 2,860 μg/L.



BASE FROM U.S. GEOLOGICAL SURVEY 1975; 1:500,000

EXPLANATION

Total-manganese concentration classes, in micrograms per liter

- 0-500
- 500-2000
- 2000-10,000
- 10,000-30,000
- Greater than 30,000

137 Site number

See section 12.1 for detailed site description.

Figure 7.6-2 Maximum observed total-manganese concentration for selected Area 1 streams.

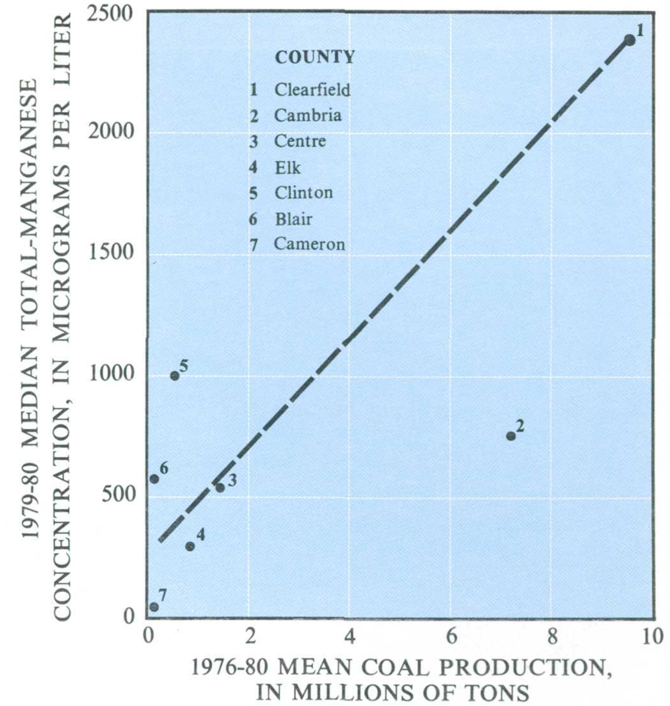


Figure 7.6-1 Total-manganese concentration and coal production, by county.

Table 7.6-1 Median stream total-manganese concentration, 1979-80, and mean coal production, 1976-80, for selected area counties.

County	Number of streams	Total-manganese concentration (µg/L)	Coal production (tons)
Clearfield	47	2,400	9,481,000
Cambria	12	765	7,059,000
Centre	11	550	1,424,000
Elk	8	310	733,000
Clinton	8	1,000	450,000
Blair	6	570	13,000
Cameron	9	30	0

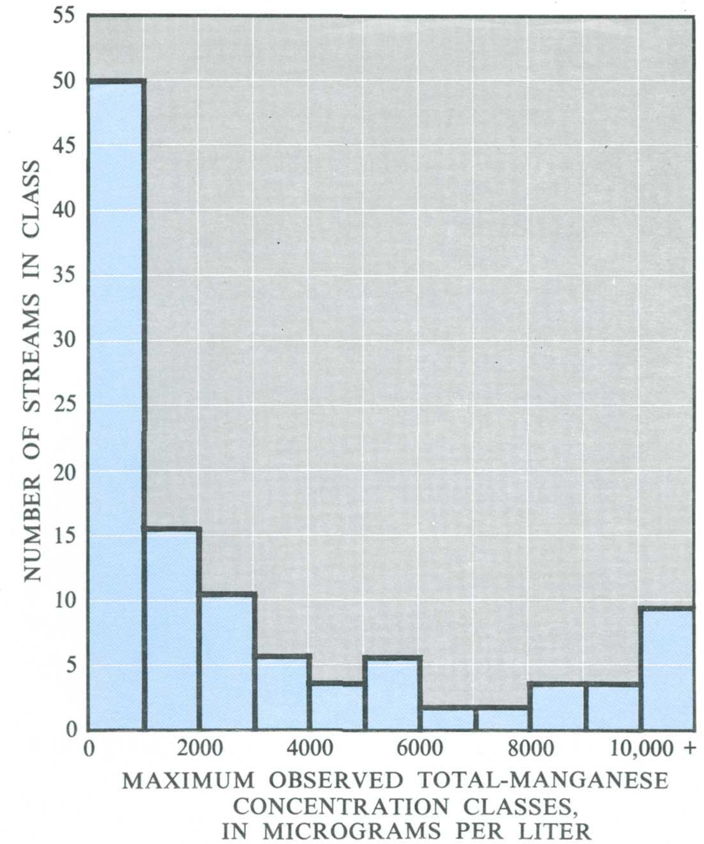


Figure 7.6-3 Histogram of maximum observed total-manganese concentration for selected Area 1 streams.

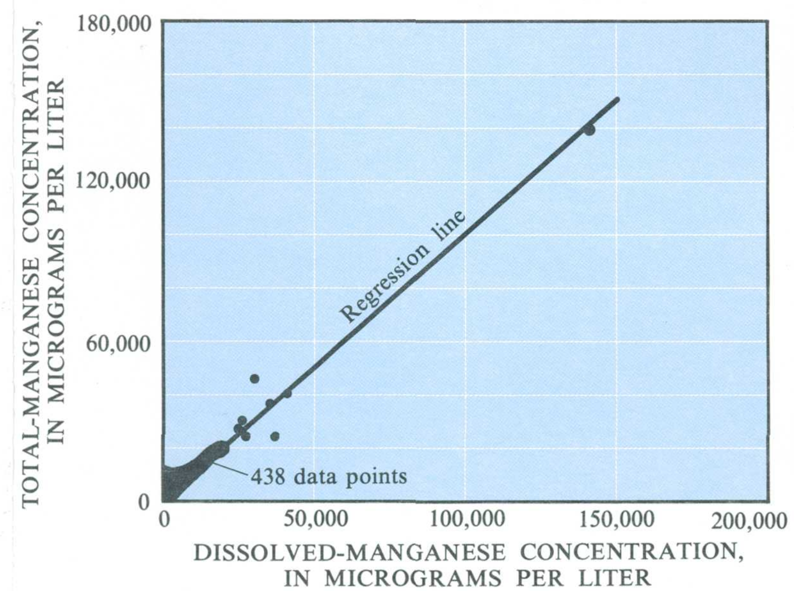


Figure 7.6-4 Relation between total- and dissolved-manganese concentration for selected Area 1 streams.

Major Coal-Producing Counties Have High Dissolved-Sulfate Concentrations

Streams in Clearfield and Cambria Counties, the major coal producers in the area, have median dissolved-sulfate concentrations 3 times greater than those for other mining counties, and more than 10 times greater than that for a non-mining county.

Streams in Clearfield and Cambria Counties, the leading coal producers in Area 1, have median dissolved-sulfate concentrations of 150 and 140 mg/L (milligrams per liter), respectively. These medians are about 3 times greater than the medians for other coal-producing counties in the area (table 7.7-1), and about 10 times greater than the median of 12.5 mg/L for Cameron County, which produces no coal. Figure 7.7-1 shows the positive correlation between coal production in a county and the median dissolved-sulfate concentration for that county.

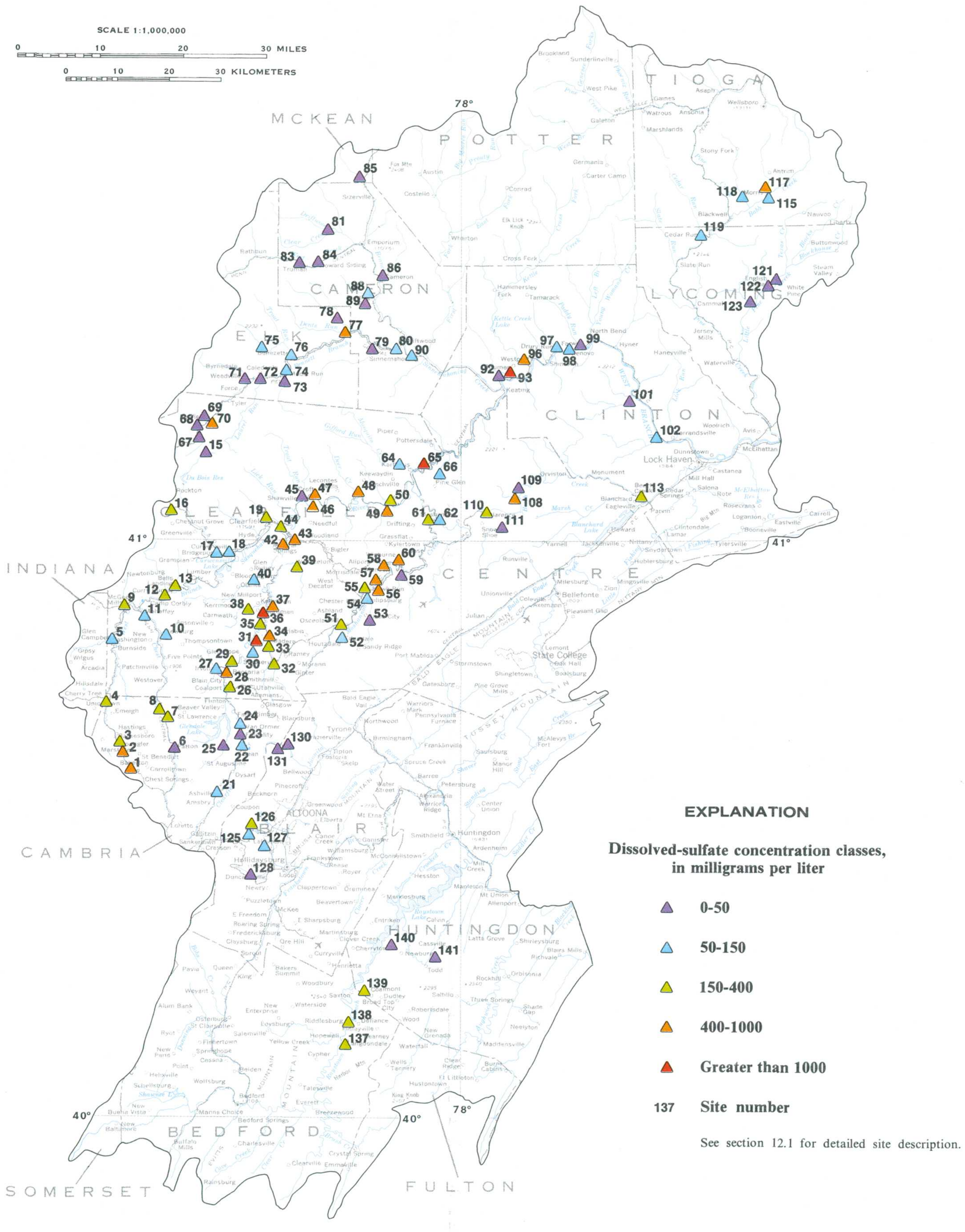
The geographic distribution of maximum observed dissolved-sulfate concentration classes for 115 streams is shown in figure 7.7-2. High dissolved-sulfate concentrations are most common in Clearfield County, where 16 of 47 streams (34 percent) had concentrations of 400 mg/L or greater. Similarly high sulfate concentrations were found in only 7 of the 68 other Area 1 streams (10 percent). Concentrations of dissolved sulfate less than 50 mg/L are found throughout the area, but are most common in the Sinnemahoning Creek basin.

Maximum dissolved-sulfate concentrations for the 115 sites which were sampled in Area 1 ranged from 8.5 to 1,800 mg/L. The mean maximum concentration was 260 mg/L while the median maximum concentration was 120 mg/L. The difference between the mean and median values is attributable to the effect of several high concentrations on the mean. Figure 7.7-3 shows that 73 streams (63 percent) had maximum dissolved-sulfate concentrations of 200 mg/L or less, whereas only 7 streams (6 percent) had maximum concentrations in excess of 800 mg/L. Almost 30 percent of the streams sampled had maximum sulfate concentrations less than 50 mg/L.

Samples for the laboratory determination of dissolved-sulfate concentration were generally collected four times during the 1979 and 1980 water years and analyzed according to procedures outlined by Skougstad and others (1979). Samples were collected during low, medium, and high base flow. Sulfate data for the 1979 and 1980 water years are published by the U.S. Geological Survey (1980, 1981).

Table 7.7-1 Median stream dissolved-sulfate concentration, 1979-80, and mean coal production, 1976-80, for selected area counties.

County	Number of streams	Dissolved-sulfate concentration (mg/L)	Coal production (tons)
Clearfield	47	150	9,481,000
Cambria	12	140	7,059,000
Centre	11	37	1,424,000
Elk	8	32	733,000
Clinton	8	42	450,000
Blair	6	39	13,000
Cameron	9	12.5	0



BASE FROM U.S. GEOLOGICAL SURVEY 1975; 1:500,000

Figure 7.7-2 Maximum observed dissolved-sulfate concentrations for selected Area 1 streams.

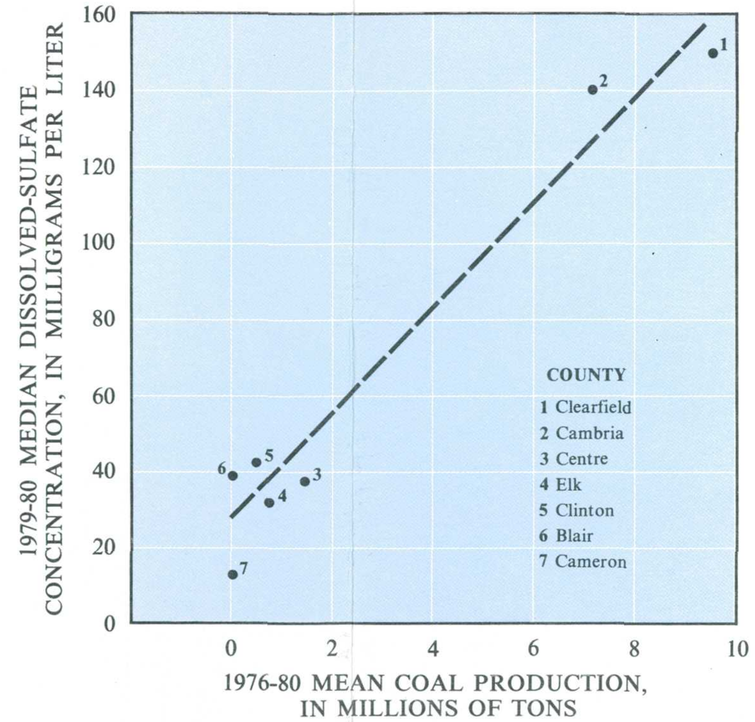


Figure 7.7-1 Dissolved-sulfate concentration and coal production, by county.

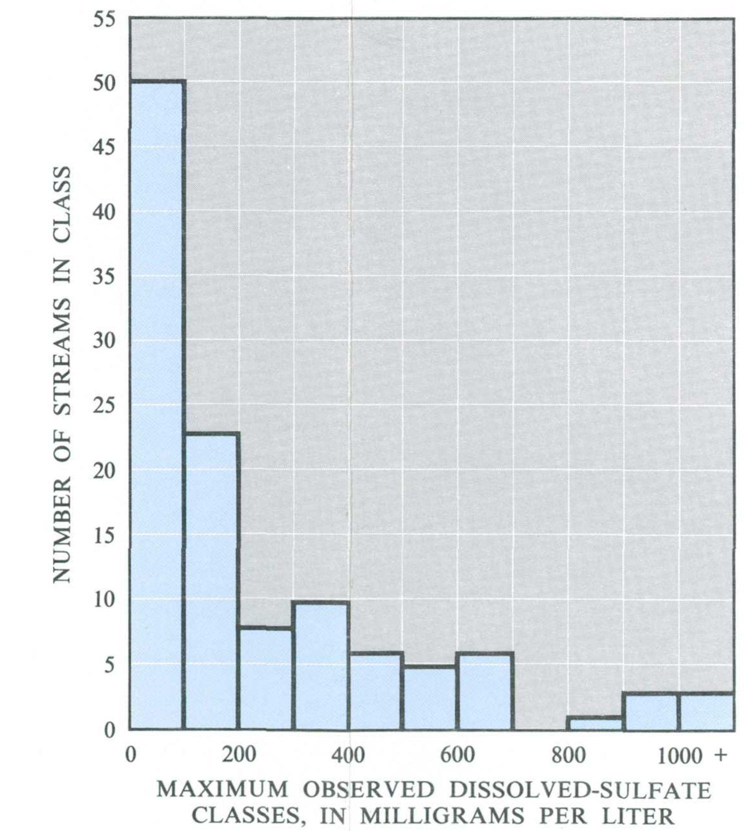


Figure 7.7-3 Histogram of maximum observed dissolved-sulfate concentration for selected Area 1 streams.

Suspended-Sediment Discharge Not Related to Acid Mine Drainage

Suspended-sediment discharges in Area 1 streams are not related to the presence of acid mine drainage even though surface-mined areas may have a great deal of sediment available for transport.

The generalized suspended-sediment transport data derived from about 400 samples at synoptic sites in Area 1 are shown in figure 7.8-1. This particular graph relates instantaneous suspended-sediment discharge in tons per day to instantaneous streamflow in $(ft^3/s)/mi^2$ (cubic feet per second per square mile). The shaded portion of figure 7.8-1 encloses 98 percent of the data collected at synoptic sites in Area 1. Note that these data show that for any given instantaneous unit discharge the instantaneous suspended-sediment discharge may vary by a factor of 350. This variability is about 7 times that shown by Wark (1965) for samples from a single large river. The sediment-transport envelope illustrated in figure 7.8-1 should indicate the possible range and uncertainty of transport values for most streams in Area 1 having drainage areas between 1 and 150 square miles. The variability may be a function of the different land uses within the area.

Porterfield (1972) states that an instantaneous transport curve may agree, in practice, with a daily transport curve. If this is the case, it should be possible to compute average annual loads using the flow-duration transport-curve method described by Miller (1951). Under this assumption a minimum annual suspended-sediment discharge for Area 1 streams was computed as shown in table 7.8-1 to establish a minimum probable yield. Average water discharges per square mile for selected time intervals were determined from a composite flow-duration curve for streams in Area 1 (fig. 7.8-2). The development of the composite flow-duration curve is discussed in section 9.5. Minimum suspended-sediment discharges corresponding to the selected streamflows were determined from the lower envelope curve for composite suspended-sediment transport data (fig. 7.8-1) and multiplied by the duration intervals of water discharge to calculate the minimum expected annual sediment load. For example, the average water discharge for Area 1 streams for 8.5 to 15 percent of the time is 3.6 $(ft^3/s)/mi^2$. The corresponding minimum suspended-sediment discharge is 0.007 $(tons/mi^2)/day$ (tons per square mile per day). Multiplying the minimum suspended-sediment discharge by the time interval for each interval in table 7.8-1 and dividing the sum of column 6 by 100 (table 7.8-1) yields the mean daily suspended-sediment discharge in $(tons/mi^2)/day$. Multiplying the mean daily suspended-sediment discharge by 365 yields the minimum annual suspended-sediment discharge in $tons/mi^2$.

Table 7.8-1 indicates that the lowest possible annual suspended-sediment discharge for streams in Area 1 would be about 2 $tons/mi^2$, but the average discharge will be higher. Wark (1965) states that the average annual suspended-sediment yield in Area 1 ranges from 20-250 $tons/mi^2$ and Williams and Reed (1972) indicate 40-200 $tons/mi^2$. Wark's 1965 figures indicate that the average suspended-sediment concentration would range from 14-180 mg/L (milligrams per liter) in the Juniata River basin and from 13-160 mg/L in the rest of Area 1. The concentrations are computed using an average discharge of 1.4 $(ft^3/s)/mi^2$ which is applicable to Juniata River basin streams and 1.6 $(ft^3/s)/mi^2$ which is applicable to the rest of Area 1. Because large amounts of sediment move in relatively short periods of storm runoff (Wark, 1965), the concentrations must be less than the average values much of the time.

Sediment-transport data for 180 samples from 52 streams exhibiting AMD (acid mine drainage) indicators fell within the sediment-transport envelope shown in figure 7.8-1. The distribution of the data was no different from that of all transport data, indicating that for the range of flows evaluated to date, those streams containing AMD do not carry larger sediment loads than nearby non-AMD streams. There may be several reasons for a lack of correlation between AMD and suspended sediment. This analysis, based on scant data, does not consider the effects of flows greater than 15 percent duration, nor does it include the effects of significant land disturbance near streams during surface mining. The indicators used to identify AMD streams may have been coming from deep mines which normally produce little sediment; therefore, the relation may not be valid for surface-mined areas. Additionally, in areas where much sediment is available, as in surface-mined areas, most of the sediment is transported on the rising portion of the hydrograph. The data shown in figure 7.8-1 may have been collected at any point on the hydrograph; therefore, they may not be representative of transport conditions from mined areas. Williams and Reed (1972) offered the opinion that "much of the erodible exposed material is carried into strip pits and other internal drainage, and never reaches the stream." The suspended-sediment and discharge data used to develop the sediment-transport curve are published by the U.S. Geological Survey (1980, 1981).

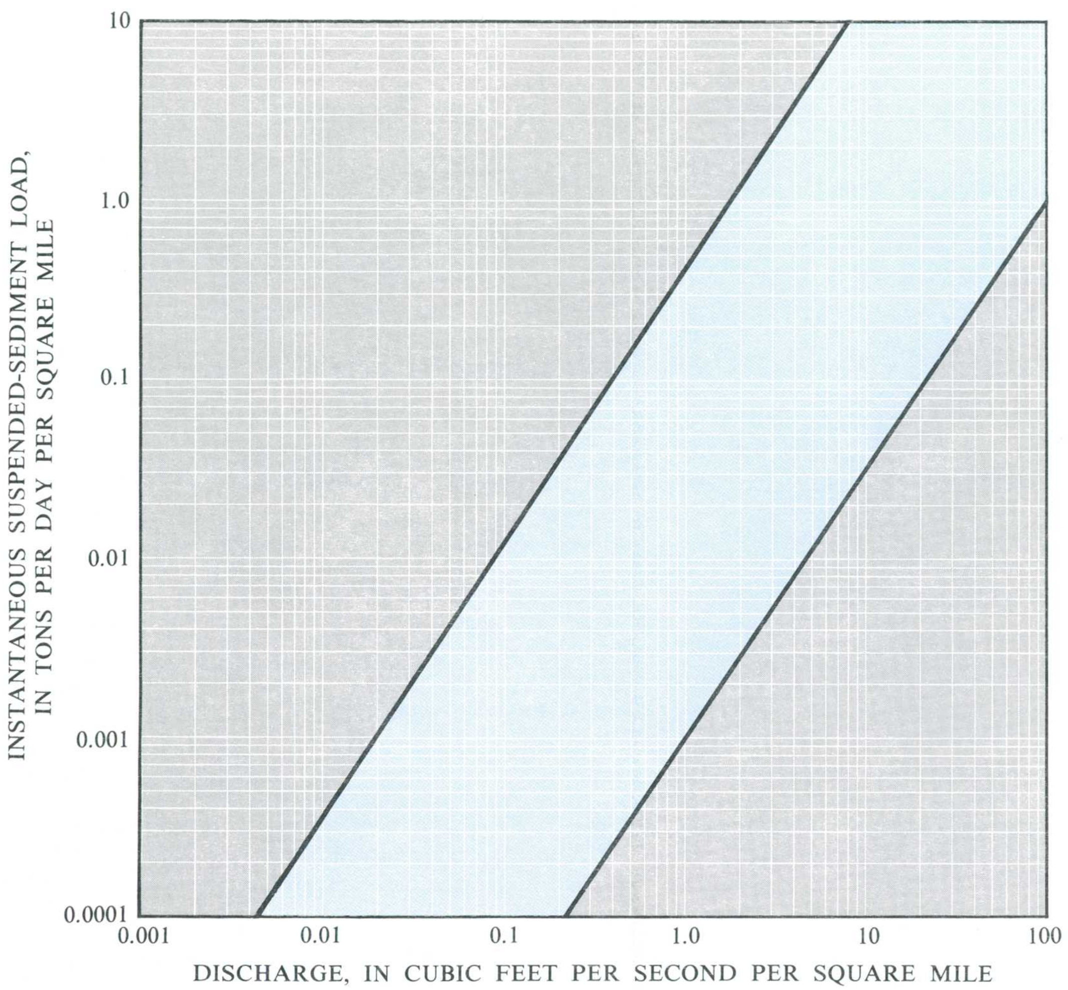


Figure 7.8-1 Suspended-sediment transport envelope for selected streams.

Table 7.8-1 Computation of minimum annual suspended-sediment load using sediment-transport and flow-duration data.

Mean daily suspended-sediment load = 0.333/100 = 0.00333 tons/mi^2
Average annual suspended-sediment load = 0.00333 x 365 = 1.2 tons/mi^2

Cumulative time (percent) (1)	Time interval (percent) (2)	Mid-ordinate (percent) (3)	Unit discharge [(ft^3/s)/mi^2] (4)	Suspended-sediment load (tons/mi^2) (5)	Load for interval[1] (tons/mi^2) (6)
0.25	0.25	0.125	20[2]	0.095	0.024
.75	.50	.500	15[2]	.070	.035
1.5	.75	1.125	10[2]	.032	.024
2.5	1.0	2.000	8.9	.029	.029
4.5	2.0	3.500	6.7	.017	.034
8.5	4.0	6.500	4.8	.012	.048
15	6.5	11.750	3.6	.007	.046
25	10	20.000	2.3	.004	.040
35	10	30.000	1.6	.023	.023
45	10	40.000	1.1	.001	.010
55	10	50.000	.83	.0008	.008
75	20	65.000	.51	.0005	.010
95	20	85.000	.23	.0001	.002
100	5	97.000	.11	---	---
Total	---	---	---	---	0.333

[1]Column 6 = column 2 x column 5.
[2]Estimated.

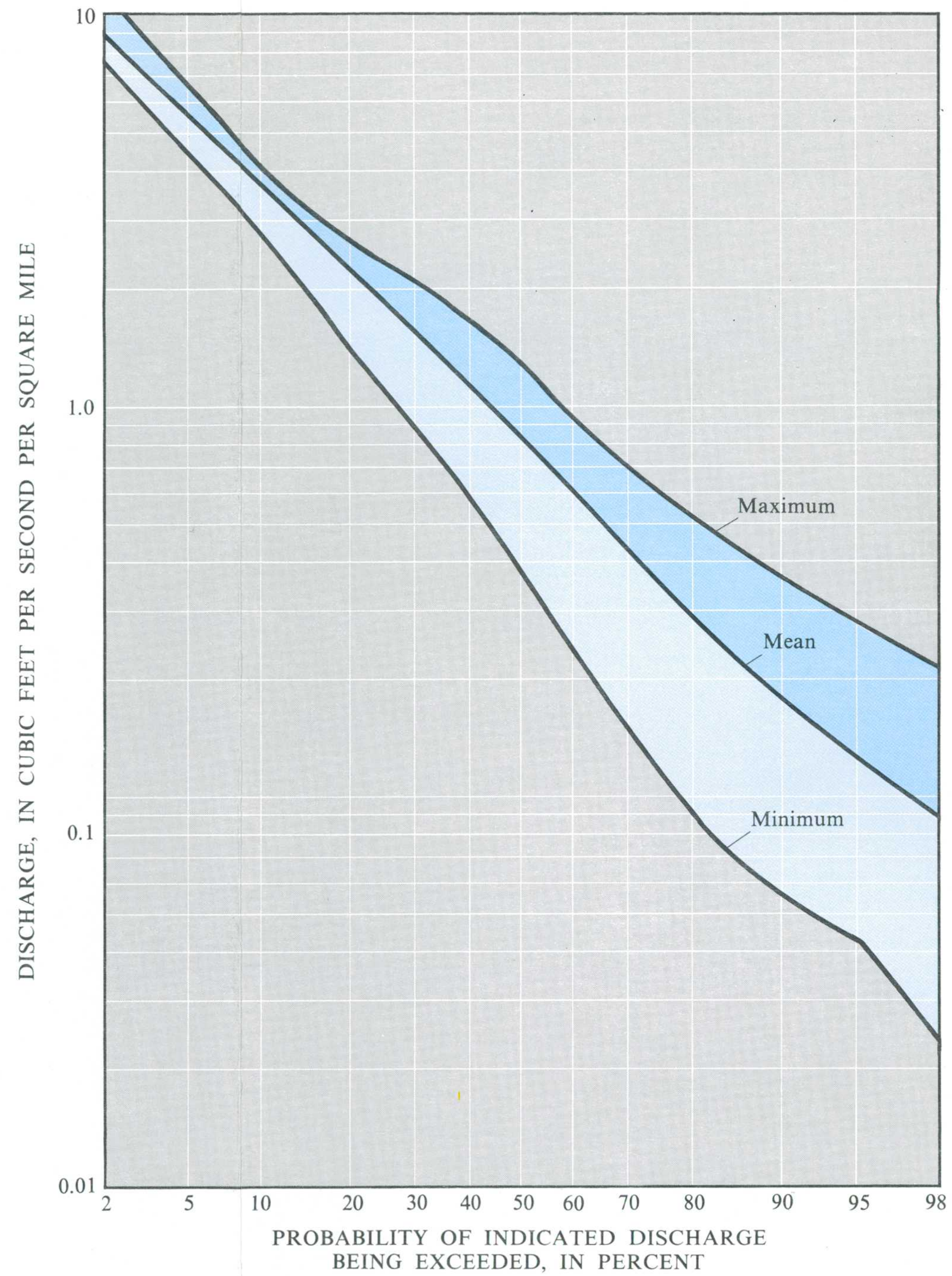


Figure 7.8-2 Composite unit flow-duration curves for streams in Area 1.

Iron Concentrations Generally Higher in Coal-Producing Counties

Streams in four of six coal-producing counties in the area had higher median bed-material iron concentrations than that for a non-coal producing county.

Streams in Cameron County, which produces no coal, had a median bed-material iron concentration of 15,000 μg/g (micrograms per gram). Four of six coal-producing counties in the area showed higher median bed-material iron concentrations, whereas two of six showed lower concentrations (table 7.9.1-1). Although figure 7.9.1-1 indicates a correlation between coal production and bed-material iron concentration, the relation is very general, and not useful for prediction.

Many streams in the Clearfield and Moshannon Creek basins (Clearfield County) have bed-material iron concentrations of 40,000 μg/g or greater (fig. 7.9.1-2). Several streams in these basins had bed-material iron concentrations of 100,000 μg/g or greater. High concentrations were most common in the southern part of Clearfield County and along the Clearfield-Centre County border. High concentrations were also found in several streams in the Sinnemahoning Creek basin and in tributaries to the West Branch Susquehanna River between Keating and Renovo. Concentrations less than 10,000 μg/g were found in scattered locations throughout Area 1.

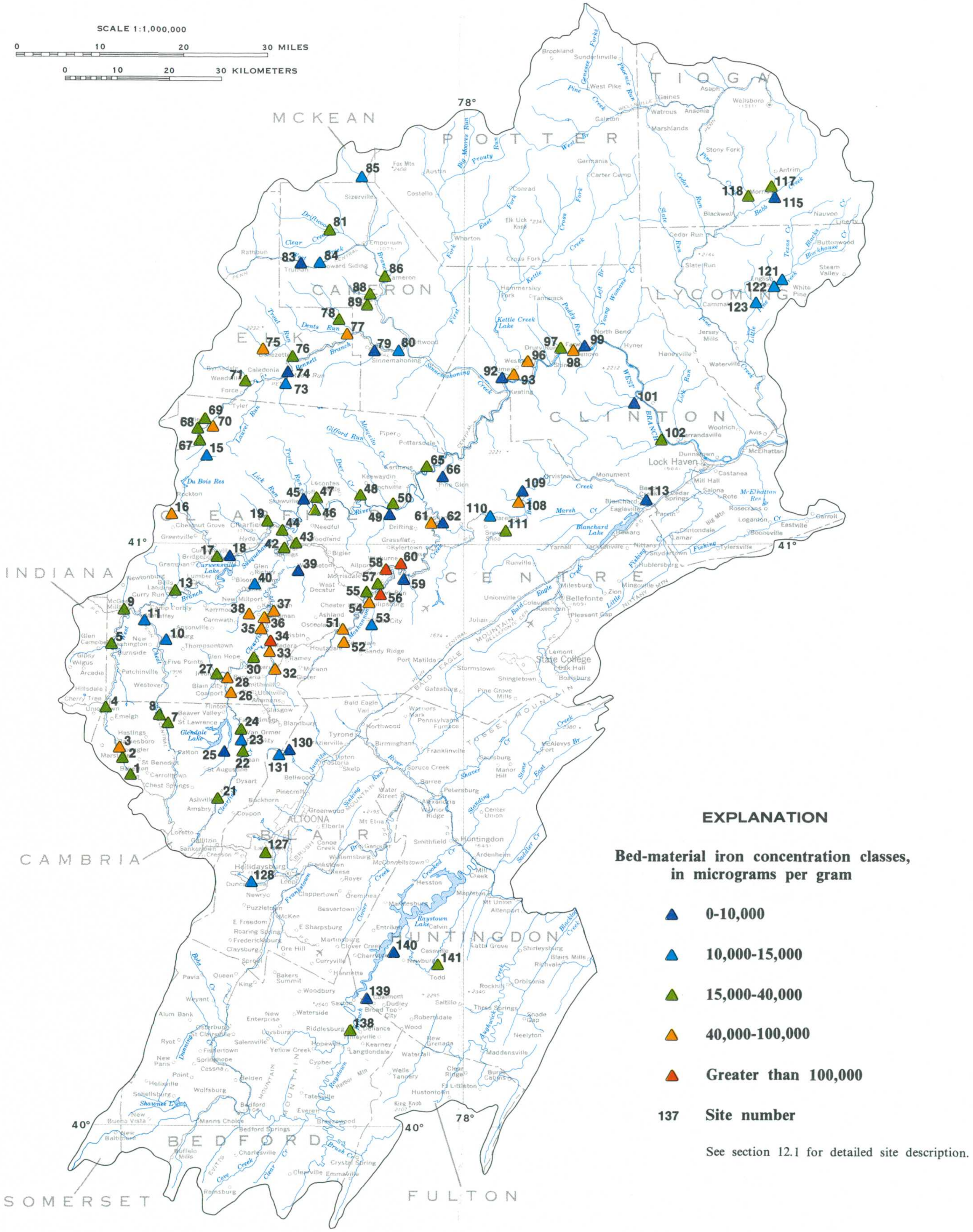
The mean bed-material iron concentration for 106 sites in Area 1 was 29,200 μg/g and the median concentration was 20,000 μg/g. Bed-material iron concentrations ranged from 2,200 to 160,000 μg/g. Concentrations below 40,000 μg/g were more common than higher concentrations (fig. 7.9.1-3). Of the 106 streams sampled, 83 (78 percent) had concentrations less than 40,000 μg/g, 69 (65 percent) had concentrations less than 30,000 μg/g, and 22 (21 percent) had concentrations less than 10,000 μg/g. Only 9 streams (8 percent) had concentrations in excess of 60,000 μg/g.

Samples for bed-material iron determinations were collected during August 1979 or August 1980, and analyzed according to procedures described by Skougstad and others (1979). Bed-material iron concentrations for the 1979 and 1980 water years are published by the U.S. Geological Survey (1980, 1981).

As materials pass through the stream channel network they are incorporated into the bed material. Unless extremely high flows scour the bed material and transport it downstream, the deposits may serve as indicators of past water-quality conditions. Feltz (1980) states that concentrations of heavy metals found in bottom materials confirmed potential contamination in the Schuylkill River even though concentrations in the water itself indicated no apparent problem. The concentrations of heavy metals in the bottom materials were several orders of magnitude higher than the concentrations in the water. Although Feltz (1980) did not consider iron, it may also be useful as an indicator of past contamination from some source within the basin.

Table 7.9.1-1 Median stream bed-material iron concentration, 1979, and mean coal production, 1976-80, for selected area counties.

County	Number of streams	Bed-material iron concentration (μg/g)	Coal production (tons)
Clearfield	42	29,500	9,481,000
Cambria	11	27,000	7,059,000
Centre	11	14,000	1,424,000
Elk	7	34,000	733,000
Clinton	8	23,000	450,000
Blair	4	11,000	13,000
Cameron	9	15,000	0



BASE FROM U.S. GEOLOGICAL SURVEY 1975; 1:500,000

Figure 7.9.1-2 Bed-material iron concentrations for selected Area 1 streams.

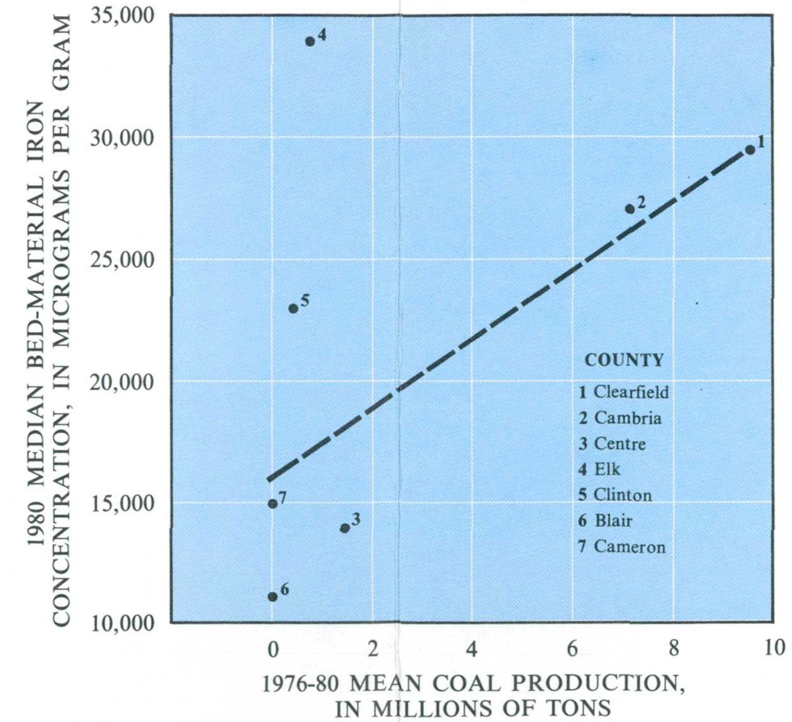


Figure 7.9.1-1 Bed-material iron concentration and coal production, by county.

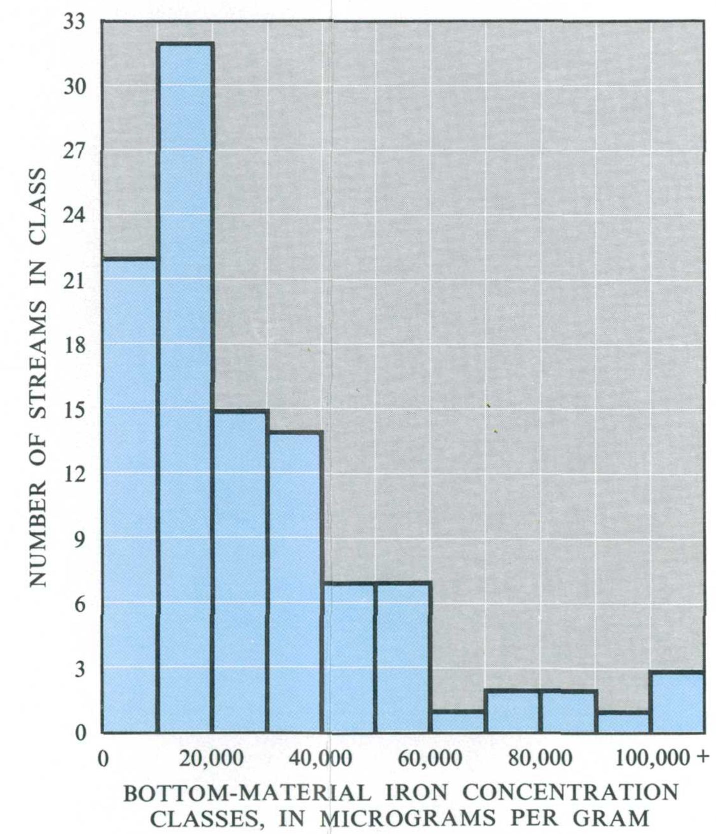


Figure 7.9.1-3 Histogram of iron concentration in bottom material for selected Area 1 streams.

Manganese Concentrations in Streams Not Related to Coal Production

Streams in major coal-producing counties do not have higher manganese concentrations than those of counties which produce little or no coal.

Table 7.9.2-1 presents bed-material manganese and coal-production data for 7 counties in Area 1. Figure 7.9.2-1 shows that bed-material manganese concentration is not related to coal production. Blair County, which produced an average of only 13,068 tons of coal annually during 1976-80 had a median bed-material manganese concentration of 1,140 μg/g (micrograms per gram), whereas Clearfield County, which produced an average of 9,480,737 tons annually during the same period, had a median concentration of only 295 μg/g. Cameron County, which produced no coal, had a median bed-material manganese concentration greater than all but one of the coal-producing counties.

Although bed-material manganese concentrations of 600 μg/g or greater were found in streams throughout Area 1, they are most common in streams in the Clearfield Creek basin and in streams tributary to the upper West Branch Susquehanna River (fig. 7.9.2-2). Numerous streams in these areas have bed-material manganese concentrations of 1,000 μg/g or greater. Bed-material manganese concentrations less than 250 μg/g were found in streams throughout Area 1, and concentrations less than 100 μg/g were relatively common in the Moshannon Creek basin.

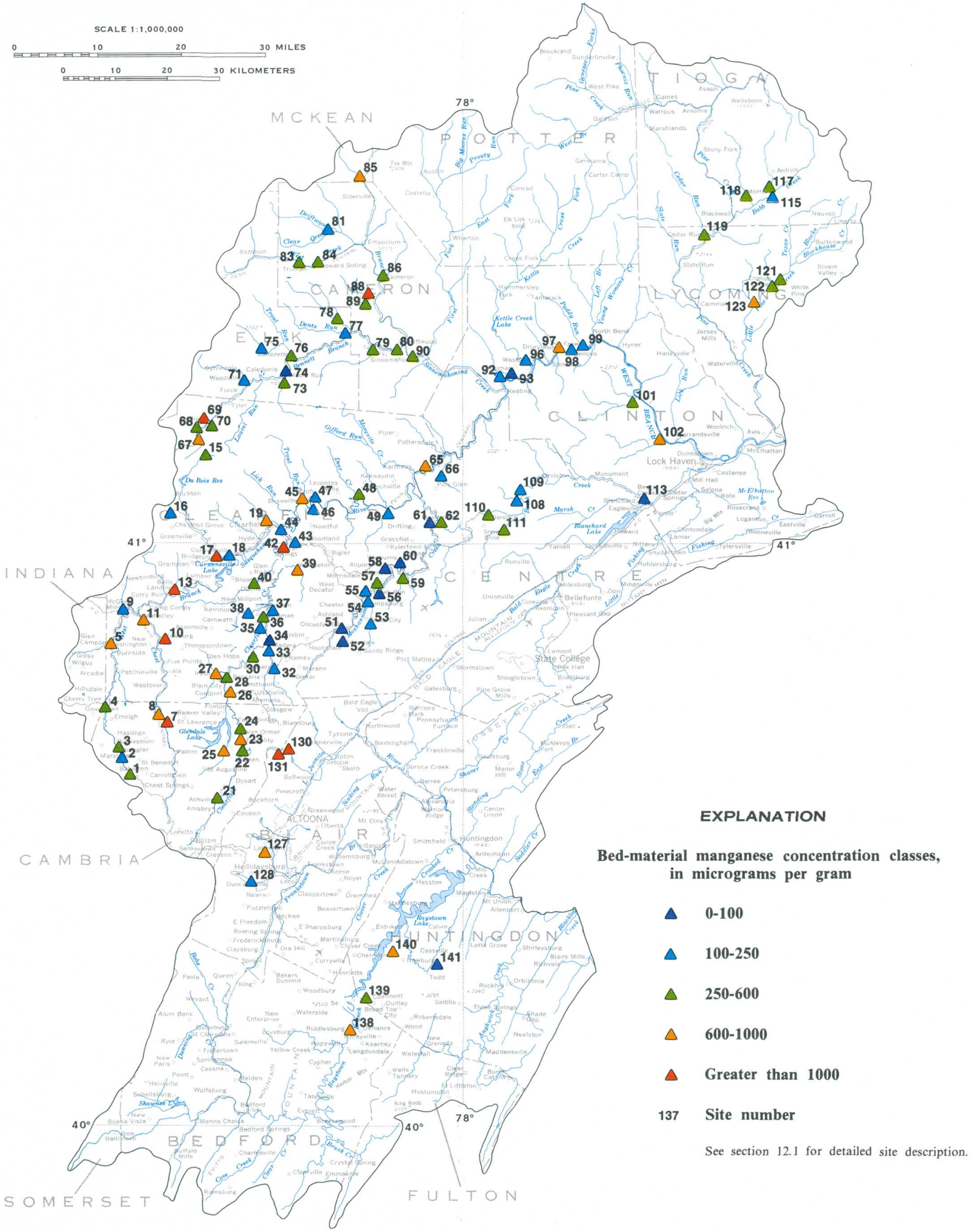
Bed-material manganese concentrations for 106 sites in Area 1 ranged from 40 to 1,800 μg/g. The mean and median concentrations were 443 and 350 μg/g, respectively. The distribution of numbers of streams in bed-material concentration classes was relatively uniform (fig. 7.9.2-3), although the 100-300 μg/g classes were more common than the others. Only 9 streams (8 percent) had concentrations greater than 1,000 μg/g, whereas 30 streams (28 percent) had concentrations of 200 μg/g or less.

Bed-material samples for manganese determinations were collected during August 1979 or August 1980, and analyzed according to procedures described by Skougstad and others (1979). Bed-material data for the 1979 and 1980 water years are published by the U.S. Geological Survey (1980, 1981).

As materials pass through the stream channel network, they are incorporated into the bed material. Unless extremely high flows scour the bed material and transport it downstream, the deposits may serve as indicators of past water-quality conditions. Feltz (1980) states that concentrations of heavy metals found in bottom materials confirmed potential contamination in the Schuylkill River even though concentrations in the water itself indicated no apparent problem. The concentrations of heavy metals in the bottom materials were several orders of magnitude higher than the concentrations in the water. Although Feltz (1980) did not investigate bed-material manganese, it also may serve as an indicator of past contamination from some source within the basin.

Table 7.9.2-1 Median stream bed-material manganese concentration, 1979, and mean coal production, 1976-80, for selected area counties.

County	Number of streams	Bed-material manganese concentration (μg/g)	Coal production (tons)
Clearfield	42	295	9,481,000
Cambria	11	430	7,059,000
Centre	11	230	1,424,000
Elk	7	230	733,000
Clinton	8	220	450,000
Blair	4	1,140	13,000
Cameron	9	440	0



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1975; 1:500,000

Figure 7.9.2-2 Bed-material manganese concentrations for selected Area 1 streams.

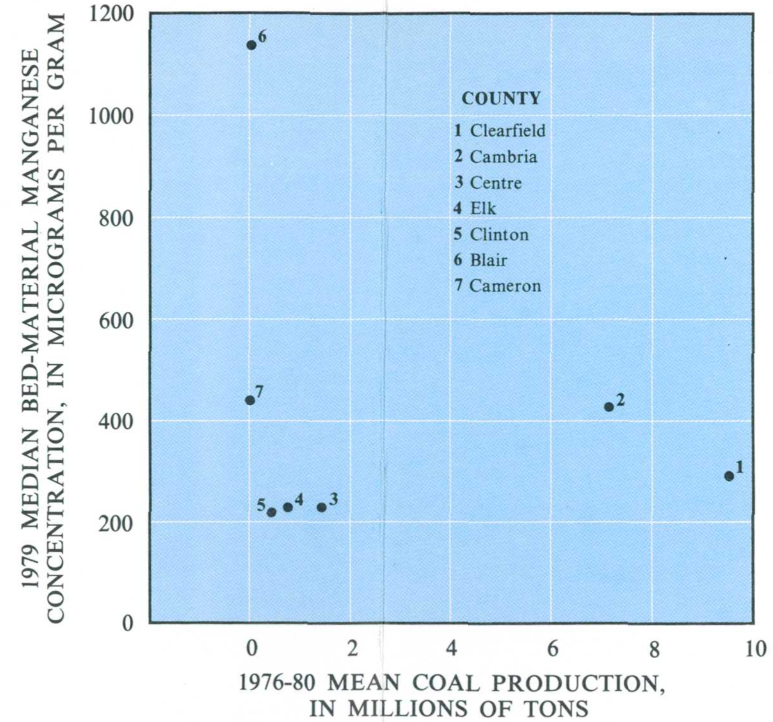


Figure 7.9.2-1 Bed-material manganese concentration and coal production, by county.

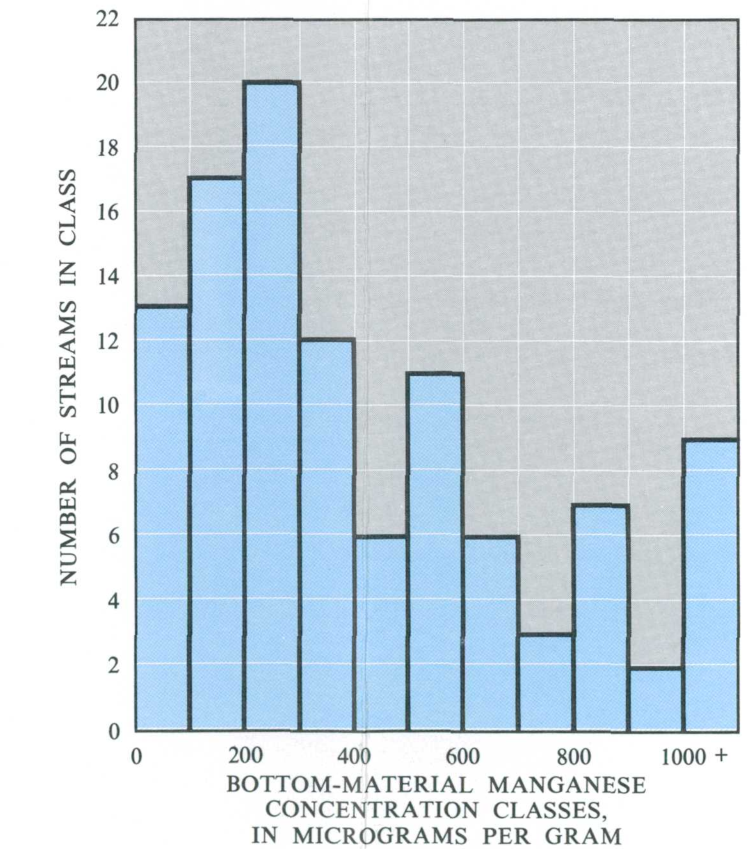


Figure 7.9.2-3 Histogram of manganese concentration in bottom material of selected Area 1 streams.

Coal-Producing Counties Have High Coal Concentrations in Stream Sediments

Streams in coal-producing counties have median bed-material coal concentrations that are generally at least twice as great as the median for a county which produces no coal.

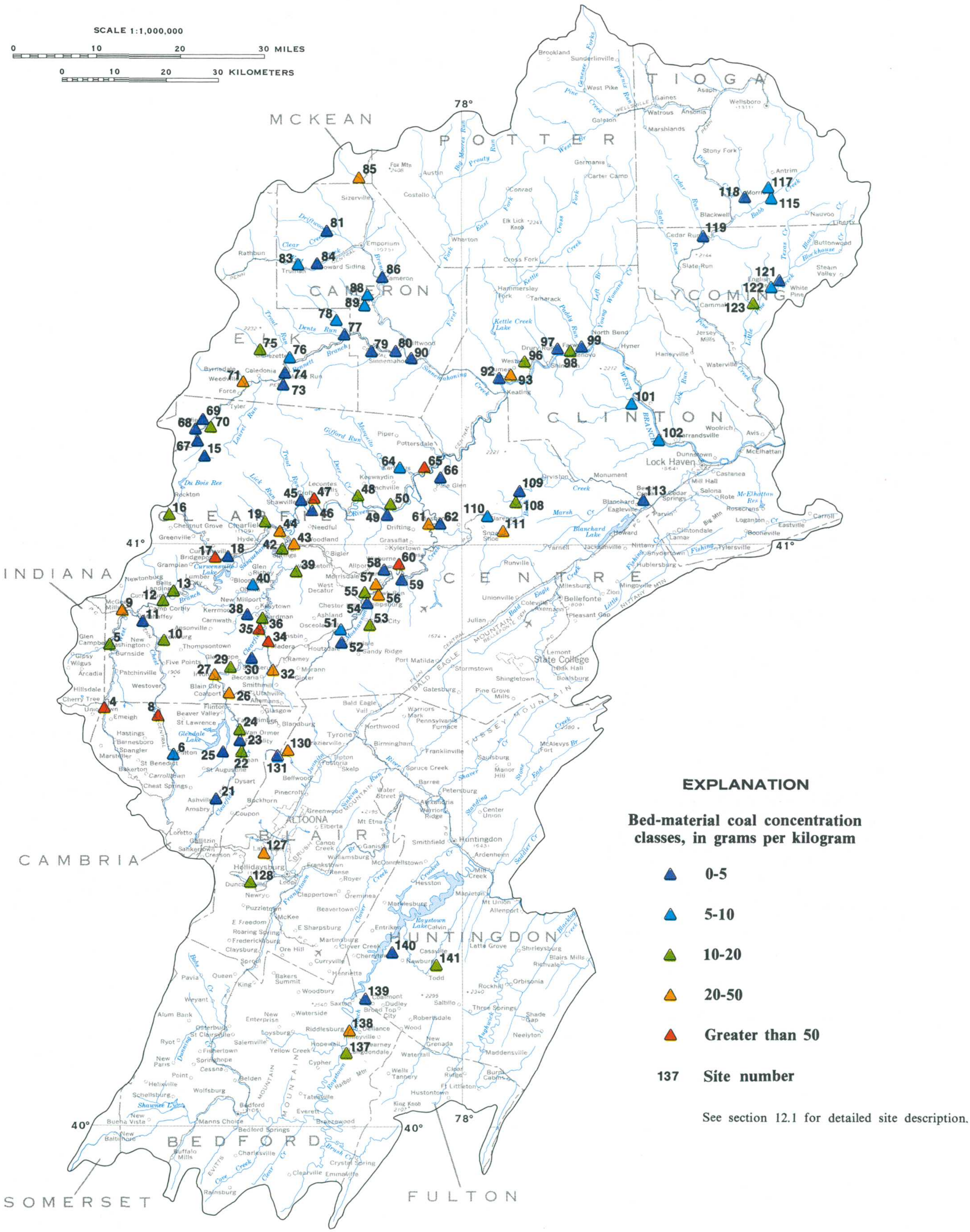
Median bed-material coal concentrations for six coal-producing counties ranged from 7.5 to 17 g/kg (grams per kilogram) (table 7.9.3-1). These concentrations were generally at least twice as great as the median of 4.0 g/kg reported for Cameron County, which produces no coal. Figure 7.9.3-1 shows that there is a close relation between coal production and bed-material coal concentration.

Bed-material coal concentrations in 14 of 42 streams (33 percent) sampled in Clearfield County equaled or exceeded 20 g/kg (fig. 7.9.3-2). A bed-material coal concentration of 20 g/kg was equaled or exceeded in only 10 of the remaining 62 streams (16 percent) sampled in Area 1. Six Clearfield County streams had bed-material coal concentrations of 50 g/kg or greater, while only two of the remaining Area 1 streams reached the 50 g/kg level. Seventeen of 21 streams sampled in the Sinnemahoning Creek basin had bed-material coal concentrations less than 10 g/kg.

Coal concentrations in the bed material of 104 streams sampled in Area 1 ranged from 0.1 to 290 g/kg. The mean coal concentration was 21 g/kg and the median concentration was 9 g/kg. Several high concentrations caused the large difference between the mean and median concentrations. Figure 7.9.3-3 shows the distribution, by concentration classes, of bed-material coal samples for Area 1 streams. The figure shows that 39 samples (38 percent) had concentrations less than 5 g/kg, and that 8 samples (8 percent) had concentrations of 50 g/kg or greater.

Samples for bed-material coal determinations were collected during August 1980. The bed material tested was that portion of a representative cross-section sample which passed through a 2 mm (millimeter) sieve, but did not pass through a 0.063 mm seive. The coal fraction was determined in the laboratory by combining the bed-material sample with a mixture of bromoform and acetone adjusted to a specific gravity of 1.65. The portion that floats on the mixture is determined to be coal. There are two interferences with the analytical procedure, both of which lead to over-estimates of the coal concentration. Sediments with a specific gravity less than 1.65, which are not soluble in acetone or bromoform, will be determined to be coal. Also, sediments with a high clay or silt content may cling to the analytical apparatus and be incorrectly reported as coal.

Prior to the analysis for coal concentration, the bed-material samples were split and a part was analyzed for organic carbon. Figure 7.9.3-4 shows the relation between bed-material coal concentration and bed-material organic-carbon concentration. The mean coal concentration for 101 streams is 20 g/kg and the mean organic-carbon concentration is 25 g/kg.



BASE FROM U.S. GEOLOGICAL SURVEY 1975; 1:500,000

Figure 7.9.3-2 Bed-material coal concentration for selected Area 1 streams.

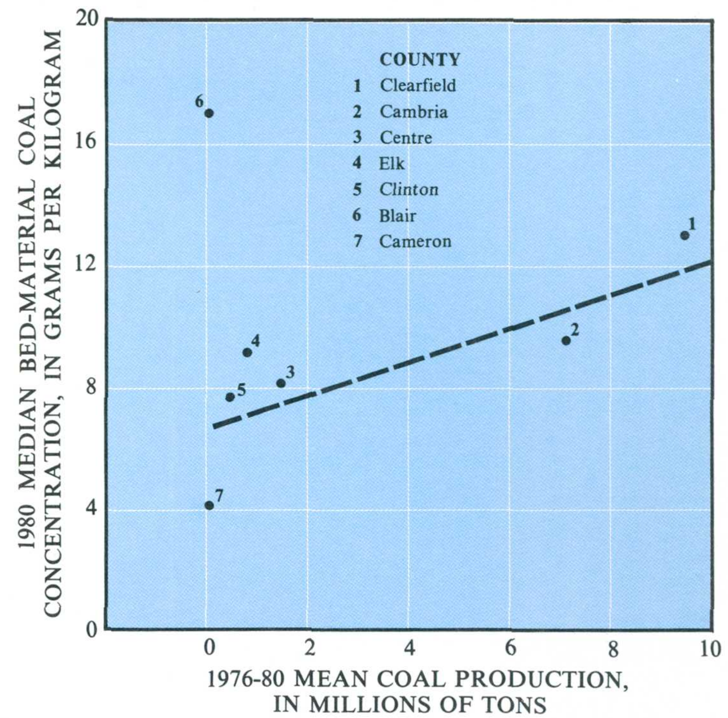


Figure 7.9.3-1 Bed-material coal concentration and coal production, by county.

Table 7.9.3-1 Median stream bed-material coal concentration, 1980, and mean coal production, 1976-80, for selected area counties.

County	Number of streams	Bed-material coal concentration (g/Kg)	Coal production (tons)
Clearfield	41	13	9,481,000
Cambria	8	9.5	7,059,000
Centre	11	8.0	1,424,000
Elk	7	9.0	733,000
Clinton	8	7.5	450,000
Blair	4	17	13,000
Cameron	9	4.0	0

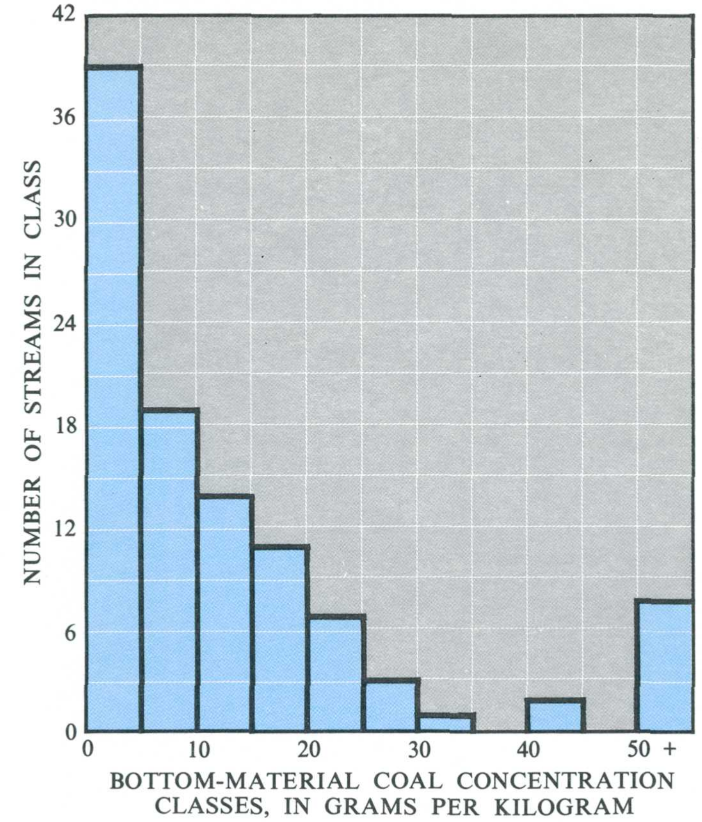


Figure 7.9.3-3 Histogram of coal concentration in bottom material for selected Area 1 streams.

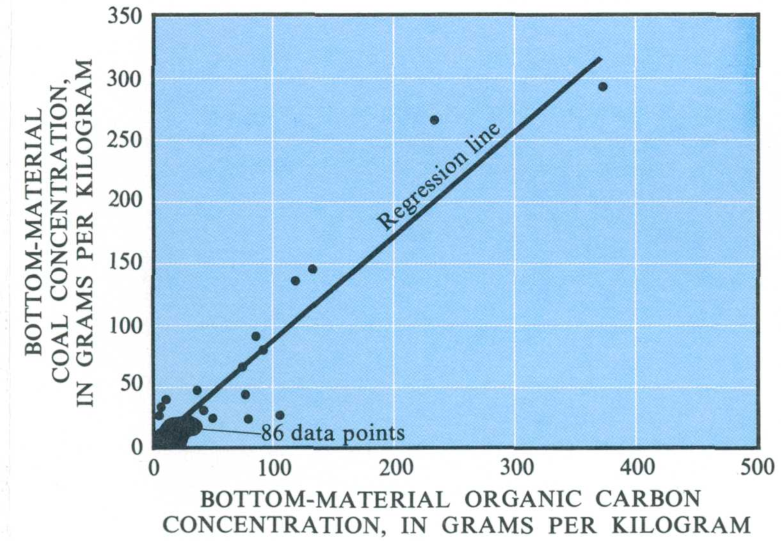


Figure 7.9.3-4 Relation between coal and organic carbon in bottom material for selected Area 1 streams.

Composition of Benthic Invertebrate Populations Good, Though Chemical Constituents Indicate Poor Water Quality

Benthic invertebrate population composition for Area 1 generally indicated good water quality, though the chemical constituents and numbers of benthic invertebrates found indicated poor water quality.

Benthic invertebrates are used as indicators of water quality because of their relatively long life, restricted mobility, and sensitivity to water contaminents (Britton and Averett, 1974), such as acid mine drainage (AMD). Although variations in tolerance to AMD may not be evident unless benthic invertebrates are identified to the species level, some broad generalizations concerning population composition and numbers can be made on the basis of identification to the order level. Good biological water quality in a stream can be characterized by a large variety of benthic invertebrate orders with no dominant population; whereas poor water quality can be characterized by a small variety of benthic invertebrate orders with one or two dominant populations or by very small populations. No benthic invertebrate population would generally indicate very poor water quality.

Benthic invertebrate composition is important in determining water quality. Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) are generally found in healthy streams, whereas unhealthy streams may be dominated by Diptera (flies, midges) and snails. Along with numbers and composition of benthic invertebrates, chemical constituents found in a stream are important in determining the over-all water quality. Most of the sites in Area 1 had a healthy or diverse benthic invertebrate population composition though numbers were small and water-chemical data indicated unhealthy stream conditions. Two sites in the area showing healthy water-quality were found in the Sinnemahoning Creek basin. These sites, 83 and 84, had high diversity index (DI) values, diverse benthic invertebrate population composition, and no AMD indicators.

Benthic invertebrate samples were collected in August 1979 and August 1980 by spending 15 minutes sampling all habitats in a stream reach. The basic technique consisted of disturbing bed material and allowing the debris and organisms to float via streamflow into a mesh net. Contents of the net were placed in a 210 μm (No. 70) sieve, rinsed with stream water and placed in a white polymer tray where specimens were separated and put in an appropriately labeled jar containing 70 percent alcohol. In 1979 benthic invertebrates were identified in a laboratory, but in 1980 they were identified in the field.

Six phyla were found in Area 1: Arthropoda, Mollusca, Annelida, Nematoda, Nematomorpha, and Platyhelminthes. Five orders and one class dominated the area, though they varied in rank from basin to basin and year to year. In August 1979 Diptera (midges, flies) was found at 87 sites, Trichoptera (caddisflies) at 53 sites, Plecoptera (stoneflies) at 49 sites, and Megaloptera (Alder, Dobson or fishflies) at 48 sites. In August 1980 Oligochaeta (aquatic worms) were found at 51 sites, Trichoptera at 46 sites, Megaloptera at 44 sites, and Ephemeroptera at 39 sites.

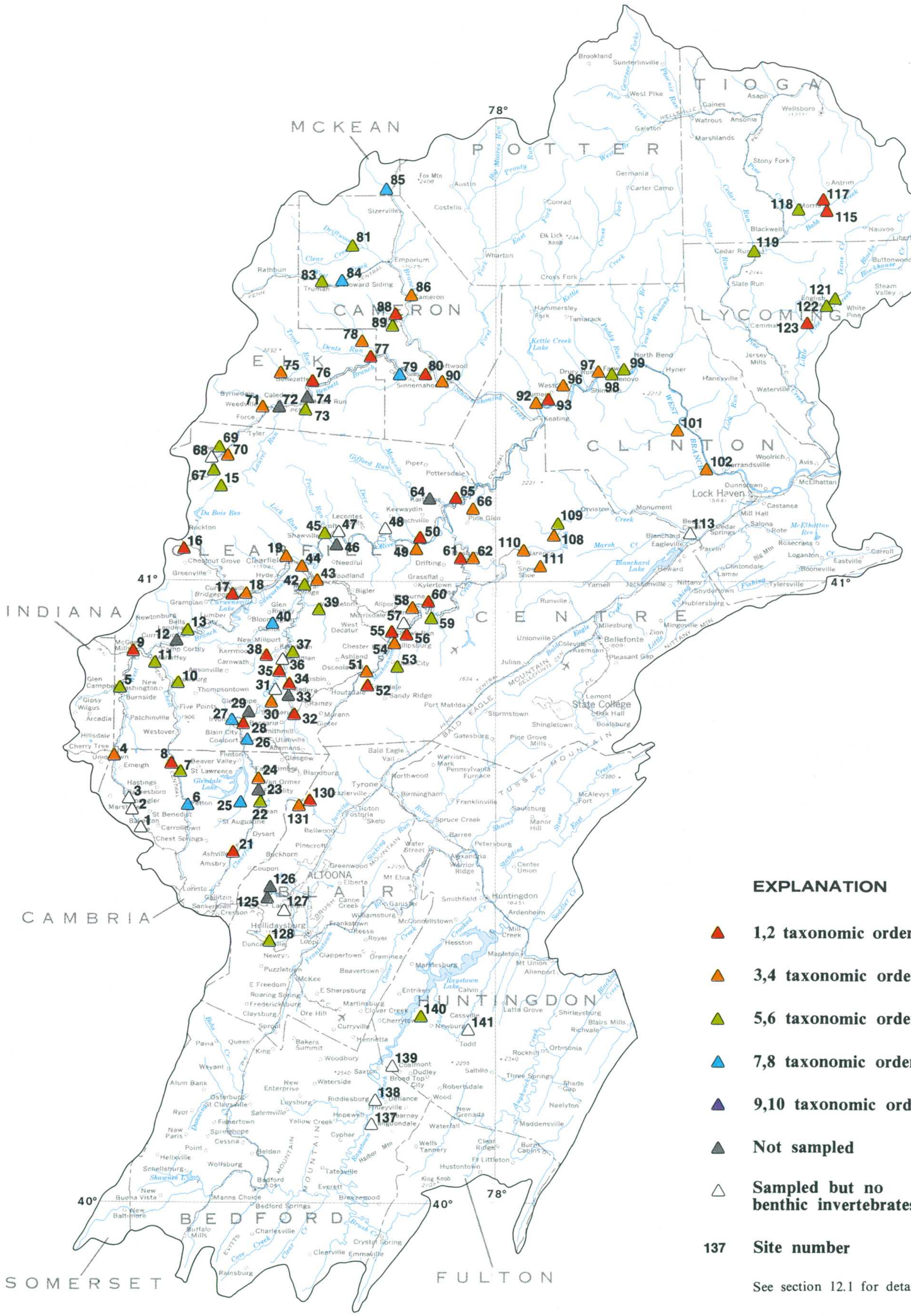
The Office of Surface Mining (1979) defines a biological community as a stream having at least two species of benthic invertebrates in either of the phyla Arthropoda or Mollusca. Twenty-eight sites in Area 1 did not have a biological community as defined above. Nineteen of these twenty-eight sites supported no benthic invertebrates.

According to the U.S. Department of the Interior (1968), dissolved sulfate values greater than 75 mg/L, total iron greater than 0.5 mg/L, total manganese greater than 0.5 mg/L, pH less than 6.0 units, and acidity values greater than alkalinity values are indicative of AMD. Seventy-five percent or 21 of the 28 sites lacking a biological community had 5 of the AMD indicators at some time during the sampling periods; whereas, 55 out of 115, or 47 percent of the total sites in Area 1 indicated AMD.

Stations in Area 1 lacking a benthic invertebrate population or having two or fewer orders of benthic invertebrates had a mean dissolved-sulfate concentration of 350 mg/L, mean total iron value of 20 mg/L and a mean pH of 4.4. Sites having seven or more benthic invertebrate orders had a mean dissolved-sulfate concentration of 31 mg/L, a mean total-iron concentration of 0.40 mg/L, and a mean pH of 7.1. The mean total iron value for sites lacking a benthic invertebrate population or having two or fewer orders of benthic invertebrates was 50 times greater than the mean total iron value for sites having seven or more benthic invertebrate orders.

The Shannon-Weaver DI was determined for the benthic invertebrate samples of August 1979. This DI is a measure of the numbers and kinds (Wilhm and Dorris, 1968) of benthic invertebrates sampled in a stream without regard to sample size (Doyle, 1979, written communication). A high DI is generally an indication of good water quality and a low DI is generally an indication of poor water quality. Nineteen of 105 sites sampled in August 1979 had order-level DI's greater than or equal to 2.0, indicating good water quality.

Low flow can concentrate contaminants in streams causing benthic invertebrates or their food sources to die. High flow generally dilutes contaminants in a stream, though runoff from a contaminated area during a storm may concentrate contaminants in the stream. Sites in Area 1 had varied baseflow during August 1979 and 1980 when benthic invertebrates were collected. Figures 7.10-1 and 7.10-2 indicate the number of benthic invertebrate orders found at sites during the 1979 and 1980 sampling.



EXPLANATION

- ▲ 1,2 taxonomic orders
- ▲ 3,4 taxonomic orders
- ▲ 5,6 taxonomic orders
- ▲ 7,8 taxonomic orders
- ▲ 9,10 taxonomic orders
- ▲ Not sampled
- △ Sampled but no benthic invertebrates found.

137 Site number

See section 12.1 for detailed site description.

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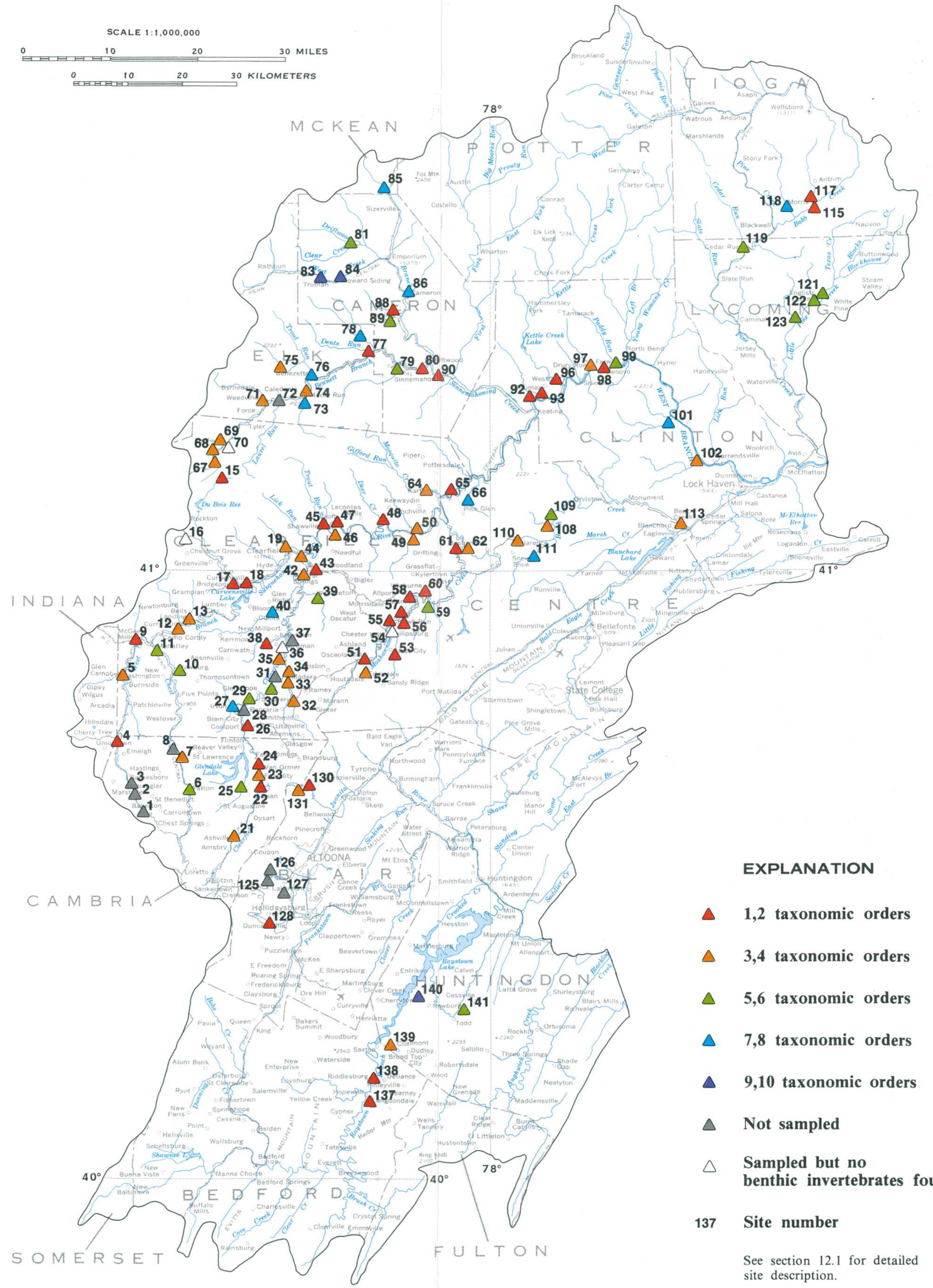
Figure 7.10-1 Numbers of benthic invertebrate orders, August 1979.



EXPLANATION

- ▲ 1,2 taxonomic orders
- ▲ 3,4 taxonomic orders
- ▲ 5,6 taxonomic orders
- ▲ 7,8 taxonomic orders
- ▲ 9,10 taxonomic orders
- ▲ Not sampled
- △ Sampled but no benthic invertebrates found.

137 Site number

See section 12.1 for detailed site description.

Figure 7.10-2 Numbers of benthic invertebrate orders, August 1980.

8.0 ACID MINE DRAINAGE

Indications of Acid Mine Drainage Were Found at Forty-Seven Percent of Sites

Data at 55 of the 115 synoptic sites in the area exceeded the levels of pH, acidity-alkalinity, total iron, total manganese, and sulfate which are indicators of acid mine drainage.

Several water-quality criteria have been proposed as indicators of acid mine drainage (AMD). Five of the common indicators are (U.S. Department of the Interior, 1968):

pH < 6.0

acidity $>$ alkalinity

total iron > 0.5 mg/L (milligrams per liter)

total manganese > 0.5 mg/L

dissolved sulfate > 75 mg/L

The Office of Surface Mining Reclamation and Enforcement (1979) defines AMD as "Water with a pH less than 6.0 and in which total acidity exceeds total alkalinity, discharged from an active, inactive, or abandoned surface coal mine and reclamation operation or from an area affected by surface coal mining and reclamation activities." Fifty-five of 115 sites (47 percent) in Eastern Coal Province Area 1 that were sampled during June 1979 to August 1980, exceeded all five indicator levels. All indicator levels may not have been exceeded during a single sampling, but each AMD indicator level was exceeded at some time when all samples were considered. The presence of AMD indicators is no guarantee of acid mine drainage.

Figure 8.0-1 shows the location of the 55 synoptic sites meeting all five AMD indicator levels. The figure also shows the 60 remaining sites in the area that have been ranked by the number of AMD indicators found during the sampling period. All streams that had AMD indicators did not exhibit the usual connections among the AMD constituents. For example, if a stream had a low pH, it did not necessarily follow that total iron or total manganese were found in high concentrations.

Equation 8.0-1 illustrates the relation between dissolved solids, residue on evaporation, and specific conductance based upon concurrent samples at the 55 AMD sites. The regression equation for the relation is:

$$ROE = 0.78\,(SC) - 38 \qquad (8.0\text{-}1)$$

where ROE = dissolved solids, in milligrams per liter and SC = specific conductance, in micromhos per centimeter at 25°C.

The multiple correlation coefficient (R^2) and standard error of estimate (SE) for equation 8.0-1 are 89 percent and 169 mg/L dissolved solids, respectively. The range for dissolved solids was 13-4,180 mg/L with a mean of 460 mg/L.

The relation between dissolved sulfate and specific conductance is illustrated by equation 8.0-2. The regression equation was computed from concurrent sample findings from the 55 AMD sites. The equation for the line is:

$$SO_4 = 0.51\,(SC) - 52 \qquad (8.0\text{-}2)$$

where SO_4 = dissolved sulfate, in milligrams per liter and SC = specific conductance, in micromhos per centimeter at 25°C.

The R^2 for equation 8.0-2 is 97 percent and the SE is 57 mg/L for dissolved sulfate. The range for dissolved sulfate was 17-2,800 mg/L with a mean of 287 mg/L.

Hem (1970) states that a specific conductance coefficient greater than about 0.75 is an indication of high sulfate concentrations. This is supported by equation 8.0-3 which shows the relation between dissolved solids and dissolved sulfate based on concurrent samples at the 55 sites indicating AMD. The equation for this line is:

$$ROE = 1.7\,(SO_4) - 7.7 \qquad (8.0\text{-}3)$$

where ROE = dissolved solids, in milligrams per liter, and SO_4 = dissolved sulfate concentration, in milligrams per liter.
Equation 8.0-3 has an R^2 of 87 percent and an SE of 245 mg/L of dissolved solids. The range of ROE values was 13-5,420 mg/L with mean a of 548 mg/L.

Sulfate is found in most coal areas because of the presence of sulfur-bearing minerals, such as pyrite. Weather and mining expose the pyrite to water and oxygen causing it to oxidize into a weak sulfuric acid. When the sulfuric acid contacts rock strata, most metals, including iron, manganese, aluminum, sodium, calcium, magnesium, and probably some trace metals are dissolved.

Harvard University (1970) presents the following overall reactions for the mine-water system:

$$FeS_2(S) + 7/2\,O_2 + H_2O = Fe^{+2} + 2SO_4^{-2} + 2H^+ \qquad (8.0\text{-}4)$$

$$Fe^+ + 1/4\,O_2 + H^+ = Fe^{+3} + 1/2\,H_2O \qquad (8.0\text{-}5)$$

$$Fe^{+3} + 3H_2O = Fe(OH)_3\,(S) + 3H^+ \qquad (8.0\text{-}6)$$

$$FeS_2(S) + 14Fe^{+3} + 8H_2O = 15Fe^{+2} + 2SO_4^{-2} + 16^+ \qquad (8.0\text{-}7)$$

In the initial step (8.0-4) pyrite (FeS_2) is exposed to water and atmospheric oxygen, producing ferrous iron and sulfate and releasing acidity into the water. Reaction 8.0-5 illustrates the oxidation of ferrous iron to ferric iron which hydrolyzes to form the insoluble ferric hydroxide (8.0-6), a step which releases more acidity to the water. Reaction 8.0-7 shows that pyrite itself can reduce ferric iron to ferrous iron accompanied by an additional release of acidity. The ferrous iron formed in the step can re-enter the reaction cycle as shown in reaction 8.0-5. In waters having low pH the oxidation of ferrous iron to ferric iron proceeds quite slowly; however, in acidic mine waters certain bacteria are thought to speed the reaction through bacterial catalysis (Harvard University, 1970).

The most obvious effect of AMD on a stream may be aesthetic. When the AMD meets alkaline waters and ferric hydroxide preciptates, a reddish-orange coating is left on the stream bed.

Other effects of AMD may not be as noticeable, but may be of greater consequence than the aesthetic considerations. These effects may alter the ability of a stream to support aquatic life, or may adversely affect the quality of the stream's water for industrial, agricultural, or domestic use.

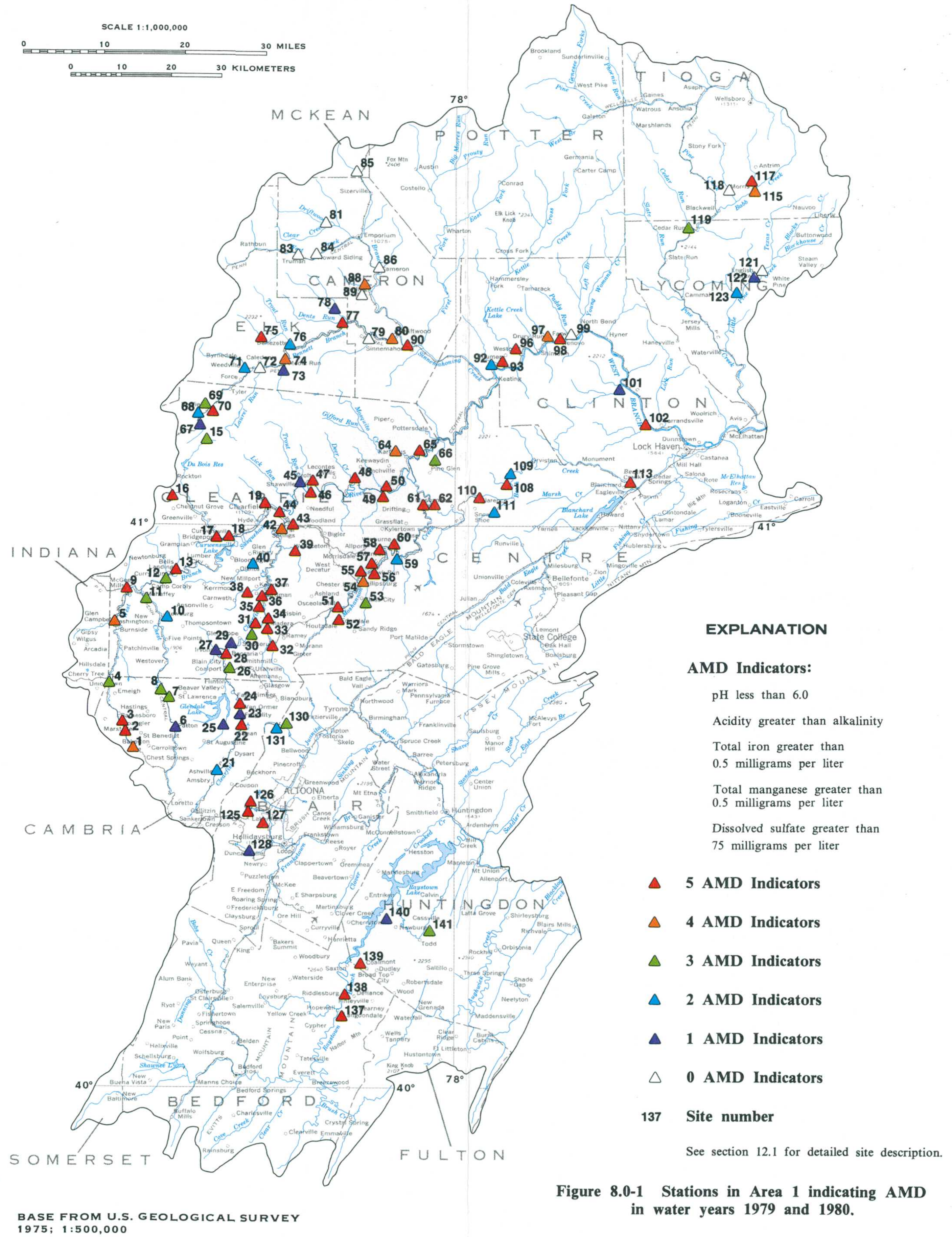


Figure 8.0-1 Stations in Area 1 indicating AMD in water years 1979 and 1980.

Daily Discharge Data Are Valuable for the Design of Hydraulic Structures and Determining Water Availability

Daily discharge is the average flow rate of water in a stream during each day. It is used in the computation of many hydrologic indices, which are needed to design hydraulic structures or to determine water availability.

The basic reporting unit of streamflow is daily mean discharge in cubic feet per second. Daily mean discharge is determined by measuring stream stage (fig. 9.1-1) at intervals ranging from 5 minutes to 1 hour, and applying a stage-discharge relation.

Daily mean discharge, although a convenient unit of flow measurement, does not show the variation of flow throughout the day. Figure 9.1-2 is a discharge hydrograph for station 98, computed from the stage hydrograph shown in figure 9.1-1, and the appropriate stage-discharge relation. The mean discharge for October 6, 1979, was 25,400 ft^3/s (cubic feet per second), but the actual recorded instantaneous discharges ranged from a low of 18,600 ft^3/s to a high of 28,100 ft^3/s. The mean stage for October 6, 1979, was 9.61 feet; the recorded stage ranged from 8.13 to 10.16 feet.

Daily mean discharges during a period can be presented in tabular form, such as table 9.1-1 for station 98 for October 1979. The daily discharges can be presented graphically, as shown in figure 9.1-3 for station 98 for the 1980 water year.

Daily discharge data have greater utility than simply reporting average discharges for individual days. Daily discharge data are used in the computation of hydrologic indices such as mean flows, low flows, and flow-duration curves or tables. These indices are useful in the safe and economical design of a wide variety of hydraulic structures such as dams and bridges. These indices are also used in determining the availability of water under different flow conditions and at different times of the year.

Table 9.1-1 Daily mean discharge in cubic feet per second, for station 98 during October 1979.

(drainage area 2975 mi^2)

Day	Discharge
1	7530
2	5700
3	6220
4	10300
5	11000
6	25400
7	23100
8	16800
9	13600
10	11700
11	10100
12	8830
13	8130
14	7170
15	6150
16	5490
17	4910
18	4560
19	4160
20	3800
21	3430
22	3160
23	2910
24	3410
25	3490
26	3110
27	2820
28	2730
29	2960
30	3030
31	2760

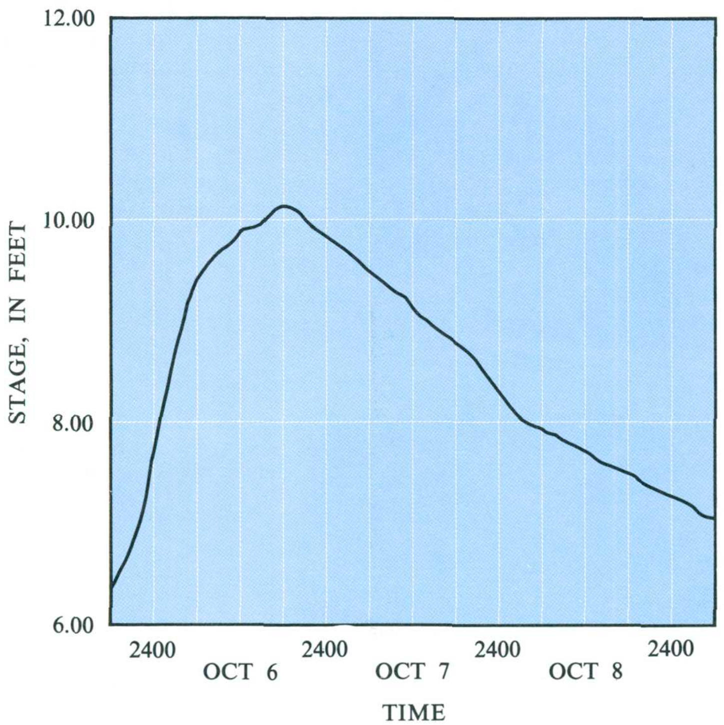


Figure 9.1-1 Stage hydrograph for station 98, October 5, 1979 through October 9, 1979.

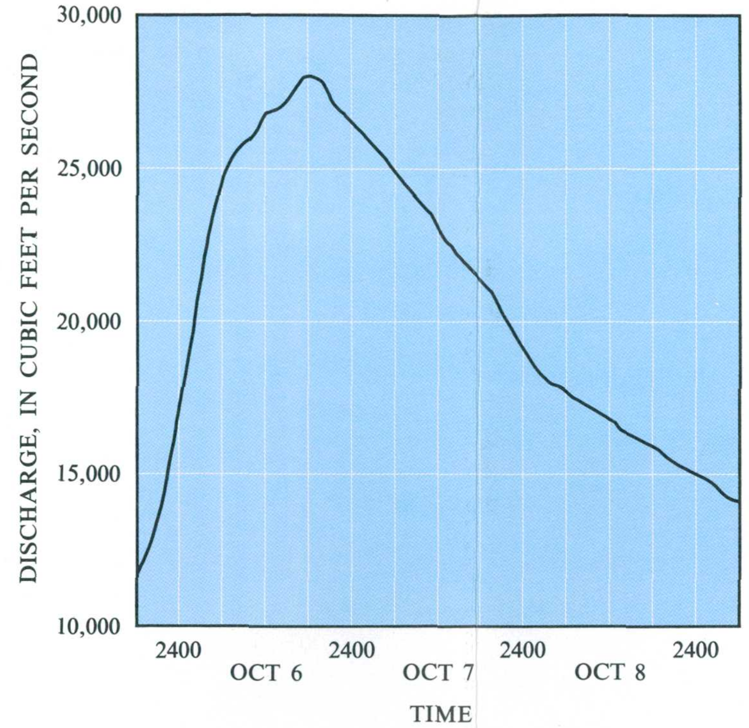


Figure 9.1-2 Discharge hydrograph for station 98, October 5, 1979 through October 9, 1979.

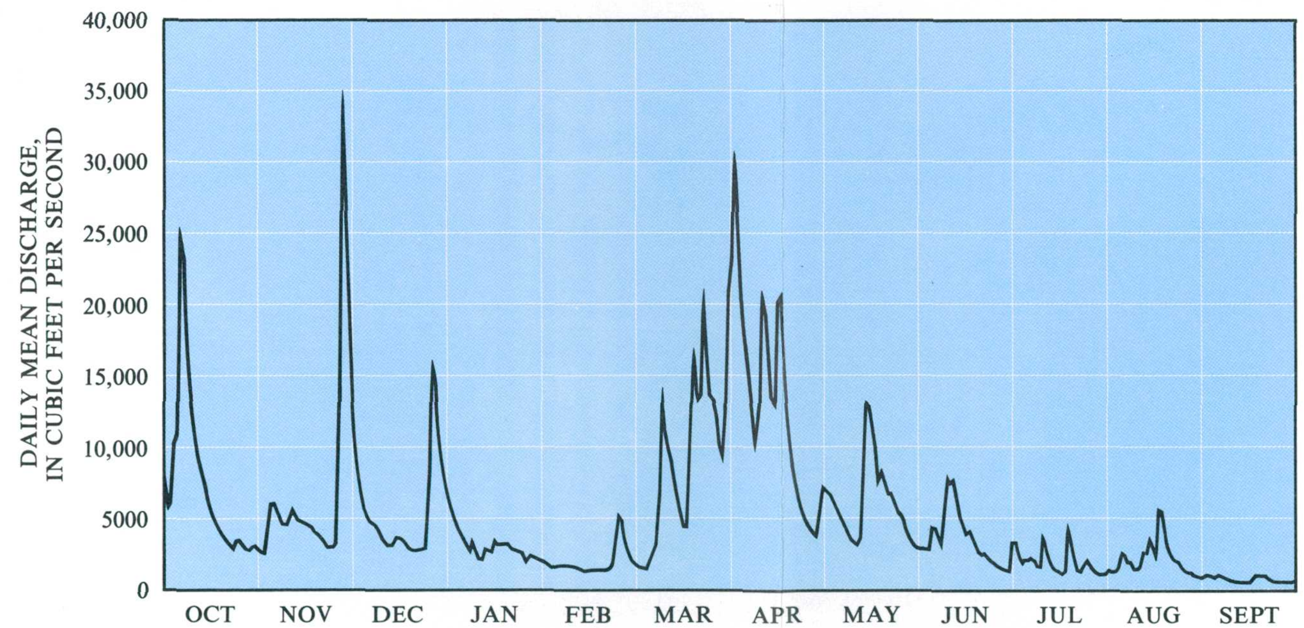


Figure 9.1-3 Daily mean discharge hydrograph for station 98, water year 1980.

Low-Flow Data Available for Gaged and Ungaged Streams

Low-flow statistics for gaged streams are computed from recorded daily discharges. Regression equations can be used to estimate low-flow statistics for ungaged, unregulated streams.

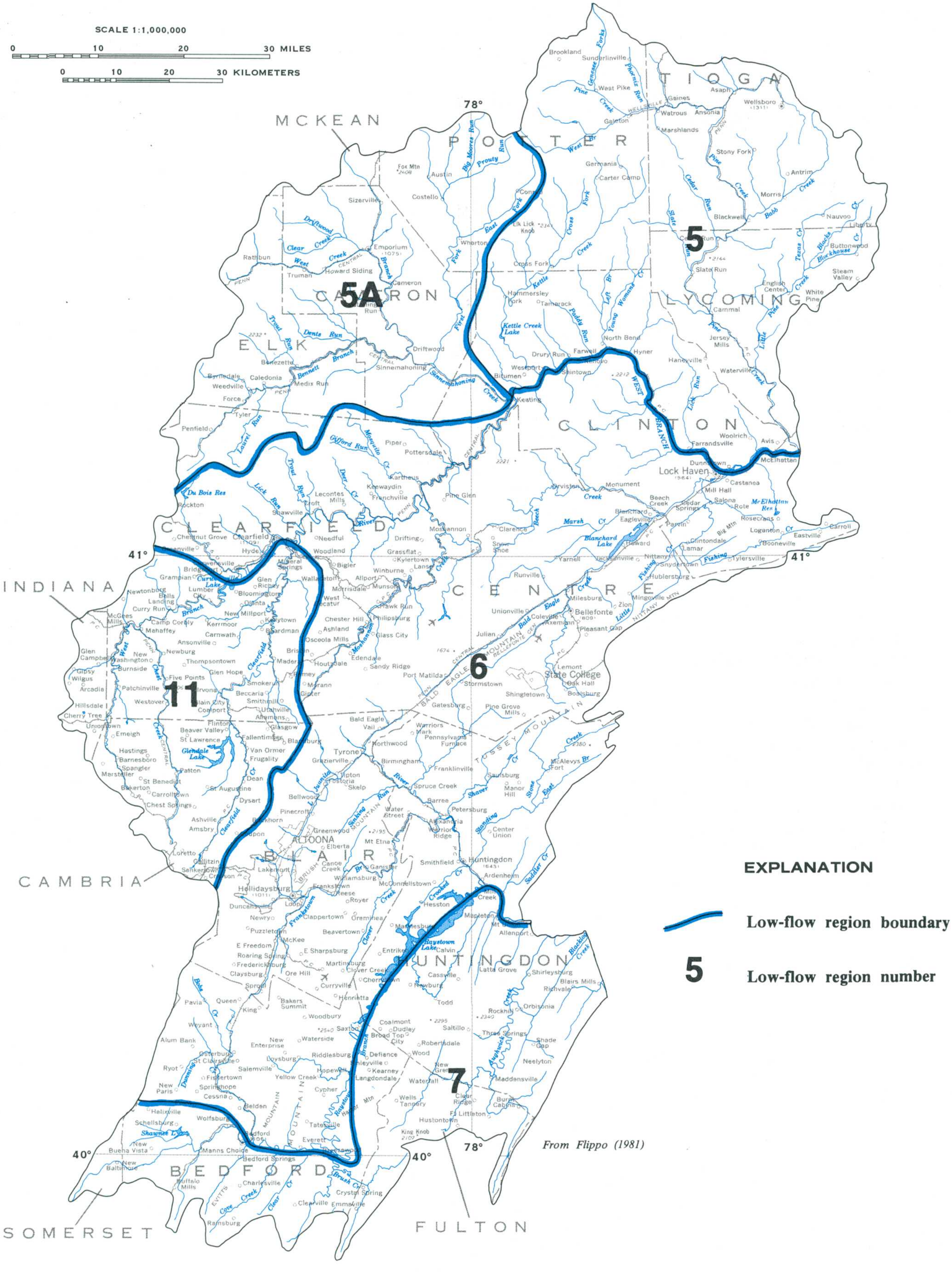
Low-flow statistics can be computed for any stream that has daily-discharge data; however, the data is meaningful only for those streams not significantly affected by regulation and diversion. Regulation and diversion can unnaturally change flow patterns thereby invalidating the low-flow estimates.

Low-flow statistics are commonly computed for 1, 3, 7, 30, and 120 consecutive-day periods at recurrence intervals of 2, 5, 10, 20, and 100 years. The statistics can be determined for annual or calendar month low flows. Naturally, monthly low flows, in most instances, will be computed for consecutive-day periods of 30 days or less.

Recurrence interval can be defined as the probability (or chance) that the average discharge for a specified period will be less than a given value in any year. A low-flow statistic is usually described by the number of consecutive days and the recurrence interval. For example, a 7-day, 10-year low flow of 40 ft^3/s (cubic feet per second) would mean that the lowest flow for seven consecutive days for this stream would be less than 40 ft^3/s at intervals averaging 10 years; therefore, the probability is 0.1.

Flippo (1981) developed a series of equations for the estimation of low flows for ungaged, unregulated streams in Pennsylvania. Some of these equations are applicable to ungaged streams in Eastern Coal Province Area 1. Flippo divided Pennsylvania into a number of low-flow regions. Area 1 contains low-flow regions 5, 5A, 6, 7, and 11 as delineated on figure 9.2-1. Low flows in each area must be estimated by a separate set of equations.

Flippo's equations can be used to estimate annual minimum discharges for 3, 7, 30, and 120 consecutive-day periods at recurrence intervals of 5, 10, 20, 50, and 100 years. Flippo also provides equations for estimating minimum discharges for 1, 3, 7, and 30 days at the same recurrence intervals for the six individual months of May through October.



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1975; 1:500,000

Figure 9.2-1 Locations of low-flow regions in Area 1.

Mean-Flow Data Available for Gaged and Ungaged Streams

Mean and mean monthly flows for gaged streams can be computed from recorded daily discharges. Regression equations can be used to estimate mean and mean monthly flows for ungaged streams.

Mean flow is the arithmetic average of all recorded daily discharge during the period of record. Mean monthly flow is the arithmetic average of all recorded daily discharges during a particular month for the period recorded. For example, the mean October discharge for a station having 40 years of record would be the arithmetic average of the daily discharges recorded during the 40 Octobers in the record period. Means computed from longer periods of record are more likely to be representative of long-term conditions than are means determined from short record periods. Table 9.3-1 contains mean flow data for 35 gaged streams in Area 1.

Herb (1981) developed a series of regression equations for the estimation of mean and mean monthly flows for ungaged, unregulated streams in Pennsylvania. Some of these equations are applicable to streams in Area 1 that are not affected by significant regulation or diversions. The applicability of the equations to streams having drainage areas less than 2 mi^2 (square miles) or to extensively surface-mined basins is unknown.

Table 9.3-2 presents the mean-flow equations and a description of the part of Area 1 to which each equation is applicable. The data required in the equations are: drainage area, mean basin elevation, and average annual precipitation excess (average annual precipitation minus potential annual evapotranspiration).

Drainage area (DA) is determined by delineating the boundary of a drainage basin above a point-of-interest on a 7.5-minute topographic map and planimetering. Mean basin elevation (E) is computed by averaging the elevation of 20 grid points overlaying the above delineated drainage area.

Annual precipitation excess (APX) is computed by subtracting annual potential evapotranspiration from average annual precipitation (Flippo, 1977). Average annual precipitation and annual potential evapotranspiration are interpolated at the centroid of the drainage basin of interest using the appropriate evapotranspiration map from Flippo's report. Flippo (1977) found, based on methods of Thornwaite and Mather (1955), potential annual evapotranspiration could be used as an unadjusted estimator of actual annual evapotranspiration for Pennsylvania. The variables used in the equations in table 9.3-2 are:

Qn = Mean discharges for specified period (where n = A, overall mean is computed; where n = 1, January mean is computed; where n = 2, February mean is computed; and so forth), in cubic feet per second,

DA = Drainage area, in square miles

E = Mean basin elevation, in thousands of feet above sea level, and

APX = Annual precipitation excess, in inches.

Each equation in table 9.3-2 is accompanied by its standard error of estimate and its coefficient of determination. The standard error of the estimate is a rough measure of the reliability of the equation. Two-thirds of the regression estimates of the mean-flow characteristics for the streams used to develop the equation fell within the percentage errors shown. The coefficient of determination is a measure of the effectiveness of the selected basin characteristics in explaining observed variations in the mean-flow characteristics. The more effective, or the more perfect, the equation is in relating selected basin characteristics to observed variations in mean-flow, the closer the coefficient of determination comes to 100 percent. All of the equations in table 9.3-1 had a coefficient of 97 percent or greater.

Table 9.3-1 Mean flows, in cubic feet per second, for continuous gaging stations in Area 1.

Station reference number	Annual	October	November	December	January	February	March	April	May	June	July	August	September	Regulated
12	558	260	404	618	741	788	1,253	945	663	392	252	208	189	No
14	664	330	491	762	730	876	1,458	1,201	803	411	370	278	269	Yes
20	12.9	8.47	10.5	14.9	12.7	15.4	27.9	22.7	14.1	11.3	6.86	4.56	6.23	No
41	581	265	394	578	729	781	1,324	1,056	775	451	247	198	184	No
51	112	48.3	66.8	105	119	131	244	221	177	105	51.3	42.3	35.0	No
63	2,507	1,111	1,710	2,609	2,931	3,183	5,524	4,910	3,490	2,034	1,119	836	782	Yes
82	8.71	4.61	8.21	11.9	8.84	9.98	19.1	17.9	10.6	5.95	2.35	1.25	3.68	No
87	455	180	375	475	529	531	1,065	942	658	319	169	110	115	No
90	1,131	443	863	1,226	1,308	1,387	2,632	2,408	1,647	769	375	246	289	No
91	389	194	336	439	364	406	931	904	507	223	147	98.8	123	Yes
94	227	100	194	239	226	234	523	521	344	162	75.1	46.0	59.5	No
95	373	190	314	398	333	398	841	898	512	263	133	82.5	121	Yes
98	4,974	2,172	3,628	4,786	5,936	6,002	11,440	9,982	7,313	3,815	1,986	1,283	1407	Yes
100	78.1	42.4	78.4	84.1	64.6	81.7	151	166	104	70.3	31.7	15.8	29.3	No
103	90.8	57.2	65.3	79.3	90.8	105	151	149	121	96.2	66.1	56.6	53.4	No
104	238	187	202	236	245	275	347	330	260	253	191	162	160	No
105	403	271	309	389	372	504	797	698	498	348	237	210	207.	No
106	457	318	448	462	430	535	874	741	564	357	281	232	240	Yes
107	58.7	28.7	48.2	67.6	54.3	78.5	141	114	73.6	43.8	22.3	16.0	17.6	No
111	24.0	16.2	24.7	26.5	24.2	28.4	45.3	43.6	28.5	22.2	12.2	7.02	9.38	No
112	289	178	286	335	290	320	545	509	348	273	173	89.9	124	No
119	863	337	730	807	832	831	1,968	1,998	1,311	590	260	182	197	No
120	58.6	32.6	60.8	66.2	57.0	61.0	134	122	83.7	41.4	17.0	12.2	15.3	No
124	1,434	652	1,226	1,477	1,248	1,524	3,288	3,373	2,013	1,169	477	309	474	Yes
129	396	186	259	366	432	538	916	771	526	306	181	146	138	No
132	77.5	34.4	52.8	76.0	87.6	98.2	175	148	115	67.7	30.7	22.7	24.3	No
133	376	186	246	348	387	471	808	723	534	352	183	141	141	No
134	1,096	557	735	1,037	1,177	1,387	2,338	2,016	1,513	977	548	449	433	No
135	5.50	2.55	3.11	5.75	5.05	8.49	15.2	10.4	7.34	4.23	1.57	.98	1.35	No
136	230	107	145	245	271	342	571	442	274	163	83.5	58.9	58.9	No
138A	918	450	564	845	1,036	1,396	2,153	1,707	1,243	730	389	271	271	No
142	1,045	373	676	940	1,196	1,658	2,642	2,091	1,474	680	391	301	230	Yes
143	1,383	1,180	1,445	1,622	1,290	1,849	2,863	2,272	1,431	1,124	618	409	534	Yes
144	2,494	1,286	1,708	2,376	2,632	3,351	5,622	4,770	3,329	2,152	1,106	855	806	Yes
145	248	120	185	269	255	365	589	467	321	205	79.1	69.3	60.6	No

Table 9.3-2 Equations for estimating mean discharges for ungaged, unregulated streams in Area 1.

To estimate specified discharge	Use equation[1]	For designated part of area	Standard error (percent)	Coefficient of determination (percent)
Mean	$Q_A = 0.099\ DA^{1.01}\ APX^{0.94}$	All	9	99.8
Mean October	$Q_{10} = 0.034\ DA^{0.99}\ E^{-0.11}\ APX^{1.14}$	Streams tributary to W. Br. Susquehanna River downstream from Sinnemahoning Creek, not including the Sinnemahoning Creek basin	23	98.7
	$Q_{10} = 0.048\ DA^{0.94}\ APX^{1.02}$	All of area except for streams tributary to W. Br. Susquehanna River downstream from Sinnemahoning Creek Sinnemahoning Creek is included	15	99.2
Mean November	$Q_{11} = 0.049\ DA^{1.00}\ E^{0.11}\ APX^{1.16}$	Pine Creek basin	19	99.2
	$Q_{11} = 0.030\ DA^{0.97}\ APX^{1.32}$	All of area except for Pine Creek basin	18	98.9
Mean December	$Q_{12} = 0.070\ DA^{1.00}\ APX^{1.07}$	Bald Eagle Creek and Juniata River basins	13	99.5
	$Q_{12} = 0.139\ DA^{0.94}\ APX^{0.96}$	All of area except for Bald Eagle Creek and Juniata River basins	9	99.8
Mean January	$Q_1 = 0.075\ DA^{1.03}\ E^{-0.10}\ APX^{1.03}$	All	17	99.3
Mean February	$Q_2 = 0.277\ DA^{0.99}\ APX^{0.69}$	Do.	16	99.3
Mean March	$Q_3 = 0.678\ DA^{1.02}\ E^{0.32}\ APX^{0.48}$	Do.	15	99.4
Mean April	$Q_4 = 0.596\ DA^{1.03}\ E^{0.42}\ APX^{0.45}$	Do.	14	99.5
Mean May	$Q_5 = 0.246\ DA^{1.01}\ E^{0.20}\ APX^{0.69}$	Do.	17	99.4
Mean June	$Q_6 = 0.230\ DA^{0.99}\ APX^{0.58}$	All of Juniata River basin in area except for Little Juniata River basin	16	99.4
	$Q_6 = 0.073\ DA^{1.00}\ APX^{0.99}$	West Branch Susquehanna River basin and Little Juniata River basin	24	98.4
Mean July	$Q_7 = 0.002\ DA^{1.06}\ APX^{1.97}$	All of Juniata River basin in area except for Little Juniata River basin	29	98.3
	$Q_7 = 0.041\ DA^{1.00}\ APX^{0.97}$	West Branch Susquehanna River basin and Little Juniata River basin	20	98.7
Mean August	$Q_8 = 0.001\ DA^{1.08}\ APX^{1.95}$	Frankstown Branch Juniata River basin	34	98.1
	$Q_8 = 0.008\ DA^{1.06}\ E^{-0.48}\ APX^{1.35}$	All of Juniata River basin in area except for Frankstown Branch Juniata River basin	23	98.6
	$Q_8 = 0.020\ DA^{1.05}\ APX^{1.07}$	West Branch Susquehanna River basin	22	98.7
Mean September	$Q_9 = 0.519\ DA^{0.96}\ E^{0.48}$	West Branch Susquehanna River basin and Little Juniata River basin	27	97.9
	$Q_9 = 0.005\ DA^{0.99}\ E^{-0.40}\ APX^{1.67}$	All of Juniata River basin in area except for Little Juniata River basin	18	99.1

[1]Terminology defined in text.

Peak Flow Data Available for Gaged and Ungaged Streams

Peak discharges at specified exceedance probabilities can be computed from flood records at gaging stations. Regression equations can be used to estimate peak discharges for ungaged streams.

Recorded peak discharges at gaging stations can be used to compute peak flows at various exceedance probabilities. Exceedance probabilities commonly used are 50, 10, 4, 2, and 1 percent, although other exceedance-probability floods may be computed. Exceedance probability is defined as the probability or chance that a given flood peak will be greater than a given value. Exceedance probability is the reciprocal of recurrence interval. An exceedance probability of 4 percent is analogous to a recurrence interval of 25 years. A flood with a recurrence interval of 25 years would be expected to be exceeded at intervals averaging 25 years. Thus, it is entirely possible for floods exceeding the 25-year flood to occur in successive years, or even in the same year. Table 9.4-1 contains peak-flow statistics for 26 gaged streams in Area 1. Peak flows at some of the lower exceedance probabilities (higher recurrence intervals) were not computed for stations 100, 105, 107, 111, and 135 because their periods of record were not sufficiently long.

Flippo (1977) and Herb (1977) developed regression equations for estimating floods at selected exceedance probabilities for Pennsylvania streams. Some of their equations are applicable to ungaged, unregulated streams in Area 1. The equations developed by Flippo use basin and climatic characteristics as the independent variables, while those equations developed by Herb use channel characteristics.

Flippo (1977) presents equations for flood-peak estimation at exceedance probabilities of 43, 10, 4, 2, and 1 percent. These equations are applicable only in the flood-frequency regions of Area 1 shown in figure 9.4.1-1. Note that region 6 has separate equations for basins having drainage areas in two size classes and region 8 occurs in scattered locations across the area. Herb (1977) presents equations for flood-peak estimation at exceedance probabilities of 99, 50, 20, 10, 4, and 2 percent for both Valley and Ridge and Appalachian Plateau streams (fig. 9.4.1-1).

Flippo indicates that his equations are applicable to unregulated, nonurban streams having drainage areas larger than 2 square miles. He also cautions about the use of the equations in basins that have been extensively strip mined. Such basins may produce anomalously low flood peaks. Herb indicates that his equations are applicable to unregulated, forested watersheds having drainage areas between 2 and 300 mi^2. The applicability of Herb's equations in extensively strip-mined basins is unknown. For more discussion of limitations and applications of the aforementioned equations please refer to Flippo (1977) and Herb (1977).

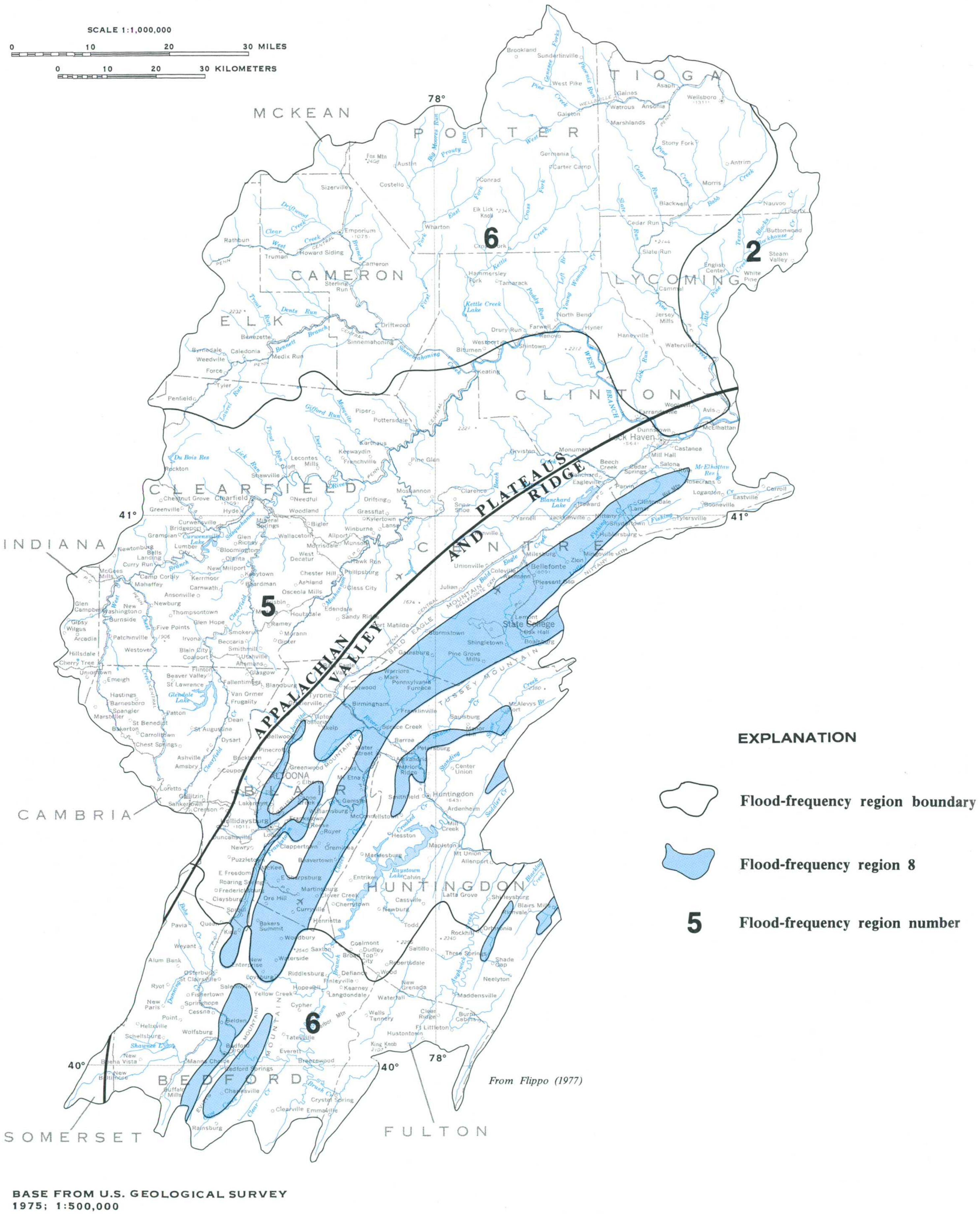

Figure 9.4.1-1 Flood-frequency regions in Area 1.

Table 9.4-1 Peak discharges at selected exceedance probabilities for continuous gaging stations in Area 1.

Station reference number	Discharge at specified exceedance probability (ft^3/s) — Exceedance probability (percent) 43	10	4	2	1	Drainage area (mi^2)
12	8,210	14,000	18,300	22,000	26,200	315
20	328	585	762	908	1,066	6.77
41	8,360	13,400	16,500	19,000	21,600	371
51	1,600	2,830	3,590	4,190	4,800	68.8
82	218	442	637	822	1,048	5.24
87	9,330	19,900	28,300	36,000	45,000	272
90	19,400	39,800	55,500	69,300	85,300	685
94	3,860	8,120	11,600	14,800	18,500	136
100	650	2,100	-	-	-	46.2
103	683	1,550	2,380	3,200	4,200	872
104	1,920	3,538	6,181	9,204	13,514	142
105	4,770	10,400	15,200	-	-	265
107	1,160	2,770	4,300	-	-	44.1
111	340	778	-	-	-	12.2
112	3,020	6,485	8,428	9,810	11,123	152
119	12,400	25,000	35,300	44,900	56,400	604
120	2,070	4,040	5,490	6,730	8,120	37.7
129	7,300	12,900	16,500	19,400	22,500	291
132	1,660	3,230	4,310	5,210	6,190	44.1
133	5,380	11,500	17,200	23,000	60,000	220
134	15,200	29,900	41,700	52,400	65,200	816
135	325	743	-	-	-	5.28
136	4,250	6,770	8,160	9,200	10,300	172
138A	14,600	26,500	34,600	41,300	48,600	756
142	15,200	22,320	24,153	25,067	25,720	957
145	6,760	14,200	19,900	25,000	30,900	205

Flood-Prone Area Maps Available for Area

Flood-prone area maps are available for 115, 7½-minute topographic maps in Area 1.

The National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 established programs for identifying towns and other areas subject to flood problems and for outlining flood-prone areas on topographic maps by approximate methods. In 1968 the Geological Survey began delineating flood-prone areas of the maximum known flood on 7½-minute topographic quadrangle maps using existing information. After 2 years it was decided that areal uniformity of the flood delineated would be desirable, so the 100-year flood (1-percent exceedance probability flood) was selected for mapping in 1970.

As of 1980, the area inundated by the 100-year flood had been delineated for selected streams on 115 of the 177 7½-minute topographic quadrangle maps covering Area 1. The delineations were based upon existing flood-depth data and flood depths estimated from the area's flood hydrology. Flood-prone maps within or partially within Area 1 are indicated by shading on figure 9.4.2-1, which also shows the names and locations of all 7½-minute topographic quadrangle maps in the area.

Copies of the flood-prone area maps for Area 1 may be obtained from:

U.S. Geological Survey
Water Resources Division
P.O. Box 1107
Harrisburg, Pennsylvania 17108-1107

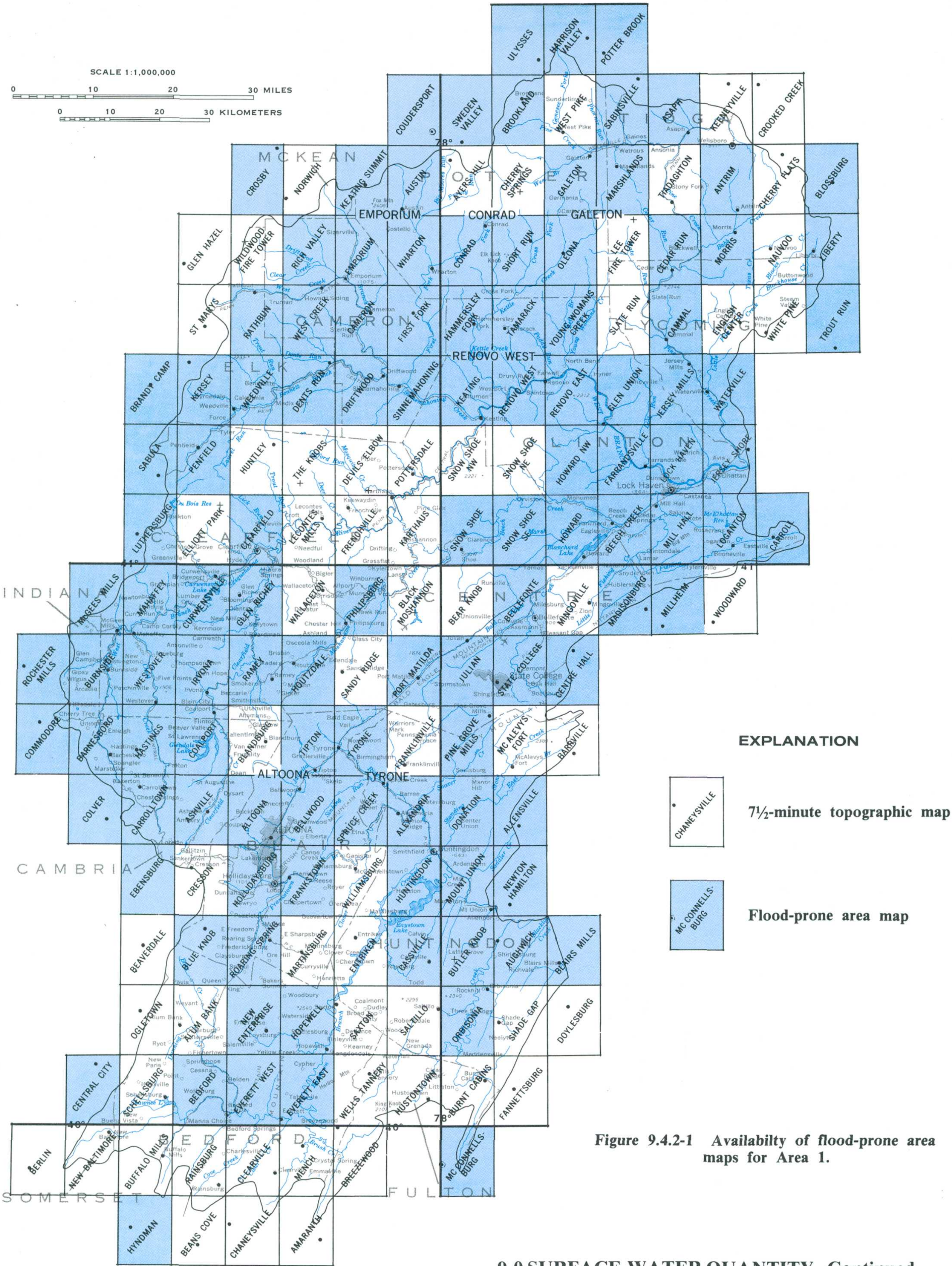

Figure 9.4.2-1 Availabilty of flood-prone area maps for Area 1.

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1975; 1:500,000

Flow-Duration Data Available for Gaged and Ungaged Streams

Recorded daily discharges are used to compute flow-duration data for gaging stations. A simple graph and knowledge of a stream's drainage area can be used to estimate flow-duration data for ungaged streams.

Figure 9.5-1 presents flow-duration curves for four stations on unregulated streams in Area 1. Similar curves or data tabulations can be made for any gaging station. A flow-duration curve is a cumulative frequency curve that shows the percentage of time a specified discharge was exceeded during a specified period (Searcy, 1959). The flow-duration curve depicts the flow characteristics of a stream over a wide range of discharges without any consideration of the sequence of flows.

A flow-duration curve is useful for more than simply depicting flow characteristics. If the period of record used in developing the curve is representative of long-term conditions, a flow-duration curve can be used in conjunction with the proper transport curve to compute loads of water-borne constituents such as suspended sediment or dissolved solids.

Using figure 9.5-1 to find the flow-duration of a specified discharge, extend a horizontal line from one of the vertical axes until it intersects the curve for the station of interest. Then drop a vertical line to the lower horizontal axis and read the flow-duration percentage. To find the discharge associated with a specific flow-duration, extend a vertical line from the lower horizontal axis to its intersection with the curve for the stream of interest. A horizontal line extended from that point will intersect one of the vertical axes at the desired discharge. The blue line in figure 9.5-1 indicates that for station 145, the discharge at a flow duration of 50 percent is about 100 cubic feet per second.

Flow duration curves can be estimated for ungaged, unregulated streams in Area 1 by a simple, graphical procedure. Figure 9.5-2 is a composite unit flow-duration curve where unit discharge is plotted against exceedance probability. Such a method of presentation allows the comparison of flow durations among streams having different drainage areas. The shaded part of the figure demonstrates the range of unit flow-duration data at the seven selected stations. The mean of the unit discharges is given by the heavy line within the shaded area.

Figure 9.5-2 can be used in the following manner:

1. Find the unit discharge that corresponds to an exceedance probability of 10 percent.

A. Extend a vertical line upward from the 10-percent point on the lower x-axis to its intersection with the mean unit discharge curve within the shaded part of figure 9.5-2.

B. Read the corresponding unit discharge, 3.7 $(ft^3/s)/mi^2$, on the y-axis.

2. This can be interpreted to mean that a unit discharge of 3.7 $(ft^3/s)/mi^2$ is exceeded 10 percent of the time.

Figure 9.5-2, in combination with a knowledge of an ungaged stream's drainage area can be used to estimate points on a flow-duration curve. As an example, we will compute the points on a flow-duration curve for a stream having a drainage area of 10 mi^2 (square miles). The mean unit flow-duration curve in figure 9.5-2 gives unit discharges of 8.9, 2.3, 0.84, 0.29, and 0.094 $(ft^3/s)/mi^2$ at exceedance probabilities of 2, 20, 50, 80, and 98 percent, respectively. Multiplying these unit discharges by the drainage area of 10 mi^2 gives discharges of 89, 23, 8.4, 2.9, and 0.94 cubic feet per second at the specified points on the flow-duration curve.

The composite flow-duration curve was constructed using computed unit flow-duration data from seven streams in or near Area 1 having drainage areas ranging from 5.2 to 69 mi^2. Because of the relatively small sample size used in developing the curve its reliability is unknown. The width of the shaded part of the figure gives some indication of the uncertainty in estimates using the procedure. Searcy (1959) presents an alternate method of developing unit flow-duration curves, however, Searcy's method requires a knowledge of the stream's mean flow before an estimate can be made. The procedure outlined herein can be used for flow-duration estimates until a better system is developed.

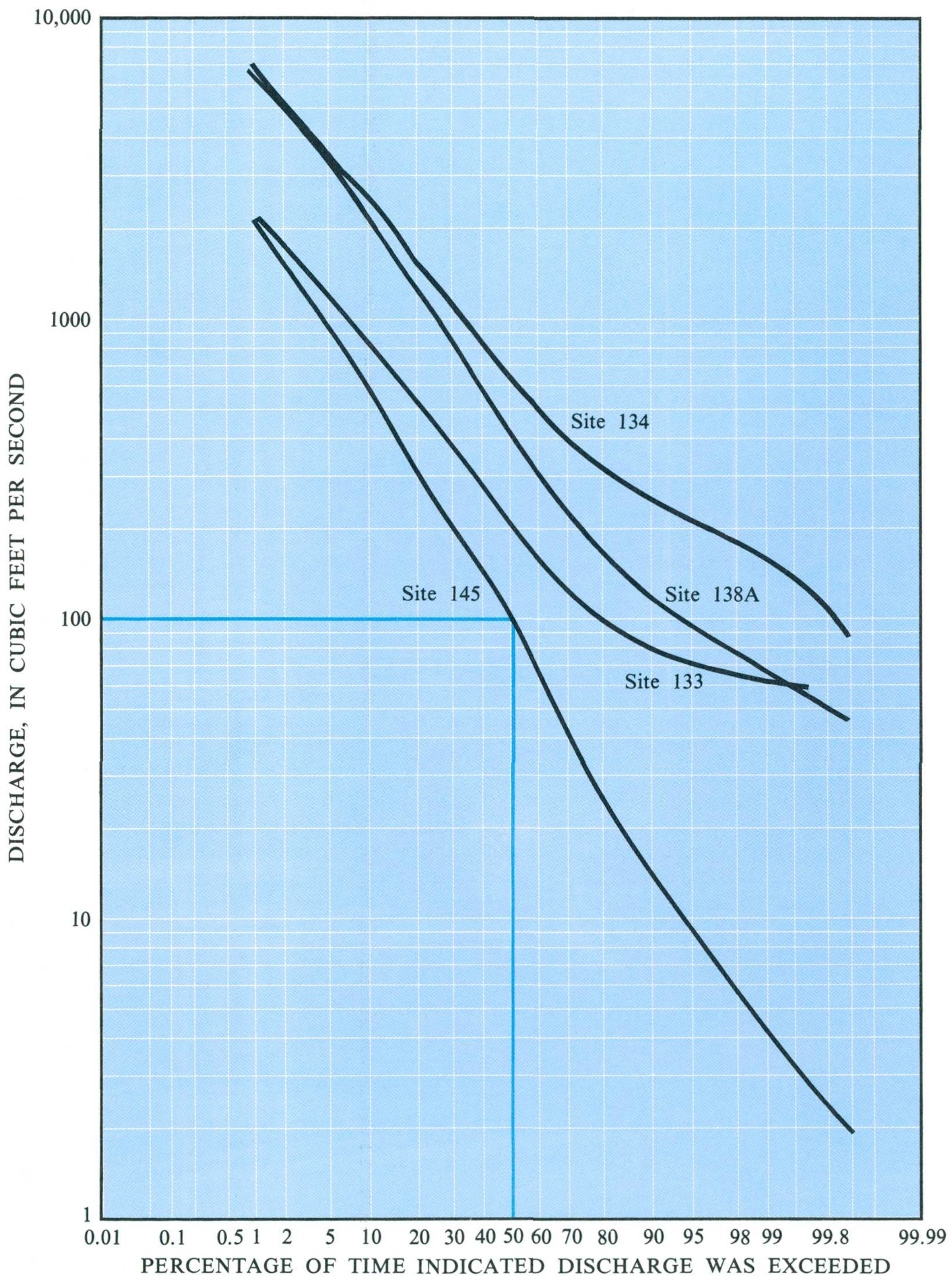

Figure 9.5-1 Flow-duration curves for gaged sites in Area 1.

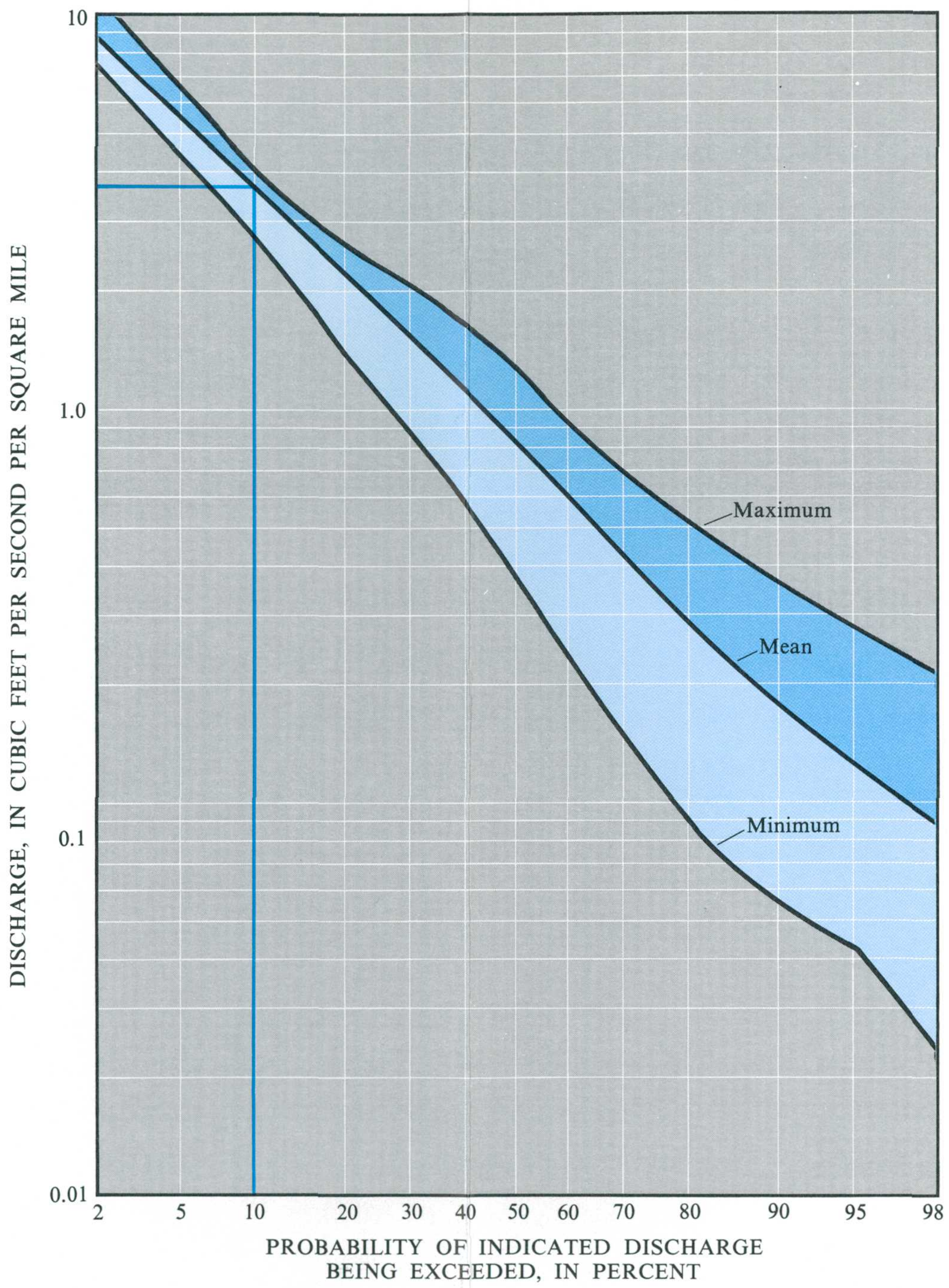

Figure 9.5-2 Composite unit flow-duration curves for streams in Area 1.

Recharge Is from Local Precipitation and Movement Is Toward Nearby Stream Valleys

Aquifers in both the Appalachian Plateaus and Valley and Ridge provinces obtain most recharge from direct precipitation on the outcrop areas. Water moves from upland areas through fractures, bedding planes, and solution openings to discharge points in valleys.

Precipitation is the source of fresh ground water in both the Appalachian Plateaus and Valley and Ridge physiographic provinces (Fenneman, 1938) (fig. 10.1-1) of Area 1. About one-half the precipitation returns to the atmosphere as evaporation and transpiration. The other half enters streams either as direct runoff, or infiltrates into the ground-water reservoir. Some of the ground water may appear as stream baseflow.

Seepage of rain and snowmelt through soil and rock recharges the ground-water reservoir. Some recharge may also occur from streams where the water level in underlying aquifers is lower than that of the stream. Comparisons between total streamflow and dry-weather streamflow indicate that about 30 percent of the average annual precipitation enters the ground-water reservoir as recharge. In carbonate-rock terrane recharge can be as much as 45 percent of precipitation.

Ground water moves continuously down the hydraulic gradient, through and across aquifers, to areas of discharge. Rates of movement vary from a few feet to a few tens of feet per year, and depend on both the hydraulic gradient and the permeability of the rock. Very permeable rocks, such as well-sorted sand, highly fractured sandstone, and limestone or other rocks having cavities enlarged by solution, transmit water readily through interconnected openings. Rocks of low permeability, such as shale or low fracture-density sandstone, limestone, and siltstone, do not transmit water readily. Dense, unfractured bedrock and clay transmit little or no water, and are considered impermeable.

Most ground water moves from topographically high terrain through fractures and along bedding surfaces to nearby stream valleys (fig. 10.1-2). In the Appalachian Plateaus, some water may move beneath local valleys and hills to more distant major stream valleys (fig. 10.1-2A). Fresh ground-water movement is generally restricted to depths less than 150 to 300 feet beneath the land surface in valleys. Salinity of the water increases rapidly below these depths.

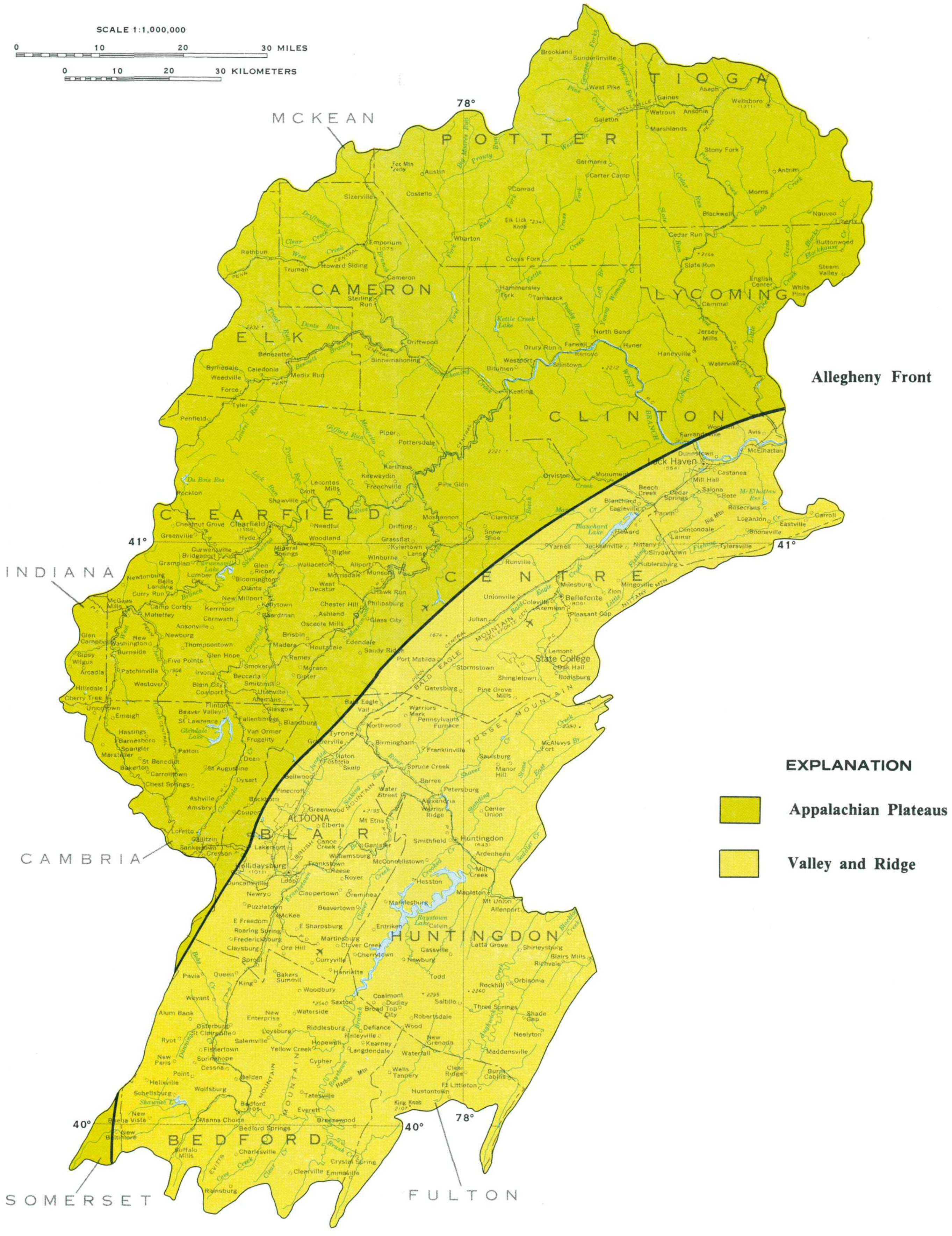

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Figure 10.1-1 Physiographic provinces.

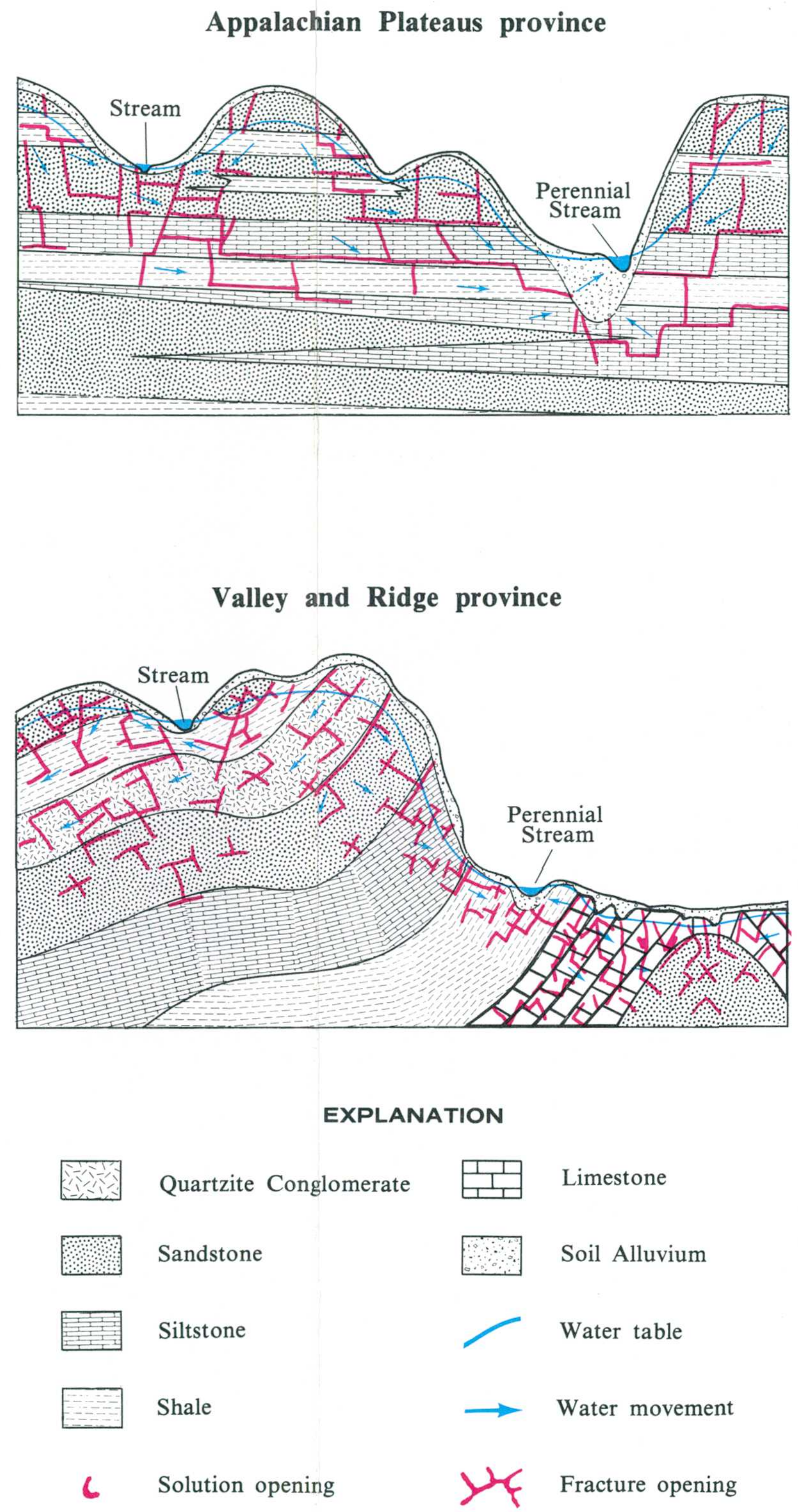


Figure 10.1-2 Ground-water movement.

Ground-Water Levels in Area Fluctuate Seasonally

The annual cycle of ground-water level fluctuations in Area 1 results from seasonal changes in the rate of recharge into, and discharge from, the ground-water reservoir.

Water levels in Area 1 vary in an annual cycle. The highest water levels occur during spring in response to recharge from precipitation and snowmelt on thawed ground. From this time a general decline in water level continues until fall, because discharge to streams and evapotranspiration losses exceed recharge. In fall, water levels begin to rise again as plant growth ceases and soil moisture deficits are replenished.

Water-level fluctuations in hillside wells BD-150 and CN-1 (fig. 10.2-1) are representative of variations in shale and sandstone wells, respectively. In general, water levels are deepest and show the greatest fluctuations under hills, and are shallowest and show the least fluctuations in valleys. Wells that penetrate multiple water-bearing zones have water levels that are composites of the levels in all zones. These levels may be greater or less than expected on the basis of topographic location. Water levels are not predictable except in shallow wells over short distances. Water levels in observation well CE-118 (fig. 10.2-1) illustrate delayed recharge to a carbonate aquifer that underlies a thick, unsaturated overburden material in the Valley and Ridge province.

Continuous water-level measurements are currently being made in seven wells in Area 1 (fig. 10.2-2). Records for these wells may be obtained from:

U.S. Geological Survey
P.O. Box 1107
4th Floor Federal Building
228 Walnut Street
Harrisburg, Pennsylvania 17108-1107

These water-level data are also published annually by the U.S. Geological Survey in "Water Resources Data for Pennsylvania, Volume 2, Susquehanna and Potomac River Basins."

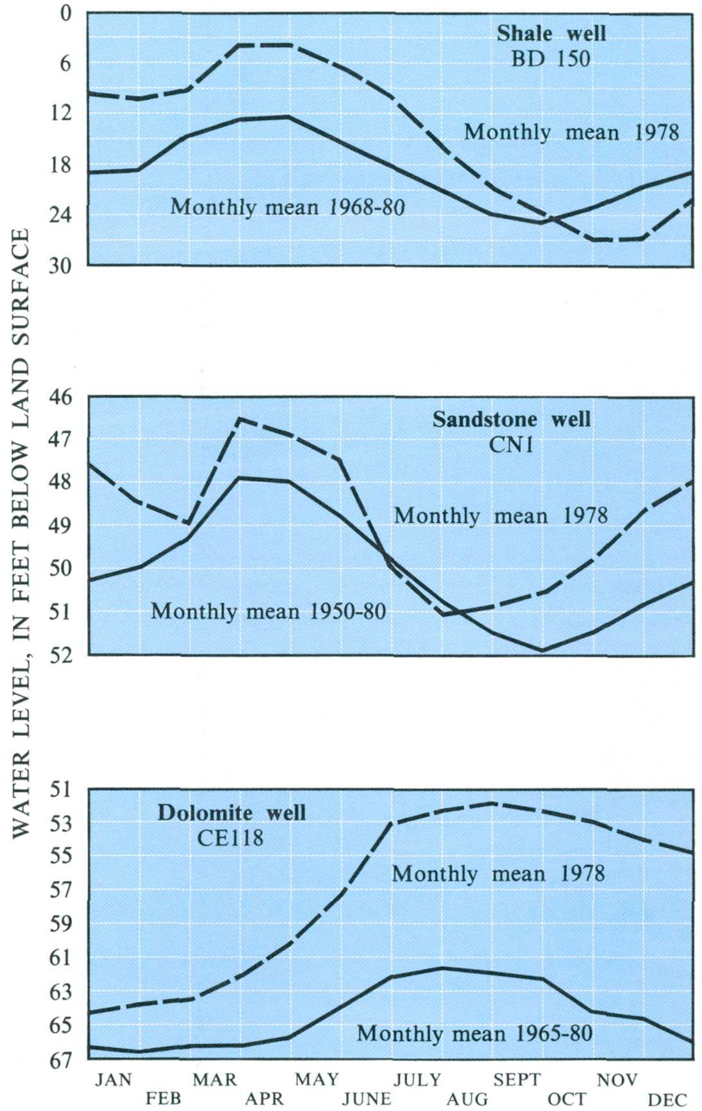
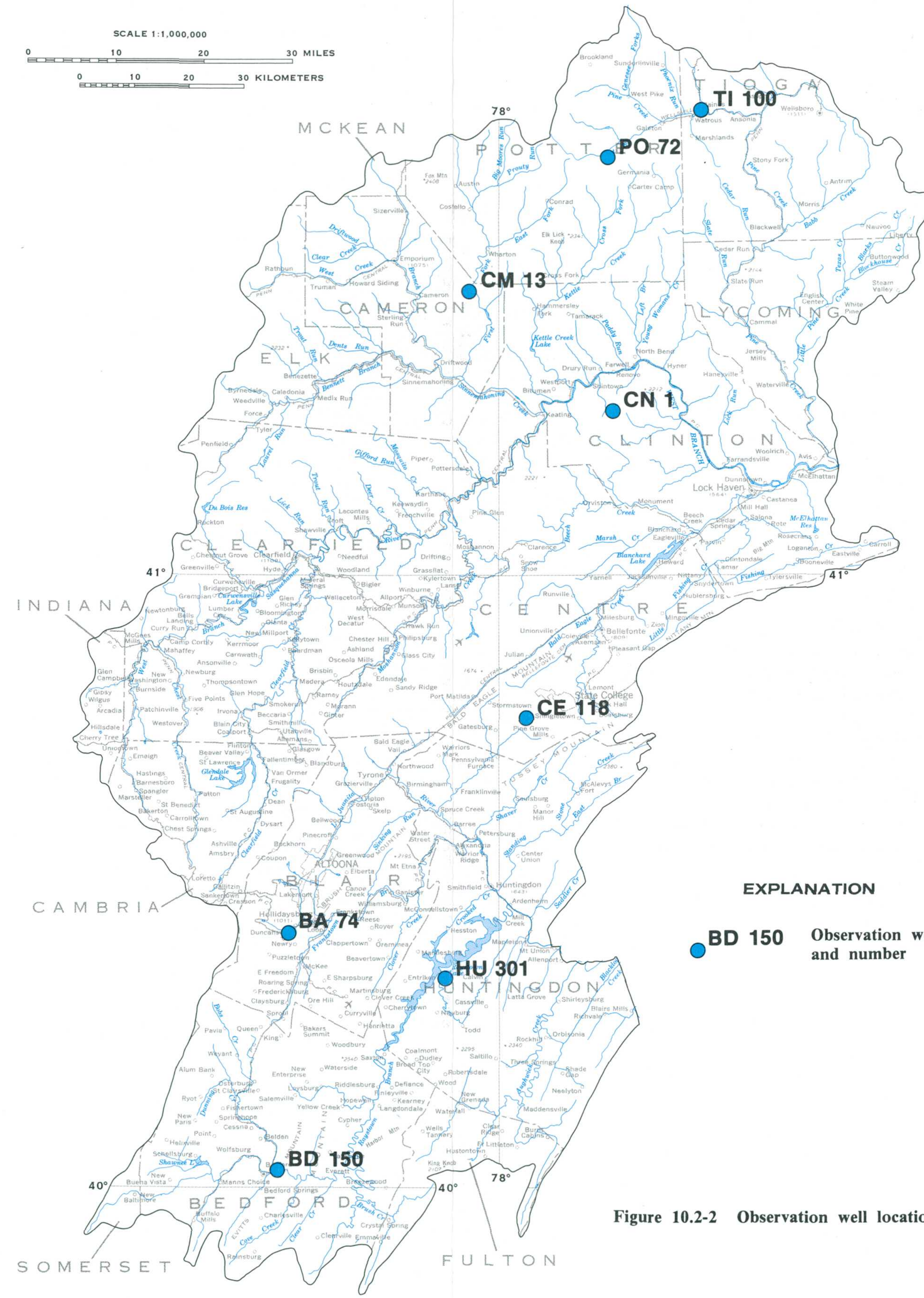


Figure 10.2-1 Water levels in selected observation wells.



EXPLANATION

BD 150 Observation well and number

Figure 10.2-2 Observation well locations.

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Rock Type Generally Determines Water-Bearing Characteristics of Area Aquifers

Maximum well yields from coal-bearing rocks range from 30 to 160 gallons per minute. Maximum yields for wells in other rocks range from 50 gal/min in shale to 2,200 gal/min in dolomite.

Four different sources provide ground-water supplies in the Appalachian Plateaus part of Area 1. A major source in the southern part of the Plateaus is the coal-bearing rocks of the Conemaugh, Allegheny, and Pottsville Formations or Groups (fig. 10.3-1). Wells in these rocks generally yield adequate domestic supplies, and have a median yield of 15 gal/min (gallons per minute) (table 10.3-1). Mississippian-age sandstone formations are a second source of ground water in the central and northern parts of the Plateaus (fig. 10.3-1). Wells in these sandstones have a median yield of 35 gal/min (table 10.3-1). A third source of supply is in interbedded shale, siltstone, and sandstone rocks in the northern part of the Plateaus (fig. 10.3-1). Yields from wells in these rocks are generally less than from those in other rocks in the area, and have a median of 10 gal/min (table 10.3-1). Saturated river and glacial outwash, sand, and gravel deposits in some stream valleys may yield as much as 350 gal/min to wells (table 10.3-1). These deposits range in thickness from a few feet to 100 feet, but are of small areal extent. The general locations of such deposits are shown in figure 10.3-2.

Ground-water supplies are obtained from more than 40 formations of diverse water-bearing properties in the Valley and Ridge province of Area 1. Formations composed of similar rock types have similar properties. Wells in shale and shaley limestone yield the least water, and wells in dolomite yield the most water (table 10.3-1).

Ground-water availability in all bedrock aquifers is not only a function of rock type, but also of topography; size and frequency of bedding, fracture, and solution openings; and the character and thickness of over-burden material. Water levels may be above land surface or as deep as 90 feet in Plateau wells and 300 feet in Valley and Ridge wells. Most wells have water levels from a few feet to 50 feet below land surface.

Table 10.3-1 Well yields in Area 1.

Source	Yield (gallons per minute) Median	Maximum
Conemaugh Group or Formation	12	30
Allegheny Group or Formation	15	150
Pottsville Group or Formation	15	160
Appalachian Plateaus province		
Alluvium and glacial outwash	15	350
Mississippian and Devonian sandstone	35	200
Devonian interbedded shale, silstone, and sandstone	10	55
Valley and Ridge province		
Mississippian and Devonian sandstone	17	550
Devonian and Ordovician interbedded shale, sandstone, and limestone	5	50
Mississippian and Silurian interbedded shale, sandstone, and limestone	10	315
Silurian and Ordovician quartzite and conglomerate	20	200
Ordovician limestone	5	50
Ordovician and Cambrian dolomite	50	2,200

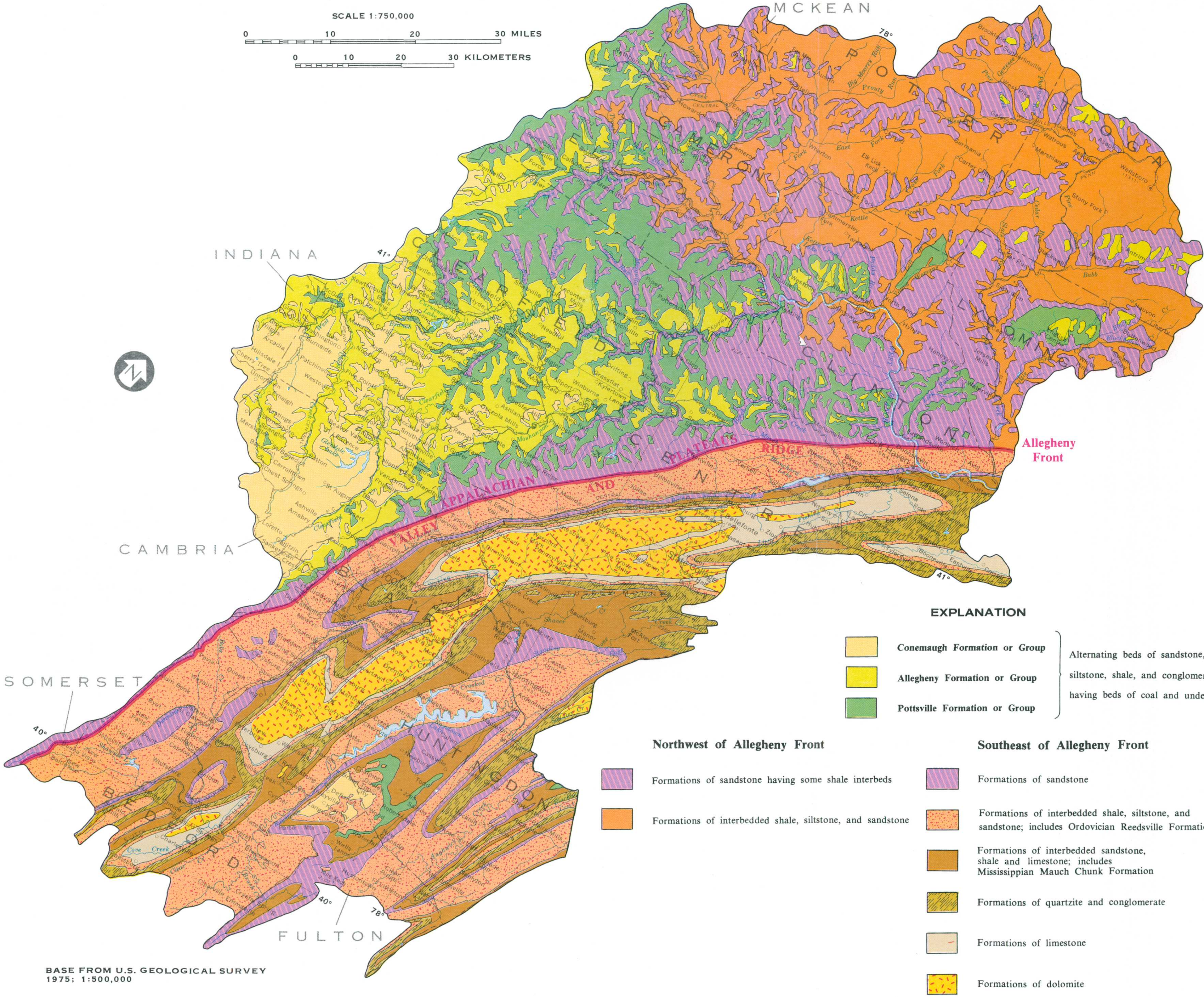

Figure 10.3-1 Geology.

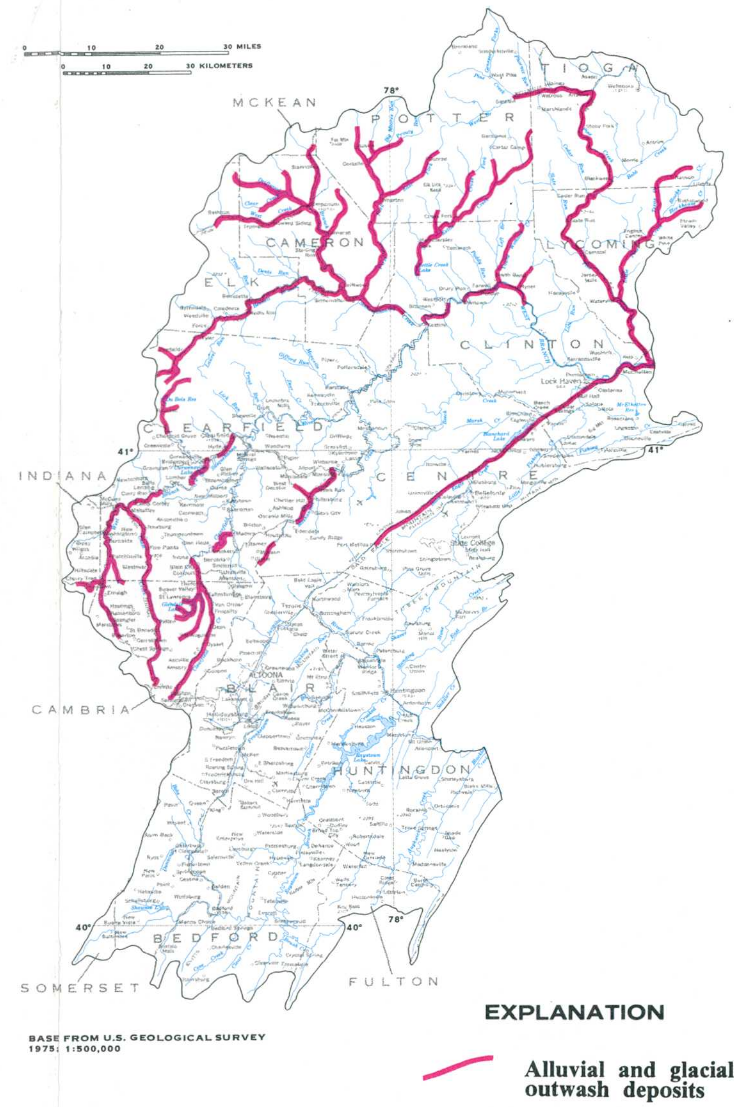

Figure 10.3-2 Alluvial and glacial outwash deposits.

Ground Water Varies in Chemical Composition But Is Generally Suitable for Most Uses

Concentrations of chemical constituents in ground water vary among rock units, but are generally low with the exceptions of iron and manganese. Ground water is generally suitable for most uses.

The quality of ground water in Area 1 is good, although some problems related to the mineralogy of the rocks do exist. Contaminants introduced to the ground-water system by man's activities cause no general problems in the area. Coal mining has increased the concentrations of iron and manganese in some ground-water samples, but these metals may also be found in undesirable quantities in ground water from noncoal-bearing rocks. Table 10.4-1 summarizes the quality of water in the area. Sections 12.2 - 12.4 provide a more detailed summary by rock units or groups of rock units. The scant number of samples available for some constituents and rock units precludes an adequate characterization of ground-water quality in some locations.

Water from formations grouped as interbedded shale, sandstone, and siltstone, or limestone are of mixed type and have calcium, magnesium, sodium, bicarbonate, and sulfate as the dominant ions. The remaining rocks have water of the calcium-magnesium bicarbonate type. Water from limestone and dolomite units is moderately hard to very hard. Water in most of the other units has hardness ranging from soft to hard. The median dissolved solids concentration is less than 100 mg/L (milligrams per liter) for the Pottsville Group, greater than 400 mg/L for limestone units, and between 100 and 250 mg/L for the remaining rock units.

Water from Mississippian and Devonian sandstone and the coal-bearing Pottsville and Allegheny in the Appalachian Plateaus province has median iron concentrations in excess of the recommended 300 micrograms per liter limit for drinking water (U.S. Environmental Protection Agency, 1977). In the Valley and Ridge province the median iron concentration exceeds the recommended limit only for the interbedded shale, siltstone, and sandstone rock units.

Table 10.4-1 Summary of ground-water quality in Area 1.

Water quality constituent	Number of Samples	Minimum	Maximum
pH, in units	127	4.4	8.6
Total arsenic, in µg/L	153	0	<10
Total aluminum, in µg/L	205	0	12,000
Alkalinity as Ca CO_3, in mg/L	239	4	328
Dissolved chloride, in mg/L	199	.3	1,250
Total chromium, in µg/L	155	0	110
Dissolved solids, in mg/L	178	10	3,780
Total Fluoride, in mg/L	178	0	73
Hardness as Ca CO_3, in mg/L	233	10	1,100
Total iron, in µg/L	220	0	52,000
Total lead, in µg/L	157	0	180
Total manganese, in µg/L	213	0	5,100
Dissolved magnesium, in mg/L	175	.1	77
Total nickel, in µg/L	152	0	80
Total nitrogen as ammonia, in mg/L	205	0	9.7
Total nitrogen as nitrite, in mg/L	146	<.002	.017
Total nitrogen as nitrate, in mg/L	198	0	11
Total potassium, in mg/L	163	.02	18
Total sodium, in mg/L	168	.1	764
Dissolved sulfate, in mg/L	234	1	659
Total zinc, in µg/L	159	5	5,000
Dissolved calcium, in mg/L	188	1.7	489
Total organic carbon, in mg/L	113	0	24
Total cadmium, in µg/L	155	0	5

[1]More detailed information in appendixes 2-4.

NAWDEX, WATSTORE, OWDC Have Water Data Information

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

Within the U.S. Geological Survey there are three activities that help to identify and improve access to the vast amount of existing water data.

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

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

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

A more detailed explanation of these three activities is given in sections 11.2, 11.3, and 11.4.

NAWDEX Simplifies Access to Water Data

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

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

Services are available through a Program Office located at the U.S. Geological Survey's National Center in Reston, Virginia, and a nationwide network of Assistance Centers located in 45 States and Puerto Rico, which provide local and convenient access to NAWDEX facilities (see fig. 11.2-1). A directory is available on request that provides names of organizations and persons to contact, addresses, telephone numbers, and office hours for each of these locations [Directory of Assistance Centers of the National Water Data Exchange (NAWDEX), U.S. Geological Survey Open-File Report 79-423 (revised)].

NAWDEX can assist any organization or individual in identifying and locating needed water data and referring the requester to the organization that retains the data required. To accomplish this service, NAWDEX maintains a computerized Master Water Data Index (fig. 11.2-2), which identifies sites for which water data are available, the type of data available for each site, and the organization retaining the data. A Water Data Sources Directory (fig. 11.2-3) also is maintained that identifies organizations that are sources of water data and the locations within these 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 the exchange of services with others.

Charges for NAWDEX services are assessed at the option of the organization providing the requested data or data service. Search assistance services are provided free by NAWDEX to the greatest extent possible. Charges are assessed, however, for those requests requiring computer cost, extensive personnel time, duplicating services, or other costs encountered by NAWDEX in the course of providing services. In all cases, 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 upon request and in all cases where costs are anticipated to be substantial.

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

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

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

Hours: 7:45-4:15 Eastern Time

or

U.S. Geological Survey
Water Resources Division
4th Floor, Federal Building
P.O. Box 1107
Harrisburg, Pennsylvania 17108

Telephone: (717) 782-3851
FTS 590-3851

Hours: 8:00-4:00 Eastern Time

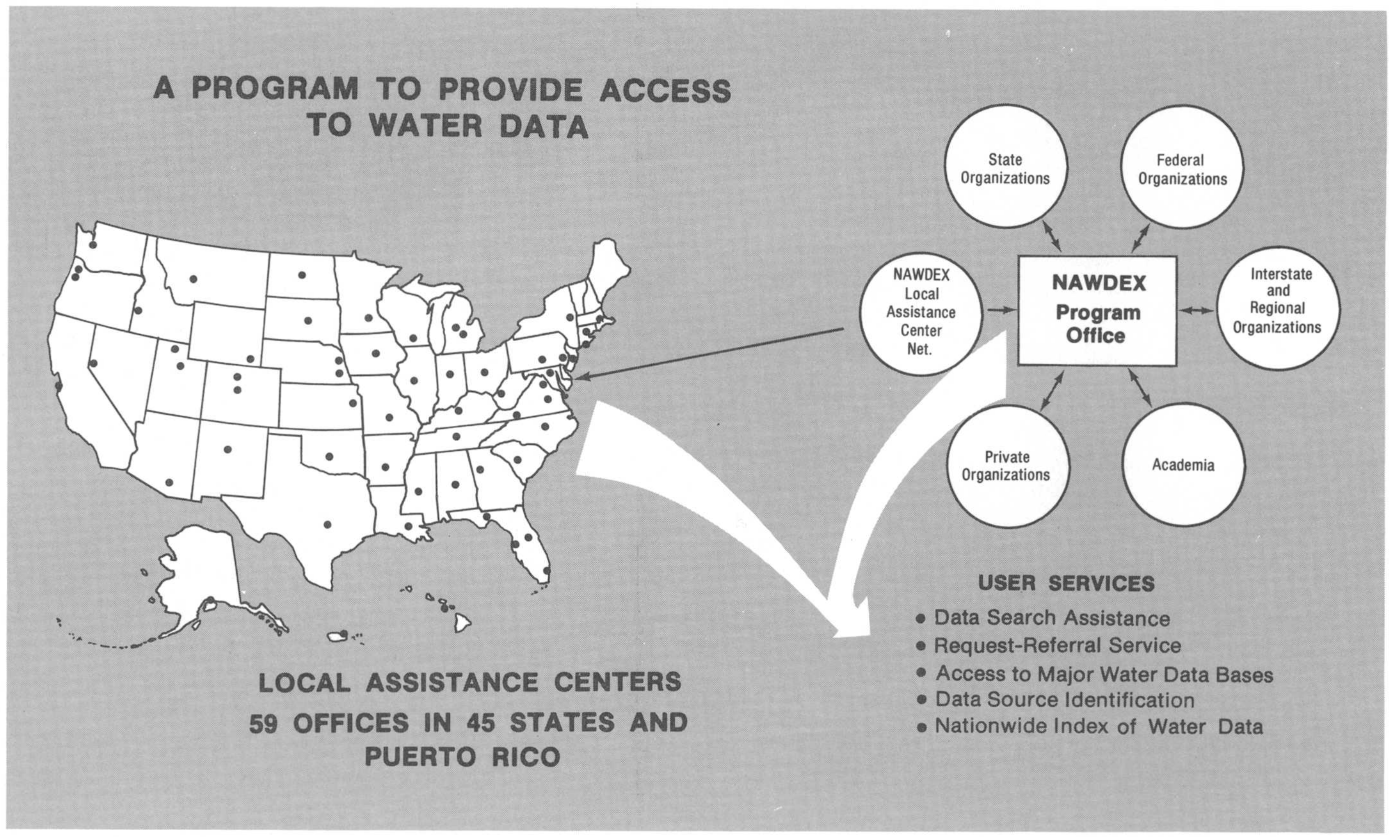

Figure 11.2-1 Access to water data.

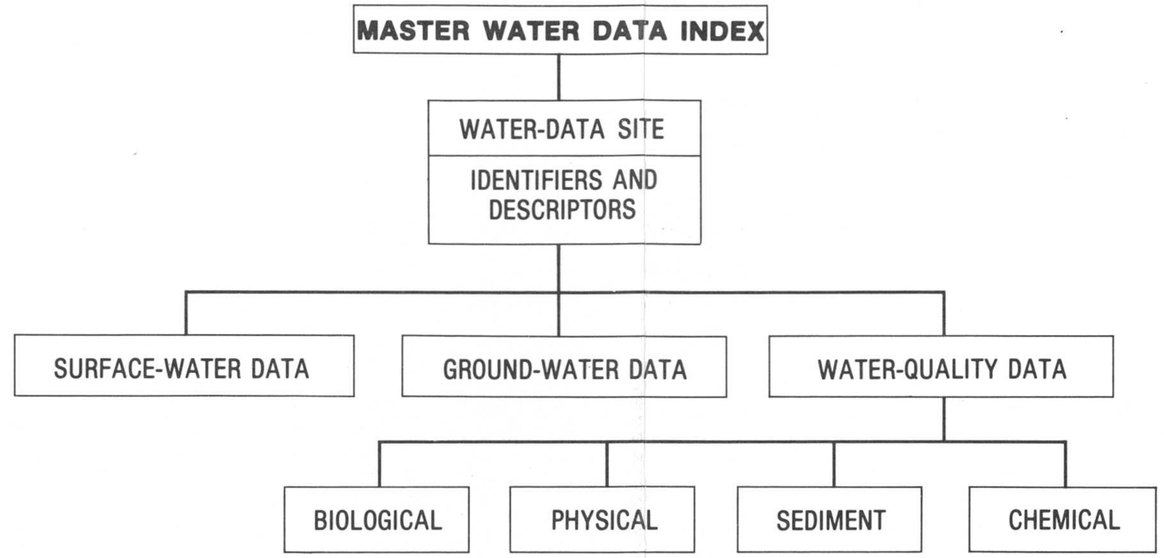

Figure 11.2-2 Master water-data index.

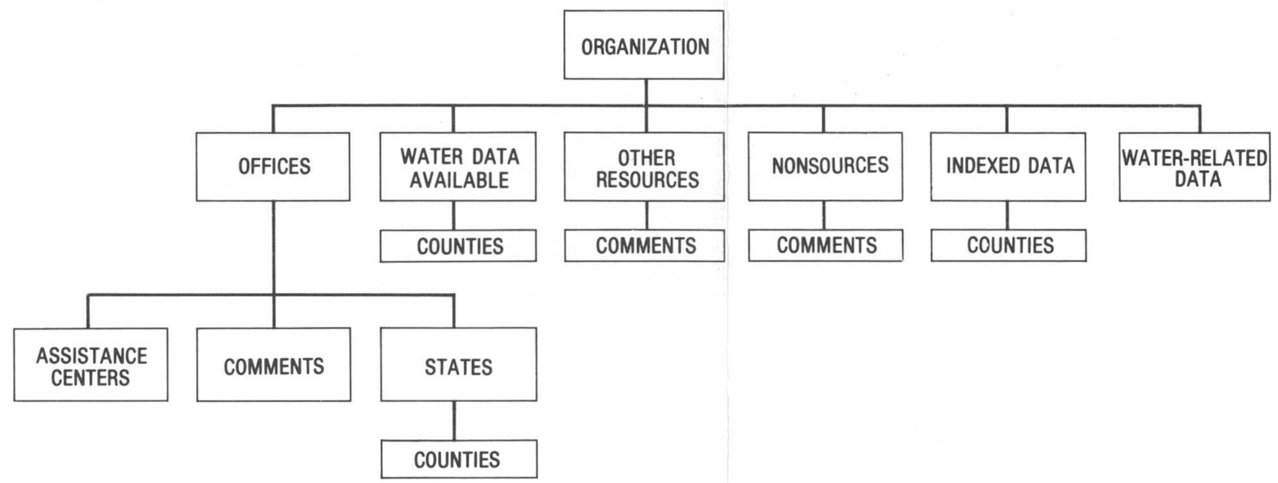

Figure 11.2-3 Water-data sources directory.

WATSTORE Automated Data System

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

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

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

or

U.S. Geological Survey
Water Resources Division
4th Floor, Federal Building
P.O. Box 1107
Harrisburg, Pennsylvania 17108

The Geological Survey currently (1980) collects data at approximately 16,000 streamgaging stations, 1,000 lakes and reservoirs, 5,200 surface-water quality stations, 1,020 sediment stations, 30,000 water-level observation wells, and 12,500 ground-water quality wells. Each year many water-data collection sites are added and others are discontinued; thus, large amounts of diversified data, both current and historical, are amassed by the Survey's data-collection activities.

The WATSTORE system consists of several files in which data are grouped and stored by common characteristics and data-collection frequencies. The system also is designed to allow for the inclusion of additional data files as needed. Currently, files are maintained for the storage of: (1) surface-water, quality-of-water, and ground-water data measured on a daily or continuous basis; (2) annual peak values for streamflow stations; (3) chemical analyses for surface- and ground-water sites; (4) water parameters measured more frequently than daily; and (5) geologic and inventory data for ground-water sites. In addition, an index file of sites for which data are stored in the system is also maintained (fig. 11.3-1). A brief description of each file is as 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 the identification, location, and physical description of nearly 220,000 sites.

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

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

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

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

Ground-Water Site-Inventory File: This file is maintained within WATSTORE, independent of the files discussed above, but it is cross-referenced to the Water-Quality File and the Daily Values File. It contains inventory data about wells, springs, and other sources of ground water. The data included are site location and identification, geohydrologic characteristics, well-construction history, and one-time field measurements such as water temperature. The file is designed to accommodate 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 retreived from WATSTORE at a number of locations that are part of a nationwide telecommunication network.

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

Digital Transmission Sites: Digital recorders are used at many field locations to record values for parameters such as river stages, conductivity, water temperature, turbidity, wind direction, and chlorides. Data are recorded on 16-channel paper tape, which is removed from the recorder and 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 national scale. Battery-operated radios are used as the communication link to the satellite. About 200 data relay stations are being operated currently (1980).

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

Water data are used in many ways by decision-makers for the management, development, and monitoring of our water resources. In addition to its data processing, storage, and retrieval capabilities, WATSTORE can provide a variety of useful products ranging from simple data tables to complex statistical analyses. A minimal fee, plus the actual computer cost incurred in producing 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 actual data or condensed indexes that indicate the availability of data stored in the files. A variety of formats is available to display the many types of data.

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

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

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

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

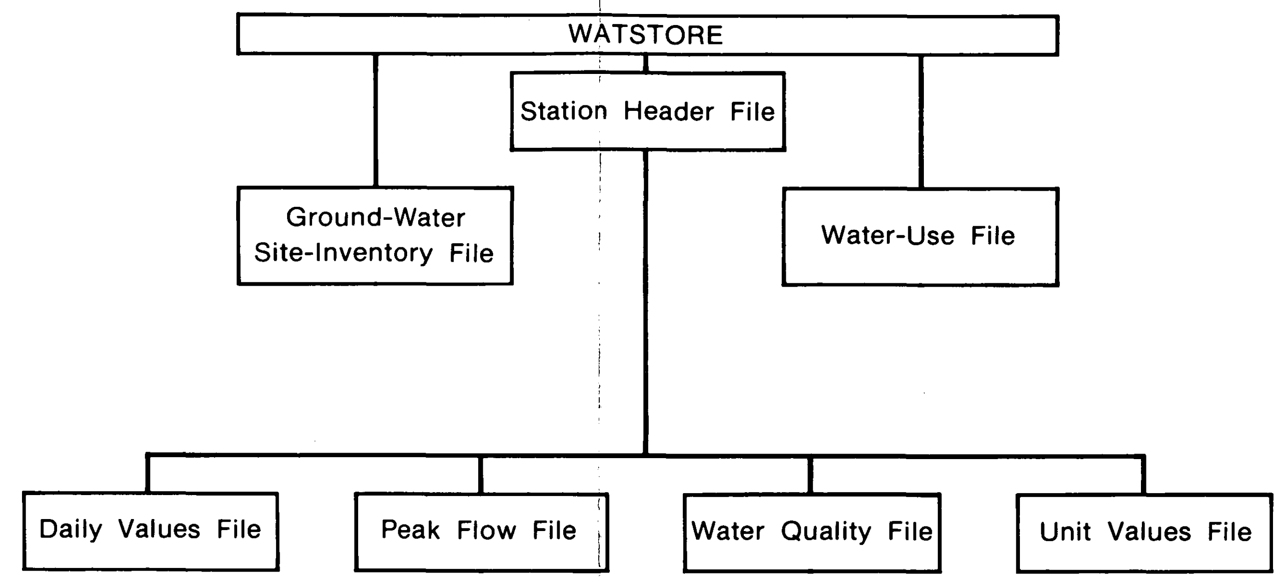

Figure 11.3-1 Index file stored data.

Water Data Index for Coal Provinces

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

The "Index to Water-Data Activities in Coal Provinces of the United States" was prepared to assist those involved in developing, managing, and regulating the Nation's coal resources by providing information on the availability of water-resources data in the major coal provinces of the United States. It is derived from the "Catalog of Information on Water Data", which is a computerized information file about water-data acquisition activities in the United States, and its territories and possessions, with some international activities included.

This special index consists of five volumes (fig. 11.4-1): Volume I, Eastern Coal province; Volume II, Interior Coal province; Volume III, Northern Great Plains and Rocky Mountain Coal provinces; Volume IV, Gulf Coast Coal province; and Volume V, Pacific Coast and Alaska Coal provinces. The information presented will aid the user in obtaining data for evaluating the effects of coal mining on water resources and in developing plans for meeting additional water-data needs. The report does not contain the actual data; rather, it provides information that will enable the user to determine if needed data are available.

Each volume of this 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) the identification and location of the station, (2) the major types of data collected, (3) the frequency of data collection, (4) the form in which the data are stored, and (5) the agency or organization reporting the activity. Part D summarizes areal hydrologic investigations and water-data activities not included in the other parts of the index. The agencies that submitted the information, agency codes, and the number of activities reported by type are shown in a table.

Those who need additional information from the Catalog file or who need assistance in obtaining water data should contact the National Water Data Exchange (NAWDEX) (See section 11.2).

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

U.S. Geological Survey
Water Resources Division
4th Floor, Federal Building
P.O. Box 1107
Harrisburg, Pennsylvania 17108

Telephone (717) 782-3851
FTS 590-3851

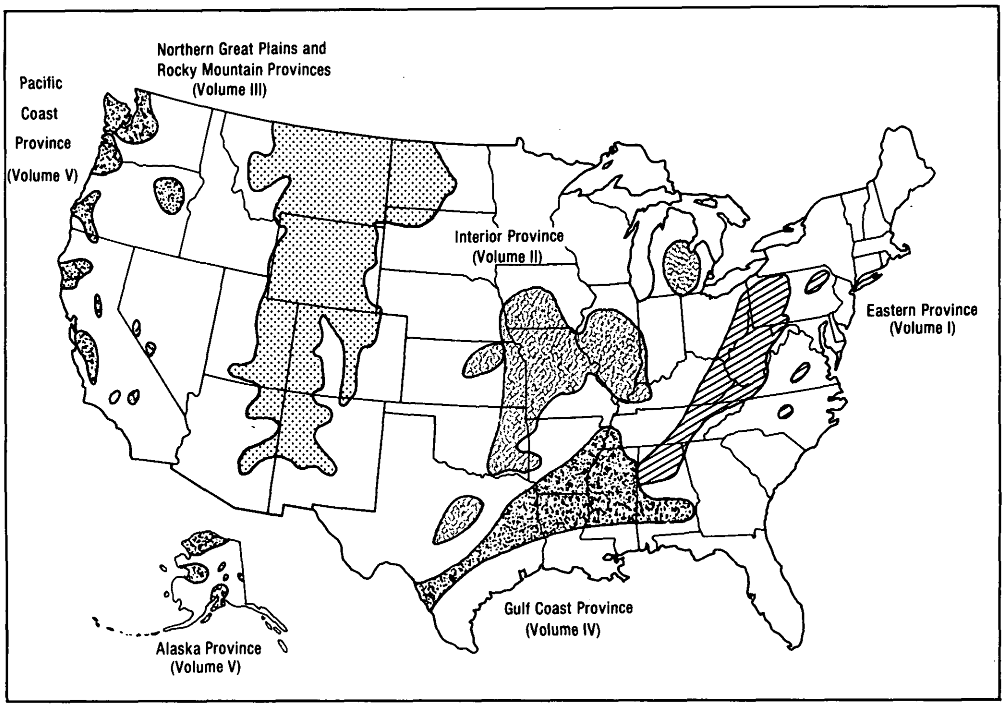

Figure 11.4-1 Index volumes and related provinces.

Table 12.1-1 Surface-water sites in Area 1

Reference[1] number	USGS station number	Station name	Drainage area (mi^2)	Latitude	Longitude	Surface-water records: Quantity: Station type[2]	Quantity: Record period	Quality: Station type[3]	Quality: Record period
1	01540590	Lesle Run near Carrolltown	7.7	403622	0784510	MI	6/79-8/80	SY,BI	6/79-8/80
2	01540592	W Br Susquehanna River near Spangler	7.81	403742	0784556	MI	6/79-8/80	SY,BI	6/79-8/80
3	01540595	Fox Run at Spangler	7.70	403819	0784604	MI	6/79-8/80	SY,BI	6/79-8/80
4	01540640	W Br Susquehanna River near Cherry Tree	41.3	404226	0784810	MI	6/79-8/80	SY,BI	6/79-8/80
5	01540710	Cush Creek near Glen Campbell	21.4	404951	0784727	MI	6/79-8/80	SY,BI	6/79-8/80
6	01540715	Chest Creek at Patton	44.5	403802	0783850	MI	6/79-8/80	SY,BI	6/79-8/80
7	01540720	Brubaker Run near Hastings	7.98	404215	0784135	MI	6/79-8/80	SY,BI	6/79-8/80
8	01540723	L Brubaker Run near Hastings	3.84	404221	0784142	MI	6/79-8/80	SY,BI	6/79-8/80
9	01540753	S Br Bear Run at McGees Mills	19.3	405301	0784556	MI	6/79-8/80	SY,BI	6/79-8/80
10	01540800	Wilson Run at Newburg	9.74	405005	0784040	MI	6/79-8/80	SY,BI	6/79-8/80
11	01540823	Chest Creek at Mahaffey	111	405206	0784314	MI	6/79-8/80	SY,BI	6/79-8/80
12	01541000	W Br Susquehanna River at Bower	315	405349	0784038	CR	10/13-9/80	PN,BI	10/13-9/80
13	01541100	Bell Run at Bells Landing	16.3	405500	0783800	MI	6/79-8/80	SY,BI	6/79-8/80
14	01541200	W Br Susquehanna River at Curwensville	367	405741	0783110	CR	10/55-9/80	--	---
15	01541207	Anderson Creek near Penfield	3.81	410751	0783614	MI	6/79-8/80	SY,BI	6/79-8/80
16	01541220	L Anderson Creek near Rockton	9.05	410311	0783924	MI	6/79-8/80	SY,BI	6/79-8/80
17	01541245	Kratzer Run at Bridgeport	15.3	405830	0783306	MI	6/79-8/80	SY,BI	6/79-8/80
18	01541248	Anderson Creek at Curwensville	76.5	405831	0783150	MI	6/79-8/80	SY,BI	6/79-8/80
19	01541305	Moose Creek at Clearfield	12.0	410210	0782656	MI	6/79-8/80	SY,BI	6/79-8/80
20	01541308	Bradley Run near Ashville	6.77	403033	0783502	CR	10/67-9/80	--	---
21	01541320	Clearfield Creek at Ashville	42.4	403340	0783305	MI	6/79-8/80	SY,BI	6/79-8/80
22	01541322	Clearfield Creek at Frugality	75.6	403913	0782947	MI	6/79-8/80	SY,BI	6/79-8/80
23	01541323	Sandy Run at Van Ormer	2.80	404000	0782937	MI	6/79-8/80	SY,BI	6/79-8/80
24	01541324	Powell Run at Van Ormer	7.50	404019	0782934	MI	6/79-8/80	SY,BI	6/79-8/80
25	01541335	Slate Lick Run near Glendale Lake	6.35	403816	0783215	MI	6/79-8/80	SY,BI	6/79-8/80
26	01541361	Blain Run at Coalport	3.57	404435	0783202	MI	6/79-8/80	SY,BI	6/79-8/80
27	01541362	N Witmer Run at Irvona	30.7	404620	0783320	MI	6/79-8/80	SY,BI	6/79-8/80
28	01541368	Pine Run near Irvona	2.37	404627	0783129	MI	6/79-8/80	SY,BI	6/79-8/80
29	01541372	Dotts Hollow near Irvona	1.4	404717	0783132	MI	3/80	SY,BI	3/80
30	01541410	Clearfield Creek near Madera	208	404830	0782814	MI	6/79-8/80	SY,BI	6/79-8/80
31	01541414	Shoff Mine at Madera	Mine	404930	0782659	MI	6/79-8/80	SY,BI	6/79-8/80
32	01541418	L Muddy Run at Smoke Run	14.5	404732	0782542	MI	6/79-8/80	SY,BI	6/79-8/80
33	01541420	Muddy Run at Madera	35.2	404911	0782615	MI	6/79-8/80	SY,BI	6/79-8/80
34	01541425	Japling Run at Madera	3.14	404945	0782610	MI	6/79-8/80	SY,BI	6/79-8/80
35	01541430	Pine Run near Madera	3.92	405104	0782650	MI	6/79-8/80	SY,BI	6/79-8/80
36	01541435	Lost Run near Madera	3.16	405137	0782643	MI	6/79-8/80	SY,BI	6/79-8/80
37	01541470	Upper Morgan Run near Kellytown	12.0	405248	0782556	MI	6/79-8/80	SY,BI	6/79-8/80
38	01541475	Potts Run at Kellytown	13.3	405254	0782738	MI	6/79-8/80	SY,BI	6/79-8/80
39	01541480	Morgan Run near Mineral Springs	13.0	405727	0782228	MI	6/79-8/80	SY,BI	6/79-8/80
40	01541485	Little Clearfield Creek near Glen Richey	31.1	400551	0782753	MI	6/79-8/80	SY,BI	6/79-8/80
41	01541500	Clearfield Creek at Dimeling	371	405818	0782422	CR	10/13-9/80	PC	10/79-7/80
42	01541513	Long Run at Mount Hope	3.75	405934	0782422	MI	6/79-8/80	SY,BI	6/79-8/80
43	01541520	Roaring Run at Mineral Springs	4.72	405948	0782140	MI	6/79-8/80	SY,BI	6/79-8/80
44	01541550	Clearfield Creek at Clearfield	44	410104	0782428	MI	6/79-8/80	SY,BI	6/79-8/80
45	01541695	Trout Run at Shawville	41.8	410425	0782143	MI	6/79-8/80	SY,BI	6/79-8/80

Table 12.1-1 Surface-water sites in Area 1--continued.

Reference[1] number	USGS station number	Station name	Drainage area (mi^2)	Latitude	Longitude	Surface-water records: Quantity: Station type[2]	Quantity: Record period	Quality: Station type[3]	Quality: Record period
46	01541710	Millstone Run near Shawville	6.36	410302	0782021	MI	6/79-8/80	SY,BI	6/79-8/80
47	01541720	Surveyor Run at Surveyor	6.00	410426	0781939	MI	6/79-8/80	SY,BI	6/79-8/80
48	01541750	Deer Creek near Frenchville	23.6	410442	0781411	MI	6/79-8/80	SY,BI	6/79-8/80
49	01541900	Rolling Stone Run near Rolling Stone	1.73	410325	0780936	MI	6/79-8/80	SY,BI	6/79-8/80
50	01541950	Mowry Run at Rolling Stone	1.01	410323	0780919	MI	6/79-8/80	SY,BI	6/79-8/80
51	01542000	Moshannon Creek at Osceola Mills	68.8	405058	0781605	CR	10/40-9/80	SY,BI	6/79-8/80
52	01542004	Trout Run at Edendale	11.3	405012	0781606	MI	6/79-8/80	SY,BI	6/79-8/80
53	01542006	Cold Stream above Glass City	18.1	405204	0781226	MI	6/79-8/80	SY,BI	6/79-8/80
54	01542008	Cold Stream at Phillipsburg	21.3	405411	0781239	MI	6/79-8/80	SY,BI	6/79-8/80
55	01542100	Emigh Run at Hawk Run	4.15	405517	0781238	MI	6/79-8/80	SY,BI	6/79-8/80
56	01542105	Onemile Run near Phillipsburg	1.88	405449	0781202	MI	6/79-8/80	SY,BI	6/79-8/80
57	01542108	Hawk Run near Hawk Run	2.65	405518	0781133	MI	6/79-8/80	SY,BI	6/79-8/80
58	01542200	Unnamed Tributary to Moshannon Creek at Munson	3.45	405714	0781025	MI	6/79-8/80	SY,BI	6/79-8/80
59	01542204	Black Bear Run near Winburne	8.76	405640	0780810	MI	6/79-8/80	SY,BI	6/79-8/80
60	01542207	Sulphur Run near Winburne	3.45	405739	0780833	MI	6/79-8/80	SY,BI	6/79-8/80
61	01542300	Moshannon Creek near Moshannon	208	410210	0780336	MI	6/79-8/80	SY,BI	6/79-8/80
62	01542400	Black Moshannon Creek at Moshannon	55.4	410208	0780322	MI	6/79-8/80	SY,BI	6/79-8/80
63	01542500	W Br Susquehanna River at Karthaus	1,462	410703	0780633	CR	10/64-9/80	TR	10/64-9/80
64	01542508	Mosquito Creek near Karthaus	63.9	410745	0780759	MI	6/79-8/80	SY,BI	6/79-8/80
65	01542520	Saltlick Run near Pottersdale	53	410915	0780600	MI	6/79-8/80	SY,BI	6/79-8/80
66	01542524	Sterling Run near Pine Glen	6.65	410659	0780251	MI	6/79-8/80	SY,BI	6/79-8/80
67	01542610	S Br Bennett Br Sinnemahoning Creek near Penfield	6.70	411027	0783500	MI	6/79-8/80	SY,BI	6/79-8/80
68	01542615	Mountain Run near Penfield	10.8	411140	0783602	MI	6/79-8/80	SY,BI	6/79-8/80
69	01542721	Wilson Run near Penfield	9.11	411232	0783430	MI	6/79-8/80	SY,BI	6/79-8/80
70	01542725	Moose Run at Penfield	2.14	411224	0783414	MI	6/79-8/80	SY,BI	6/79-8/80
71	01542732	Kersey Run at Weedville	29.5	411629	0782937	MI	6/79-8/80	SY,BI	6/79-8/80
72	01542743	Laurel Run near Weedville	37.9	411642	0782722	MI	6/79-8/80	SY	6/79-8/80
73	01542748	Medix Run near Medix Run	24.9	411629	0782406	MI	6/79-8/80	SY,BI	6/79-8/80
74	01542750	Bennett Br Sinnemahoning Creek at Medix Run	169	411721	0782348	MI	6/79-8/80	SY,BI	6/79-8/80
75	01542755	Spring Run near Weedville	8.13	411927	0782728	MI	6/79-8/80	SY,BI	6/79-8/80
76	01542760	Trout Run at Benzette	55.7	411850	0782305	MI	6/79-8/80	SY,BI	6/79-8/80
77	01542770	Dents Run at Dents Run	24.6	412120	0781547	MI	6/79-8/80	SY,BI	6/79-8/80
78	01542775	E Br Hicks Run near Huston Hill	17.6	412247	0781646	MI	6/79-8/80	SY,BI	6/79-8/80
79	01542780	Mix Run near Driftwood	33.2	412010	0781153	MI	6/79-8/80	SY,BI	6/79-8/80
80	01542790	Bennett Br Sinnemahoning Creek at Driftwood	365	412002	0780808	MI	6/79-8/80	SY,BI	6/79-8/80
81	01542800	Driftwood Br Sinnemahoning Creek near Lockwood	33.1	413202	0781847	MI	6/79-8/80	SY,BI	6/79-8/80
82	01542810	Waldy Run near Emporium	5.24	413444	0781734	CR	10/64-9/80	--	---
83	01542835	Big Run at Truman	4.91	412838	0782208	MI	6/79-8/80	SY,BI	6/79-8/80
84	01542845	West Creek at Howard Siding	52.8	412837	0781928	MI	6/79-8/80	SY,BI	6/79-8/80
85	01542886	Parker Run at Gardeau	9.25	413716	0781333	MI	6/79-8/80	SY,BI	6/79-8/80

Table 12.1-1 Surface-water sites in Area 1

Reference[1] number	USGS station number	Station name	Drainage area (mi^2)	Latitude	Longitude	Surface-water records: Quantity: Station type[2]	Quantity: Record period	Quality: Station type[3]	Quality: Record period
86	01542990	Hunts Run at Cameron	30.7	412708	0781029	MI	6/79-8/80	SY,BI	6/79-8/80
87	01543000	Driftwood B Sinnemahoning Creek at Sterling Run	272	412448	0781150	CR	10/13-9/80	--	---
88	01543004	Sterling Run near Sterling Run	11.4	412524	0781311	MI	6/79-8/80	SY,BI	6/79-8/80
89	01543008	Tannery Hollow Run near Sterling Run	4.74	412519	0781324	MI	6/79-8/80	SY,BI	6/79-8/80
90	01543500	Sinnemahoning Creek at Sinnemahoning	685	411902	0780612	CR	10/38-9/80	SY,BI	10/75-9/80
91	01544000	First Fork Sinnemahoning Creek near Sinnemahoning	245	412406	0780128	CR	10/53-9/80	--	---
92	01544204	Cooks Run near Keating	22.4	411716	0775416	MI	6/79-8/80	SY,BI	6/79-8/80
93	01544208	Crowley Hollow near Keating	2.67	411722	0775400	MI	6/79-8/80	SY,BI	6/79-8/80
94	01544500	Kettle Creek at Cross Fork	136	412833	0774934	CR	10/40-9/80	--	---
95	01545000	Kettle Creek near Westport	233	411912	0775227	CR	10/54-9/80	--	---
96	01545017	Twomile Run near Westport	9.12	411857	0775130	MI	6/79-8/80	SY,BI	6/79-8/80
97	01545490	Drury Run at Drury Run	18.4	411945	0774647	MI	6/79-8/80	SY,BI	6/79-8/80
98	01545500	W Br Susquehanna River at Renovo	2,975	411928	0774503	CR	10/07-9/80	SY,BI	6/79-8/80
99	01545504	Paddy Run near Renovo	22.2	411950	0774342	MI	6/79-8/80	SY,BI	6/79-8/80
100	01545600	Young Womans Creek near Renovo	46.2	412322	0774128	CR	10/65-9/80	RF,PN	10/65-9/80
101	01545660	Baker Run near Hyner	31.4	411445	0773630	MI	6/79-8/80	SY,BI	6/79-8/80
102	01545680	Tangascootack Creek near Lock Haven	36.5	411036	0773253	LF,MI	11/77-8/80	SY,BI	6/79-8/80
103	01546500	Spring Creek near Axemann	87.2	405323	0774740	CR	10/40-9/80	--	---
104	01547100	Spring Creek at Milesburg	142	405554	0774713	CR	10/67-9/80	--	---
105	01547200	Bald Eagle Creek below Spring Creek at Milesburg	265	405635	0774712	CR	10/55-9/80	--	---
106	01547500	Bald Eagle Creek at Blanchard	339	410306	0773617	CR	10/54-9/80	--	---
107	01547700	Marsh Creek at Blanchard	44.1	410334	0773622	CR	10/55-9/80	--	---
108	01547704	Sandy Run near Snow Shoe	13.0	410424	0775212	MI	6/79-8/80	SY,BI	6/79-8/80
109	01547706	Wolf Run near Snow Shoe	8.90	410522	0775207	MI	6/79-8/80	SY,BI	6/79-8/80
110	01547760	N Fk Beech Creek at Clarence	16.0	410302	0775625	MI	6/79-8/80	SY,BI	6/79-8/80
111	01547800	S Fk Beech Creek near Snow Shoe	12.2	410130	0775415	CR	10/69-9/80	SY,BI	10/69-9/80
112	01547950	Beech Creek at Monument	152	410642	0774209	CR	10/68-9/80	PC,DR	10/68-9/80
113	01547980	Beech Creek at Beech Creek	170	410429	0773530	MI	6/79-8/80	SY,BI	6/79-8/80
114	01548000	Bald Eagle Creek at Beech Creek Station	559	410355	0773403	CR	10/70-9/80	--	---
115	01548403	Babb Creek at Morris	53	413543	0771739	CR	11/77-9/80	SY,BI	11/77-9/80
116	01548408	Wilson Creek above Sand Run near Antrim	12.6	413851	0771826	CR	7/78-9/80	PN	7/78-9/80
117	01548423	Wilson Creek at Morris	22.8	413551	0771750	CR	11/77-9/80	SY,PN,BI	11/77-9/80
118	01548427	Stony Fk near Mouth Near Blackwell	37.1	413456	0772046	CR	11/77-9/80	SY,PN,BI	11/77-9/80
119	01548500	Pine Creek at Cedar Run	604	413118	0772652	CR	10/18-9/80	PC,PN,BI	10/75-9/80
120	01549500	Blockhouse Creek near English Center	37.7	412825	0771352	CR	10/40-9/80	--	---
121	01549543	L Pine Creek near English Center	118	412608	0771725	MI	6/79-8/80	SY,BI	6/79-8/80
122	01549547	English Run at English Center	9.4	412608	0771725	MI	6/79-8/80	SY,BI	6/79-8/80
123	01549560	Otter Run at Carsontown	22.8	412425	0782005	MI	6/79-8/80	SY,BI	6/79-8/80
124	01549700	Pine Creek below L Pine Creek near Waterville	944	411625	0771928	CR	10/57-9/80	--	---
125	01555831	Glenwhite Run near Altoona	5.0	402947	0782910	MI	6/79-8/80	SY	6/79-8/80
126	01555835	Kittanning Creek near Altoona	3.57	402954	0782904	MI	6/79-8/80	SY	6/79-8/80

Table 12.1-1 Surface-water sites in Area 1--continued.

Reference[1] number	USGS station number	Station name	Drainage area (mi^2)	Latitude	Longitude	Surface-water records: Quantity: Station type[2]	Quantity: Record period	Quality: Station type[3]	Quality: Record period
127	01555849	Sugar Run near Altoona	8.30	402804	0782623	MI	6/79-8/80	SY,BI	6/79-8/80
128	01555855	Blairs Gap Run near Foot of Ten	15.4	402509	0782843	MI	6/79-8/80	SY,BI	6/79-8/80
129	01556000	Frankstown Br Juniata River at Williamsburg	291	402747	0781200	CR	10/16-9/80	--	---
130	01556430	Bells Gap Run near Blandburg	12.4	403827	0782401	MI	6/79-8/80	SY,BI	6/79-8/80
131	01556432	Shaw Run near Blandburg	3.94	403822	0782344	MI	6/79-8/80	SY,BI	6/79-8/80
132	01557500	Bald Eagle Creek at Tyrone	44.1	404101	0781402	CR	10/44-9/80	--	---
133	01558000	L Juniata River at Spruce Creek	220	403645	0780827	CR	10/38-9/80	PN	10/75-9/78
134	01559000	Juniata River at Huntingdon	816	402905	0780109	CR	10/41-9/80	PN	11/75-8/78
135	01559700	Buffalo Run Tributary near Manns Choice	5.28	395840	0783708	CR	10/61-9/78	--	---
136	01560000	Dunning Creek at Belden	172	400418	3782934	CR	10/39-9/80	--	---
137	01561430	Sandy Run at Hopewell	17.0	400741	0781541	MI	6/79-8/80	SY,BI	6/79-8/80
138	01561600	Sixmile Run near Riddlesburg	14.7	400943	0781511	MI	6/79-8/80	SY,BI	6/79-8/80
138A	01562000	Raystown B Junita River at Saxton	756	401257	0781556	CR	9/11-9/80	PN	7/72-9/80
139	01562008	Sharp Run near Saxton	18.2	401320	0781254	MI	6/79-8/80	SY,BI	6/79-8/80
140	01562250	Tatman Run near Entriken	7.47	401803	0780947	MI	6/79-8/80	SY,BI	6/79-8/80
141	01562450	Great Trough Creek near Cassville	24.6	401647	0780252	MI	6/79-8/80	SY,BI	6/79-8/80
142	01563000	Raystown B Juniata River near Huntingdon	957	402535	0780150	CR	10/46-9/71	--	---
143	01563200	Raystown B Juniata River below Raystown Dam near Huntingdon	960	402544	0775929	CR	10/69-9/80	--	---
144	01563500	Juniata River at Mapleton Depot	2,030	402332	0775607	CR	10/37-9/80	--	---
145	01564500	Aughwick Creek near Three Springs	205	401245	0775532	CR	10/38-9/80	--	---

[1]Used on figures.
[2]Types of surface-water quantity stations (description and frequency of measurements given in section 6.1).
CR = continuous-record
CS = crest-stage, partial-record
LF = low-flow, partial record
MI = miscellaneous
[3]Types of surface-water quality stations (description and frequency of sampling given in sections 6.2 and 6.3).
TR = trend
RF = reference
PC = partial-record (coal hydrology)
PN = partial-record (non-coal hydrology)
DR = daily record
SY = synoptic
BI = benthic invertebrate data available

Table 12.2-1 Summary of ground-water quality in rock units of the Appalachian Plateaus province in Area 1

	Alluvium				Conemaugh Group or Formation				Allegheny Group or Formation			
Constituent	Number of Samples	Min-imum	Max-imum	Median	Number of Samples	Min-imum	Max-imum	Median	Number of Samples	Min-imum	Max-imum	Median
pH, in units	--	--	--	--	13	5.7	7.7	6.3	5	6.7	7.3	**
Total arsenic, in µg/L	4	5	8	**	18	<1	<10	<1	10	<.005	<1	<.005
Total aluminum, in µg/L	4	30	170	**	18	40	150	70	10	20	310	70
Alikalinity as $CaCO_3$, in mg/L	4	15	98	**	18	68	304	148	10	6	104	54
Dissolved chloride, in mg/L	4	6	66	**	18	1	36	9.5	10	2	27	7.5
Total chromium, in µg/L	4	10	10	**	18	<10	40	15	10	<10	50	20
Dissolved solids, in mg/L	4	52	328	**	17	124	980	230	10	59	396	126
Total fluoride, in mg/L	4	.1	.35	**	18	.1	.68	.14	9	.1	73	.18
Hardness as $CaCO_3$, in mg/L	4	40	174	**	17	20	654	123	10	32	182	66
Total iron, in µg/L	4	70	7,910	**	18	40	5,550	175	10	30	13,600	5,550
Total lead, in µg/L	4	50	50	**	18	<50	100	<50	10	<5	<50	14
Total manganese, in µg/L	4	20	460	**	18	10	1,750	80	10	20	1,400	495
Dissolved magnesium, in mg/L	4	2	11	**	18	.1	40	8.2	10	2	16	4.8
Total nickel, in µg/L	4	10	20	**	18	<10	50	10	9	0	40	20
Total nitrigen as ammonia in mg/L	4	.06	.21	**	18	.01	.39	.02	10	.01	.13	.08
Total nitrogen as nitrite, in mg/L	4	0.002	0.002	**	18	0.002	0.006	0.002	10	0.002	0.004	0.002
TotaL nitrogen as nitrate, in mg/L	4	.02	11	**	18	.02	1.57	.13	10	.02	1.1	.02
Total potassium, in mg/L	4	.9	2.44	**	18	.14	2.16	1.0	10	.2	2.54	1.23
Total sodium, in mg/L	4	5.3	16	**	18	1.5	124	4.9	10	.3	12.7	1.0
Dissolved sulfate, in mg/L	4	5	55	**	18	5	510	12	10	<5	170	12
Total zinc, in µg/L	4	10	2,270	**	18	10	920	20	10	10	160	20
Dissolved calcium, in mg/L	4	6	60	**	18	6	489	46	10	7.2	77.3	23.4
Total organic calcium, in mg/L	4	1	2.2	**	0	**	**	**	6	0	0	0
Total organic carbon. in µg/L	4	<3	<3	**	18	<3	3	<3	10	<1	<3	<1

Table 12.2-1 Summary of ground-water quality in rock units of the Appalachian Plateaus province in Area 1--continued.

	Pottsville Group or Formation				Sandstone formations (Devonian and Mississippian)				Interbedded shale, siltstone and sandstone formations (Devonian)			
Constituent	Number of Samples	Minimum	Maximum	Median	Number of Samples	Minimum	Maximum	Median	Number of Samples	Minimum	Maximum	Median
pH, in units	2	7.3	7.6	**	3	6.3	7.0	**	27	6.5	8.5	7.5
Total arsenic, in µg/L	7	<.005	<5	<1	11	<5	6.1	<5	95	<5.0	46	*
Total aluminum, in µg/L	7	50	670	90	11	10	170	40	95	10	420	80
Alkalinity as $CaCO_3$, in mg/L	7	14	54	28	11	10	102	50	95	8	328	122
Dissolved chloride, in mg/L	7	1	11	2	11	1	735	7	95	1	846	6
Total chromium, in µg/L	7	0	30	10	11	<10	40	<10	95	<10	30	*
Dissolved solids, in mg/L	7	10	132	74	11	48	1,560	106	95	20	3,780	182
Total fluoride, in mg/L	7	.10	.19	.11	11	<.1	2.3	.11	95	<.10	0.7	*
Hardness as $CaCO_3$, in mg/L	6	15	<200	33	11	13	372	62	94	10	330	102
Total iron, in µg/L	7	50	4,980	350	11	20	10,800	390	95	10	3,510	90
Total lead, in µg/L	7	<5	<50	<50	11	<5	<50	<50	95	4.6	<50	*
Total manganese, in µg/L	7	10	600	140	11	10	640	30	95	<10	1,470	20
Dissolved manganesium, in mg/L	7	.4	12	1.7	11	.9	13.8	2.8	92	.5	32	6.1
Total nickel, in µg/L	5	<10	40	18	10	<10	40	*	93	<10	<30	*
Total nitrogen as ammonia in mg/L	7	.01	.15	.04	11	<.01	.13	.07	95	.01	.65	.05
Total nitrogen as nitrite, in mg/L	7	0.002	0.02	0.002	11	0.002	0.17	0.024	95	<0.002	0.122	0.002
Total nitrogen as nitrate, in mg/L	7	.02	.96	.08	11	.02	2.12	.02	95	.01	3.96	.12
Total potassium, in mg/L	7	.02	1.82	.70	11	.46	2.68	.86	93	.22	5.22	1.32
Total sodium, in mg/L	7	.10	26	.60	11	.76	279	4.8	95	.4	764	11.7
Dissovled sulfate, in mg/L	7	5	19	6	11	4	60	6	95	<5.0	130	15
Total zinc, in µg/L	7	10	4,020	40	11	10	620	60	94	<10	3690	30
Dissolved calcium, in mg/L	7	1.7	23.4	10.7	11	3.2	117	22	95	1.9	78	32
Total organic calcium, in mg/L	5	0	<1	0	11	1	8.4	1.2	87	<1.0	24	1.8
Total organic carbon, in µg/L	7	<1	<3	<3	11	<.5	<3	<3	95	<.5	<3.0	*

* Unable to determine due to qualified values
** Insufficient observations

Table 12.3-1 Summary of ground-water quality in the Broad Top coal field.

	Conemaugh Group or Formation				Allegheny Group or Formation			
	Number of Samples	Minimum	Maximum	Median	Number of Samples	Minimum	Maximum	Median
pH, in units	22	5.9	7.6	6.8	18	4.4	6.6	5.8
Acidity as $CaCO_3$, in mg/L	22	0	10	0	18	0	100	3
Alkalinity as $CaCO_3$, in mg/L	22	10	178	61	18	4	68	13
Total aluminum, in μg/L	22	<10	160	40	18	10	12,000	120
Dissolved chloride, in μg/L	22	1	11	3	18	2	36	6
Hardness as $CaCO_3$, in mg/L	22	<20	185	75	18	<20	275	48
Total iron, in μg/L	22	30	6,800	260	18	60	5,200	100
Total manganese, in μg/L	22	<10	1,400	50	18	<10	5,100	190
Total nitrogne as ammonia, in mg/L	22	.02	3.5	.49	18	.02	9.7	2.3
Dissolved sulface, in mg/L	22	10	125	20	18	15	110	38

[1] From Taylor, L., Werkheiser, W., Dupont, Nancy and Kriz, Marylou (in press).

Table 12.4-1 Summary of ground-water quality in rock units of the Valley and Ridge province in Area 1 (excluding Broad Top coal field).

	Formations of sandstone (Mississippian and Upper Devonian)				Formations of interbedded shale, siltstone, and sandstone (Middle and Lower Devonian)				Formations of quartzite and conglomerate (under Silurian and Ordivician)			
Constituent	Number of Samples	Min- imum	Max- imum	Median	Number of Samples	Min- imum	Max- imum	Median	Number of Samples	Min- imum	Max- imum	Median
pH, in units	3	7.5	7.8	**	5	5.9	7.4	**	12	6.7	8.6	7.9
Total arsenic, in µg/L	-----	----	----	-----	2	0	0	**	2	0	0	**
Total aluminum, in µg/L	-----	----	----	-----	3	0	90	**	3	20	190	**
Alkalinity as $CaCO_3$, in mg/L	4	32	121	**	6	10	86	67	24	13	260	129
Dissolved chloride, in mg/L	4	.3	26	**	6	1	33	4	24	1	1,250	3.8
Total chromium, in µg/L	-----	----	----	-----	3	2	110	**	3	0	30	**
Dissolved solids, in mg/L	3	44	140	**	4	41	230	**	10	98	510	223
Total fluoride, in mg/L	3	0	.2	**	4	0	.2	**	10	0	.3	.2
Hardness as $CaCO_3$, in mg/L	4	31	120	**	6	20	171	90	22	37	1,100	165
Total iron, in µg/L	2	40	250	**	6	10	6,100	420	10	0	4,500	235
Total lead, in µg/L	-----	----	----	-----	3	0	47	**	8	0	180	4
Total manganese, in µg/L	2	10	40	**	5	0	180	**	10	20	480	105
Dissolved manganese in mg/L	3	1.6	3.7	**	4	.2	13	**	17	4.5	77	13
Total nickel, in µg/L	-----	----	----	-----	3	10	40	**	4	0	11	**
Total nitrogen as ammonia, in mg/L	-----	----	----	-----	2	0	.1	**	3	0	.2	**
Total nitrogen as nitrite, in mg/L	1	0.004	0.004	**	-----	----	----	-----	-----	----	----	-----
Total nitrogen as nitrate, in mg/L	4	.01	1.1	**	6	0	.81	.03	23	0	9.5	.21
Total potasium, in mg/L	2	.8	1.3	**	4	.2	1.4	**	8	.6	18	1.1
Total sodium, in mg/L	2	.7	1.4	**	4	2.5	7.2	**	11	4.1	95	16
Dissolved sulfate, in mg/L	4	1	24	**	6	8.6	86	26	24	4	659	30
Total zinc, in µg/L	-----	----	----	-----	3	70	260	**	8	30	5,000	755
Dissolved calcium, in mg/L	4	9.9	43	**	6	7.6	47	24	23	7	310	41
Total cadmium, in µg/L	-----	----	----	-----	3	0	5	**	3	0	5	**

	Formations of quartzite and conglomerate (Lower Silurian and Ordivician)				Formations of limestone (Ordivician)				Formatins of dolomite (Ordivician and Cambrian)			
Constituent	Number of Samples	Min- imum	Max- imum	Median	Number of Samples	Min- imum	Max- imum	Median	Number of Samples	Min- imum	Max- imum	Median
pH, in units	2	6.6	8.2	**	8	7	7.4	7.2	7	5.5	8.0	7.4
Total arsenic, in µg/L	1	0	0	**	-----	----	----	-----	3	0	0	**
Total aluminum, in µg/L	1	10	10	**	-----	----	----	-----	3	0	0	**
Alkalinity as $CaCO_3$, in mg/L	3	32	129	**	10	156	318	188	7	24	180	95
Dissolved chloride, in mg/L	3	.5	6	**	10	1.8	196	21	7	1	11	2.5
Total chromium, in µg/L	1	30	30	**	-----	----	----	-----	3	8	80	9
Dissolved solids, in mg/L	2	76	145	**	8	200	790	414	7	85	236	140
Total fluoride, in mg/L	2	.1	.5	**	8	0	.3	.1	7	0	.1	.1
Hardness as $CaCO_3$, in mg/L	2	62	140	**	10	120	730	310	7	72	220	100
Total iron, in µg/L	2	100	1,100	**	8	120	1,200	250	7	0	460	100
Total lead, in µg/L	1	0	0	**	-----	----	----	-----	-----	----	----	-----
Total manganese, in µg/L	2	20	490	**	4	0	10	**	5	0	110	**
Dissolved managanese, in mg/L	2	7.2	13	**	3	11	65	**	4	5.3	24	**
Total nickel, in µg/L	1	10	10	**	-----	----	----	-----	3	20	80	**
Total nitrogen as ammonia, in mg/L	1	0	0	**	8	0	.04	.02	6	0	.1	.02
Total nitrogen as nitrite, in mg/L	-----	----	----	-----	-----	----	----	-----	-----	----	----	-----
Total nitrogen as nitrate, in mg/L	3	0.07	0.51	**	10	0.07	3.8	1.35	7	0.11	0.6	0.23
Total potasium, in mg/L	2	.2	4.6	**	-----	----	----	-----	4	.7	2.2	*
Total sodium, in mg/L	2	1.4	2	**	-----	----	----	-----	4	1.7	18	**
Dissolved sulfate, in mg/L	3	11	22	**	6	12	523	93	6	1.9	42	20
Total zinc, in µg/L	1	40	40	**	-----	----	----	-----	3	5	30	**
Dissolved calcium, in mg/L	3	13	35	**	3	86	186	**	4	20	46	**
Total cadmium, in µg/L	1	5	5	**	-----	----	----	-----	3	0	0	**

* Unable to determine due to qualified values
** Insufficient observation

13.0 LIST OF REFERENCES

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