DESCRIPTION OF THE PHYSICAL ENVIRONMENT AND COAL-MINING HISTORY OF WEST-CENTRAL INDIANA, WITH EMPHASIS ON SIX SMALL WATERSHEDS

U.S. GEOLOGICAL SURVEY

Open-File Report 87-212

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By Jeffrey D. Martin, Charles G. Crawford,
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FACTORS FOR CONVERTING INCH-POUND UNITS TO METRIC (INTERNATIONAL SYSTEM) UNITS

Multiply inch-pound units	By	To obtain SI units
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
acre	4,047	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
inch per year (in/yr)	2.54	centimeter per year (cm/yr)
foot per day (ft/d)	0.3048	meter per day (m/d)
gallon per minute (gal/min)	3.785	liter per minute (L/min)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
ton, short (2,000 pounds)	0.9072	megagram (Mg)
pound per cubic foot (lb/ft^3)	0.01602	grams per cubic centimeter (g/cm^3)

To convert degree Fahrenheit (°F) to degree Celsius (°C)

$$5/9 \times (°F - 32) = °C$$

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."

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ABSTRACT

This report describes the physical and human environment and coal-mining history of west-central Indiana, with emphasis on six small watersheds selected for study of the hydrologic effects of surface coal mining. The report summarizes information on the geology, geomorphology, soils, climate, hydrology, water use, land use, population, and coal-mining history of Clay, Owen, Sullivan, and Vigo Counties in Indiana. Site-specific information is given on the morphology, geology, soils, land use, coal-mining history, and hydrologic instrumentation of the six watersheds which are each less than 3 square miles in area.

West-central Indiana is underlain by coal-bearing Pennsylvanian rocks. Nearly all of the area has been glaciated at least once and is characterized by wide flood plains and broad, flat uplands. Most of the soils have formed in loess, or in loess overlying Illinoian till. The Wabash, White, and Eel Rivers are the major drainages in west-central Indiana. Average annual precipitation is about 39.5 inches per year and average annual runoff is about 13 inches per year. The most productive aquifers are confined or unconfined outwash aquifers located along the major rivers. Bedrock aquifers are regionally insignificant but are the sole source of ground water for areas that lack outwash, alluvium, or sand and gravel lenses in till.

Indiana has more than 17 billion short tons of recoverable coal reserves; about 11 percent can be mined by surface methods. Almost half of Indiana's surface reserves are in Clay, Owen, Sullivan, and Vigo Counties. More than 50,000 acres in west-central Indiana have been disturbed by surface coal mining from 1941 through 1980.

Big Slough and Hooker Creek are streams that drain unmined, agricultural watersheds. Row-crop corn and soybeans are the principal crops. Soils are moderately well-drained silt loams, and the watersheds have well-developed dendritic drainage systems.

Unnamed tributary to Honey Creek and unnamed tributary to Sulphur Creek are streams that drain mined and reclaimed watersheds. Ridges of mine spoil have been graded to a gently rolling topography. Soils are well drained and consist of 6 to 12 inches of silt-loam topsoil that was stockpiled and then replaced over shale and sandstone fragments of the graded mine spoil. Grasses and legumes form the vegetative cover in each watershed.

Pond Creek and unnamed tributary to Big Branch are streams that drain mined and unreclaimed watersheds. Approximately one-half of the Pond Creek watershed is unmined, agricultural land. Soils are very well-drained shaly silty loams that have formed on steeply sloping spoil banks. Both watersheds contain numerous impoundments of water and have enclosed areas that do not contribute surface runoff to streamflow. The ridges of mine spoil are covered with pine trees, but much of the soil surface is devoid of vegetation.

INTRODUCTION

This report describes the physical and human environment and coal-mining history of west-central Indiana, with emphasis on six small watersheds selected for study of the hydrologic effects of surface coal mining. The report summarizes information on the geology, geomorphology, soils, climate, hydrology, water use, land use, population, and coal-mining history of Clay, Owen, Sullivan, and Vigo Counties in Indiana. Site-specific information is given on the morphology, geology, soils, land use, coal-mining history, and hydrologic instrumentation of the six watersheds that were selected for intense study. The watersheds include mined and unreclaimed; mined and reclaimed; and unmined, agricultural land uses and are each less than 3 mi^2 (square miles) in area. The descriptive information allows the reader to (1) understand the physical conditions that influence watershed hydrology, (2) compare the physical conditions among watersheds, and (3) compare the physical and human environment in west-central Indiana to those in other areas of interest.

DESCRIPTION OF PHYSICAL ENVIRONMENT AND COAL-MINING HISTORY OF WEST-CENTRAL INDIANA

The area selected for study is Clay, Owen, Sullivan, and Vigo Counties in west-central Indiana (fig. 1). These counties are in the northern, glaciated part of the Indiana coal-mining region.

Physical Environment

Geology

The stratigraphic nomenclature used in this report is from Shaver and others (1986). The nomenclature, especially for members, formations, and groups, conforms with the current usage of the Indiana Geological Survey.

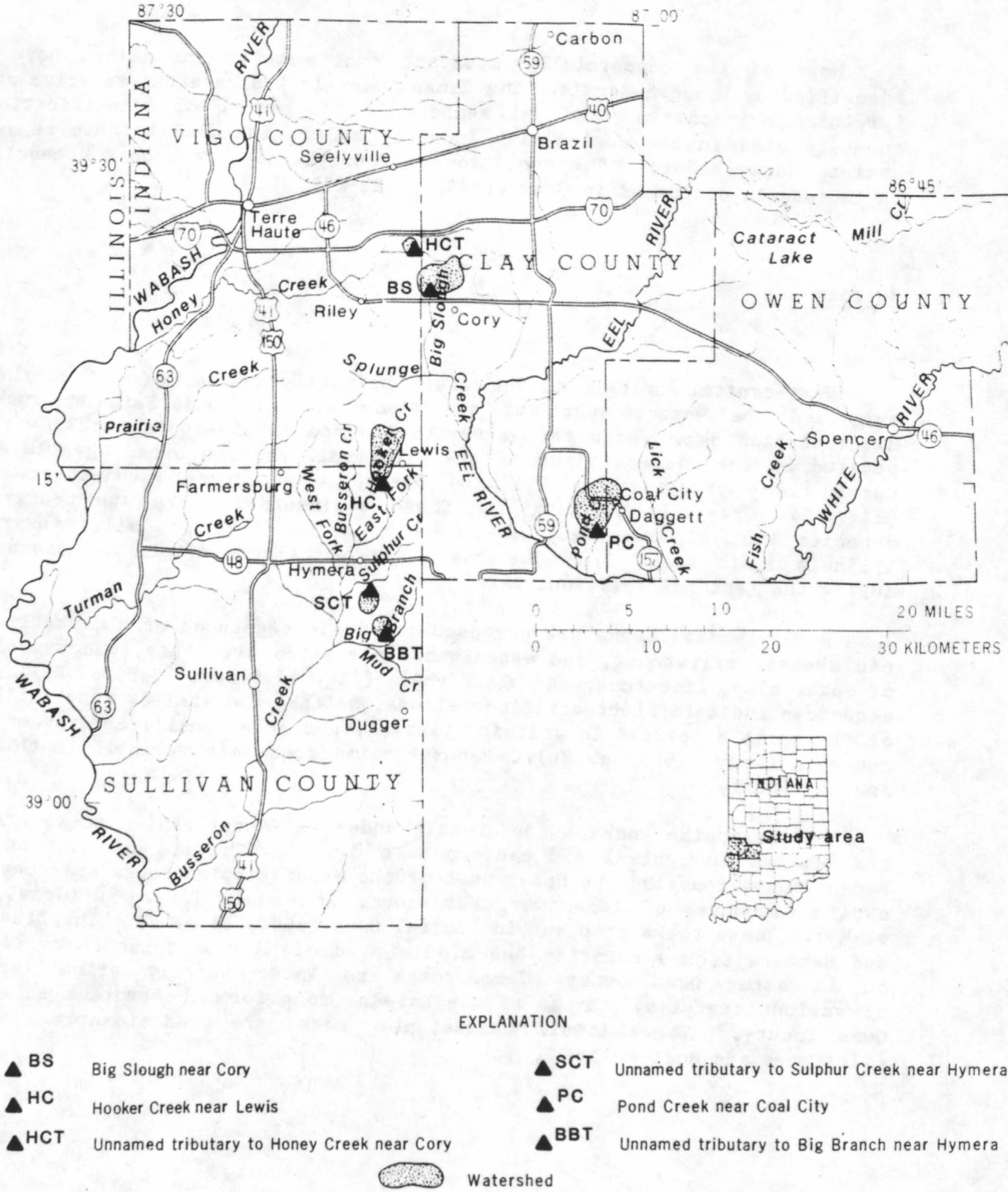


Figure 1.-- Location of the six study watersheds and streamflow-gaging stations in Clay, Owen, Sullivan, and Vigo Counties.

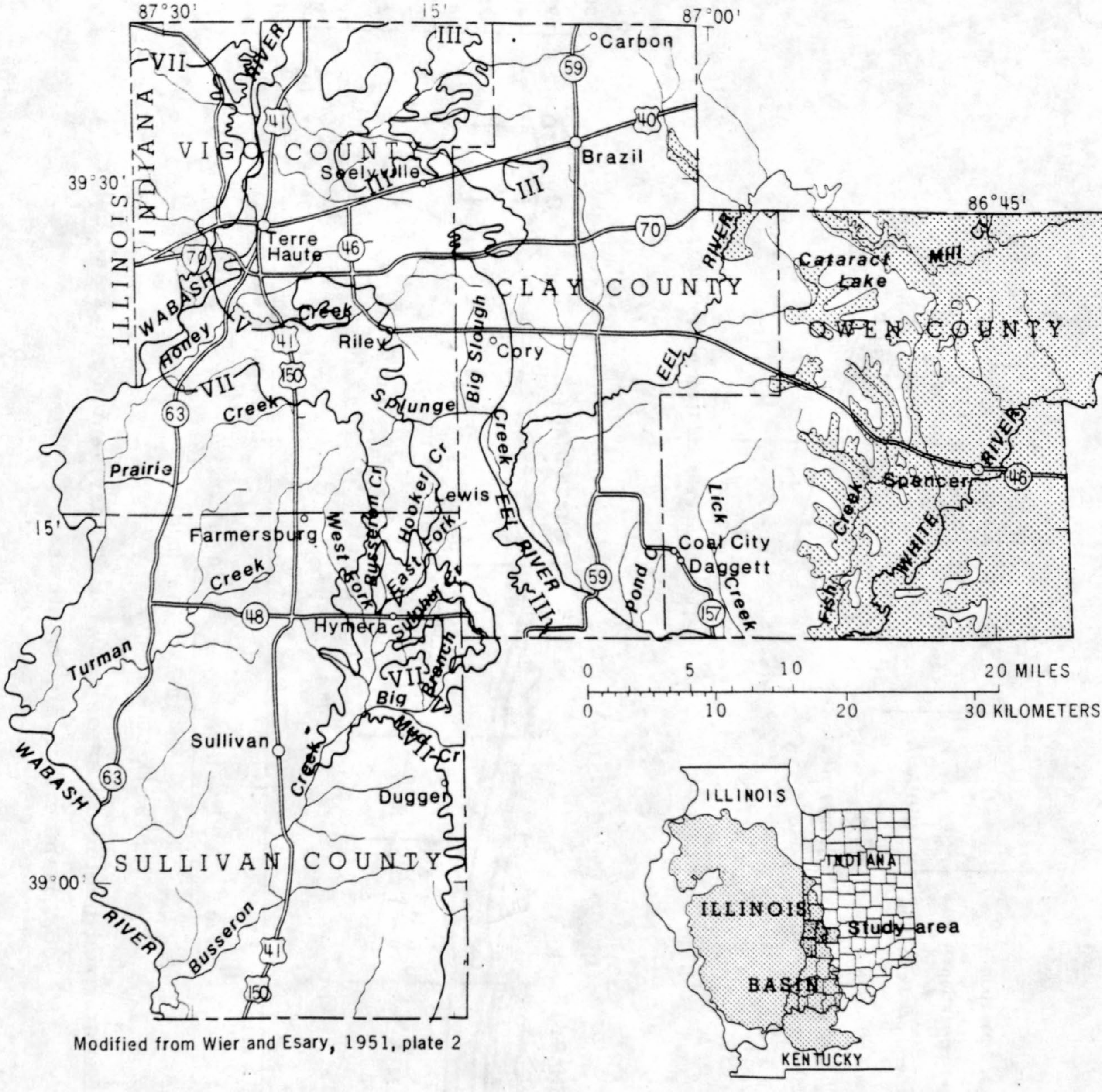
Most of the commercially-important coal members in Indiana have been identified by Roman numerals. The Roman numerals indicate the relative stratigraphic positions of the coal members. This method of identification is commonly used in the coal-mining industry and is included in this report to assist these readers. The evolution of Pennsylvanian rock-unit nomenclature in Indiana is discussed in Gray (1979, p. K3-K5).

Bedrock

West-central Indiana is underlain primarily by rocks of Pennsylvanian age, and the eastern part of the study area is underlain by rocks of Mississippian age. Both the Pennsylvanian and Mississippian rocks were deposited on the western flank of the Cincinnati Arch, a broad, gentle structural rise bordering the Illinois Basin, a structural sedimentary basin (fig. 2) (Gray, 1979, p. K9). These sedimentary rocks are nearly flat deposits that dip southwest at 20 to 30 ft/mi (feet per mile) toward the Illinois Basin (fig. 3). The basin has had little structural disturbance during the last half billion years.

Pennsylvanian rocks are composed of cyclic sequences of dominantly clastic shales, siltstones, and sandstones intermixed with thin, widespread beds of coal, clay, limestone, and black shale (fig. 4) (Gray, 1979, p. K1). These sequences indicate fluctuating shorelines, deltas, and shallow seas, with most of the rocks deposited in deltaic, fluvial, and occasionally coal-swamp environments (Gray, 1979, p. K6). Pennsylvanian rocks are variable in thickness and continuity.

Mississippian rocks unconformably underlie Pennsylvanian rocks and form the bedrock in central and eastern Owen County. The Stephensport and West Baden Groups comprise the upper part of the Mississippian rocks and consist of cyclic sequences of limestone, sandstone, and shale (fig. 5) (Gray, 1979, p. K3). These rocks crop out in central Owen County (fig. 2). The Blue River and Sanders Groups comprise the middle part of Mississippian rocks and crop out in eastern Owen County. These rocks are almost entirely marine limestones of various textures. Rocks of the Borden Group form the bedrock in eastern Owen County. These Lower Mississippian rocks are predominantly resistant siltstones and soft shales.



Modified from Wier and Esary, 1951, plate 2

EXPLANATION

Pennsylvanian rocks

Mississippian rocks

—III— Outcrop of the Seelyville Coal Member of the Staunton Formation

—V— Outcrop of the Springfield Coal Member of the Petersburg Formation

—VII— Outcrop of the Danville Coal Member of the Dugger Formation

Figure 2.-- Location of the Illinois Basin, limit of coal-bearing Pennsylvanian rocks, and outcrops of selected coal members.

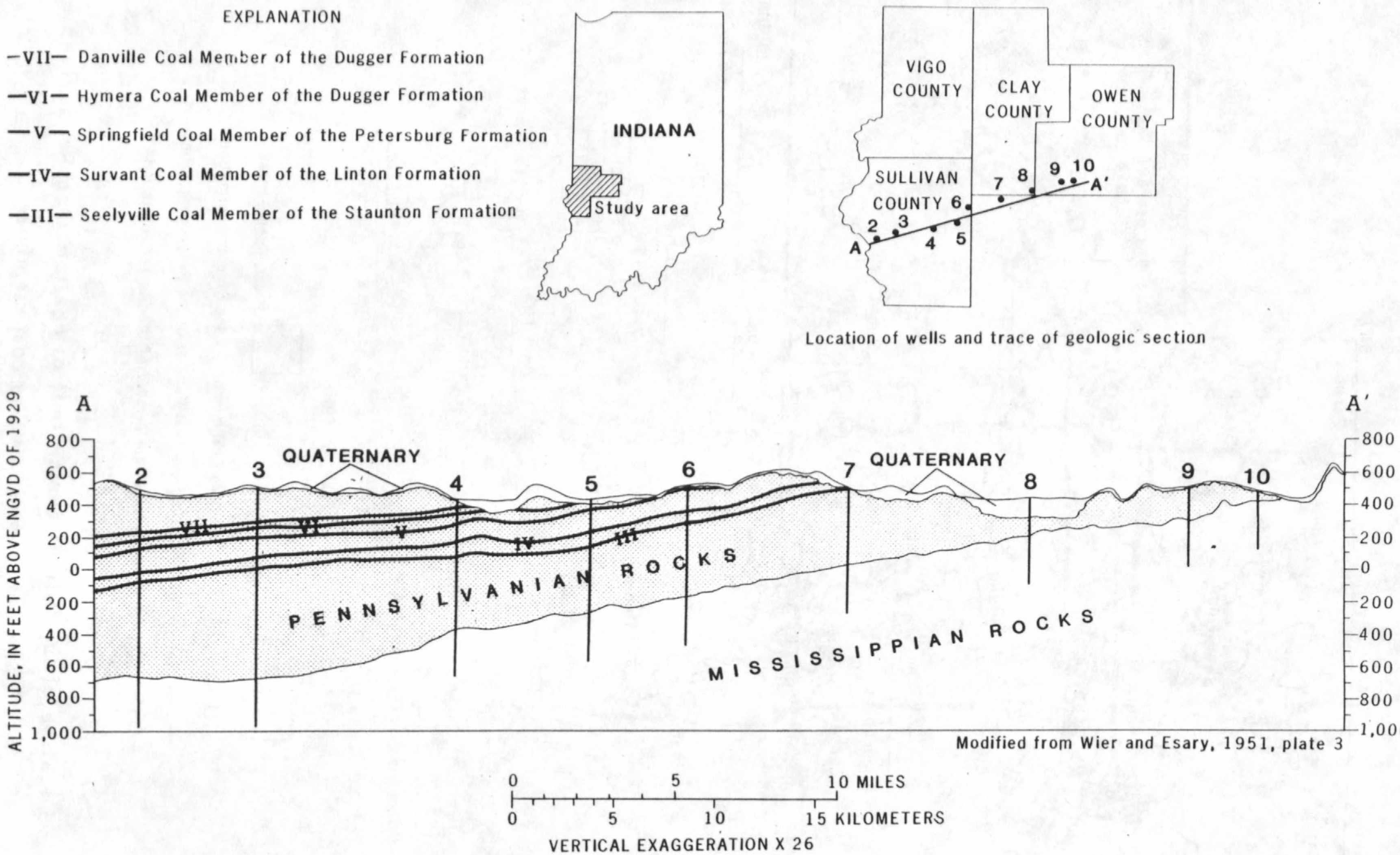
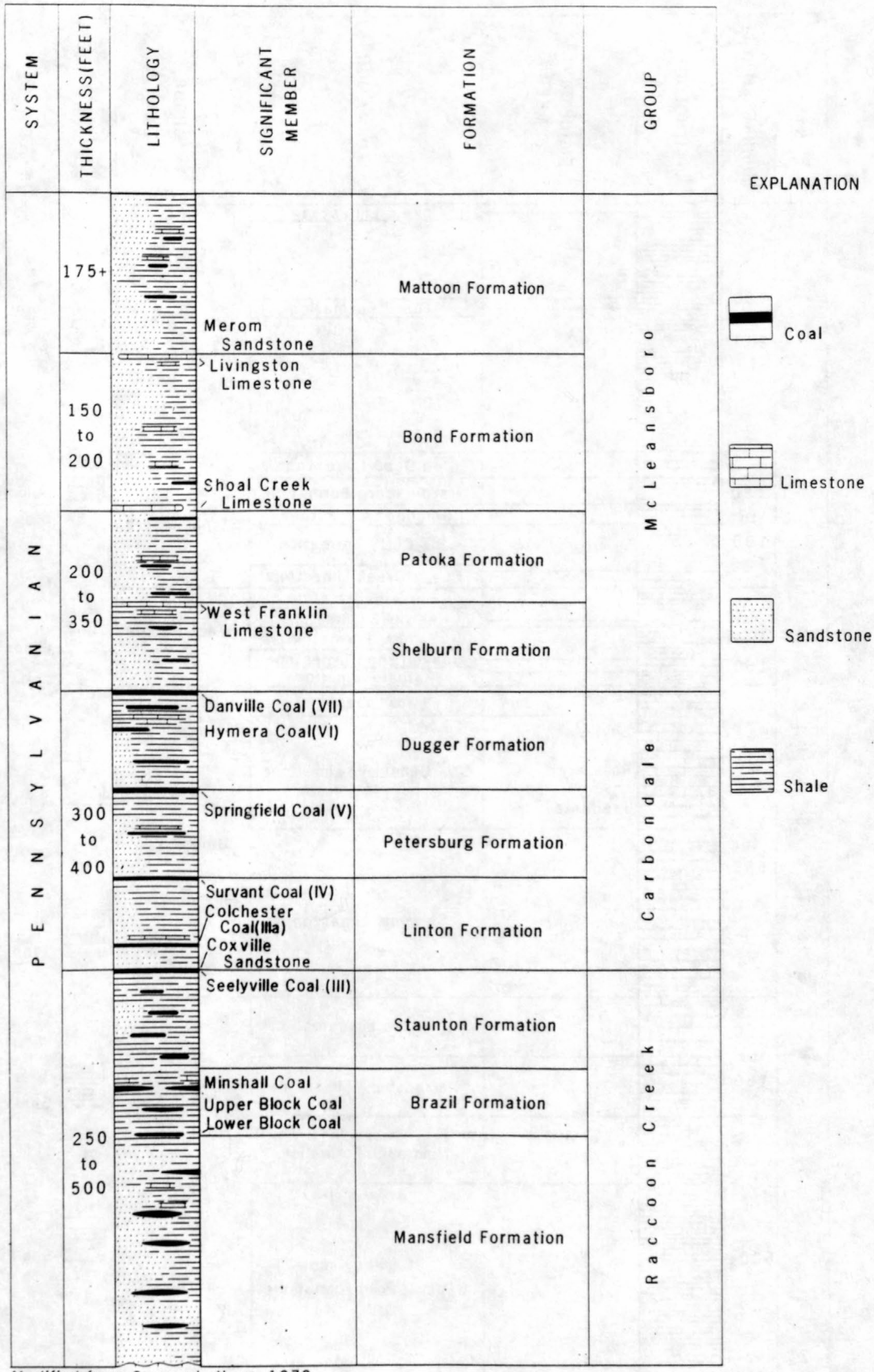
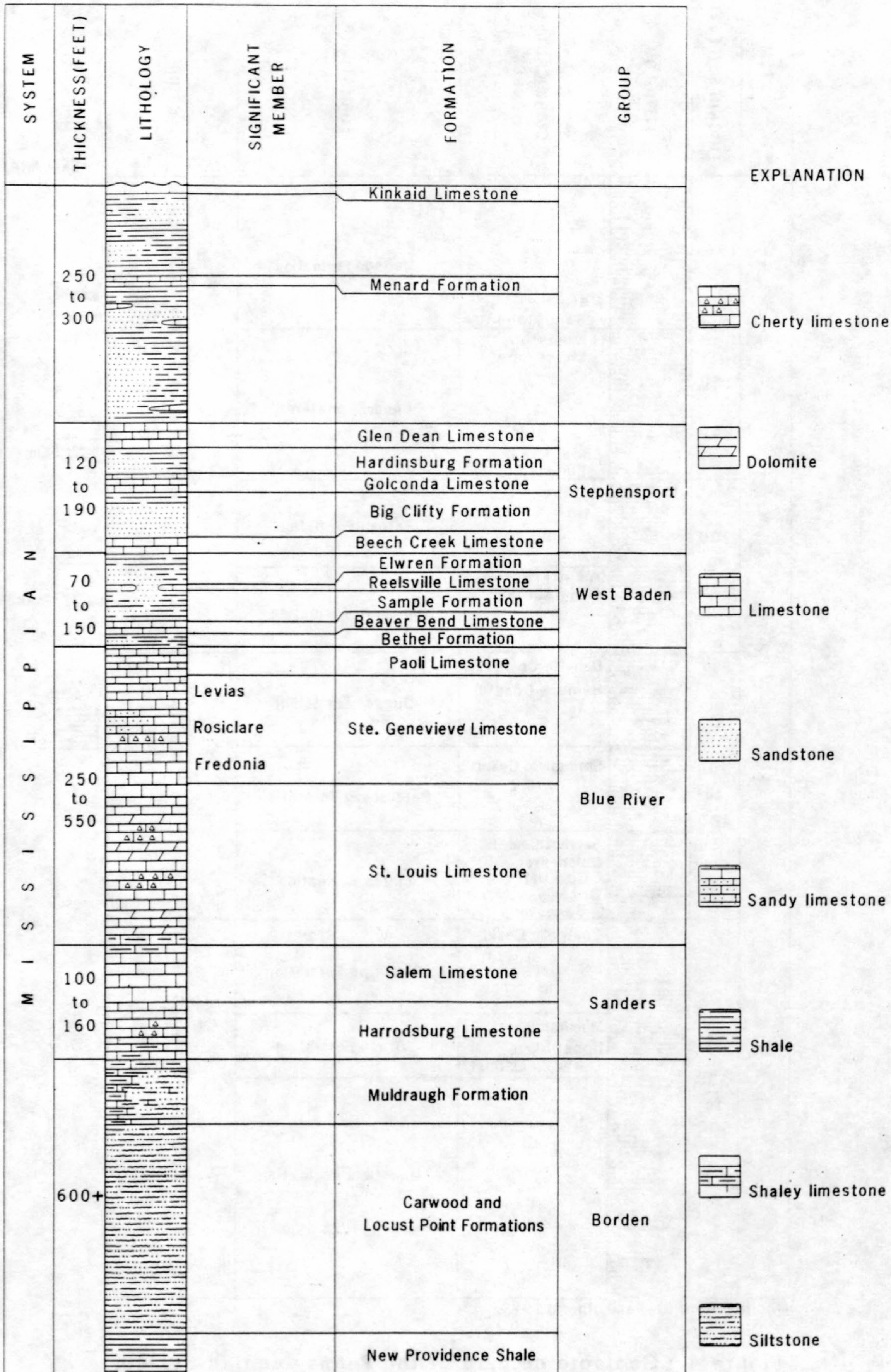


Figure 3.-- Generalized geologic section showing Pennsylvanian rocks and selected coal members dipping southwest.



Modified from Gray and others, 1979.

Figure 4.-- Geologic column of the Pennsylvanian System in Indiana.



Modified from Gray and others, 1979.

Figure 5.-- Geologic column of the middle and upper Mississippian System in Indiana.

The coal-producing area of southwestern Indiana is underlain by Pennsylvanian rocks and includes approximately 6,500 mi^2--about one-sixth of the State's total area (Wier, 1973, p. 4). Coal is found in at least 45 different stratigraphic positions in Indiana but comprises only about three percent of the Pennsylvanian rocks (Wier, 1973, p. 4, 7). Some coal is produced from the Raccoon Creek Group, primarily from the Seelyville Coal Member (III) of the Staunton Formation, and the Minshall, Upper Block, and Lower Block Coal Members of the Brazil Formation (fig. 4). Most of the other coal members in the Raccoon Creek Group are thin and discontinuous. The McLeansboro Group has no commercially minable coal beds. The Carbondale Group contains the thickest, the most extensive, and therefore, the most commercially important coal beds. The most commonly mined coal members in the Carbondale Group are the Survant Coal Member (IV) of the Linton Formation, the Springfield Coal Member (V) of the Petersburg Formation, and the Hymera (VI) and Danville (VII) Coal Members of the Dugger Formation (figs. 2, 4).

All Indiana coals are ranked as high-volatile bituminous coal (Wier, 1973, p. 14). Analysis of the coals shows considerable variation in Btu (British thermal unit) ratings and percentages of sulphur and ash. The average Btu per pound for the commercial coal beds is 11,105 with a maximum of 11,615 and a minimum of 10,310. The average sulphur content (in percent) is 2.98 with a maximum of 6.06 and a minimum of 1.16. The average ash content (in percent) is 10.5 with a maximum of 17.9 and a minimum of 6.3 (Wier, 1973, table 2, p. 16).

Surficial deposits

At least three separate glacial advances during the Pleistocene Epoch have covered parts of the study area, and all but a small part of southwestern Owen County have been glaciated at least once. The Illinoian glaciation was the second and most extensive glacial advance, covering most of the study area with ice-laid till deposits and burying Kansan drift from a previous glaciation. The Wisconsin glaciation covered only a small part of northwestern Vigo County, and this glacial boundary forms the southern limit of the Tipton Till Plain geomorphic province (fig. 6).

The result of these glacial episodes is a blanket of drift in the study area ranging in thickness from less than 50 ft to more than 100 ft (Purdue University Water Resources Research Center and Geosciences Research Associates, Inc., 1980, plate 6). Glacial sand and gravel outwash deposits occur along the Wabash River. A wide band of windblown sand and loess covers the till deposits east of the Wabash River. Recent alluvial deposits are found in the flood plains of the major rivers and streams, especially the Wabash and Eel Rivers. Postglacial lake deposits composed of clay, silt, and sand are found in some stream valleys adjacent to the Eel River.

Geomorphology

Clay, Owen, Sullivan, and Vigo Counties contain five distinct geomorphic units (fig. 6). The Wabash Lowland is the most extensive unit, covering all of Sullivan County, most of Clay and Vigo Counties, and a part of southwestern Owen County. The Crawford Upland occupies eastern Clay and central Owen Counties. The Mitchell Plain and, to a smaller extent, the Norman Upland are present in eastern Owen County. The Tipton Till Plain occupies a small part of northwestern Vigo County.

The Wabash Lowland is a lowland area with wide, flat flood plains as the most common feature. Most of the bedrock is composed of soft shales and siltstones of the Pennsylvanian Period, covered by glacial deposits of Illinoian age. Most major stream valleys were once narrow bedrock valleys, but these have been filled with glacial and lake deposits of the Pleistocene Epoch. The upland areas are broad, rolling plains with slight slopes. The Wabash Lowland has an average altitude[1] of 500 ft (feet) above the National Geodetic Vertical Datum of 1929 (NGVD of 1929). This altitude is approximately 300 to 400 ft below the crest of the Crawford Upland (Schneider, 1966, p. 48, 49).

The Crawford Upland is an upland area with well-developed dendritic drainage patterns. The topography is controlled by westward-sloping, resistant sandstone beds of the Pennsylvanian Mansfield Formation and resistant limestone beds of the Upper Mississippian Series. The sandstone and limestone beds form narrow, flat-topped ridges. The sides of the ridges slope sharply toward the stream valleys, and the ridgetops are as much as 350 ft above the narrow valley flood plains. Flood plains are usually the only level land in the area. The Crawford Upland contains deposits from the Illinoian glaciation of the Pleistocene Epoch; consequently, the topographic relief is less than that in unglaciated southern Indiana (Schneider, 1966, p. 48).

The Mitchell Plain is an area of low relief that has formed on middle Mississippian limestones. This karst plain has numerous sinkholes and solution features and is characterized by discontinuous surface streams with subterranean drainage.

The Norman Upland is topographically similar to the Crawford Upland and has formed on resistant siltstones and shales of the Borden Group of the Lower Mississippian Series. Both the Mitchell Plain and the Norman Upland contain glacial deposits of Illinoian age that tend to mask the bedrock features.

The Tipton Till Plain contains extensive till deposits of the Pleistocene Epoch that mask the Pennsylvanian bedrock. The southern extent of this unit is sharply marked by the Wisconsin glacial boundary (fig. 6). The Tipton Till Plain has a flat-to-rolling topography, except along the Wabash River in west-central Indiana where streams have formed narrow bedrock valleys up to 150 ft deep (Schneider, 1966, p. 50).

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[1] Altitude in this report refers to the distance above or below the NGVD of 1929.

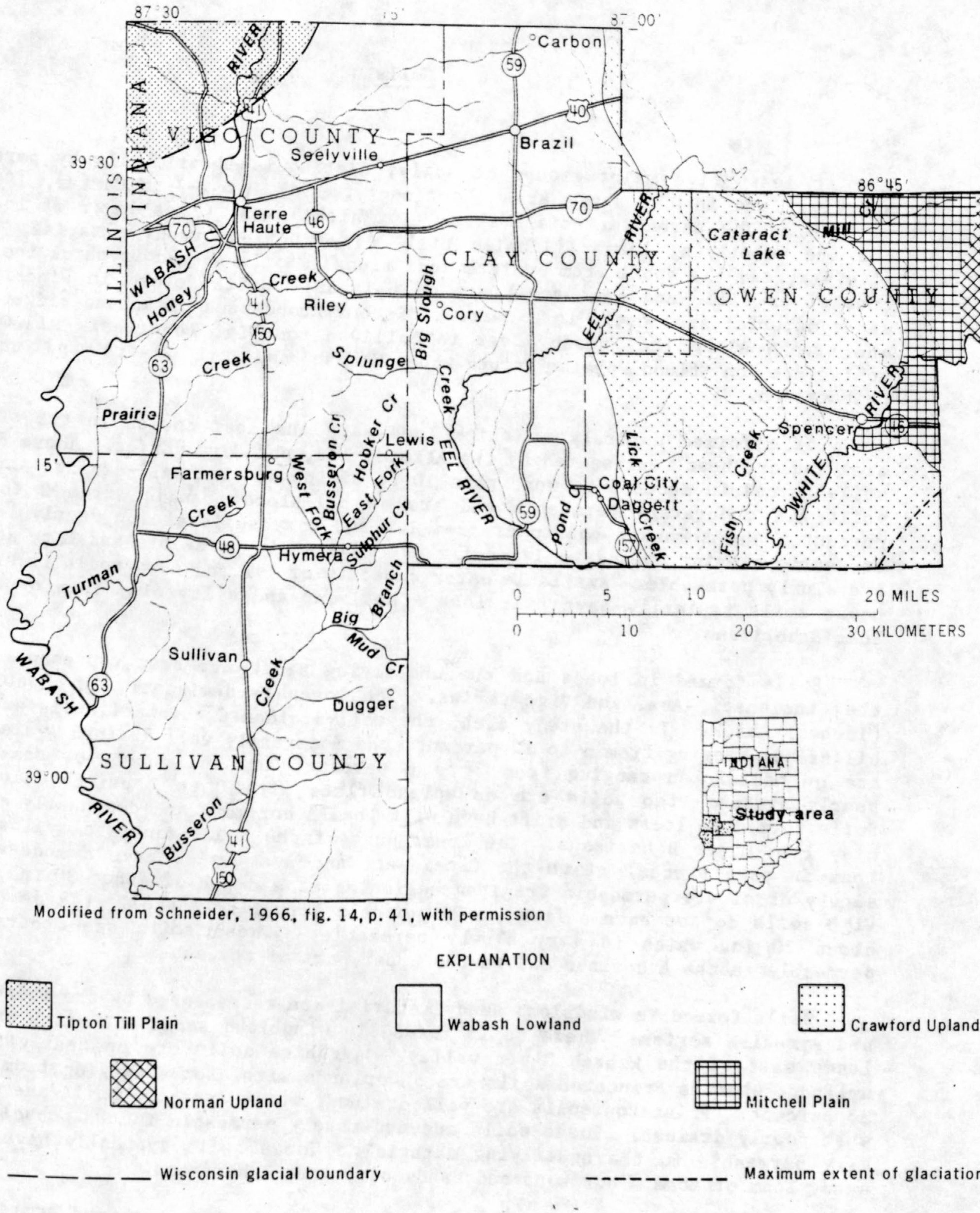


Figure 6.-- Geomorphic units and the Wisconsin glacial boundary.

Soils

At least five major groups of soils, distinguished primarily by parent material, are in the study area (Montgomery, 1974, p. 2-9; McCarter, 1982, p. 5-10). The parent materials are: (1) Thick loess, (2) a layer of loess and the underlying loamy Illinoian till, (3) windblown sandy material, (4) alluvium, and (5) spoil from surface coal mines. Soils formed in thick loess, loess over till, and mine spoil are on uplands. Soils formed in windblown sandy material are mostly in a narrow, discontinuous band on upland ridgetops and breaks along the Wabash River in Sullivan and Vigo Counties. Alluvial soils are on flood plains along the Wabash and Eel Rivers and their tributaries.

Soils formed entirely in thick loess are the most common in the study area and are best represented by the Alford, Iva, and Cory series. These deep soils formed in about 5 to more than 10 ft of loess. The well-drained Alford soils are moderately permeable and are on hillslopes ranging from 2 to 40 percent. The somewhat poorly drained Iva and Cory soils are on nearly level to gently sloping uplands. Iva soils are moderately permeable and Cory soils are slowly permeable. Available water capacity of Iva and Cory soils is high. Loess soils typically have silt loam A horizons and silty clay loam or silt loam B horizons.

Soils formed in loess and the underlying drift are best represented by the Cincinnati, Ava, and Vigo series. The loess is dominantly 20 to 60 in. (inches) thick. In the study area, the well-drained Cincinnati soils are on hillslopes ranging from 6 to 12 percent; the moderately well-drained Ava soils are on hillslopes ranging from 2 to 6 percent; and the poorly or somewhat poorly drained Vigo soils are on upland flats with 0 to 2 percent slopes. Soils formed in loess and drift have silt loam A horizons and dominantly silty clay loam upper B horizons. The lower part of the B horizon is clay loam or loam in some places. Both the Cincinnati and Ava series have a moderately slowly or slowly permeable fragipan beginning at a depth of about 30 in. The Vigo soils do not have a fragipan but have a very firm subsoil at a depth of about 20 in. which is very slowly permeable. These soils are moderately permeable in the A horizon and in the upper part of the subsoil.

Soils formed in windblown sandy material are represented by the Princeton and Ayrshire series. These soils formed in windblown sands and silts on uplands east of the Wabash River valley. Ayrshire soils are on nearly level uplands, whereas Princeton soils are on uplands with slopes ranging from 2 to 25 percent. Princeton soils are well drained, while Ayrshire soils are somewhat poorly drained. These soils are moderately permeable in the subsoil and very permeable in the underlying material. These soils typically have fine sandy loam or loam A horizons and sandy clay loam B horizons.

Alluvial soils are represented by the Genesee, Petrolia, and Armiesburg series in the Wabash River valley and the Stendal, Shoals, and Chagrin series in the Eel River valley. The well-drained Genesee, Armiesburg, and Chagrin series are moderately permeable. The somewhat poorly drained Stendal and

Shoals series are also moderately permeable. The poorly drained Petrolia soils are moderately slowly or slowly permeable. Alluvial soils in the study area typically have silt loam A horizons and silt loam or loam B horizons.

Fairpoint soils formed in spoil from surface coal mines. Fairpoint soils are a heterogeneous mixture of loess, loamy glacial drift, masses of soil, and fragments of bedrock. Fairpoint soils are classified into two map units: FcB, a shaly silt loam with 0 to 8 percent slopes; and FcG, a shaly silty clay loam with 33 to 90 percent slopes.

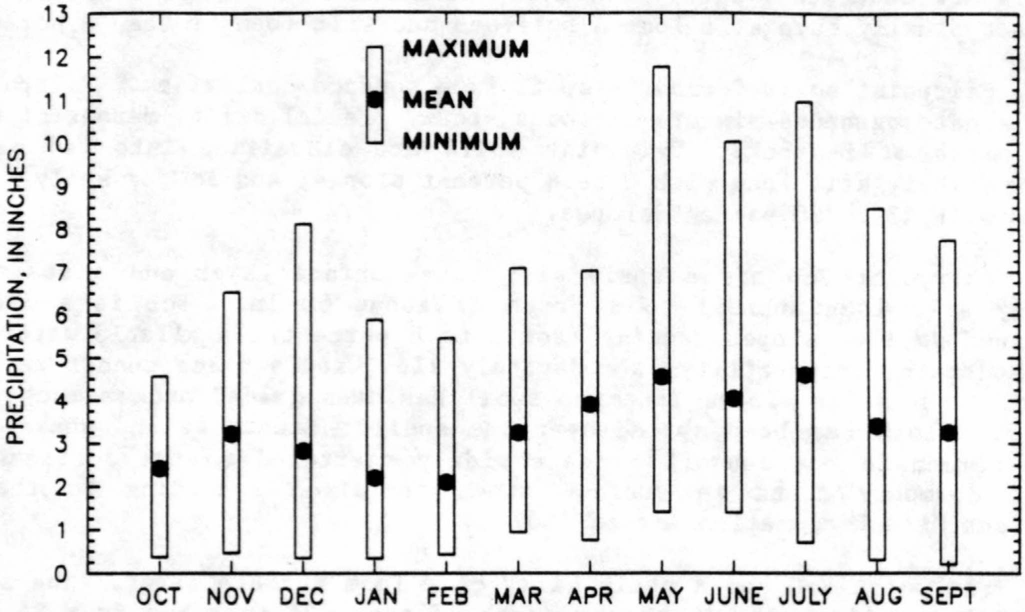
Fairpoint FcB has a shaly silt loam surface layer and a shaly or very shaly silt loam subsoil to a depth of about 60 in. FcB is a deep, well-drained soil on slopes ranging from 0 to 8 percent. Available water capacity is moderate, permeability is moderately slow, and surface runoff is medium to rapid. In a few areas, the mine spoil has been graded and as much as 36 in. of silt loam has been spread over the spoil. Sandstone and shale fragments are common in the subsoil and are widely scattered on the surface. FcB is most commonly found in surface mines reclaimed according to the Indiana Surface Mine Reclamation Act of 1967.

Fairpoint FcG has a shaly silty clay loam surface layer. The subsoil is very shaly silty clay loam to a depth of about 24 in., but from 24 to 60 in. the subsoil is partially weathered, soft shale fragments. FcG is a deep, well-drained soil on slopes ranging from 33 to 90 percent. Available water capacity is moderate, permeability is moderately slow, and surface runoff is very rapid. This soil consists of ungraded spoil in banks 15 to greater than 40 ft high. Sandstone and shale rocks are common on the surface and in the subsoil. FcG is typical of the soil found in unreclaimed surface mines.

Climate

Indiana has a continental climate with highly variable weather influenced by the interaction of cold polar air from the north and warm gulf air from the south. These air masses generally move in an easterly direction across the State.

Climatic data from the National Weather Service at Terre Haute were analyzed for the period from October 1955 to September 1982. Annual precipitation averaged 39.5 in/yr (inches per year) and ranged from 27.9 to 56.2 in/yr. July is usually the wettest month with 4.6 in. of precipitation, and February is usually the driest month with 2.1 in. of precipitation (fig. 7) (U.S. Department of Commerce, 1955-82). Summer rains often originate from thunderstorms. Thunderstorms can be severe and are quite local. Rain falling at other times of the year is typically from frontal systems that are less intense than thunderstorms and extend over larger areas. Twenty-four-hour rainfall intensities for the study area range from about 2.5 in. (1-year recurrence interval) to about 5 in. (25-year recurrence interval). One-hour rainfall intensities range from about 1.2 in. (1-year recurrence interval) to 2.4 in. (25-year recurrence interval) (Hershfield, 1961).



Data from U.S. Department of Commerce, 1955–82

Figure 7. — Mean, maximum, and minimum monthly precipitation at Terre Haute, 1955–82.

The mean annual temperature at Terre Haute is 52.4 °F (degrees Fahrenheit). July is usually the warmest month (75.4 °F) and January is usually the coldest month (25.0 °F) (fig. 8). Temperatures can exceed 95 °F during the summer and can drop below 0 °F during the winter.

Free-water-surface evaporation in the study area averages about 34 to 36 in. annually or about 26 to 28 in. for May through October (Farnsworth and others, 1982, maps 2, 3). Free-water-surface evaporation is commonly used as a measure of potential evapotranspiration (Farnsworth and others, 1982, p. 1). Maximum potential evapotranspiration occurs during June or July, and the minimum occurs during December or January.

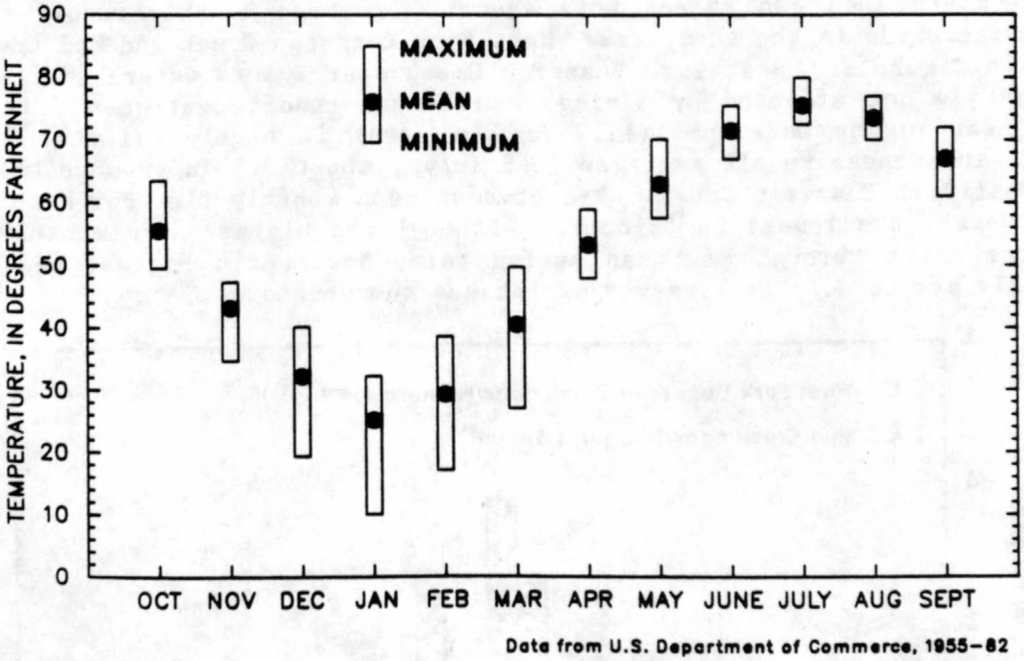


Figure 8. — Mean, maximum, and minimum monthly average air temperature at Terre Haute, 1955–82.

Surface water

West-central Indiana has three major drainages that flow in a generally southern direction (fig. 1). The Wabash River drains Vigo and Sullivan Counties primarily through its tributaries Honey, Prairie, Turman, and Busseron Creeks. The Eel River drains Clay and the western third of Owen County before its confluence with the White River. The White River drains eastern Owen County through minor tributaries.

Of the average 39.5 in. per year of precipitation in the area, approximately 13 in. runs off (C. G. Crawford and L. J. Mansue, U.S. Geological Survey, written commun., 1984). However, runoff from areas containing surface-mined land can exceed this amount. Average monthly runoff for two small watersheds in the study area--West Fork Busseron Creek and Mud Creek--is shown in figure 9. West Fork Busseron Creek near Hymera watershed (14.4 mi^2 in area) is not affected by mining, and annual runoff averages 13 in. Mud Creek near Dugger watershed (11.9 mi^2 in area) is highly affected by past mining, and annual runoff averages 16.5 in/yr, about 3.5 in/yr more than that from West Fork Busseron Creek. The highest mean monthly flow for both creeks is in March, the lowest in October. Although the highest mean monthly flows are from March through May when spring rains occur, the highest peak flows typically are in July as a result of intense thunderstorms.

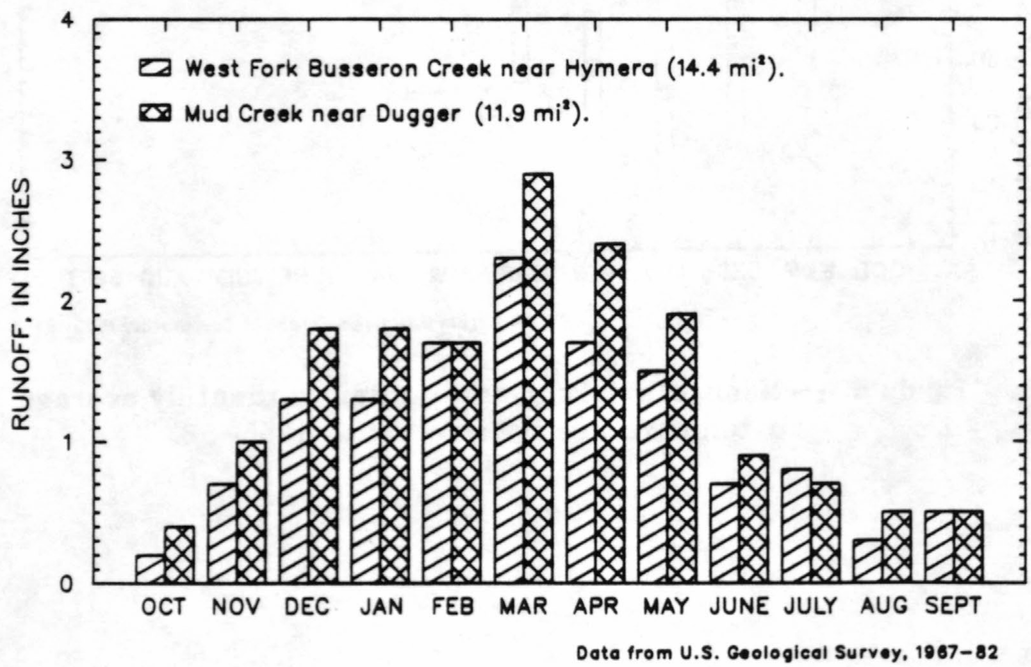


Figure 9. -- Mean monthly runoff for West Fork Busseron Creek near Hymera and Mud Creek near Dugger, 1966-81 water years.

Ground water

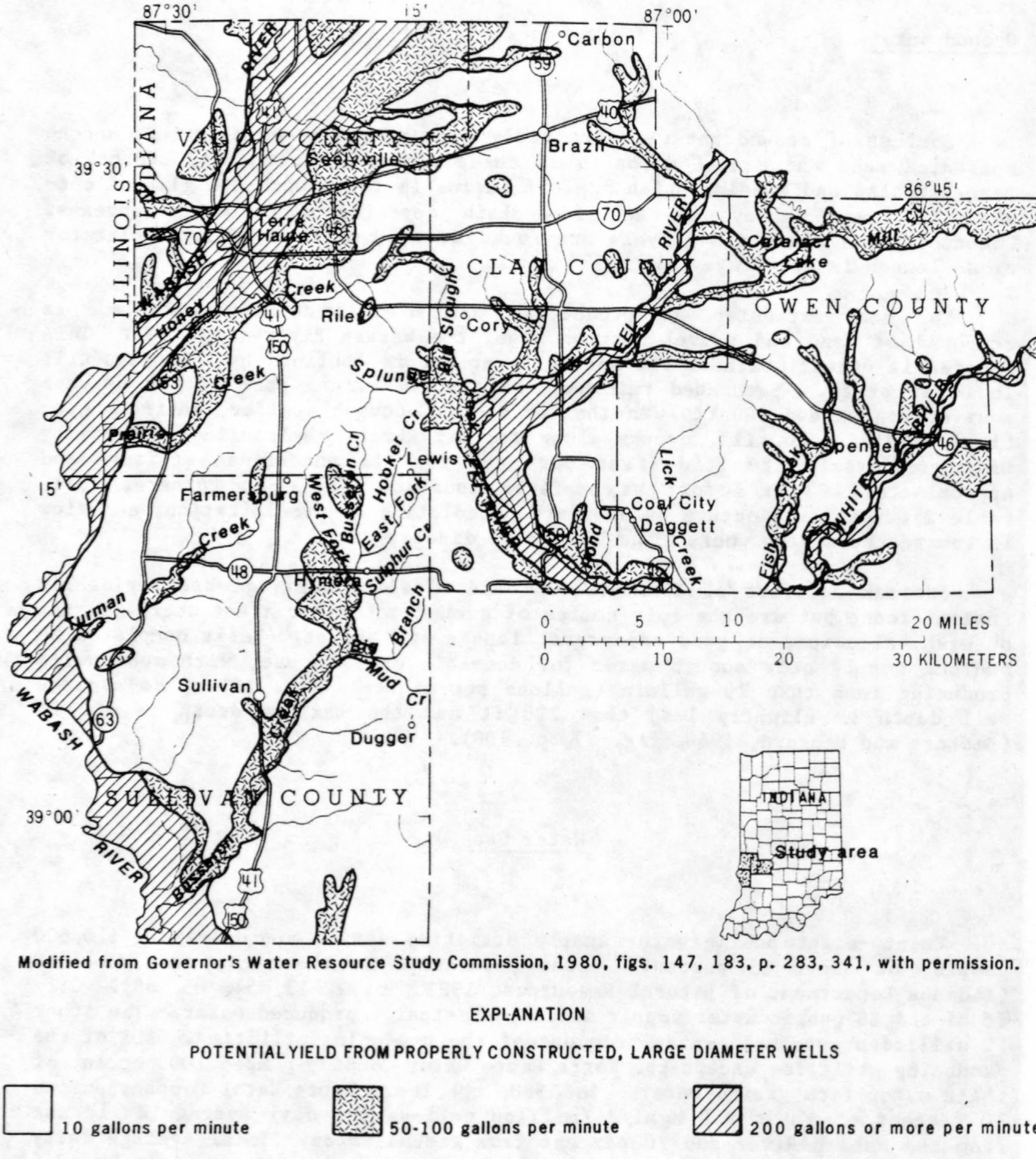
Sources of ground water in the study area are Holocene alluvium, unconsolidated sand and gravel deposits of the Pleistocene Epoch, and bedrock of Pennsylvanian and Mississippian age. Alluvium is found with the glacial outwash in river valleys or as flood-plain deposits along small streams. Unconsolidated sands and gravels are found as outwash from glacial meltwater or as lenses in the clayey till.

The most extensive and productive aquifer in west-central Indiana is composed of sand and gravel outwash along the Wabash River (fig. 10). This aquifer is unconfined near the Wabash River but is confined by Illinoian till in other areas. Saturated thickness in the unconfined part of the outwash aquifer can exceed 100 ft. Another extensive outwash aquifer, entirely confined by Illinoian till, occurs along the Eel River. Hydraulic conductivity is approximately 180 ft/d (feet per day) for the unconfined aquifers and approximately 83 ft/d for the confined aquifers (Cable and others, 1971, table 2). Recharge occurs by downward percolation of precipitation, and flow is toward the rivers where ground water is discharged.

Bedrock aquifers of Pennsylvanian and Mississippian age are regionally insignificant but are the sole source of ground water for areas where glacial outwash, alluvium, or sand and gravel lenses are absent. Wells completed in bedrock supply only enough water for domestic or farm use, with most wells producing less than 20 gal/min (gallons per minute) (fig. 10). The average well depth is slightly less than 200 ft and the maximum depth is 400 ft (Bechert and Heckard, 1966, fig. 27, p. 108).

Water Use

Twenty-eight public water supply utilities served approximately 110,600 people, or about 63 percent of the population of the study area in 1980 (Indiana Department of Natural Resources, 1982b, p. 2, 13, 54, 65, 69). Only 16 of the 28 public water supply utilities actually produced water. The other 12 utilities purchased water from one of the producing utilities. All of the producing utilities except the Terre Haute Water Company pumped 100 percent of their water from ground water. In 1980, the Terre Haute Water Company pumped 30 percent of their 9.0 Mgal/d (million gallons per day) average daily use from the Wabash River and 70 percent from ground water. Total average daily use for public water supply in the four-county area was approximately 13.2 Mgal/d in 1980 (table 1).



Modified from Governor's Water Resource Study Commission, 1980, figs. 147, 183, p. 283, 341, with permission.

EXPLANATION

POTENTIAL YIELD FROM PROPERLY CONSTRUCTED, LARGE DIAMETER WELLS

10 gallons per minute | **50-100 gallons per minute** | **200 gallons or more per minute**

Figure 10.-- Availability of ground water.

Table 1.--Public water supply average daily use and population served, 1975 and 1980

[Data adapted from Indiana Department of Natural Resources, 1982b, p. 13, 54, 65, 69; Mgal/d, million gallons per day]

County	1975 Population served[1]	1975 Average daily use (Mgal/d)	1980 Population served[1]	1980 Population served[2] (percent)	1980 Average daily use (Mgal/d)
Clay	12,800	1.160	18,000	65	2.065
Owen	5,800	.320	7,000	37	.362
Sullivan	10,600	1.010	12,400	65	1.642
Vigo	70,800	8.850	73,200	65	9.164
Study area total	100,000	11.790	110,600	63	13.233

[1] Population estimates are for comparative purposes only. The population estimates are summations of estimated population served by individual public water supply utilities in the county. Uncertainties are caused by utilities that serve more than one county. Population estimates are rounded to the nearest 100.

[2] 1980 county populations taken from U.S. Department of Commerce, 1982, p. 16-8.

Both the average daily use and the population served by public water supply utilities increased from 1975 to 1980 (table 1). This trend is in agreement with an observation of the Governor's Water Resources Study Commission that Indiana counties with limited ground-water resources will show rapid growth of public supply systems until 80 to 90 percent of the county is served (Governor's Water Resource Study Commission, 1980, p. 56).

No data for industrial self-supplied water use have been published at the county level, however some data are published at the regional level. Industrial self-supplied water use was 34.8 Mgal/d in 1977 for the Region 7 Planning District (Clay, Sullivan, Vigo, Parke, Putnam, and Vermillion Counties) (Governor's Water Resource Study Commission, 1980, p. 290). The majority of the industrial self-supplied water is withdrawn from ground water.

Rural domestic self-supplied systems are used by approximately 65,000 people to obtain water for domestic use (table 2). The average daily use for rural self-supplied systems in 1980 was 4.8 Mgal/d. Average daily use for livestock was the smallest of any water use, only 1.1 Mgal/d in 1980. Ground water is the source of most rural self-supplied water.

Table 2.--Rural domestic self-supplied population and average daily use and livestock self-supplied average daily use, 1980

[Data adapted from Indiana Department of Natural Resources, 1982a, p. 5-13; Mgal/d, million gallons per day]

County	Rural domestic self-supplied			Livestock self-supplied[1]
	Population	Population[2] (percent)	Average daily use (Mgal/d)	Average daily use (Mgal/d)
Clay	8,680	35	0.638	0.321
Owen	9,910	63	.728	.302
Sullivan	7,360	35	.541	.236
Vigo	38,940	35	2.862	.208
Study area total	64,890	37	4.769	1.067

1 Includes beef cattle, dairy cattle, chickens, and hogs.
2 1980 county population from U.S. Department of Commerce, 1982, p. 16-8.

Irrigation is a seasonal water use, with ground water being used during the growing season to supplement rainfall. At least 2,000 acres of cropland in Sullivan County and 100 acres of cropland in Parke County were irrigated in 1977. About 5.6 Mgal/d of ground water were applied during the peak irrigating months of July and August (Governor's Water Resource Study Commission, 1980, p. 290). At least 2,300 acres in Sullivan County, 101 acres in Vigo County, and a confidential, unreported number of acres in Owen County were irrigated in 1978 (U.S. Department of Commerce, 1978, p. 122). Approximately 15,000 acres in Sullivan County and 10,000 acres in Vigo County located adjacent to the Wabash River have very high potential for irrigation.

Water use for energy production exceeds all other water uses combined. Two coal-fired electric generating stations in Sullivan and Vigo Counties produce a total of 1,357 megawatts of power. Both stations have once-through water cooling systems that use a total of 1,065 Mgal/d from the Wabash River (Governor's Water Resource Study Commission, 1980, p. 294). An additional 980-megawatt station under construction in Sullivan County will have a cooling pond system that will require 21.3 Mgal/d of water from the Wabash River.

Two coal preparation plants in Clay and Sullivan Counties each use less than 1 Mgal/d for washing coal. Surface water stored in final-cut lakes is the source of water for use in the preparation plants.

Land Use

Row-crop agriculture and pasture are the predominant land uses in Clay, Sullivan, and Vigo Counties, but forest is the predominant land use in Owen County. Over two-thirds of the land in the study area is used for agriculture, while only one-fourth of the land is in forest (table 3).

The major cultivated crops are corn, soybeans, and wheat; the major forage crops are clover, alfalfa, and grasses. Much of the forest is on steeply sloping uplands or near streams in the lowlands. Red oak, white oak, hickory, tulip poplar, and sugar maple dominate the upland forest, and pin oak, silver maple, slippery elm, and sweetgum dominate the lowland forest.

Table 3.--1975 land use[1]

[Data from State Planning Services Agency, 1977; ---, land use class not used]

County	Total area, in square miles	Land use, in percent of total area						
		Urban and built-up	Row-crop agricul-ture and pasture	Forest	Water	Barren	Wetland	Other
Clay[2]	364	4.1	62.8	31.0	0.3	1.7	---	---
Owen[3]	390	1.3	46.2	46.5	.8	4.7	0.4	0.1
Sullivan[2]	457	1.5	83.8	10.0	1.0	3.6	---	---
Vigo[2]	415	8.5	72.2	15.9	1.2	2.3	---	---
Study area total	1,626	3.8	67.1	25.0	.8	3.1	.1	.0

[1] Percentages do not total 100.0 percent because of rounding.
[2] Landsat data interpreted by the West Central Economic Development Commission.
[3] Data provided by the Region 10 Development Commission.

Population

The total population of Clay, Owen, Sullivan, and Vigo Counties was 174,195 in 1980 (table 4). Vigo County, the most populated county, comprised over 64 percent of the total population of the study area. Owen County, the least populated county, comprised only about 9 percent of the total population. Although the total population of the study area increased 2.9 percent from 1960 to 1970 and 2.2 percent from 1970 to 1980, no trend in population is apparent at the county level.

Table 4.--Population and percent change in population, 1960, 1970, and 1980

[Data from U.S. Department of Commerce, 1982, p. 16-8]

	Population (number of inhabitants)			Population change (percent)	
County	1960	1970	1980	1960 to 1970	1970 to 1980
Clay	24,207	23,933	24,862	-1.1	3.9
Owen	11,400	12,163	15,841	6.7	30.2
Sullivan	21,721	19,889	21,107	-8.4	6.1
Vigo	108,458	114,528	112,385	5.6	-1.9
Study area total	165,786	170,513	174,195	2.9	2.2

Almost 52 percent of the total population resided in cities and towns of more than 2,500 people in 1980, down more than 3 percent from the number of urban residents in 1970 (table 5). Vigo County, which contains Terre Haute, the largest city in the region, had the largest proportion of urban residents (66.5 percent) in 1980. Only 17.2 percent of the population of Owen County were urban residents in 1980. No trend in urban population was evident at the county level, but rural population increased at least 7.4 percent from 1970 to 1980 in each of the four counties (table 5).

Table 5.--Urban and rural population and percent change in population, 1970 and 1980

[Data from U.S. Department of Commerce, 1982, p. 16-9]

	Urban population[1]			Rural population[2]		
	(Number of inhabitants)		Population change (percent)	(Number of inhabitants)		Population change (percent)
County	1970	1980	1970 to 1980	1970	1980	1970 to 1980
Clay	8,163	7,852	-3.8	15,770	17,010	7.9
Owen	0	2,732	---	12,163	13,109	7.8
Sullivan	4,683	4,774	1.9	15,206	16,333	7.4
Vigo	80,908	74,736	-7.6	33,620	37,649	12.0
Study area total	93,754	90,094	-3.9	76,759	84,101	9.6

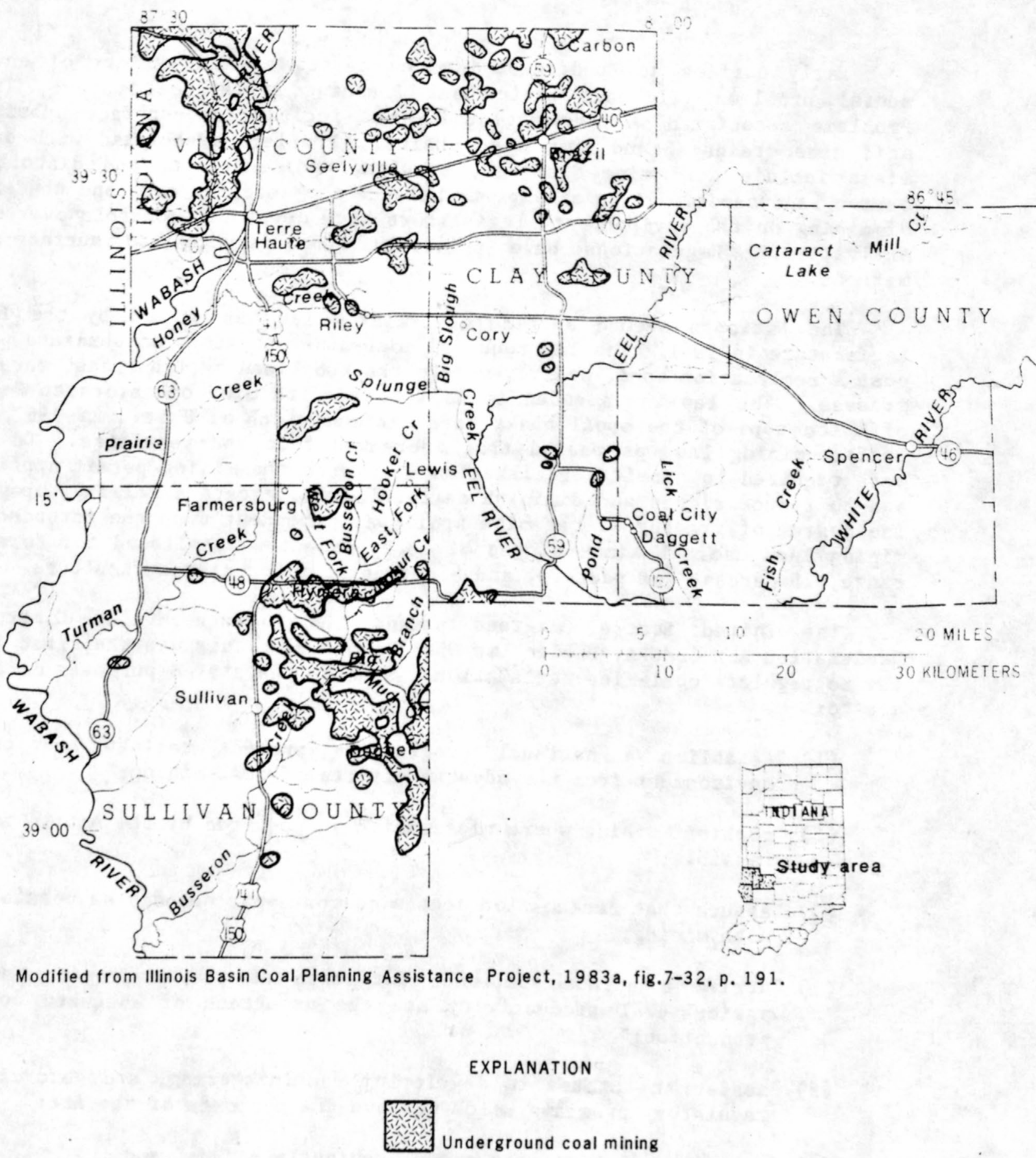
[1] Places with a population greater than 2,500 inhabitants.
[2] Places with a population less than or equal to 2,500 inhabitants.

Methods and Regulations

Underground and surface methods have been used to mine coal in Clay, Owen, Sullivan, and Vigo Counties. Underground methods are primarily used where the coal seam is more than 100 to 150 ft below land surface. Underground mines are classified by the type of entrance; either drift, slope, or shaft; and by the method of coal removal; either conventional or continuous (Illinois Basin Coal Planning Assistance Project, 1983a, p. 25, 28). Drift mines are typically the shallowest underground mines and intersect the coal seam more or less horizontally at the outcrop. Access to the coal seam in slope mines is gained through an inclined shaft. Shaft mines are typically the deepest underground mines and access to the coal seam is by a vertical shaft.

The room-and-pillar method is an example of a conventional underground mining method. About half of the coal is removed in a pattern of small areas or tunnels (rooms) and the remaining coal (pillars) supports the overlying strata. The longwall method is an example of a continuous underground mining method. Large areas are mined by a self-propelled machine that supports the overlying strata and extracts all of the coal. As mining progresses, the overlying strata are allowed to collapse in the mined-out areas. Extensive areas in northwestern Vigo County and east-central Sullivan County, in addition to numerous smaller areas in northern Clay County, have been mined for coal by underground methods (fig. 11).

Surface methods are used where the coal seam is within 100 to 150 ft of the surface. Area, contour, and auger are three types of surface-mining methods. Contour and auger methods are used primarily in rugged terrain. Nearly all of the coal mined by surface methods in the study area has been by the area method. Area mining begins by clearing woody vegetation and by removing and stockpiling topsoil from the land where the initial cut will be made. The initial cut, or pit, is approximately 100 ft wide, up to 1 mi (mile) or more long, and is located where the coal is closest to the land surface. The long dimension of the pit is aligned parallel to the strike of the coal seam and mining progresses down the dip of the coal seam. Consolidated strata in the overburden are fractured and loosened by explosives placed in holes drilled into the strata. Overburden is removed from the pit by draglines or stripping shovels and is placed in piles adjacent to the pit, opposite the direction of mining. Overburden that has been removed and redeposited is termed spoil. As overburden is removed, coal is exposed and front-end loaders or small shovels load coal into haul trucks for removal. After the initial cut is completed and the coal has been removed, another cut is started down dip of the initial cut. Overburden is removed from the second cut and placed in the initial cut. This procedure is repeated and results in a series of parallel cuts, each filled with the spoil from the subsequent cut. The procedure stops when mining is no longer feasible and the final cut is usually allowed to fill with water. In compliance with current reclamation regulations, spoil banks are graded to the approximate original contour, topsoil is replaced, and vegetation is reestablished.



Modified from Illinois Basin Coal Planning Assistance Project, 1983a, fig.7-32, p. 191.

Figure 11.-- Location of areas mined for coal by underground methods.

Early surface and underground mines caused a wide variety of environmental problems (Illinois Basin Coal Planning Assistance Project, 1983b). Problems associated with underground mines include land-surface subsidence, acid mine drainage, and open mine shafts. Problems associated with surface mines include acid mine drainage, erosion, sedimentation, and disturbed or barren landscapes. In an attempt to balance the need for coal and the effects of mining on the environment, legislators have developed controls over mining activities. Regulations have primarily been directed to surface-mining methods.

The Nation's second surface coal-mining law was passed by the Indiana Legislature in 1941. The law required coal-mine operators to obtain a permit, post a reclamation bond, and revegetate the spoil banks with trees, shrubs, or grasses. The law was amended in 1951 to require mine operators to "strike-off" the tops of the spoil banks to a minimum width of 8 ft. In 1967, a new surface-mining law was passed that increased fees and penalties. Operators were required to submit a reclamation plan with the mining permit application and to reduce ridges and diminish depressions to create a rolling topography. The degree of grading of the mine spoil was dependent upon the intended post-mining land use. Maximum slopes of 33.3 percent were allowed for forest and range, 25 percent for pasture, and 8 percent for row-crop agriculture.

The United States Congress passed the Surface Mining Control and Reclamation Act (SMCRA, Public Law 95-87) in 1977. This was the first Federal law to regulate coal-mine reclamation. Some of the stated purposes of the Act are to:

(1) "establish a national program to protect society and the environment from the adverse effects of coal mining;"

(2) "prohibit mining where reclamation as required by the Act is not feasible;"

(3) "assure that reclamation occurs as contemporaneously as possible with mining;"

(4) "strike a balance between protection of the environment and agricultural productivity and the assurance of adequate coal production;"

(5) "assist the States in developing, administering, and enforcing regulatory programs which achieve the purposes of the Act:"

(6) "achieve reclamation of areas previously mined;" and

(7) "provide appropriate procedures for public participation in the development of regulations, standards, and programs under SMCRA" (U.S. Department of the Interior, 1979, p. AII-2).

Protection of surface- and ground-water systems is emphasized in the regulations implementing SMCRA. Minimum performance standards are specified for the protection of the hydrologic balance during exploration, mining, and reclamation. Extensive hydrologic information must be obtained before mining permits are authorized. Permit applications must include descriptions of the quality and quantity of surface and ground water, including seasonal variations, both at the mine and in surrounding areas. Permit applications must also include a determination of the probable hydrologic effects of mining and reclamation. In addition, the cumulative hydrologic effects of mining must be determined by the regulatory authority.

Reserves and Production

Indiana has 17,133,966,000 short tons of recoverable coal reserves (Illinois Basin Coal Planning Assistance Project, 1983a, fig. 7-18, p. 173). Of the total coal reserves, 11.3 percent can be mined by surface methods and 88.7 percent can be mined by underground methods. Clay, Owen, Sullivan, and Vigo Counties have 45.6 percent of Indiana's surface reserves and 34.1 percent of Indiana's underground reserves (table 6). Of the total coal reserves in the study area, 14.5 percent can be mined by surface methods.

Coal was first mined in the study area in 1838 near Lewis and Farmersburg in Sullivan County and near Seelyville and Riley in Vigo County (fig. 1). In 1852, Block coal was mined near Brazil and Carbon in Clay County. The early surface miners used picks and shovels or horse-powered drag buckets to remove the overburden.

After the initial and brief use of surface-mining methods in the mid-1800's, nearly all Indiana coal was mined by underground methods until World War I (Powell, 1972, fig. 9, p. 10). The proportion of coal mined by surface methods gradually increased after World War I, until World War II when surface production equaled underground production (Watson, 1983, p. 13). In 1982, coal mined by surface methods accounted for 98.4 percent of Indiana's total coal production (Indiana Coal Association, 1983). The projected proportion of Indiana coal mined by surface methods for the year 2000 ranges from 52 to 68 percent of the total Indiana coal production (Willard and others, 1980, table 8-1, p. 62).

Total coal production in the study area by both surface and underground methods was 614,397,000 short tons by 1982 (table 7). This tonnage represents 37.3 percent of Indiana's total coal production from 1812 to 1982. Coal produced in the study area comprised over half of the total coal production in Indiana from 1851 to 1900. The contribution of the study area to the total coal production of the State has decreased to only 14.7 percent of the total production from 1980 to 1982.

Table 6.--Surface and underground recoverable coal reserves

[Data from Illinois Basin Coal Planning Assistance Project, 1983a, fig. 7-18, p. 173]

	Recoverable coal reserves					
	Surface[1]		Underground[2]		Total	
County	Reserves (thousands of short tons)	Percentage of Indiana surface reserves	Reserves (thousands of short tons)	Percentage of Indiana underground reserves	Reserves (thousands of short tons)	Percentage of Indiana total reserves
Clay	307,793	15.9	252,366	1.7	560,159	3.3
Owen	50,456	2.6	0	.0	50,456	.3
Sullivan	272,874	14.1	3,482,337	22.9	3,755,211	21.9
Vigo	249,760	12.9	1,448,432	9.5	1,698,192	9.9
Study area total	880,883	45.6	5,183,135	34.1	6,064,018	35.4
Indiana total	1,933,396	100.0	15,200,570	100.0	17,133,966	100.0

[1] Surface reserves are coal seams greater than or equal to 28 in. thick and within 150 ft of the land surface.

[2] Underground reserves are coal seams greater than or equal to 28 in. thickness and within 150 to 1,000 ft of the land surface.

Table 7.--Total coal production, 1812-1982

[Data from Indiana Coal Association, 1980, 1982, 1983; Illinois Basin Coal Planning Assistance Project, 1983, table 7-4, p. 175;]

	Total coal production											
	1812-1850		1851-1900		1901-1949		1950-1979		1980-1982		1812-1982	
County	Tons[1]	Percent[2]	Tons[1]	Percent[2]	Tons[1]	Percent[2]	Tons[1]	Percent[2]	Tons[1]	Percent[2]	Tons[1]	Percent[2]
Clay	5	2.9	25,265	31.1	54,102	6.0	30,250	5.2	4,823	5.3	114,445	6.9
Owen	0	.0	383	.5	3,261	.4	754	.1	212	.2	4,610	.3
Sullivan	5	2.9	8,630	10.6	139,742	15.5	86,224	15.0	6,617	7.3	241,218	14.6
Vigo	34	19.8	8,475	10.4	195,752	21.8	48,184	8.4	1,679	1.9	254,124	15.4
Study area total	44	25.6	42,753	52.6	392,857	43.7	165,412	28.7	13,331	14.7	614,397	37.3
Indiana total	172	100.0	81,344	100.0	899,225	100.0	576,359	100.0	90,412	100.0	1,647,512	100.0

1 Total coal production, in thousands of short tons.
2 Percentage of total Indiana coal production.

Clay County produced 31.1 percent of Indiana's total coal production from 1851 to 1900 but only 5.7 percent from 1901 to 1982. Sullivan and Vigo Counties have been major coal-producing counties, contributing 30.1 percent of the total State and 80.6 percent of the total study area coal production from 1812 to 1982. Coal production in Vigo County dramatically increased from 1950 to 1979, whereas Sullivan County maintained the same relative level of production (table 7). Owen County never has been a major coal-producing county, with total production representing only 0.3 percent of Indiana's total coal production and only 0.8 percent of the total production of the study area.

Twenty-one surface mines produced coal in the study area in 1981 (table 8). Clay and Sullivan Counties each had one mine that produced more than 1,000,000 short tons of coal. All five mines in Owen County produced less than 25,000 short tons. Vigo County had no mines that produced more than 100,000 short tons. The lack of large mines is additional evidence that the importance of Vigo County as a coal-producing county has decreased. No underground mines produced coal in the study area in 1981.

Table 8.--Number of active coal mines, 1981

[Data from Indiana Bureau of Mines and Mining, undated, p. 7, 11, 14]

	1981 coal production (thousands of short tons)				
County	Less than 25	25-100	101-250	251-1,000	More than 1,000
Clay	3	1	3	0	1
Owen	5	0	0	0	0
Sullivan	1	0	0	2	1
Vigo	2	2	0	0	0
Study area total	11	3	3	2	2
Indiana total	40	37	31	12	8

Nearly every commercially valuable Indiana coal seam has been surface-mined in the study area. Although production data are not available by coal seam, the relative amounts of coal produced by seam can be inferred from the mined acreage by seam. Using mined acreage as an indicator of production is an approximation because of differences in seam thickness and mining techniques.

By the late 1960's, 23,885 acres in the study area had been surface-mined for coal (Powell, 1972, table 3, p. 12, 13). Over 42 percent of the mined land was in Clay County and only 5.6 percent was in Owen County. The Upper Block and Lower Block Coal Members of the Brazil Formation accounted for 31.1 percent of the mined land in the study area. The Springfield Coal Member (V) of the Petersburg Formation accounted for 19.9 percent; the Danville Coal Member (VII) of the Dugger Formation accounted for 16.9 percent; the Seelyville Coal Member (III) of the Staunton Formation accounted for 12.4 percent; the Hymera Coal Member (VI) of the Dugger Formation accounted for 11.1 percent; and the Survant Coal Member (IV) of the Linton Formation, the Minshall Coal Member of the Brazil Formation, and other coals comprised the remaining 8.6 percent of the land surface-mined for coal in the study area.

As a result of surface coal mining, 50,340 acres in the study area were disturbed (affected by coal extraction and (or) deposition of mine spoil) from 1941 through 1980 (table 9). Areas mined by surface methods are less extensive but more numerous than those mined by underground methods. Most surface-mined land in the study area is located in eastern Sullivan and Vigo Counties, central Clay County, and along the southern part of the Clay and Owen County boundary (fig. 12). These areas correspond to outcrops of the major coal members (fig. 3).

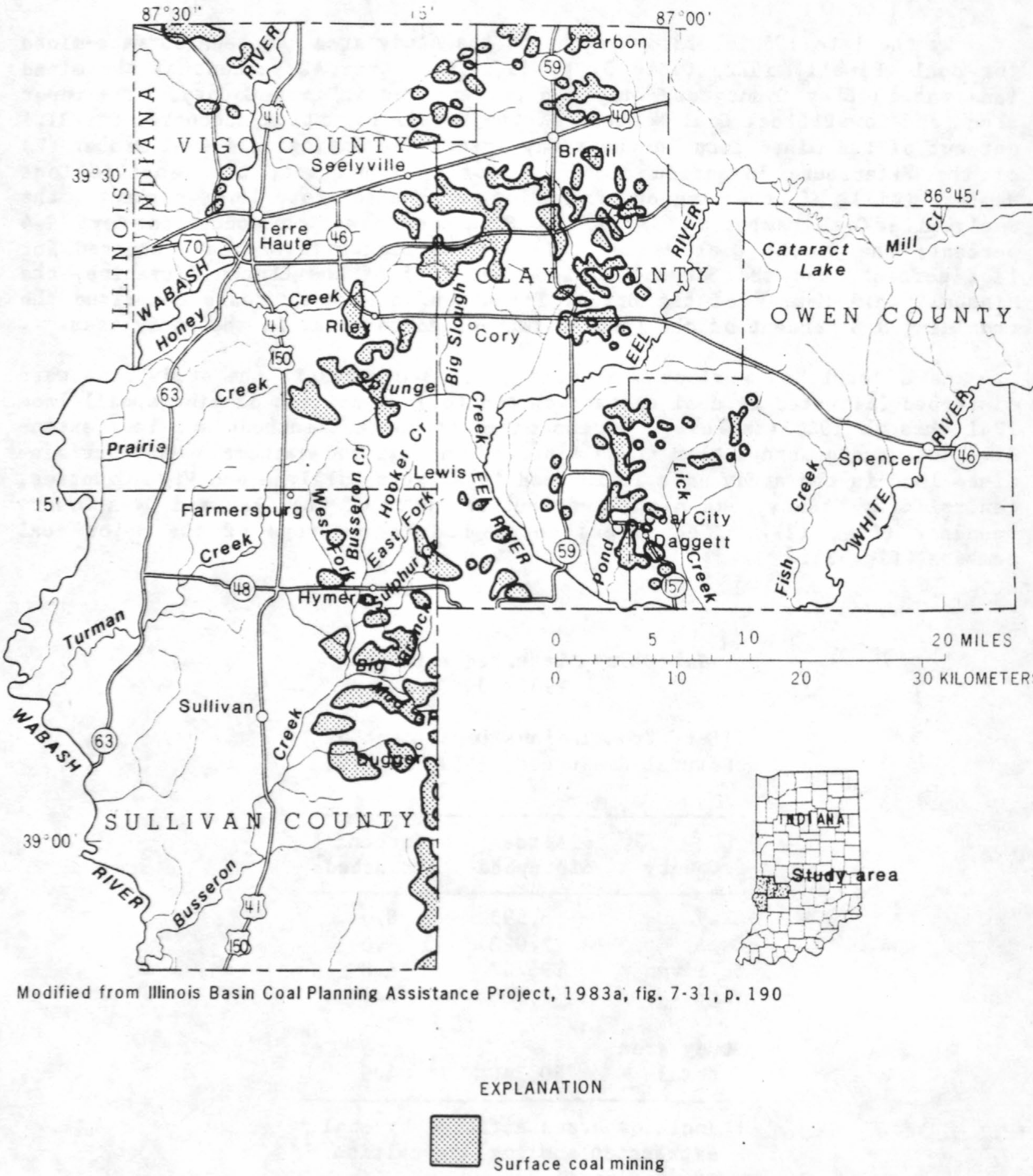
Table 9.--Disturbed acreage, 1941-80

[Data from Indiana Department of Natural Resources, 1983, fig. 2]

County	Acres disturbed[1]	Percent disturbed[1]
Clay	18,595	8.0
Owen	2,023	.8
Sullivan	19,762	6.8
Vigo	9,960	3.8
Study area total	50,340	4.9

[1] Includes areas affected by coal extraction and (or) deposition of mine spoil.

Eighty-six percent of the land surface mined in Clay County was for the Upper Block, Lower Block, and Seelyville (III) Coal Members (Powell, 1972, table 3, p. 12, 13). The Upper Block and Lower Block Coal Members were the only coals mined in Owen County. The Danville (VII) and Hymera (VI) Coal Members comprised 80.2 percent of the surface-mined land in Sullivan County. The Springfield (V) and Danville (VII) Coal Members comprised 79.1 percent of the surface-mined land in Vigo County.



Modified from Illinois Basin Coal Planning Assistance Project, 1983a, fig. 7-31, p. 190

Figure 12.-- Location of areas mined for coal by surface methods.

Six watersheds were selected for intense study (fig. 1). Two watersheds are predominately agricultural (Big Slough and Hooker Creek; two were surface mined and reclaimed according to the guidelines established under the 1967 Indiana Surface Mine Reclamation Act (an unnamed tributary to Honey Creek and an unnamed tributary to Sulphur Creek; one was partially mined and is a mixture of agricultural and unreclaimed mined land (Pond Creek); and the last study watershed was surface mined and unreclaimed (an unnamed tributary to Big Branch).

In order to reduce wordiness and repetition, the word "unnamed" has been dropped from the stream and watershed names. For example, unnamed tributary to Honey Creek is hereafter referred to in the text as Honey Creek tributary. The name refers to either the stream or the watershed, depending on the context of use. References to the watersheds in the report refer to the drainage areas above the gaging stations.

A detailed description of the hydrologic instrumentation, methods used to collect hydrologic data, and tables of daily hydrologic data for all six watersheds are given in Renn and others (1985).

Big Slough

Big Slough is located in west-central Clay County near the Vigo County border (fig. 1). The stream drains a predominantly agricultural area. Big Slough flows south to its confluence with Splunge Creek approximately 4.5 mi south of Cory. A streamflow-gaging station (03360109 Big Slough near Cory) with a natural control was established at State Highway 46, 1.5 mi west of Cory and 5.2 mi upstream from the confluence with Splunge Creek (fig. 13). The drainage area of Big Slough at the gage is 1,731 acres (2.70 mi^2).

Watershed Morphology

Big Slough watershed is irregularly shaped (fig. 13) and is located in the Wabash Lowland geomorphic unit (fig. 6). The main channel of the stream is 14,300 ft in length and is relatively straight except for a 110- degree bend approximately 7,000 ft upstream of the gage. The drainage pattern is generally dendritic. Drainage from the uplands in the western half of the watershed is almost exclusively from a series of first-order tributaries and gullies. Upland areas in the eastern half of the watershed have less relief and the drainage pattern is more developed. The stream has a narrow flood plain with a maximum width of about 750 ft. Total relief in the basin is 85 ft. The highest point in the watershed is a hill on the northeastern drainage divide that is 650 ft above NGVD of 1929. The elevation of the channel at the gage is 565 ft above NGVD of 1929. The average channel slope is 0.4 percent.

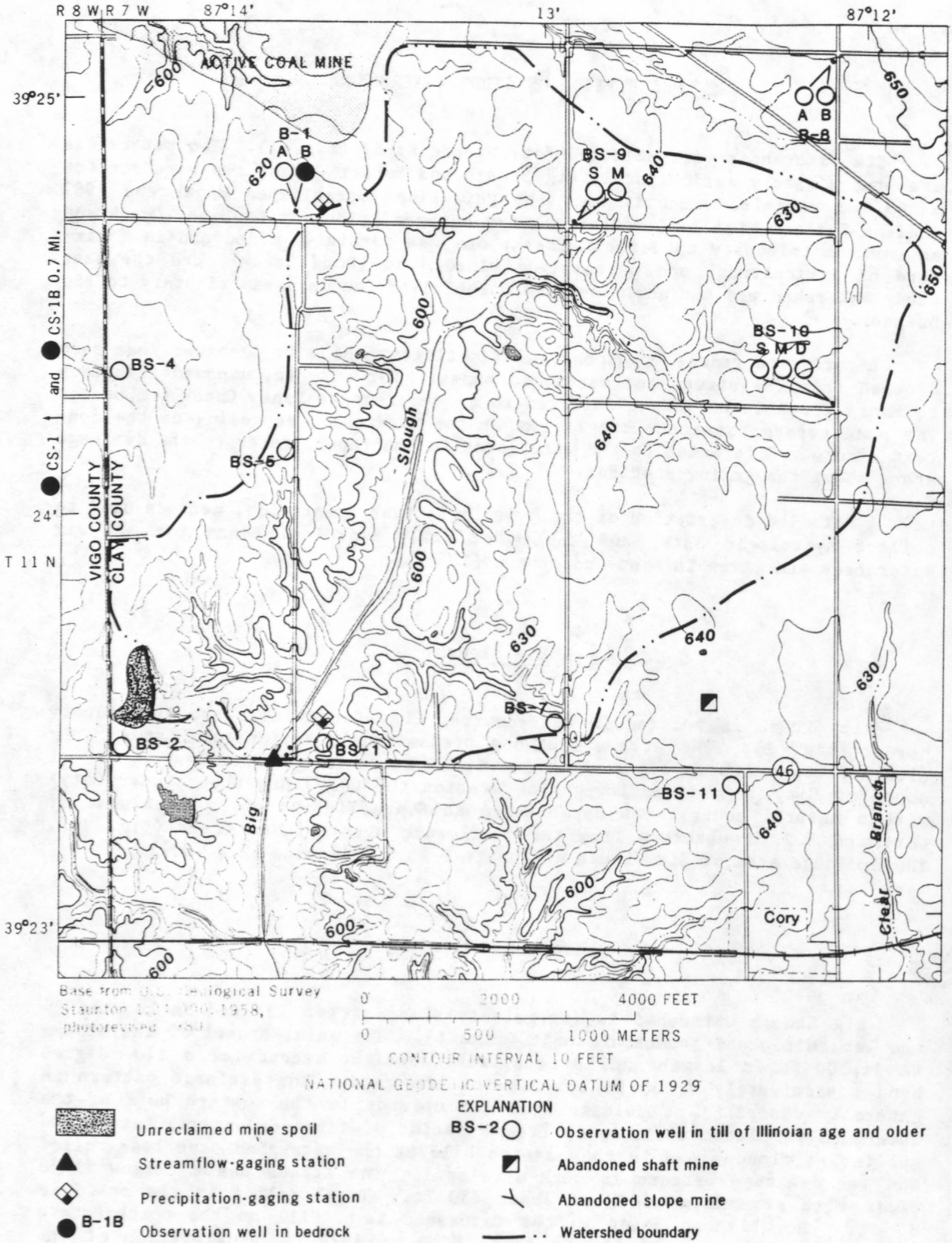


Figure 13.-- Big Slough watershed and data-collection sites.

Geology

Illinoian and older tills, ranging in thickness from approximately 15 to 50 ft, cover the bedrock in Big Slough watershed. The till is composed of clay and silt with smaller amounts of intermixed sand and gravel. Test drilling encountered no lenses of sand and gravel within the watershed. Well logs from the northern and eastern parts of the watershed indicate more sand and gravel in the till.

Underlying the till are rocks of the Linton Formation (fig. 14). These rocks dip to the southwest at about 25 to 30 degrees and were eroded prior to glacial deposition, forming a valley in the bedrock beneath the present stream channel. The Linton Formation contains the oldest rocks in the Carbondale Group (fig. 4). Shale and sandstone are the dominant rock types, however several coals are present, notably the Colchester Coal Member (IIIa). A continuous layer of sandstone about 12 ft thick is located near the base of this formation and probably correlates with the Coxville Sandstone Member of the Linton Formation.

Underlying the Linton Formation, the Seelyville Coal Member (III) marks the top of the Staunton Formation. The Staunton Formation is similar to other Pennsylvanian formations and contains beds of shale, sandstone, limestone, coal, and underclay.

Soils

Major soils in Big Slough watershed are the Iva, Cory, Newark, Ava, Cincinnati, Muren, Pike, Hoosierville, and Hickory soil series (McCarter, 1982). Iva, Cory, and Hoosierville soils are on nearly level upland flats. Ava, Muren, and Pike soils are on gently sloping to moderately sloping upland ridgetops and side slopes. Cincinnati and Hickory soils are on steeply sloping upland ridgetops and side slopes. Newark soils are on the flood plain. A summary of the characteristics of these soils is presented in table 10.

Land Use

Most of the land in Big Slough watershed is used for row-crop agriculture, with corn and soybeans the principal crops. About 18 percent of the basin is deciduous forest, primarily on the steeper valley walls. Less than 0.5 percent of the basin is covered by open water (primarily farm ponds).

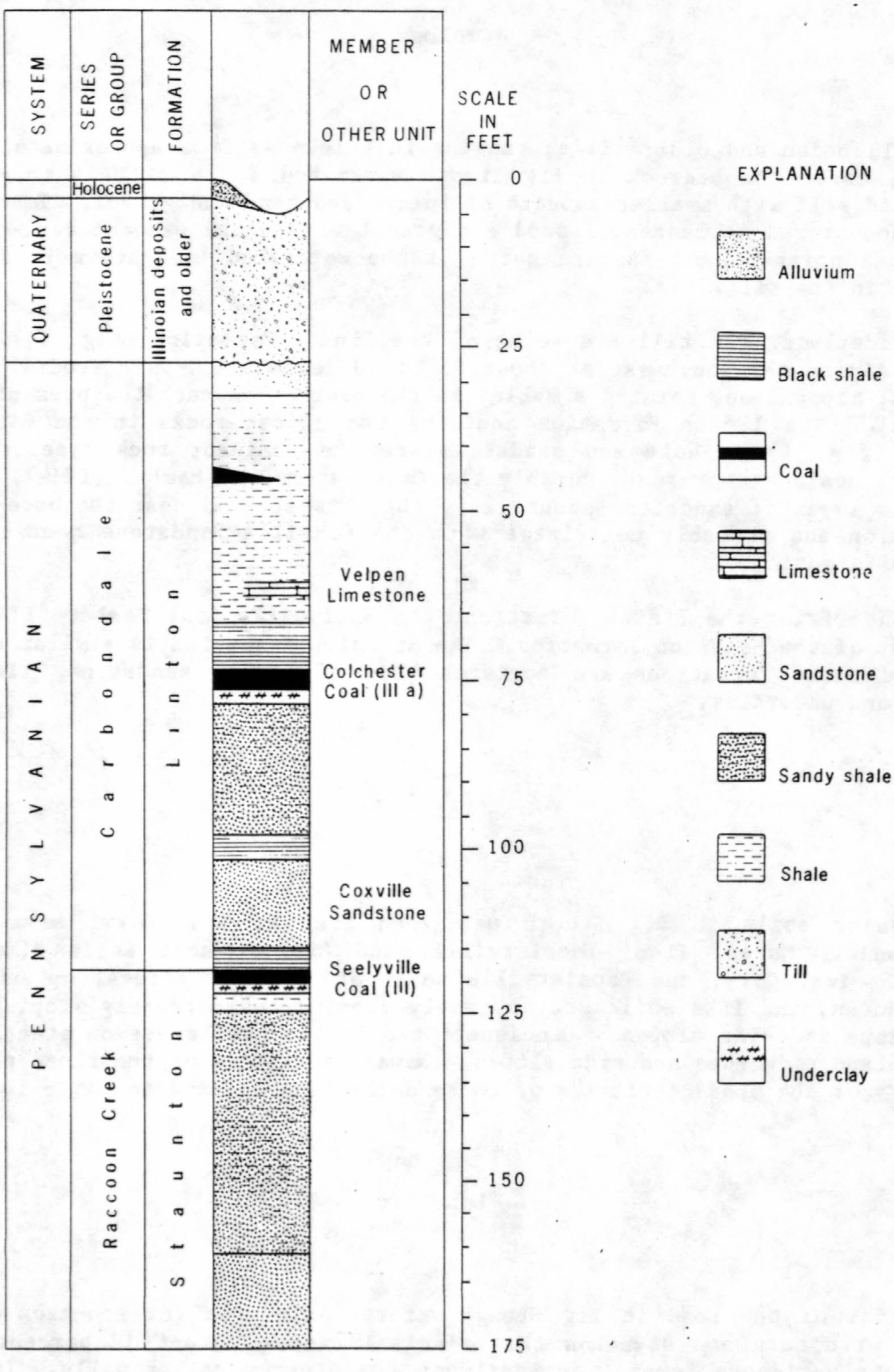


Figure 14.-- Geologic column for Big Slough watershed showing generalized stratigraphy.

Table 10.--Soil profiles and physical and hydrologic properties of the major soils in the study watersheds

[Data from U.S. Department of Agriculture, undated; CL, clay loam; GR-CL, gravelly clay loam; L, loam; SCL, sandy clay loam; SH-SICL, shaly silty clay loam; SH-SIL, shaly silt loam; SHV-SICL, very shaly silty clay loam; SICL, silty clay loam; SIL, silt loam; SL, sandy loam; SR-S-SCL, stratified sand to sandy clay loam; SR-SIL-SL, stratified silt loam to sandy loam; <, less than]

Soil series	Depth (inches)	Texture	Clay (percentage less than 0.002 milli-meters)	Fragments (percentage greater than 3 inches)	Moist bulk density (grams per cubic centimeter)	Permea-bility (inches per hour)	Available water capacity (inches per inch)	Hydro-logic soil group[1]	Slope (per-cent)	Remarks
Ava	0-10	SIL,SICL	20-35	0	1.25-1.50	0.6 -2.0	0.18-0.23	C	0-18	Moderately well-drained soils with a fragipan on uplands
	10-24	SICL,SIL	22-35	0	1.40-1.60	.6 -2.0	.18- .21			
	24-34	SICL,SIL	25-35	0	1.50-1.70	.2 - .6	.18- .22			
	34-50	SICL,L,CL	20-30	0	1.65-1.80	<.06	.09- .11			
	50-60	L,SIL,CL	20-30	0	1.55-1.75	.2 - .6	.15- .18			
Cincinnati	0-10	SIL	15-25	0	1.30-1.50	.6 -2.0	.22- .24	C	1-45	Well-drained soils with a fragipan on uplands
	10-35	SICL,L,SIL	22-35	0	1.45-1.65	.6 -2.0	.15- .19			
	35-52	CL,L,SICL	24-35	0	1.60-1.85	.06- .6	.08- .12			
	52-90	CL,L	24-40	0	1.55-1.75	.06- .6	.08- .12			
Cory	0-13	SIL	13-20	0	1.25-1.40	.6 -2.0	.22- .24	C	0- 6	Somewhat poorly drained soils on uplands
	13-19	SIL	18-27	0	1.30-1.50	.6 -2.0	.20- .22			
	19-52	SICL	27-33	0	1.35-1.55	.06- .2	.18- .20			
	52-60	SIL	10-20	0	1.35-1.55	.6 -2.0	.20- .22			
Fairpoint[2] PcB	0- 3	SH-SIL	18-27	5-15	1.40-1.55	.6 -2.0	.09- .18	C	0- 8	Well-drained soils on graded coal-mine spoil
	3-60	GR-CL,SHV-SICL	18-35	15-30	1.60-1.80	.2 - .6	.03- .10			
Fairpoint[3] PcG	0- 2	SH-SICL	27-35	5-20	1.45-1.65	.2 - .6	.06- .15	C	33-90	Well-drained soils on unreclaimed coal-mine spoil
	2-60	GR-CL,SHV-SICL	18-35	15-30	1.60-1.80	.2 - .6	.03- .10			
Hickory	0-12	L,SIL	19-35	0-5	1.30-1.50	.6 -2.0	.20- .22	C	5-70	Well-drained soils on uplands
	12-46	CL,SICC,GR-CL	27-35	0-5	1.45-1.65	.6 -2.0	.15- .19			
	46-60	SL,L,GR-CL	15-32	0-5	1.50-1.70	.6 -2.0	.11- .19			
Hoosier-ville	0-13	SIL	10-18	0	1.30-1.45	0.6 -2.0	0.20-0.24	C	0- 2	Poorly drained soils on uplands
	13-18	SIL	16-24	0	1.35-1.50	.6 -2.0	.20- .22			
	18-60	SICL,SIL	26-32	0	1.40-1.60	.2 - .6	.18- .20			
	60-80	SIL	10-18	0	1.35-1.55	.2 - .6	.20- .22			
Iva	0-17	SIL	18-27	0	1.25-1.40	.6 -2.0	.22- .24	C	0- 6	Somewhat poorly drained soils on uplands
	17-40	SICL	22-30	0	1.35-1.55	.6 -2.0	.18- .20			
	40-60	SIL	10-20	0	1.35-1.55	.6 -2.0	.20- .22			
Muren	0-11	SIL,SICL	15-30	0	1.25-1.45	.6 -2.0	.21- .24	B	0-30	Moderately well-drained soils on uplands
	11-48	SICL,SIL	22-30	0	1.35-1.50	.6 -2.0	.18- .20			
	48-70	SIL	8-20	0	1.30-1.45	.6 -2.0	.20- .22			
Newark	0- 9	SIL,SICL,L	7-35	0	1.20-1.40	.6 -2.0	.15- .23	C	0- 3	Somewhat poorly drained soils on flood plains
	9-32	SIL,SICL	18-35	0	1.20-1.45	.6 -2.0	.18- .23			
	32-60	SIL,SICL	12-40	0-3	1.30-1.50	.6 -2.0	.15- .22			
Pike	0-10	SIL	18-27	0	1.25-1.40	.6 -2.0	.22- .24	B	0-18	Well-drained soils on uplands
	10-45	SICL,SIL	22-35	0	1.30-1.45	.6 -2.0	.18- .22			
	45-70	SICL,SIL,SCL	18-35	0	1.30-1.45	.6 -2.0	.12- .18			
	70-99	SR-S-SCL	14-20	0	1.45-1.65	2.0 -6.0	.05- .12			
Shoals	0- 9	SIL,SICL,L,CL	18-32	0	1.30-1.55	.6 -2.0	.21- .24	C	0- 2	Somewhat poorly drained soils on flood plains
	9-36	SIL,L SICL	18-33	0	1.35-1.55	.6 -2.0	.17- .22			
	36-60	SR-SIL-SL	12-25	0-3	1.35-1.60	.6 -2.0	.12- .21			
Stendal	0-10	SIL,SICL	18-35	0	1.30-1.45	.6 -2.0	.22- .24	C	0- 2	Somewhat poorly drained soils on flood plains
	10-60	SIL,SICL	18-35	0	1.45-1.65	.6 -2.0	.20- .22			
Vigo	0- 8	SIL	10-16	0	1.30-1.45	.6 -2.0	0.22-0.24	D	0- 4	Poorly drained soils on till plains
	8-20	SIL	12-24	0	1.35-1.50	.6 -2.0	.20- .22			
	20-50	SICL,SIL	24-35	0	1.40-1.55	<.06	.18- .22			
	50-90	CL,L	20-30	0	1.40-1.55	<.06	.14- .16			

[1] Hydrologic soil group is a relative classification based on the surface runoff generated by long-duration storms on bare, thoroughly wet soil, regardless of slope. Soils in group B have a moderate infiltration and water-transmission rate. Soils in group C have a slow infiltration and water-transmission rate. Soils in group D have a a very slow infiltration and water-transmission rate, and a high runoff potential (McCarter, 1982, p. 65, 99, 100).

[2] Soil commonly found in surface mines that have been reclaimed according to the Indiana Surface Mine Reclamation Act of 1967. This description does not include topsoil that has been replaced in compliance with regulations issued under authority of the Surface Mining Control and Reclamation Act of 1977.

[3] Soil commonly found in unreclaimed surface mines.

Coal-Mining History

Although no land in Big Slough watershed has been mined for coal, adjacent areas to the north and south have been mined (fig. 13). Prior to 1954, the Survant Coal Member (IV) was surface mined in an area adjacent to the southwestern part of the watershed and the Colchester Coal Member (IIIa) was mined by underground methods near the southeastern portion of the watershed (Hutchison, 1956). At present, the Seelyville Coal Member (III), the Colchester Coal Member (IIIa), and the Survant Coal Member (IV) are being surface mined less than 500 ft from the northern watershed divide.

Hooker Creek

Hooker Creek is located in southeastern Vigo and northeastern Sullivan Counties, just west of the Clay County line (fig. 1). Hooker Creek watershed is predominantly agricultural. The stream flows south to its confluence with East Fork Busseron Creek near Hymera. A streamflow-gaging station (03342110 Hooker Creek near Lewis) with a natural control was installed at Sullivan County Road 1100 North, approximately 1.5 mi southwest of Lewis and 1.7 mi upstream from the confluence with East Fork Busseron Creek (fig. 15). The drainage area of Hooker Creek at the gage is 1,740 acres (2.72 mi^2).

Watershed Morphology

Hooker Creek watershed is rectangular in shape, approximately 1 mi wide and 3 mi long (fig. 15), and is located in the Wabash Lowland geomorphic unit (fig. 6). The main channel of the stream is 16,800 ft in length. The basin has a modified dendritic drainage pattern and an unusually large number of first-order streams that flow directly into the main channel. The flood plain begins near the middle of the watershed and increases to about 600 ft in width near the outlet. The watershed is generally flat with a total relief of 100 ft. The highest elevation in the watershed is 630 ft above above NGVD of 1929 on the eastern drainage divide. The lowest elevation is the stream channel at the gage, 530 ft above NGVD of 1929. The average channel slope is 0.5 percent.

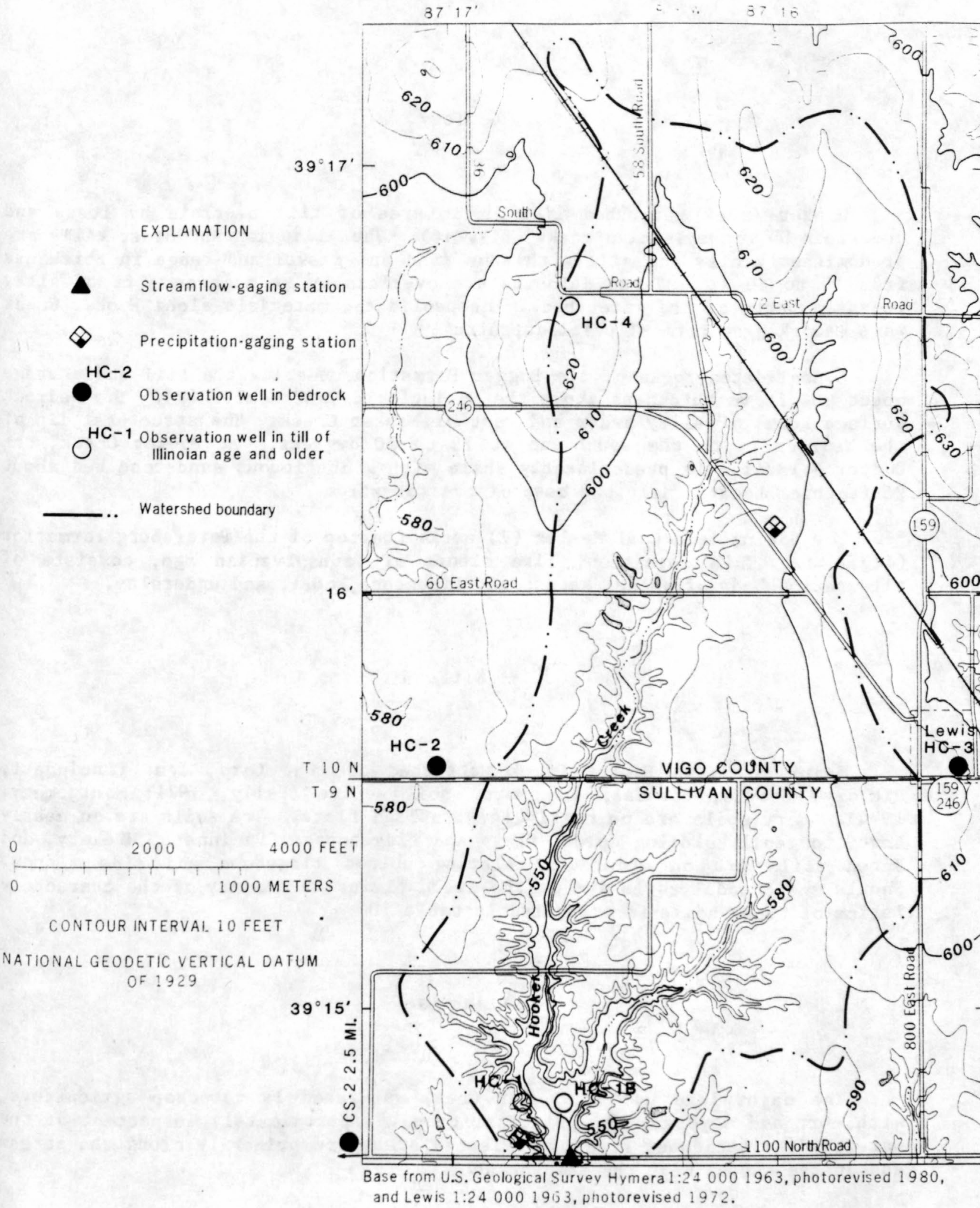


Figure 15.-- Hooker Creek watershed and data-collection sites.

Geology

Hooker Creek watershed lies in an area of till overlain by loess and underlain by Pennsylvanian rocks (fig. 16). The Illinoian and older tills are predominantly clay and silt with some sand and gravel and range in thickness from 10 to 60 ft. These deposits are overlain by as much as 5 ft of silty loess in parts of the watershed. Unconsolidated materials along Hooker Creek were reworked to form alluvial deposits.

Consolidated rocks of the Dugger Formation underlie the till and average about 100 ft in thickness above the Springfield Coal Member (V). The bedrock surface forms a valley under and west of Hooker Creek. The structural dip of the bedrock is to the southwest at 25 to 30 degrees. At Hooker Creek, the Dugger Formation is predominantly shale with a continuous sandstone bed about 25 ft thick located near the base of the formation.

The Springfield Coal Member (V) marks the top of the Petersburg Formation (fig. 4). This formation, like others of Pennsylvanian age, consists of alternating beds of shale, sandstone, limestone, coal, and underclay.

Soils

Major soils in Hooker Creek watershed are the Cory, Iva, Cincinnati, Hickory, Shoals, Stendal, and Muren soil series (Kelly, 1971; Montgomery, 1974). Cory soils are on nearly level upland flats. Iva soils are on nearly level to gently sloping upland flats and ridgetops. Cincinnati, Hickory, and Muren soils are on moderately sloping upland ridgetops and side slopes. Shoals and Stendal soils are on the flood plain. A summary of the characteristics of these soils is presented in table 10.

Land Use

The major land use in Hooker Creek watershed is row-crop agriculture, with corn and soybeans the principal crops. Approximately 16 percent of the watershed is deciduous forest. Forested areas are primarily along the stream and on the slopes near the main channel.

Coal-Mining History

No land has been mined for coal in Hooker Creek watershed.

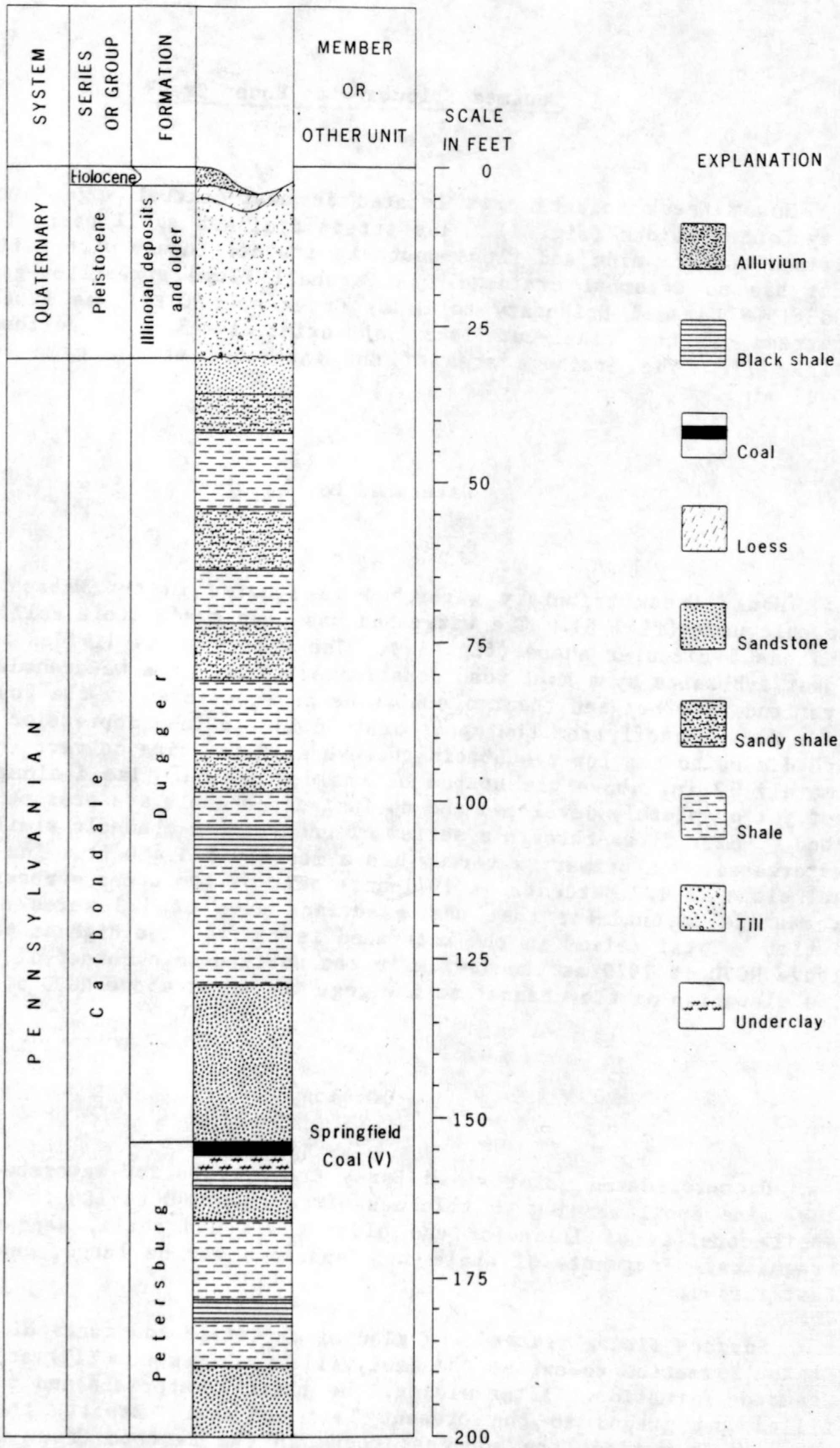


Figure 16.-- Geologic column for Hooker Creek watershed showing generalized stratigraphy.

Unnamed Tributary to Honey Creek

Honey Creek tributary is located in east-central Vigo County near the Clay County border (fig. 1). The stream drains a small part of a large reclaimed surface mine and flows south to its confluence with a final-cut lake that has no external drainage. A Parshall flume streamflow-gaging station (03341568 Unnamed tributary to Honey Creek near Cory) was installed 210 ft upstream of the final-cut lake, approximately 3.6 mi northwest of Cory (fig. 17). The drainage area of the watershed at the gage is 68.4 acres (0.11 mi^2).

Watershed Morphology

Honey Creek tributary watershed is located in the Wabash Lowland geomorphic unit (fig. 6). The watershed has been graded to a rolling topography and has a circular shape (fig. 17). The watershed is divided into upper and lower subbasins by a haul road constructed through the watershed. Movement of overland flow between the two subbasins is restricted by the road, which acts as a dam. Runoff from the upper basin collects in a depression near the road and drains to the lower subbasin through a 10-in. pipe culvert located approximately 12 in. above the bottom of the depression. The drainage network has not yet completely developed and no incised channels are present in the watershed. Water flows through a series of undeveloped channels similar to grassed waterways. The primary waterway has a length of 1,450 ft. The average channel slope is 1.2 percent. A 10.1-acre part of the upper subbasin drains into a manmade impoundment that has a surface area of 1.3 acres and no surface outlet. Total relief in the watershed is 35 ft. The highest point is 618 ft above NGVD of 1929 at the divide in the northwestern corner of the watershed. The elevation of the channel at the gage is 583 ft above NGVD of 1929.

Geology

Unconsolidated material in Honey Creek tributary watershed is reclaimed coal-mine spoil ranging in thickness from about 60 to 100 ft (fig. 18). The spoil consists of Illinoian and older tills and shale, sandstone, and coal fragments. Fragments of shale and sandstone may be large, measuring several feet across.

Surface mining removed the glacial materials and rocks of the underlying Linton Formation to expose the Seelyville Coal Member (III) at the top of the Staunton Formation. After mining, the glacial materials and rocks were backfilled and graded to the present land surface. Beneath the spoil is the Staunton Formation, the youngest rocks in the Raccoon Creek Group (fig. 4). The Staunton Formation is typical of most Pennsylvanian formations and contains beds of shale, sandstone, limestone, coal, and underclay.

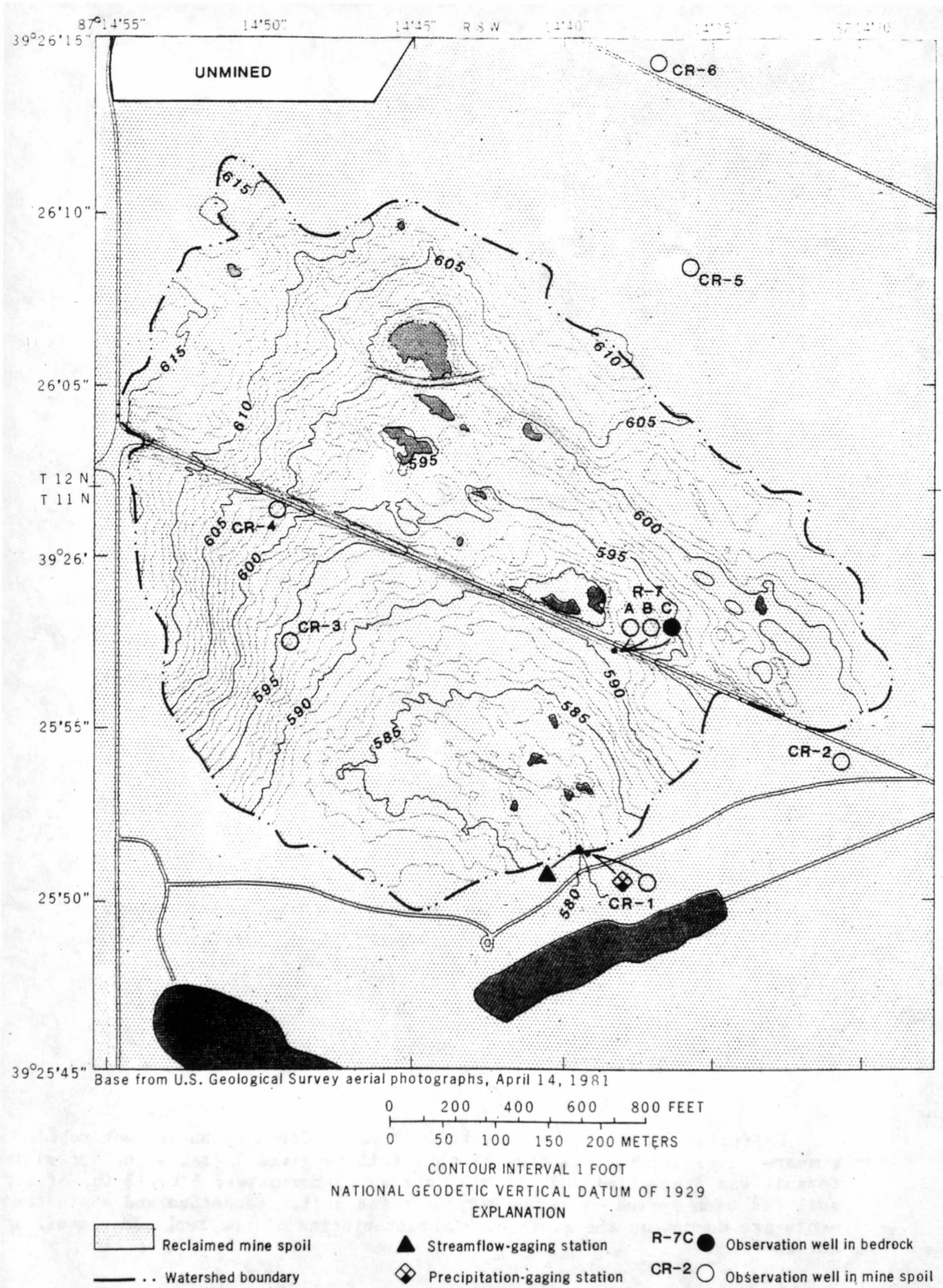


Figure 17.- Unnamed tributary to Honey Creek watershed, and data-collection sites.

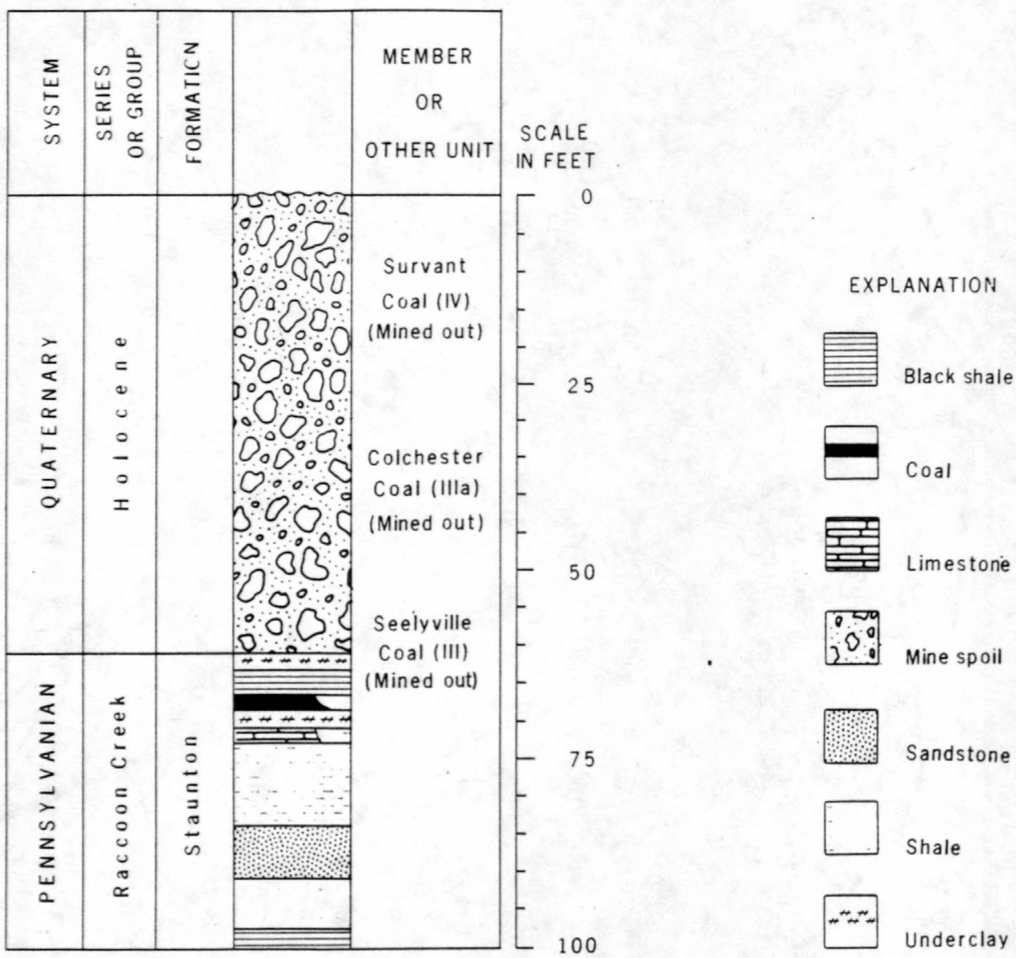


Figure 18.-- Geologic column for unnamed tributary to Honey Creek watershed showing generalized stratigraphy.

Soils

Fairpoint (FcB) is the only soil in Honey Creek tributary watershed. A summary of the characteristics of this soil is given in table 10. Premining topsoil was stockpiled and, in many areas, approximately 6 to 12 in. of topsoil has been spread over the Fairpoint FcB soil. Sandstone and shale fragments are common on the surface. Characteristics of the replaced topsoil are not known.

Land Use

The entire Honey Creek tributary watershed has been surface mined for coal. The watershed has been reclaimed to a gently rolling topography and is covered by a generally sparse growth of sweet clover, bush clover, and grasses. A road, dividing the watershed into two parts, covers slightly less than 2 percent of the watershed. A small impoundment in the northern half of the watershed covers 2 percent of the watershed.

Coal-Mining History

The Honey Creek tributary watershed and surrounding areas were surface mined for the Seelyville Coal Member (III), the Colchester Coal Member (IIIa), and the Survant Coal Member (IV) in the early 1970's (Hasenmueller, 1981). A dragline was used to remove the overburden and mining progressed from the northeast to the southwest following the southwest dip of the coal members. As much as 100 ft of overburden and coal was removed and the spoil was graded to a rolling topography. Six to 12 in. of topsoil was replaced and seeded with legumes and grasses. Three final-cut lakes are located south and southwest of the watershed.

Unnamed Tributary to Sulphur Creek

Sulphur Creek tributary is located in northeastern Sullivan County (fig. 1). The stream drains a small, reclaimed surface mine and flows north to its confluence with Sulphur Creek near Hymera. A broad-crested, V-notch weir streamflow-gaging station (03342167 Unnamed tributary to Sulphur Creek near Hymera) was installed 0.3 mi upstream from the confluence with Sulphur Creek at the outlet of a final-cut lake 1.6 mi southeast of Hymera (fig. 19). The drainage area of the watershed at the gage is 135 acres (0.21 mi^2). The surface area of the lake is 12.1 acres.

Watershed Morphology

Sulphur Creek tributary watershed is located in the Wabash Lowland geomorphic unit (fig. 6). The watershed has irregularly shaped drainage divides typical of coal-mined land in Indiana (fig. 19). Most of the watershed has been graded to a gently rolling topography, and all of the drainage enters the final-cut lake at the northern end of the watershed. A drainage network is beginning to develop in the mined area, and a dendritic pattern is apparent from the gullies that have eroded in the soil. The main channel of the stream originates near several small surface-mine impoundments in unreclaimed spoil in the headwaters and flows through a narrow, unmined valley into two small impoundments before reaching the final-cut lake. The length of the main channel (including the length of the final-cut lake) is 3,630 ft. The distance between the inlet and the outlet of the final-cut lake is 1,490 ft. The average channel slope is 3.3 percent. Total relief in the watershed is 97 ft. A spoil ridge in the headwaters is the highest point in the basin (620 ft above NGVD of 1929). The lowest point is the elevation of the final-cut lake at the gage (approximately 523 ft above NGVD of 1929).

Geology

Unconsolidated material in Sulphur Creek tributary watershed consists of 20 to 30 ft of till and as much as 60 ft of reclaimed or unreclaimed coal-mine spoil (fig. 20). Reclaimed and unreclaimed areas differ in that spoil in reclaimed areas was graded to a rolling topography and 6 to 12 in. of topsoil was spread over the spoil.

Surface mining has removed as much as 60 ft of the Dugger Formation in the northern part of the watershed to expose the Springfield Coal Member (V) at the top of the Petersburg Formation. In the southern part of the watershed, Coal V was not mined and only the upper part of the Dugger Formation was removed to mine the Hymera Coal Member (VI). Thick overburden and local thinning of Coal V to the south were responsible for Coal V not being mined in the southern part of the watershed. Coal VI is not present in the northern part of the watershed. Fifty to 100 ft of Dugger Formation rocks underlie the spoil in the southern part of the watershed. These rocks are mostly shale, although some sandstone, limestone, coal, and underclay are present.

Beneath the Dugger Formation, the Petersburg Formation is locally composed of a grey shaly sandstone, 80 ft thick in some areas. This sandstone grades into a sandy shale in the northern part of the watershed. Below the sandstone, the Petersburg Formation may contain beds of shale, sandstone, limestone, coal, and underclay.

Soils

Fairpoint soils dominate Sulphur Creek tributary watershed. Fairpoint FcB is north of Sullivan County Road 500 North in the reclaimed part of the watershed. Fairpoint FcG is the dominant soil in the upper end of the watershed south of the road (fig. 19). A small area of Hickory and Ava soils is located in and east of the narrow, unmined valley north of the headwaters (Kelly, 1971). A summary of the characteristics of these soils is presented in table 10. Premining topsoil was stockpiled and approximately 6 to 12 in. of topsoil has been spread over the Fairpoint FcB soil in most of the reclaimed areas. Characteristics of the replaced topsoil are not known.

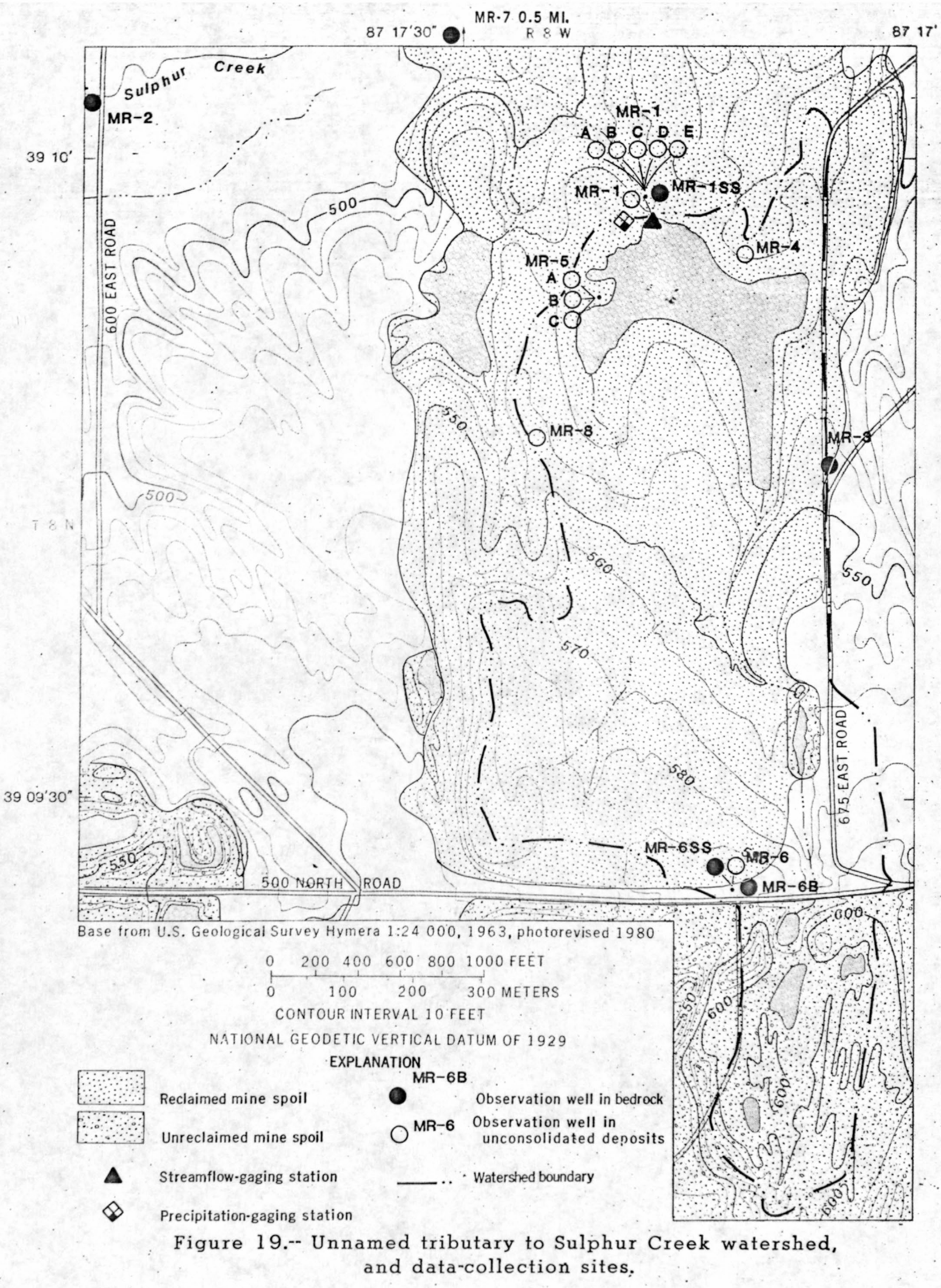


Figure 19.-- Unnamed tributary to Sulphur Creek watershed, and data-collection sites.

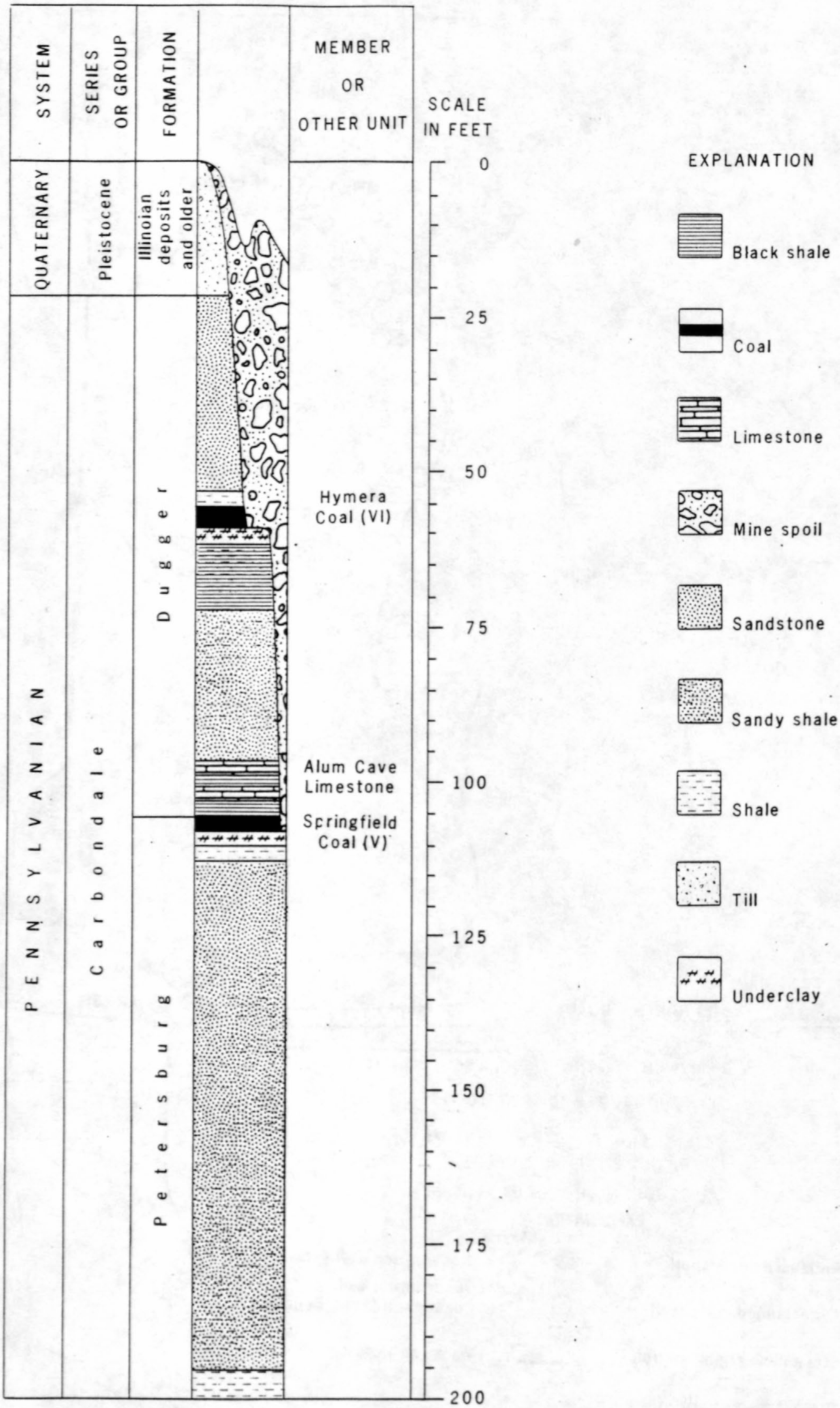


Figure 20.-- Geologic column for unnamed tributary to Sulphur Creek watershed showing generalized stratigraphy.

Land Use

Over 94 percent of Sulphur Creek tributary watershed has been surface mined for coal. Most of the mined area has been reclaimed to a gently rolling topography. The spoil is covered with a generally dense growth of sweet clover and bush clover. The headwaters were not graded and have the ridge-and-swale topography typical of unreclaimed surface mines. The headwaters are sparsely covered with short grasses and scattered trees and shrubs. This area is used primarily for pasture. A rural residence, farm buildings, and fields used for pasture occupy the unmined part of the watershed. A final-cut lake covers about 9 percent of the watershed. Four small surface-mine impoundments cover slightly more than 1 percent of the watershed.

Coal-Mining History

Coal has been mined by both surface and underground methods at several different times in Sulphur Creek tributary watershed. During the 1920's, the Danville Coal Member (VII) was mined by underground methods beneath the headwaters of the watershed (Wier, 1953). By 1953, the headwaters area had been surface-mined for the Hymera Coal Member (VI) and the Danville Coal Member (VII). Between the early 1950's and 1963, two small surface mines extracted Coal VI in the central part of the watershed.

By 1977, the surface mine that created the present-day Sulphur Creek tributary watershed was operating. Topsoil was stockpiled in the west-central part of the basin when mining began. A dragline removed the overburden and dozers loaded the coal. The half-mile-long pit was oriented north and south and mining progressed west to east. Coal VI was mined in the southern part of the watershed and Coal V was mined in the northern part. During and after mining, the spoil ridges were graded and 6 to 12 in. of topsoil was replaced. Coal was mined last in the northern part of the watershed. The final cut was partially filled with spoil and the remaining pit was allowed to fill with water. The maximum depth of the final-cut lake is approximately 30 ft.

Pond Creek

Pond Creek is located in southwestern Owen and southeastern Clay Counties (fig. 1). Pond Creek watershed drains a mixture of agricultural and unreclaimed surface-mined land. Pond Creek flows south to its confluence with the Eel River. A streamflow-gaging station (03360125 Pond Creek near Coal City) with a natural control was installed at Clay County Road 108 East, 1.6 mi southwest of Coal City, approximately 2.8 mi upstream from the confluence with the Eel River (fig. 21). The drainage area of Pond Creek at the gage is 1,259 acres (1.97 mi^2).

Watershed Morphology

Pond Creek watershed has a somewhat circular shape (fig. 21) and is located at the eastern edge of the Wabash Lowland geomorphic unit (fig. 6). Two main channels converge approximately 3,200 ft upstream from the gage. The channel draining the western part of the watershed is 11,700 ft long and has an average slope of 0.8 percent. The channel draining the eastern part of the watershed is 9,400 ft long and has an average slope of 1.2 percent. The drainage pattern prior to mining was dendritic. During mining, a number of the channels were straightened but left primarily in their original locations. Two final-cut lakes, with a total surface area of 10.1 acres and no external outlets, drain about 271 acres of unreclaimed mine spoil. Two different final-cut lakes with a total surface area of 15.3 acres and one manmade impoundment with a surface area of 6.2 acres do have external outlets and periodically contribute to surface runoff in Pond Creek.

Slopes range from 0 to 12 percent in agricultural areas and range from 0 to 90 percent in unreclaimed areas. The watershed has a total relief of 130 ft. The highest point in the watershed is 670 ft above NGVD of 1929 near a tipple (coal-loading facility) on the eastern drainage divide. The lowest point in the watershed is the channel at the gage (540 ft above NGVD of 1929).

Geology

Unconsolidated material in Pond Creek watershed consists of glacial drift and coal-mine spoil. The drift is predominantly a sandy clay till ranging in thickness from about 10 to 25 ft and generally occupies the perimeter of the watershed (fig. 21). The center of the watershed has been mined and the unreclaimed spoil is about 65 ft thick.

Consolidated rocks of the Brazil Formation form the bedrock beneath Pond Creek (fig. 22). The Brazil Formation consists mostly of shale with sandstone, coal, and underclay. Lower Block, Upper Block, and Minshall Coal Members may be present. The base of the Lower Block Coal Member marks the top of the Mansfield Formation. The Mansfield Formation generally contains more sandstone than the Brazil Formation. Drillers' logs indicate as much as 60 ft of sandstone in the Mansfield rocks.

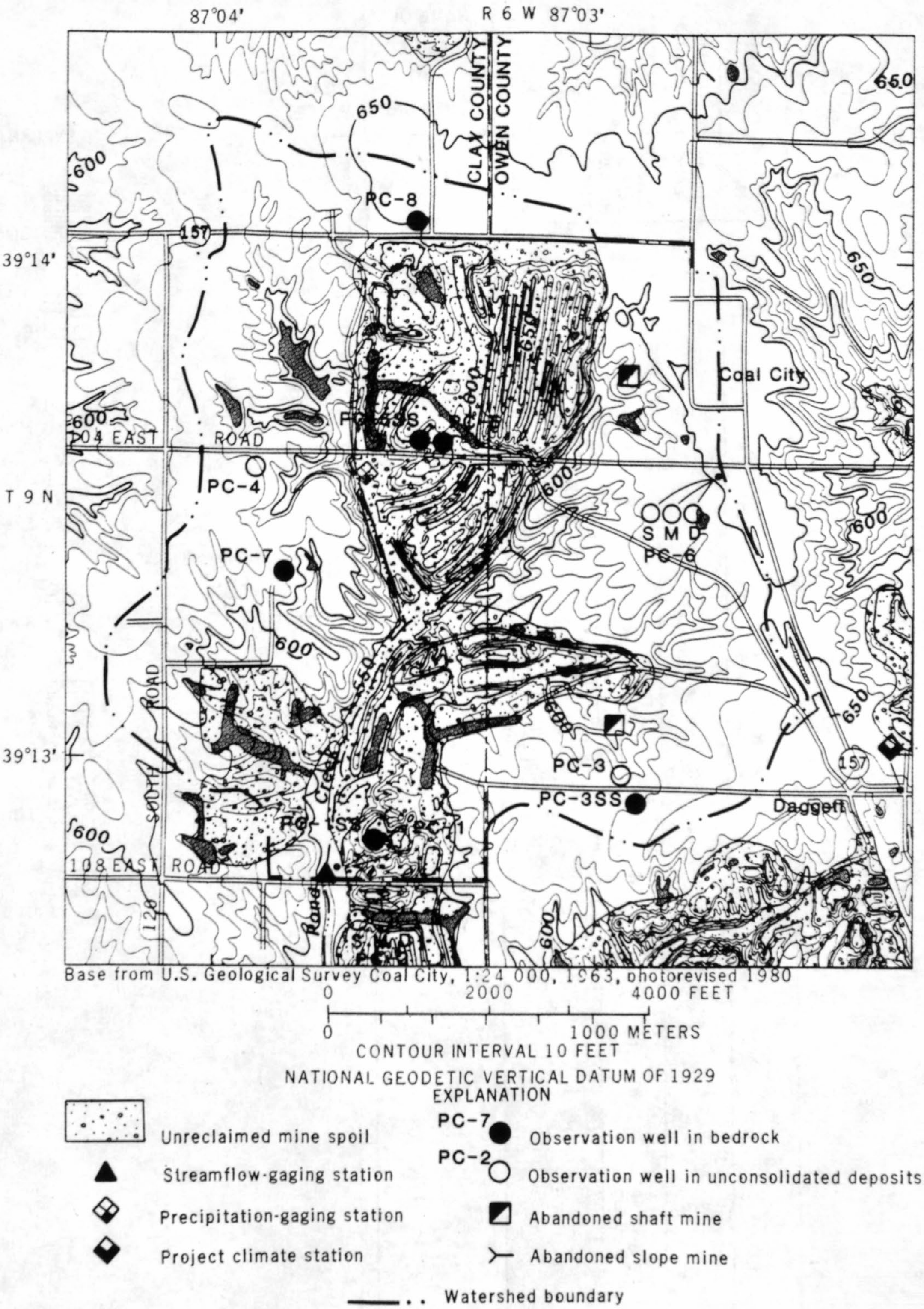


Figure 21.-- Pond Creek watershed and data-collection sites.

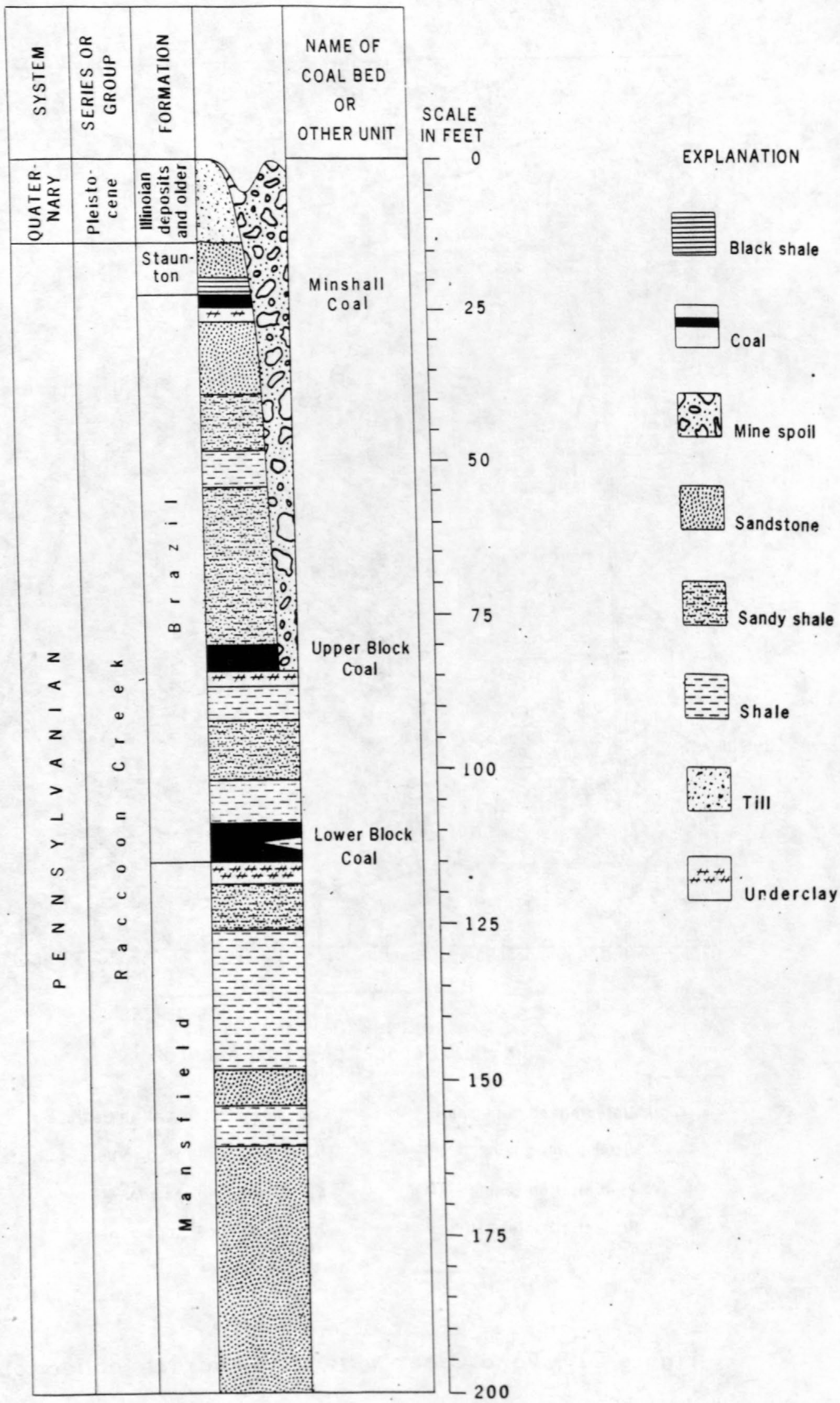


Figure 22.-- Geologic column for Pond Creek watershed showing generalized stratigraphy.

Soils

Major soils in Pond Creek watershed are the Fairpoint, Vigo, Ava, Cincinnati, Hickory, and Stendal soil series (Sanders and others, 1964; McCarter, 1982). Fairpoint FcG soils have formed in unreclaimed spoil near the center of the watershed. Vigo and Ava soils are on the upland flats near the drainage divides. Cincinnati and Hickory soils are on ridgetops, side slopes, and swales. Stendal soils are on the unmined parts of the flood plain. A summary of the characteristics of these soils is presented in table 10.

Land Use

Land use in Pond Creek watershed is approximately 40 percent agricultural, 37 percent unreclaimed mine spoil, 19 percent forest, 3 percent open water, and 1 percent urban. Most agricultural land is on the broad uplands and is used for row-crop corn and soybeans. Forested areas are primarily along the stream channel. Surface-mined areas are in the center of the watershed. Spoil banks are covered with pine trees, but much of the surface is bare or sparsely covered with vegetation.

Coal-Mining History

Minshall, Upper Block, and Lower Block Coal Members underlie Pond Creek watershed. Between 1953 and 1956, the Upper Block Coal Member was surface mined in the northern part of the watershed. Prior to 1959, three small shaft mines were used to deep mine the Lower Block Coal Member 50 to 65 ft beneath the upland area that forms the eastern drainage divide (Kottlowski, 1959). Prior to 1963, the Upper Block Coal Member was extensively surface mined from east to west in the center of the watershed, creating two large final-cut lakes. After 1963, the Upper Block Coal Member was mined on the drainage divide in the southwestern part of the watershed. All of the surface mines are unreclaimed.

Unnamed Tributary to Big Branch

Big Branch tributary is located in northeastern Sullivan County (fig. 1). The stream drains an unreclaimed surface mine and flows southeast to its confluence with Big Branch northwest of Dugger. A V-notch weir streamflow-gaging station (03342219 Unnamed tributary to Big Branch near Hymera) was installed 0.3 mi upstream from the confluence with Big Branch at the outlet of a final-cut lake at Sullivan County Road 700 East, 4.1 mi southeast of Hymera (fig. 23). The drainage area of the watershed at the gage is 206 acres (0.32 mi^2).

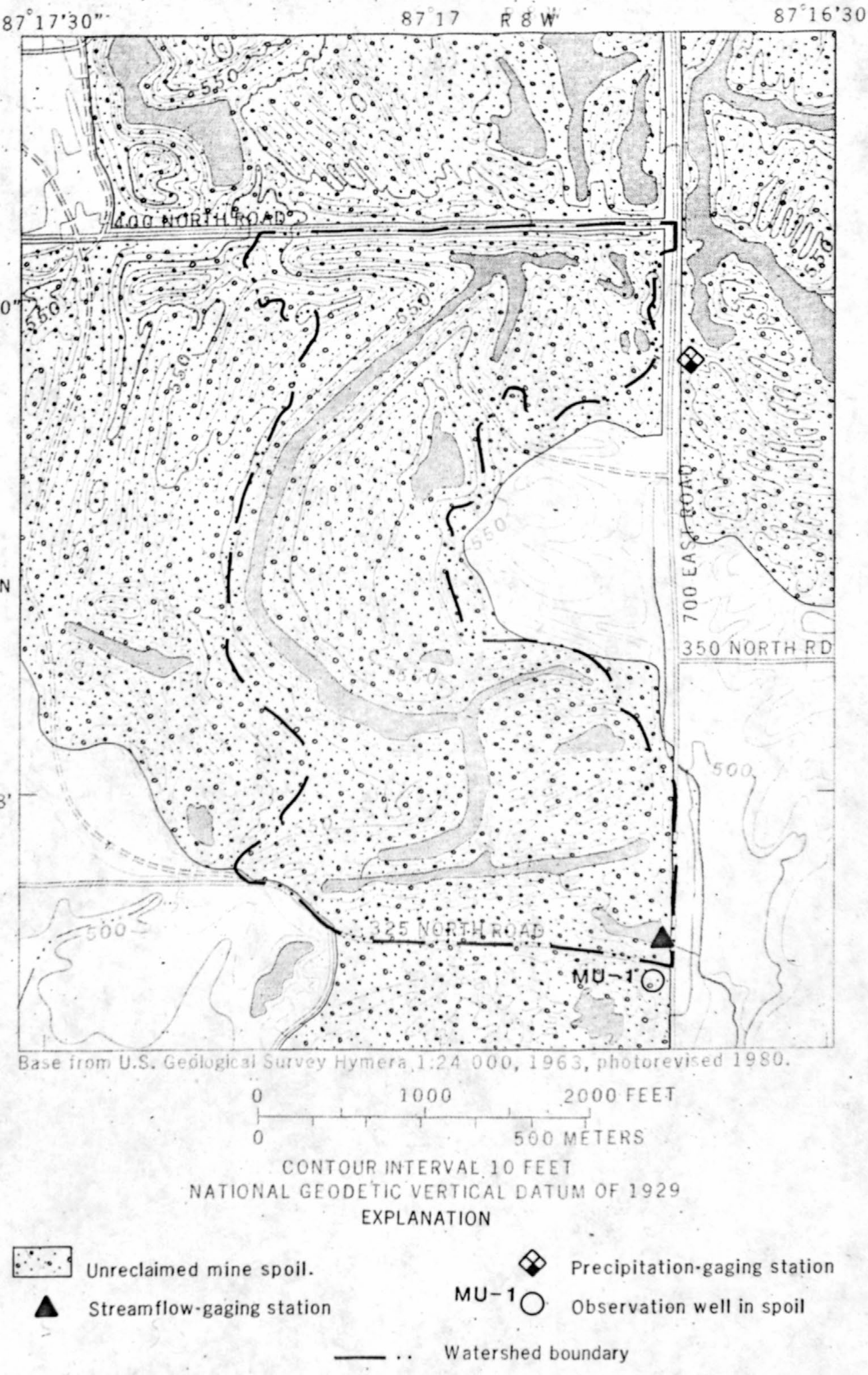


Figure 23.-- Unnamed tributary to Big Branch watershed, and data-collection sites.

Watershed Morphology

Big Branch tributary watershed is roughly rectangular in shape (fig. 23) and is located in the Wabash Lowland geomorphic unit (fig. 6). The watershed has no well-defined stream channel. Water flows out of the watershed through a series of three lakes connected by short channel segments. The lakes have surface areas of 21.4, 4.8, and 1.2 acres. The main drainage channel through the lakes is 8,000 ft in length and has an average slope of 0.01 percent. Total relief in the basin is 98 ft. The highest elevation in the watershed is 600 ft above NGVD of 1929. Elevation of the lake at the gage is about 502 ft above NGVD of 1929. Slopes of the unreclaimed spoil range from 0 to 90 percent.

Geology

Unconsolidated material in Big Branch tributary watershed is unreclaimed spoil from surface mining. Approximately 20 to 50 ft of overburden was removed and redistributed during mining of the Hymera Coal Member (VI) of the Dugger Formation. The spoil contains glacial material and rock fragments and generally forms long, narrow ridges and depressions.

The bedrock is the lower part of the Dugger Formation, consisting of about 60 ft of shale, sandstone, and limestone (fig. 24). The Petersburg Formation underlies the Dugger Formation and consists of a thick (90-120 ft) sequence of sandstone and shale with some limestone and coal. Beneath the Petersburg Formation, the Survant Coal Member (IV), at the top of the Linton Formation, has been mined using underground methods.

Soils

Soil in Big Branch tributary watershed is entirely Fairpoint FcG soil that has formed in unreclaimed spoil. A summary of the characteristics of this soil is presented in table 10.

Land Use

The entire Big Branch tributary watershed has been surface mined for coal. The land is unreclaimed and is characterized by a ridge-and-swale topography. Pine trees and shrubs cover the spoil banks, but the surface of the spoil is essentially devoid of vegetation. Three lakes cover 13 percent of the watershed. The remaining 87 percent of the basin is unreclaimed mine spoil and long, narrow, water-filled depressions.

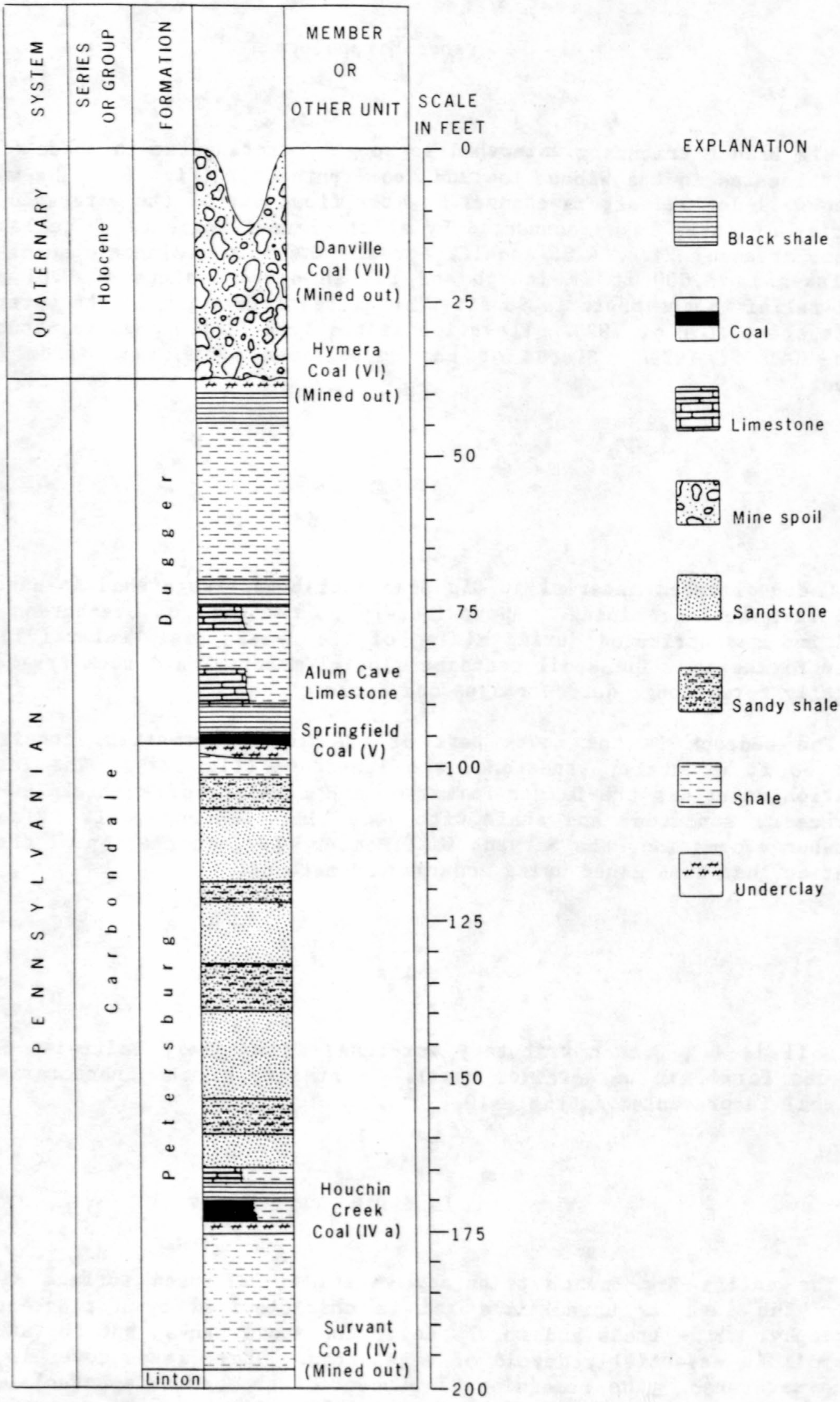


Figure 24.-- Geologic column for unnamed tributary to Big Branch watershed showing generalized stratigraphy.

Coal-Mining History

Coal has been mined by both surface and underground methods in the Big Branch tributary watershed. From 1918 to 1945, the Survant Coal Member (IV) was deep mined 211 ft beneath the watershed (Wier, 1953). Between 1943 and 1953, the Hymera Coal Member (VI) was surface mined throughout the watershed (Wier, 1953). Prior to 1953, and most likely concurrent with the mining of Coal VI, the Danville Coal Member (VII) was surface mined in the western half of the watershed. Spoil from the surface mines is unreclaimed. The Springfield Coal Member (V) is present in the watershed but has not been mined.

SUMMARY

This report describes the physical and human environment and coal-mining history of west-central Indiana, with emphasis on six small watersheds selected for study of the hydrologic effects of surface coal mining. The report summarizes information on the geology, geomorphology, soils, climate, hydrology, water use, land use, population, and coal-mining history of Clay, Owen, Sullivan, and Vigo Counties in Indiana. Site-specific information is given on the morphology, geology, soils, land use, coal-mining history, and hydrologic instrumentation of the six small watersheds.

West-central Indiana is underlain by Pennsylvanian rocks composed of cylic sequences of shale, siltstone, and sandstone with smaller amounts of coal, underclay, limestone, and black shale. Nearly all of the area has been glaciated at least once and is characterized by wide flood plains and broad, flat uplands. Most of the soils in west-central Indiana have formed in loess, or in loess overlying Illinoian till. Permeability and available water capacity are variable and a fragipan or layer of firm subsoil is common.

The Wabash, White, and Eel Rivers are the major drainages in west-central Indiana. Mean monthly flows typically are greatest in March through May when spring rains occur. Peak flows typically are greatest in July as a result of thunderstorms. Average annual precipitation is about 39.5 in. and average annual runoff is about 13 in. The most productive aquifers are confined or unconfined outwash aquifers located along the major rivers. Bedrock aquifers are regionally insignificant but are the sole source of ground water for areas that lack outwash, alluvium, or sand and gravel lenses in till.

Underground and surface methods have been used to mine coal in west-central Indiana. Currently, the area surface-mining method is almost exclusively used. Indiana has more than 17 billion short tons of recoverable coal reserves; about 11 percent can be mined by surface methods. Almost half of Indiana's surface reserves are in Clay, Owen, Sullivan, and Vigo Counties. More than 50,000 acres in west-central Indiana have been disturbed by surface coal mining from 1941 through 1980.

Big Slough and Hooker Creek are streams that drain unmined, agricultural watersheds. The drainage area of Big Slough at the gage is 2.70 mi^2 and the drainage area of Hooker Creek at the gage is 2.72 mi^2. Row-crop corn and soybeans are the principal crops. Soils are moderately well-drained silt loams, and the watersheds have well-developed dendritic drainage systems.

Unnamed tributary to Honey Creek and unnamed tributary to Sulphur Creek are streams that drain mined and reclaimed watersheds. The drainage area of Honey Creek tributary at the gage is 0.11 mi^2 and the drainage area of Sulphur Creek tributary at the gage is 0.21 mi^2. Ridges of mine spoil have been graded to a gently rolling topography. Soils are well drained and consist of 6 to 12 in. of silt-loam topsoil that was stockpiled and then replaced over shale and sandstone fragments of the graded mine spoil. Sulphur Creek tributary is beginning to develop an incised drainage system, but Honey Creek tributary is not. Grasses and legumes form the vegetative cover in each watershed. Vegetation is generally sparse in Honey Creek tributary and generally dense in Sulphur Creek tributary.

Pond Creek and unnamed tributary to Big Branch are streams that drain mined and unreclaimed watersheds. The drainage area of Pond Creek at the gage is 1.97 mi^2 and the drainage area of Big Branch tributary at the gage is 0.32 mi^2. Approximately one-half of Pond Creek watershed is unmined, agricultural land. Soils are very well-drained shaly silty loams that have formed on steeply sloping spoil banks. Both watersheds contain numerous impoundments of water from past surface mining. Drainage systems are complex with many enclosed areas that do not contribute surface runoff to streamflow. The ridges of mine spoil are covered with pine trees, but much of the soil surface in both watersheds is devoid of vegetation.

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