UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-QUALITY AND OTHER HYDROLOGIC DATA COLLECTED IN AND AROUND A SURFACE COAL MINE, CLAY AND VIGO COUNTIES, INDIANA, 1977-80

By Linda L. Bobo and Stephen E. Eikenberry

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Indianapolis, Indiana
October 1982

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

Multiply inch-pound unit	By	To obtain SI unit
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
acre	4.046×10^3	square meter
cubic foot per second (ft^3/s)	0.0283	cubic meter per second (m^3/s)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
ton (short)	0.907	metric ton (t)

DATUM USED IN THIS REPORT

National Geodotic 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."

USE OF TRADE NAMES

Any use of trade names in this report is for descriptive purposes only and does not constitute endorsement by the U.S Geological Survey.

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ABSTRACT

Few data are available for evaluating water-quality and other hydrologic properties in and around surface coal mines, particularly in areas where material having a high acid-production potential is selectively buried. This report contains hydrologic data collected in coal-mining areas in Clay and Vigo Counties, Indiana, from September 1977 through February 1980. Methods of sampling and analysis used in collecting data are also described.

The data include field and laboratory measurements of water at 41 wells and 24 stream sites. Variables measured in the field include water temperature, specific conductance, pH, Eh, dissolved oxygen, ground-water levels, and streamflow; and in the laboratory, concentrations of major ions, alkalinity, hardness, trace elements (in this report, elements having concentrations of 1 milligram per liter or less), organic carbon, phosphorus, and dissolved solids. Other variables measured in the laboratory include ferrous iron concentration of water samples from selected wells, percent sulfur by weight and the potential acidity of core samples of reclaimed cast overburden, concentrations of elements adsorbed on streambed materials, concentrations and particle size of suspended sediment in water, and populations and Shannon diversity indices of phytoplankton in water. Dissolved-solids concentrations and pH of ground water ranged from 173 to 5,130 milligrams per liter and from 6.1 to 8.9, respectively, and of surface water, from 120 to 4,100 milligrams per liter and from 6.1 to 8.8, respectively.

INTRODUCTION

Coal is the most abundant fossil fuel in the United States, and the quantity mined will probably be increased to meet the Nation's energy demands. In Indiana, 97 percent of the electricity consumed is generated from coal. Only Illinois, Pennsylvania, and Ohio use more coal to generate electricity (Wier, 1973, p. 1).

Coal underlies nearly 6,500 mi^2 (square miles) of southwestern Indiana (about one-sixth of the State). Most of the coal mining is done in six counties--Clay, Greene, Pike, Sullivan, Vigo, and Warrick (Wier, 1973, p. 4)--along a north-south line where coal beds of Pennsylvanian age crop out or lie at shallow depths.

Surface mining, currently the most efficient method of mining coal in Indiana, accounts for 90 percent of the State's annual production. However, surface mining disturbs vast land areas and alters topography and hydrologic systems. In the last 50 yr, almost 100,000 acres in southwestern Indiana has been disturbed by surface mining (Powell, 1972, p. 1).

Surface-water and ground-water systems have been altered by mining and reclamation. During mining, streams have been rerouted, drainage areas have been altered, lakes have been formed and aquifers have been disturbed or removed. During subsequent reclamation, the cast overburden may become a man-made unconsolidated aquifer hydraulically connected to adjacent consolidated and unconsolidated aquifiers.

Acid mine drainage in streams that drain old mined areas results from the oxidation of pyrite and marcasite in spoil piles. In Indiana, these areas were mined before the Indiana Surface Mine Act of 1967 (Indiana code 13-46), which mandates that spoil piles be graded and a cover crop be established. Studies by Renn and others (1980, p. 53 and 60), Bobo and Peters (1980, p. 39), and Eikenberry (1978, p.17), indicated that acid mine drainage in streams draining unreclaimed lands mined before 1967 is still a problem in southwestern Indiana.

In surface coal mining, rock units of high acid-production potential (pyrite and marcasite) are selectively buried on the bottom of cast-overburden piles (Wiram, 1976, p. 1). "Cast overburden" is the unconsolidated rock and broken bedrock removed during surface mining of coal. Selective burial has reduced acid mine drainage in streams affected by mining. However, other water-quality problems have been observed in these streams. Higher than background concentrations of most major dissolved and suspended constituents, including trace elements aluminum, iron, and manganese, have been detected in water samples from streams. ("Trace elements" in this report means an element having a concentration of 1 milligram per liter or less.) Erosion from unreclaimed areas of old (mined before 1967) mines or unvegetated areas in new mines can substantially increase sediment loads in streams. Increases in sediment loads were evident in studies of streams in southwestern Indiana by Renn and others (1980, p. 60) and Bobo and Peters (1980, p. 39)

Purpose and Scope

To supplement the scarcity of water-quality data for mined areas, the U.S. Geological Survey in cooperation with the Indiana Department of Natural Resources and the U.S. Environmental Protection Agency, collected the following

data: quality of ground and surface water, ground-water levels, and instantaneous discharge in and around a surface coal mine in Clay and Vigo Counties, Ind. These data were collected from 41 wells and 24 stream sites from September 1977 through February 1980. The data and summary statistics are presented in 34 tables. In addition, methods and equipment for sampling ground water and surface water are discussed.

Acknowledgments

The authors are grateful to Amax Coal Co. for assistance in installing wells and analyzing cast overburden samples and for access to company property. Mr. William Herring of the company deserves special mention for providing access to Amax property, assistance by Amax employees, two drill rigs, and maps and aerial photographs of Amax property.

Description of Study Area

Physiography and Geology

The topography of the 21-mi^2 flat to gently undulated study area (figs. 1 and 2), in Clay and Vigo Counties, Ind., is typical of the Wabash Lowland physiographic region (Malott, 1922, p. 66). Gently sloping streams with well-developed dendritic drainage patterns flow south and west. Streambeds are mostly fine to coarse sands and bedrock.

Bedrock in the study area consists of alternating layers of Pennsylvanian shale, sandstone, underclay, and coal (fig. 3), which dip gently and irregularly 25 to 35 ft/mi (feet per mile) southwest toward the center of the Illinois Basin. Most of the coal mined is the Seelyville coal (III) of the Staunton Formation, which underlies most of the area. Survant coal (IV) of the Linton Formation is also mined at scattered sites, where commercially feasible.

Soils in the study area are developed on loess that overlies 17 to 70 ft (feet) of Illinoian till. These soils are poorly drained, except on valley slopes (Montgomery 1974, p. 19-32; Jones and others, 1927, p. 1393-1406).

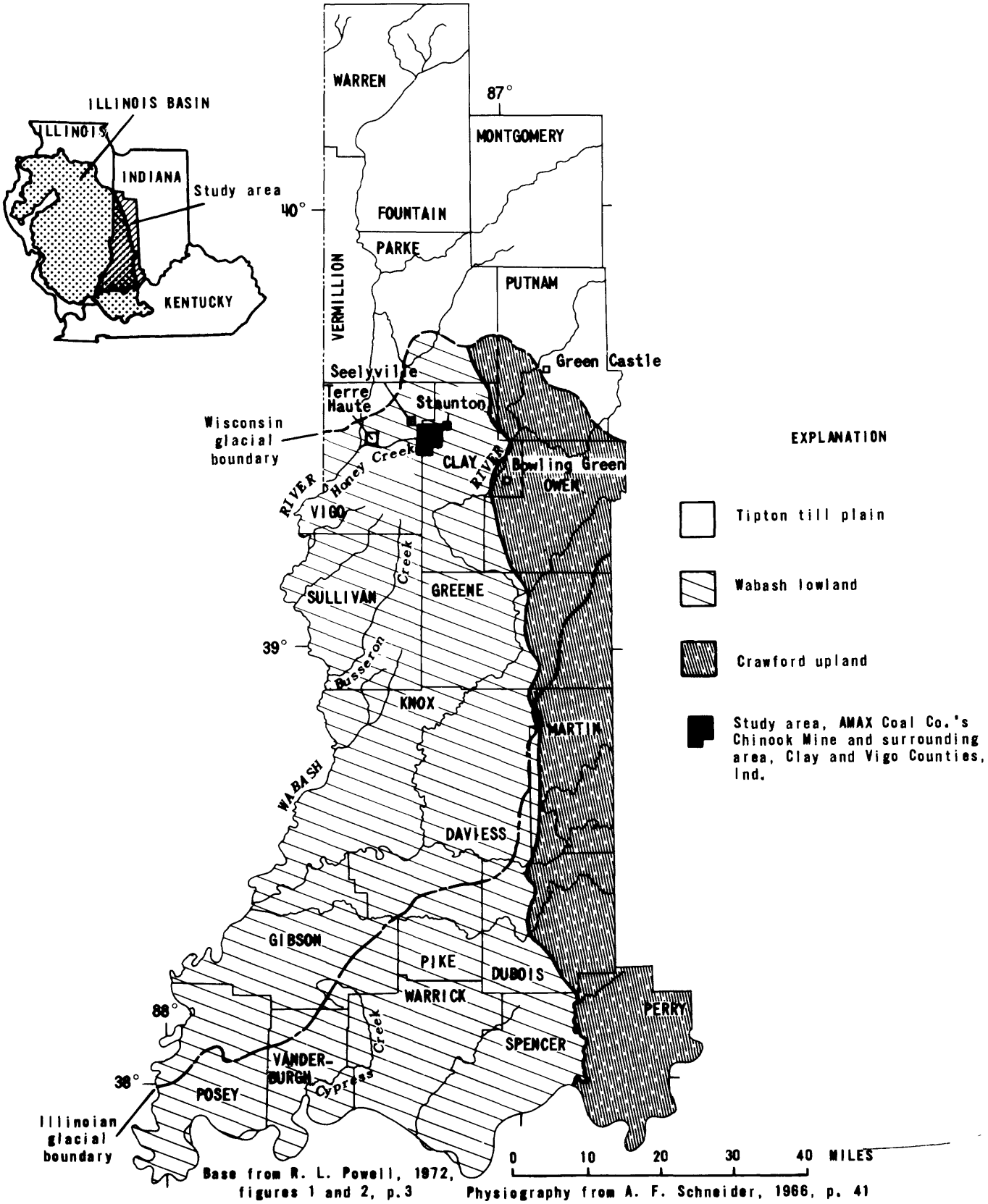


Figure 1.-- Study area in Clay and Vigo Counties, Ind., and the Illinois Basin.

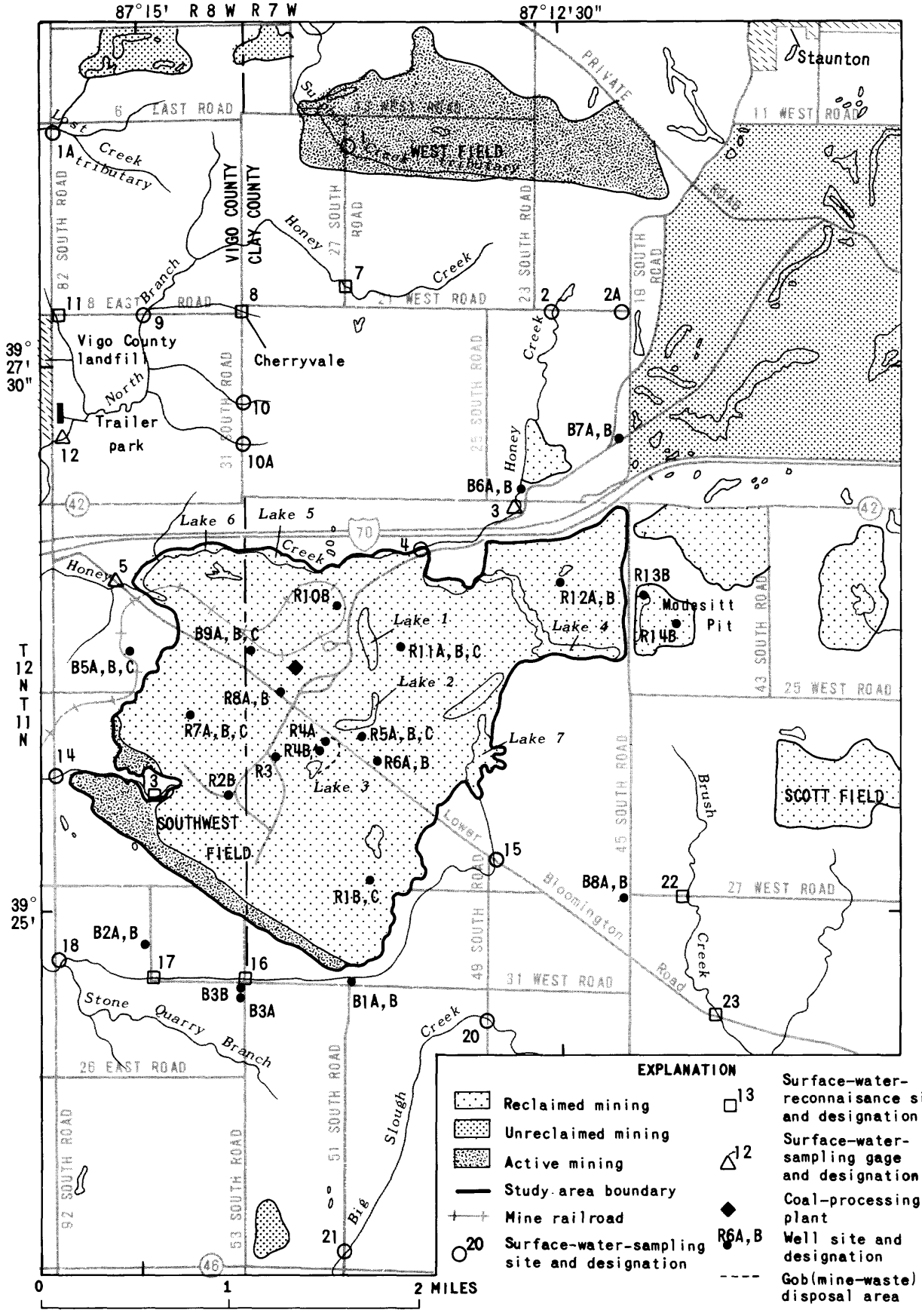


Figure 2.-- Locations of surface- and ground-water-data collection sites in and around a surface coal mine, Clay and Vigo Counties, Ind.

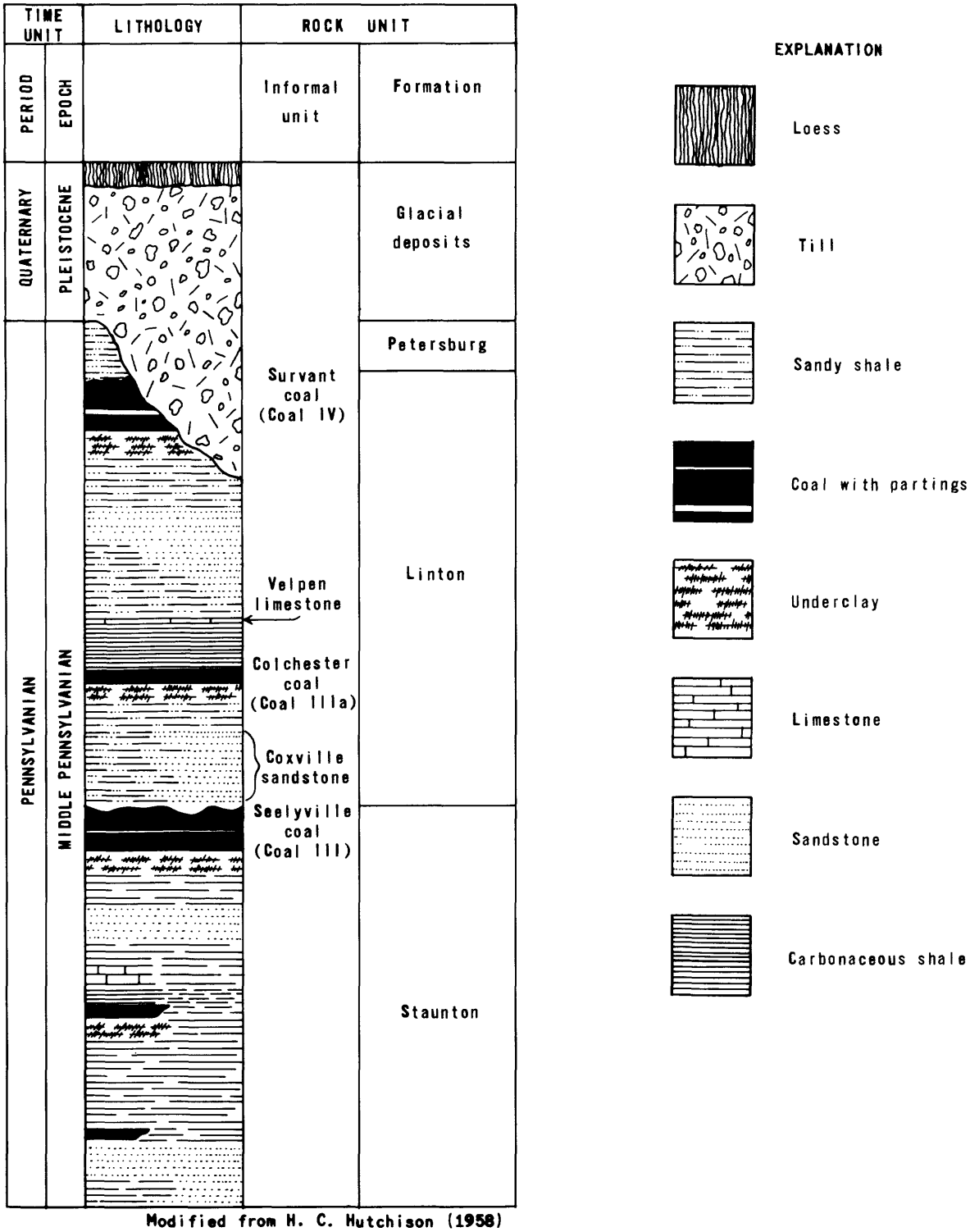


Figure 3.-- Generalized stratigraphic column showing the position of selected geologic formations of the Pleistocene Series and the Pennsylvanian System in the study area, Clay and Vigo Counties, Ind.

Land Use

Land use in Clay and Vigo Counties includes agriculture, 67.8 percent; forest, 22.9 percent; urban, 6.5 percent; unused, 2.0 percent; and water, 0.8 percent (James R. Roserau, Indiana State Planning Services Agency, Department of Commerce, written commun., January 1981).

Land use in the study area includes agricultural and forested areas, parts of which have been affected by mining, and areas of reclaimed and unreclaimed surface coal mines.

Climate

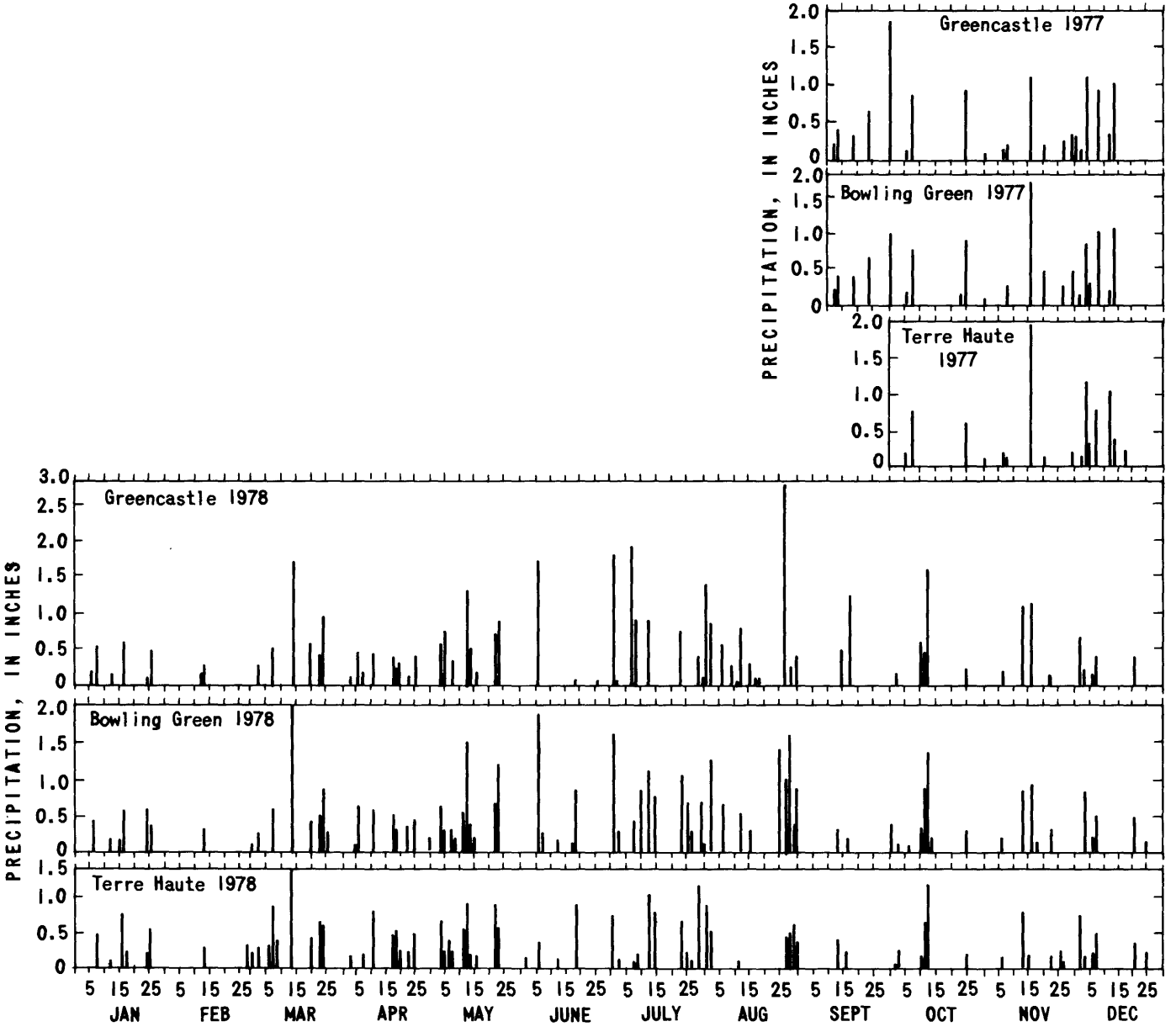
During the study, mean monthly temperature ranged from -14.6° C (degrees Celsius) in February 1978 to 30° C in July 1978 at the Terre Haute weather station. Mean annual rainfall at Terre Haute was 38.41 in. for the 1941-70 period of record (U.S. Department of Commerce, 1973), and mean annual runoff was 13 in. for 1951-80 (L. J. Mansue, written commun., September 15, 1981). Daily precipitations at the Greencastle, Bowling Green, and Terre Haute weather stations from September 1977 through December 1979 are presented in figure 4.

Chinook Mine

Approximately 4 mi^2 of the study area is the reclaimed part of Amax Coal Co.'s Chinook Mine (fig. 2). A part of the mine was chosen for study because the mine is fairly typical of large-scale area surface mining in the glaciated part of the Eastern Interior Coal Province (William Herring, Amax Coal Co., oral commun., January 5, 1981). Much of the overburden material has high acid-production potential and is selectively buried on the bottom of reclaimed cast-overburden piles at the mine.

The surface of the piles of graded cast overburden in the reclaimed surface coal mine ranges from flat to gently undulated. The reclaimed cast overburden consists of a mixture of glacial materials (clay, sand, and gravel), shale and sandstone fragments that are as thick as several feet and some small coal fragments.

The mine consists of three active excavation pits or fields: (1) West Field, in the north part of the study area; (2) Southwest Field, in the southwest part; and (3) Scott Field, in the southeast part. During the study period, most of the mining was done in the Southwest Field, and data collection was concentrated in and around this field.


Greencastle 1977
Bowling Green 1977
Terre Haute 1977
Greencastle 1978
Bowling Green 1978
Terre Haute 1978
PRECIPITATION, IN INCHES
JAN
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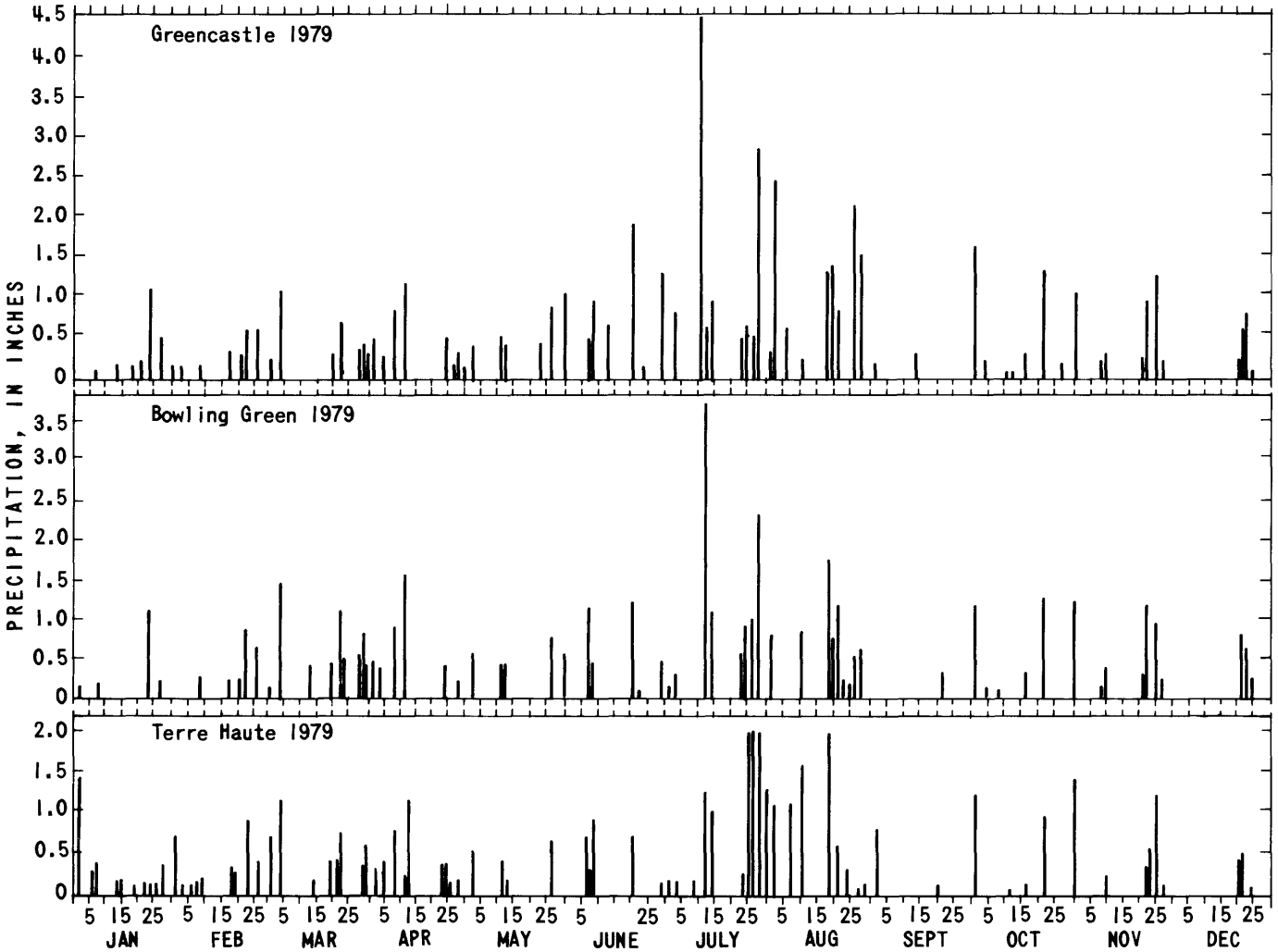

Figure 4.-- Daily precipitation at selected weather stations in Indiana.

Annual coal production (William Herring, Amax Coal Co., oral commun., January 5, 1981) and acreage disturbed by mining (David Kiehl, Indiana Department of Natural Resources, Division of Reclamation, oral commun., January 15, 1981) of the Chinook Mine during the study are given in the following tables:

Annual coal production from the Chinook Mine

Year	Tons of coal produced
1976	1,058,000
1977	1,124,129
1978	1,300,823
1979	1,792,200
1980	1,394,369

Acres of land disturbed by mining of the three active excavation pits of the Chinook Mine

	Excavation pit at		
Year	Southwest Field	West Field	Scott Field
1977	90.0	207	45
1978	251.2	397.3	81.1
1979	147	312.2	None.

Wells in and Around the Surface Coal Mine

To determine the effects of current surface coal mining and reclamation on ground-water quality, the authors and Amax Coal Co. installed 44 wells in and around the Southwest Field of the company's Chinook Mine. Only 41 of these however, were sampled for water-quality analysis. Well locations are shown in figure 2, and description of the 44 wells are presented in table 1 and in figure 5. Wells with the prefix "R" are at the reclaimed mine, and wells with the prefix "B" are outside the reclaimed mine.

Twenty-three 5-inch diameter wells, constructed of white PVC (polyvinyl chloride) casing, were installed in reclaimed cast overburden at 14 sites. Nine of the 14 sites have two wells labeled as "R_A" and "R_B" and 5 of the 14 sites have only "R_B" wells. The "R_A" wells (for example, R3A) are shallow

wells screened 20-40 ft below the water table and ranging in depth from 55 to 91 ft, and the "R_B" wells are deeper wells (for example, R3B) screened on the floor of the reclaimed mine and ranging in depth from 24 to 151 ft.

One 2-inch-diameter well was constructed of grey PVC casing at each of six sites at the reclaimed mine. These wells were screened in sandstone or sandy shale of the Staunton Formation beneath the Seelyville coal (III) horizon. The wells are labeled "R_C" (for example R1C). Outside the reclaimed mine, well B5C was constructed of 2-inch-diameter, white, PVC casing and was screened in sandstone underlying the Seelyville coal (III) horizon.

Fifteen 2-inch-diameter wells were constructed of grey and white PVC casing at seven sites surrounding the reclaimed mine. These wells were sampled for background data and are labeled as "B_A" (for example, B1A) and "B_B" (for example, B1B), respectively. The "B_A" wells were screened in glacial sand and (or) gravel and are at shallower depths than "B_B" wells. The "B_B" wells were screened in thin sandstone layers of the Linton Formation above the Seelyville coal (III) horizon.

Streams in and Around the Surface Coal Mine

Four drainage basins (Honey Creek, North Branch Honey Creek, Stone Quarry Branch, and Big Slough) and several tributaries (Lost Creek tributary, Sulphur Creek tributary, and Brush Creek) were studied to determine the effects of surface coal mining and reclamation on surface-water quality. Locations and stream names of sampling sites are presented in table 2 and figure 2, respectively.

Drainage boundaries were determined by field surveys and by inspection of U.S. Geological Survey topographic maps (Seelyville, 1:24,000, 1963, and Staunton, 1:24,000, 1958, photorevised 1972) updated from aerial photographs (1:80,000). These photographs, taken on May 9, 1977, were obtained from the EROS Data Center, Sioux Falls, S. Dak., and were used to estimate drainage boundaries and areas of watersheds affected by mining.

Honey Creek

Honey Creek, a tributary of the Wabash River, is the largest watershed studied (about 3.9 mi^2). Most of the land in the watershed is reclaimed surface coal mines; however, some of the land is farmed or forested. Six sampling sites (2, 2A, 3, 4, 5, and 14) were selected for study. Automatic digital recorders for continuous measurement of stream stage were installed at sites 3 and 5.

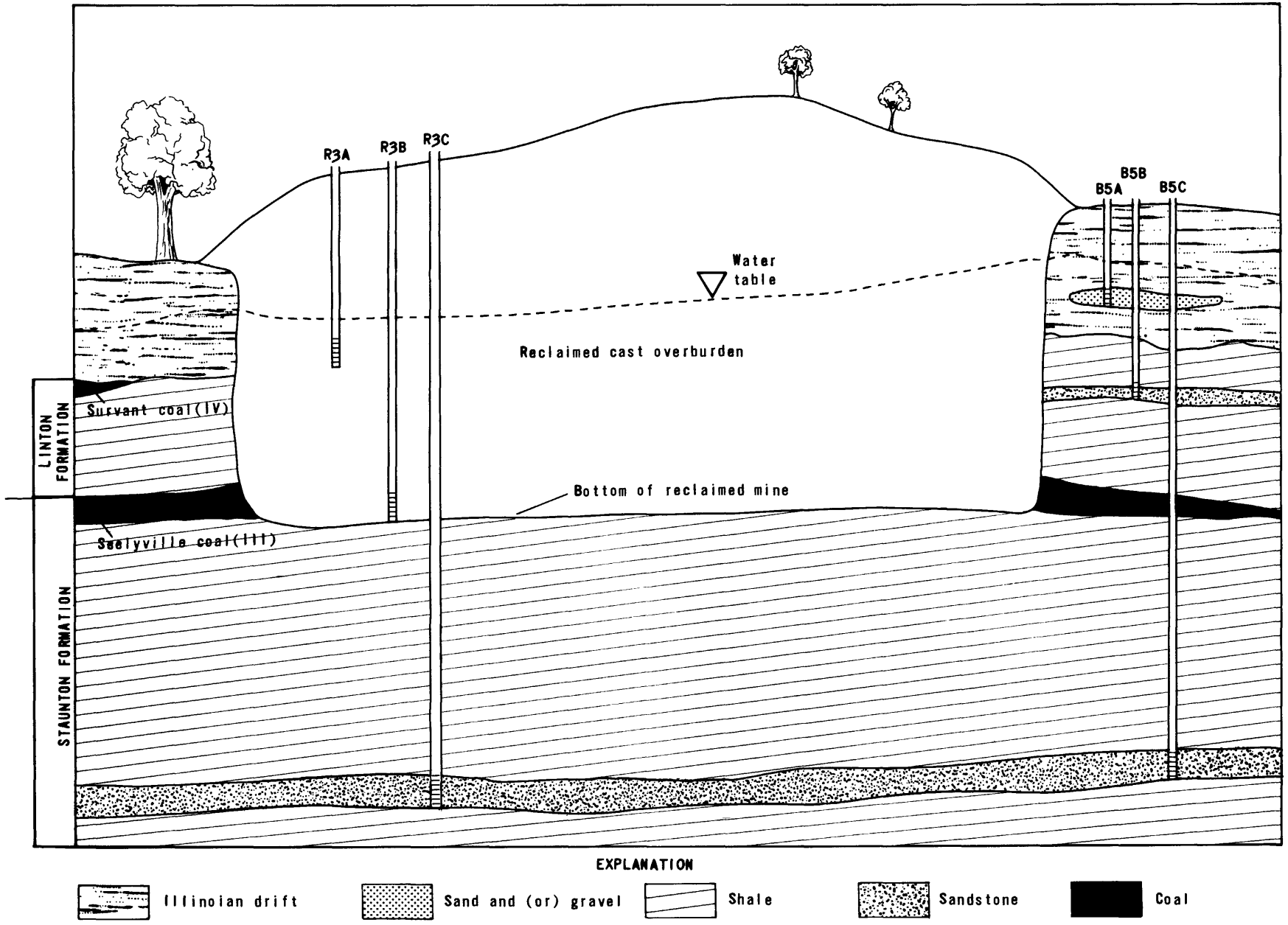

Figure 5.-- Generalized diagram showing relation of stratigraphic and screened intervals in and around a surface coal mine, Clay and Vigo Counties, Ind.

Table 1.--Description of water wells installed in and around a surface coal mine, Clay and Vigo Counties, Ind.

[All 5-in., inside-diameter wells have a 5-ft length of 0.040 in. slotted screen, and all 2-in., inside-diameter wells have a 2-ft length of 0.12-in., slotted screen, unless otherwise noted; data collected by U.S. Geological Survey and Amax Coal Co., Chinook Mine, near Staunton, Ind.]

Well	Latitude/ longitude	Depth to bottom of screen (feet below top of well)	Inside diameter of well (inches)	Water-bearing formation	Construction details
R1B	39°25'10" 87°13'45"	151	5	Reclaimed cast overburden.	Gravel packed.
R1C	39°25'10" 87°13'45"	176	2	Sandstone	0.015-in. slot screen; packers at 158.6-259.0 and 170.5 ft.
R2B	39°25'50" 87°14'10"	108	5	Reclaimed cast overburden.	Gravel packed.
R3A	39°25'55" 87°40'00"	75	5	do.	Gravel packed.
R3B	39°25'55" 87°40'00"	99	5	do.	Gravel packed.
R3C	39°25'55" 87°40'00"	120	2	Sandstone	0.015-in. slot screen; packer at 114.0 ft.
R4A	39°25'46" 87°13'56"	58	5	Reclaimed cast overburden.	4-in. diameter; 5-ft, 0.018-in. slot screen. Set blank at 30-ft, plug at 60 ft, and packer at 63 ft.
R4B	39°25'46" 87°13'56"	79	5	do.	4-in. diameter; 5-ft, 0.018-in. slot screen.
R5A	39°25'47" 87°13'38"	91	5	do.	Gravel packed.

Table 1.--Description of water wells installed in and around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Well	Latitude/ longitude	Depth to bottom of screen (feet below top of well)	Inside diameter of well (inches)	Water-bearing formation	Construction details
R5B	39°25'47" 87°13'38"	115	5	Reclaimed cast overburden.	Gravel packed; bottom 7 ft of hole filled by sloughing information.
R5C	39°25'47" 87°13'38"	153	5	Sandstone	0.015-in. slot screen; 10 ft of blank pipe and packer at 139.5 ft.
R6A	39°25'36" 87°13'25"	90	5	Reclaimed cast overburden.	Gravel packed.
R6B	39°25'36" 87°13'25"	122	5	do.	Gravel packed; 3-ft of blank pipe on bottom.
R7A	39°25'55" 87°14'41"	66	5	do.	Gravel packed.
R7B	39°25'55" 87°14'41"	90	5	do.	Gravel packed; 6-ft of blank pipe on bottom and packer at 84 ft.
R7C	39°25'55" 87°14'41"	97	2	Sandstone	0.015-in. slot screen; 3 ft of blank pipe on bottom and packers at 92 and 104 ft.
R8A	39°26'00" 87°14'07"	82	5	Reclaimed cast overburden.	Gravel packed.
R8B	39°26'00" 87°14'07"	109	5	do.	Gravel packed.
R9A	39°26'11" 87°14'18"	61	5	do.	0.015-in. slot screen; 20-ft hacksaw slotted casing.

Table 1.--Description of water wells installed in and around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Well	Latitude/ longitude	Depth to bottom of screen (feet below top of well)	Inside diameter of well (inches)	Water-bearing formation	Construction details
R9B	39°26'11" 87°14'18"	89	5	Reclaimed cast overburden.	0.015-in. slot screen; packer at 97 ft.
R9C	39°26'11" 87°14'18"	117	2	Sandy Shale	0.015 in. slot screen; packer at 97 ft.
R10B	39°26'11" 87°14'18"	68	5	Reclaimed cast overburden.	Gravel packed; 3 ft of blank pipe on bottom.
R11A	39°26'25" 87°13'48"	70	5	do.	Gravel packed bottom.
R11B	39°26'25" 39°13'48"	99	5	do.	Packer at 35 ft.
R11C	39°26'25" 87°13'48"	109	2	Sandstone	0.012-in. slot screen; packer at 93 ft.
R12A	39°26'31" 87°12'32"	55	5	Reclaimed cast overburden.	Gravel packed.
R12B	39°26'31" 87°12'32"	72	5	do.	Gravel packed; Bottom 5 ft of hole filled by sloughing formation.
R13B	39°26'26" 87°11'56"	24	5	do.	2-ft of 2-in. diameter pipe, 0.015-in. slot screen.
R14B	39°26'22" 87°11'47"	35	5	do.	Do.
B1A	39°24'42" 87°13'45"	26	2	Sand	10 ft of blank pipe on bottom
B1B	39°24'42" 86°13'45"	30	2	Sandstone	----------

Table 1.--Description of water wells installed in and around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Well	Latitude/ longitude	Depth to bottom of screen (feet below top of well)	Inside diameter of well (inches)	Water-bearing formation	Construction details
B2A	39°24'53" 87°15'03"	22	2	Sand and gravel.	----------
B2B	39°24'53" 87°15'03"	52	2	Sandstone	Packer at 30 ft.
B3A	39°24'36" 87°15'03"	22	2	Sand and gravel.	----------
B3B	39°24'36" 87°15'35"	106	2	Sandstone	----------
B5A	39°25'14" 87°15'02"	67	2	Sand and gravel	----------
B5B	39°25'14" 87°15'02"	100	2	Sandstone	Packer at about 90 ft.
B5C	39°25'14" 87°15'02"	138	2	do.	Packer at 126.5 ft and 124 ft.
B6A	39°27'02" 87°12'39"	36	2	Sand	----------
B6B	39°27'02" 87°12'39"	92	2	Sandstone	----------
B7A	38°27'10" 87°12'07"	26	2	Sand	----------
B7B	39°27'10" 87°12'07"	44	2	Sandstone	3-ft of blank pipe on bottom and packer at 39.0 ft.
B8A	39°25'05" 87°12'20"	56	2	Sand and gravel.	----------
B8B	39°25'05" 87°12'20"	88	2	Sandstone	Packer at 84.0 ft.

Table 2.--Description of surface-water sites in and around a surface coal mine, Clay and Vigo Counties, Ind.

[Cr, Creek; trib., tributary; S., South; Rd., Road; N., North; Br, Branch; E., East; W., West; SR, State Road]

Sampling site	Latitude/ longitude	Stream name and location	Remarks
Sites on streams draining agricultural and forested lands affected by active mining			
1	39°28'28" 87°14'45"	Sulphur Cr trib. at 27 S. Rd.	Stream was reconstructed by mining in autumn 1978.
13	39°25'41" 87°14'57"	Honey Cr trib. at 31 W. Rd.	Stream was removed by mining in summer 1978.
14	39°25'38" 87°15'27"	Honey Cr trib. at 92 S. Rd.	Sediment pond used to receive water pumped from the excavation pit was at the Southwest Field upstream from site 14 until November 1978, when it was drained and the area was subsequently mined.
16	39°24'40" 87°14'22"	Stone Quarry Br trib. (ditch) at 27 W. Rd.	Stream site directly affected by water pumpage from the Southwest Field.
17	39°25'35" 87°15'25"	Stone Quarry Br trib. (ditch) at 27 W. Rd.	Do.
18	39°24'50" 87°15'31"	Stone Quarry Br at 27 W. Rd.	Do.
Sites on streams draining reclaimed surface coal-mine lands			
3	39°27'44" 87°14'56"	Honey Cr at SR 42 (gaging station)	Stream gaging station.
4	39°26'42" 87°13'08"	Honey Cr trib. at haul road in mine.	Stream downstream from site 4 drains water recirculation system used by coal processing.

Table 2.--Description of surface-water sites in and around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling site	Latitude/ longitude	Stream name and location	Remarks
Sites on streams draining reclaimed surface-coal-mine land--Continued			
5	39°26'32" 87°15'09"	Honey Cr at Lower Bloomington Rd. (gaging station.)	Stream at site 5 drains coal-mine lake 6 that is the source of water for coal-processing recirculation. Stream gaging station.
Sites on streams affected by a transition of land use, from unmined to mined			
9	39°27'44" 87°14'57"	N. Br Honey Cr at 8 E. Rd.	Stream gaging station at site 12. The stream at sites 9 and 12 drained agricultural and forested land. After October 1978, the streams were affected by pumping of water from the Westfield excavation pit into the stream.
12	39°27'11" 87°15'31"	N. Br Honey Cr at 82 S. Rd.	In September 1979, a settling pond was installed upstream from site 9 to receive water pumped from the excavation pit.
Sites on streams draining agricultural and forested land, streams unaffected by mining			
1A	39°28'40" 87°15'25"	Lost Cr trib. at 4 E. Rd. and 82 S. Rd. intersection	
2	39°27'45" 87°12'30"	Honey Cr at 21 W. Rd.	
2A	39°27'45" 87°13'00"	Honey Cr trib. at 21 W. Rd.	
7	39°27'41" 87°13'39"	N. Br Honey Cr at 27 S. Rd.	

Table 2.--Description of surface-water sites in and around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling site	Latitude/ longitude	Stream name and location	Remarks
Sites on streams draining agricultural and forested land, streams unaffected by mining			
8	39°27'38" 87°14'20"	N. Br Honey Cr trib. at Cherryvale	
10	39°27'38" 87°14'58"	N. Br Honey Cr trib. at 31 S. Rd.	
10A	39°27'09" 87°14'20"	N. Br. Honey Cr trib. at 31 S. Rd.	
11	39°24'29" 87°12'46"	N. Br Honey Cr at 8 E. Rd.	
15	39°25'16" 87°12'52"	Stone Quarry Br trib., at Lower Bloomington Rd.	Site located downstream from lake formed by the damming of the old headwaters of Honey Creek.
20	39°24'31" 87°12'57"	Big Slough at 49 S. Rd.	Streams may be affected by a small unreclaimed mine southwest part of the watershed.
21	39°23'29" 87°13'49"	Big Slough at 51 S. Rd.	
22	39°25'10 87°11'58"	Brush Cr at 27 W. Rd.	
23	39°24'38" 87°11'53"	Brush Cr at 29 W. Rd.	

Land use in the headwaters of Honey Creek, upstream from site 3, is primarily forest and agriculture; however, the area contains a small reclaimed surface coal mine. An unreclaimed surface coal mine (mined before 1967), northeast of the watershed, probably contributes ground water to Honey Creek but does not contribute surface water.

Downstream from site 3, Honey Creek has been rerouted around the north part of the Southwest Field, and, thence, the creek drains into two coal-mine lakes (lakes 5 and 6, respectively). Water from lake 6 is used for coal washing and processing in a recirculation system. Water is pumped from lake 6 to the preparation plant that processes coal. After coal processing, washwater carrying coal fines is discharged through pipes and ditches to lake 4, which drains

into Honey Creek downstream from site 4. The water then drains into Honey Creek and through lakes 5 and 6, respectively. Site 5 is on Honey Creek, downstream from the outlet of lake 6.

Until November 1978, Honey Creek tributary at site 14 drained a sediment settling pond that received water pumped from the Southwest Field. Since that time, this settling pond has been drained, and the area has been mined.

North Branch Honey Creek

North Branch Honey Creek drains into Honey Creek west of the study area. Land use in the 3.3-mi^2 watershed is primarily agriculture and forest. Six sampling sites (7, 8, 9, 10, 11, and 12) were selected for study. An automatic digital recorder for continuous measurement of stream stage was installed at site 12.

Before October 1978, the watershed was unaffected by mining; however, since then water has been pumped from the West Field excavation pit into the stream (William Herring, Amax Coal Company, oral commun., July 1979). In September 1979, a sediment settling pond was constructed upstream from site 9 to receive water pumped from the West Field excavation pit.

Stone Quarry Branch

Stone Quarry Branch drains into Honey Creek west of the study area. Land use in the 3-mi^2 watershed is primarily agriculture, forest, and mining. Four sampling sites (15, 16, 17, and 18) in the watershed were selected for study.

Drainage from part of the headwaters of Honey Creek has been rerouted around the Southwest Field and discharges into Stone Quarry Branch. Site 15 is downstream from the outlet of lake 7, which was formed by damming the headwaters of Honey Creek. Downstream from site 15, water is pumped from the Southwest Field into ditches that discharge into Stone Quarry Branch (sites 16 and 17) upstream from site 18.

Big Slough

Big Slough, a tributary to the Eel River (not shown in fig. 2), has a 2.5 mi^2 drainage area within the study area. This watershed consists primarily of agricultural and forested lands. There was no surface coal mining in the watershed during the study period. However, a small abandoned surface mine (mined before 1967) in the southwest part of the watershed may contribute runoff to Big Slough during periods of intense rainfall. Two sampling sites on Big Slough (sites 20 and 21) were selected for study.

Lost Creek and Sulphur Creek Tributaries and Brush Creek

Lost Creek and Sulphur Creek are tributaries of the Wabash River. Lost Creek tributary, which drains agricultural and forested land, was sampled at site 1A. Sulphur Creek tributary was sampled at site 1, where the stream drains primarily agricultural and forested land affected by mining of the West Field. In the summer of 1978, Sulphur Creek tributary was reconstructed during mining in the West Field.

Brush Creek is a tributary of the Eel River and drains primarily agricultural and forested land. The stream may have been affected by surface mining in the Scott Field. Brush Creek was sampled at sites 22 and 23.

METHODS OF INVESTIGATION

Installation and Development of Wells

In the reclaimed mine, 8-inch-diameter augers were used to drill holes where 23 wells, constructed of 5-inch-diameter, white, PVC (polyvinyl chloride) casing, were screened in the water-bearing formation. These wells are identified as "R_A" and "R B", respectively. Five 2-inch-diameter, grey, PVC-encased wells (identified as "R_C") were installed and screened in the sandstone and sandy shale below the Seelyville coal (III) horizon of the Staunton Formation. The holes for these wells were drilled by auger to bedrock and then by the water-rotary method to the proposed well-screen depth.

Outside the reclaimed mine, 2-inch-diameter, grey and white, PVC-encased wells ("B_A", and "B_B", and B5C) were screened in sand and (or) gravel and sandstone, respectively. The holes for these wells were drilled by the water-rotary method. Construction details for all wells are presented in table 1.

All wells were initially developed with compressed nitrogen. Five-inch-diameter wells were further developed with a Red Jacket submersible pump, and 2-inch-diameter wells were further developed by bailing.

Split-Drive Samples

Split-drive samples of reclaimed cast overburden were collected during the drilling of the holes for the 5-inch-diameter wells ("R_A" and "R_B"). Samples were collected above and below proposed well-screen locations for "R_A" wells and at 10-ft intervals at "R_B" well sites.

A standard 1-ft length, split-drive sampler was used to collect overburden samples by removing the auger bit and lowering the sampler through the center of the auger to the bottom of the hole. The sampler was then driven into fresh material below the auger. After the sampler was recovered from the hole, the sampler halves were separated, and the sample materials were visually examined for rock and mineral content. The samples were then transferred to 1-quart, plastic-freezer cartons and were refrigerated at 4° C until analyzed. Percent sulfur by weight was determined by the Geological Survey and the Amax Coal Co., and acid-production potential was determined by the Geological Survey. The determinations are listed in table 3, and methods of analysis are described by Smith and others (1974, p. 43-49).

Ground-Water Sampling Methods

Water levels were monitored monthly in 44 wells from April 1978 through February 1980 (table 4). Levels were measured to the nearest 0.01-ft with a stainless-steel tape. In September 1978, elevations of the tops of all wells were measured to the nearest 0.01-ft with a Zeiss level (table 5).

Ground-water quality in the study area was evaluated from analyses of water samples collected from 41 wells in and around a surface coal mine.

Five-Inch-Diameter Wells

Hydraulic tests were made before the collection of water-quality samples. Initially, static water levels in 5-inch-diameter wells were measured before the wells were pumped. Water levels were also measured immediately after pumping and regularly, thereafter, to determine recovery rates of wells. For wells that displayed significant drawdown, recovery ranged from 2 to 24 hours, depending on the well. Wells that did not draw down completely were evacuated a minimum of six times to ensure that samples would be collected from water in recent contact with aquifer materials. Water was pumped from the middle of the water column and then from the top of the screen in these wells. Water columns in wells that did display complete drawdown were pumped from the top of the screen. A Red Jacket submersible pump was used to pump water from all 5-inch-diameter wells. Pumping rates for all wells were determined by the volumetric method with a stop watch and a 5-gallon bucket.

Data from the hydraulic tests were used to calculate specific capacity, hydraulic conductivity, transmissivity, and permeability of saturated, reclaimed cast overburden.

Immediately after nearly complete recovery of the water level in each well, water samples were collected at the well screen with an acrylic Foerst sampler. The sampler was raised out of the well into a detachable, opaque casing placed on top of the well to prevent light from affecting the sample. Samples were drawn through Tygon tubing attached to a spigot at the bottom of the sampler and were then prepared for analysis.

Verification of Sample-Collection Methods for 5-inch-Diameter Wells.--Water samples were collected from well R10B on September 28 and 29, 1978, to verify sample-collection methods. Duplicate water samples were collected immediately after pumping ceased and again 23 hours later. The well did not have a significant drawdown. The analyses of the samples collected at the two times differed very little; for example, dissolved-solids concentrations for the first and second times of sampling were 3,770 and 3,740 mg/L. The analyses of the samples collected from well R10B are given in table 6.

Two-Inch-Diameter Wells

Initially, measurement of static water level in each 2-inch diameter well was followed by either bailing or pumping the well. Water-quality samples were collected immediately after water-level recovery.

For well depths greater than 32 ft below land surface, a 1.5-inch diameter, white, PVC bailer was used to evacuate the water column and collect water samples at the well screen. For well depths less than 32 ft below land surface, a peristaltic pump with Tygon tubing was used to evacuate the water column and collect water samples at the well screen.

After bailing or pumping of water from the wells, the authors measured water levels periodically until the water level was near recovery. Recovery rates ranged from 2 to 30 hours, depending on the well. Immediately after recovery of the water level in the well, water-quality samples were collected at the well screen and were prepared for analysis.

Analysis of Water Samples From 5-Inch- and 2-Inch-Diameter Wells

Water samples from all wells were analyzed by the Geological Survey for concentrations of dissolved major cations and anions, phosphorus, organic carbon, metals and trace elements (including alumninum, iron, and manganese), solids residue at 180° C, and total hardness. These data are reported in tables 7-16. Field determinations of alkalinity concentrations in well-water samples were done by methods outlined in American Public Health Association, Inc., and others (1975, p. 278-282).

After water samples were collected from a well, water temperature, specific conductance, pH, Eh, in all wells, and dissolved-oxygen concentrations in 5-inch-diameter wells were measured at the well screen by a Hydrolab water-quality analyzer. The instrument was calibrated and checked daily. Readings were recorded until they became stable and are reported in tables 7-11.

Methods of Determining Concentrations of Ferrous Iron and Dissolved Oxygen in Ground Water

Water samples from 5-inch-diameter wells were analyzed in the field for concentrations of ferrous iron and dissolved oxygen. Two chemical methods for determining ferrous iron concentration of well water (a colorimetric method that uses 2,2-bipyridine, by Sandell, 1959, p. 537-542; and a colorimetric method that uses phenanthroline, by American Public Health Association, Inc., and others, 1975, p. 208-213) were modified by Geological Survey employees Arthur J. Horowitz, the authors, and Stephen M. Woods, who used the modified methods to determine concentrations of ferrous iron in water from 5-inch-diameter wells. Pretreated well-water samples were also sent to the Geological Survey Central Laboratory, Doraville, Ga., for determining ferrous iron concentrations. Dissolved-oxygen concentration was determined by a method described in American Public Health Association, Inc., and others, (1975, p. 488-449).

A Foerst sampler was lowered twice to the well screen to collect water samples for testing the reliability of the sample-collection method and the accuracy of the determinations of ferrous iron and dissolved-oxygen concentrations of well-water samples. The content of each filled sampler was divided into two sets of water samples. Concentrations of duplicate determinations of ferrous iron and of dissolved oxygen were nearly identical (table 17).

Dissolved-oxygen concentrations measured at the well screen by a Hydrolab water-quality analyzer are given in tables 7 through 11.

Statistical Analyses and Confidence Intervals

Summary statistics of selected properties and concentrations of constituents dissolved in ground water are presented in tables 9-12. Mean (except pH), median, standard deviation, and range are shown for constituent concentration and properties that had at least three data points and a coefficient of variation (C.V.) of 25 percent or less. The coefficient of variation was calculated by:

$$C.V. = \frac{\text{Standard deviation}}{\text{mean}} \times 100$$

The coefficient of variation of a set of data is generally small where the data are closely grouped and measurements are significantly higher than the detection limit. In contrast, the coefficient of variation of a set of data is generally large where the data vary because of temporal changes or the data are very close to the detection limit. Concentrations of some constituents are very close to the detection limit of the analytical methods used. For these constituents, variation of concentration among samples may have been 100 percent or more.

Summary statistics for stream water quality and ground-water trace-element data are not presented because the coefficients of variation for most of these data exceeded 25 percent.

Reliability of the summary statistics may be limited because of the small number of data points. The reliability of the mean of a group of data can be estimated by calculating a confidence interval ($CI(\ )$) of the mean of the population from which the data were obtained:

$$CI(\ ) = \overline{X} \quad \frac{t\ s}{\sqrt{n}}$$

where

$CI(\ )$ is the confidence interval and probability,

$\overline{X}$ the mean,

t the Student's t from the following table,

s the standard deviation,

and

n the number of data points.

	t for percent probability		
n-1	90	95	99
2	2.920	4.303	9.925
3	2.353	3.182	5.841
4	2.132	2.776	4.604
5	2.015	2.571	4.032

This calculation is based on the assumption that the data points are from a normal population. (See Miller and Freund, 1965, p. 136.) The confidence interval calculated by the preceding equation is a range within which the mean of the whole population falls at 90-, 95-, or 99-percent probability.

For example, the confidence interval of the mean dissolved-solids concentration for well R4B at the 95-percent probability level is determined as follows:

where

$\overline{X}$ = 3,910 mg/L, s = 772 mg/L, and n=5;

$$CI_{95} = 3{,}910 \pm \frac{2.776(722)}{\sqrt{5}}$$

and

$$CI_{95} = 3{,}910 \pm 896 \text{ mg/L}.$$

Thus, the mean dissolved-solids concentration of water from well R4B has a 95-percent probability of falling within the range from 3,014 to 4,806 mg/L.

Calculation of the confidence intervals at 90- and 99-percent probability gives the following results:

$$CI_{90} = 3,910 \pm 688 \text{ mg/L}$$

$$CI_{99} = 3,910 \pm 1,302 \text{ mg/L}$$

Thus, higher probabilities result in wider ranges that should contain the mean of the population.

Stream-Sampling Methods

Water-quality and other hydrologic data were collected intermittently from September 1977 through February 1980 at 24 stream sites (tables 18 through 34).

Stream stage was measured continuously at sites 3, 5, and 12 with automatic digital recorders; streamflow was measured monthly. During sampling periods, streamflow was measured at these and other sites with the methods outlined by Carter and Davidian (1968).

Selected water-quality properties and constituents (temperature, specific conductance, pH, Eh, and dissolved-oxygen concentration) were measured at all stream sites with a Hydrolab water-quality analyzer. The instrument was calibrated daily and was checked periodically each sampling day. Additionally, alkalinity concentrations of water samples were determined in the field by a method described in American Public Health Association, Inc., and others, (1975, p. 278-282).

Water samples collected at selected sites (1, 3, 4, 5, 6, 9, 12, 14, 15, 18, 20, and 21) were analyzed for concentrations of major cations and anions, metals and trace elements (including aluminum, iron, and manganese), organic carbon, phosphorus, dissolved-solids residue at 180° C, hardness, and phytoplankton. These samples were also analyzed for suspended-sediment concentrations and particle-size distribution. Also, the concentrations of trace elements (including aluminum, iron, and manganese) adsorbed on streambed materials were determined.

All water-quality and streambed samples were collected and analyzed by methods outlined in Georlitz and Brown (1972); Greeson and others (1977); Guy and Norman (1970); Skougstad and others (1979); Slack and others (1973); and Wood (1976).

SUMMARY OF TABLES

Ground-water data and summary statistics for most of the wells are given in tables 1 and 3 through 17. The data are divided into eight categories:

1. Description of well sites (table 1).

2. Percent sulfur by weight and acid-production potential of reclaimed cast overburden (table 3).

3. Summary statistics of water levels in all wells (table 4).

4. Elevations of tops of water wells (table 5).

5. Verification of ground-water sampling methods (table 6).

6. Field and laboratory measurements of water quality and related properties of water in wells (tables 7 through 11).

7. Concentrations of trace elements in water from wells (tables 12 through 16).

8. Ferrous iron and dissolved-oxygen concentrations of water from wells screened in reclaimed cast overburden (table 17).

Categories 4 and 5 were further divided into the following five subcategories:

1. Wells screened in reclaimed cast overburden, 20-40 ft below the water table (wells "R_A" in tables 7 and 12).

2. Wells screened in reclaimed cast overburden, on the floor of the mine (Wells "R_B" in tables 8 and 13).

3. Wells screened in sandstone or sandy shale of the Staunton Formation below Seelyville coal (III) horizon in and around a surface coal mine, Clay and Vigo Counties, Indiana (wells "R_C" and B5C in tables 9 and 14).

4. Background wells screened in sand and (or) gravel around a surface coal mine, Clay and Vigo Counties, Indiana (wells "B_A" in tables 10 and 15).

5. Background wells screened in sandstone of the Linton Formation above Seelyville coal (III) horizon around a surface coal mine, Clay and Vigo Counties, Indiana (wells "B_B" in tables 11 and 16).

Surface-water data and summary statistics for most of these data by stream site are given in tables 2 and 18 through 34. The data are divided into eight categories:

1. Description of surface-water sampling sites (table 2).

2. Instantaneous stream discharge for sites 3, 5, and 12 (table 18) and mean daily discharge for stream sites 5 and 12 (tables 19 and 20).

3. Field measurements of water quality and related properties at stream reconnaissance sites (tables 21 and 22).

4. Field and laboratory measurements of water quality and related properties of water (tables 23 through 26).

5. Concentrations of metals and trace elements in water at stream sites (tables 27 through 30).

6. Concentrations and particle size of a suspended-sediment sample from stream site 5 (table 31).

7. Concentrations of aluminum, iron, and manganese adsorbed on streambed materials (table 32).

8. Concentrations of metals and trace elements adsorbed on streambed materials (table 33).

9. Phytoplankton data for selected stream sites (table 34).

Surface-water categories 2 through 4 were further divided into the following subcategories:

1. Sites on streams draining agricultural and forested lands affected by mining (tables 21, 23 and 27).

2. Sites on streams draining reclaimed lands (tables 24 and 28).

3. Sites on streams affected by a transition in land use from unmined to mined (tables 25 and 29).

4. Sites on streams draining agricultural and forested lands unaffected by mining (tables 22, 26 and 30).

Stream sites are listed in numerical (downstream) order in all tables.

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Tables 3-34

Table 3.--Percent sulfur by weight and potential acidity of reclaimed cast overburden sample at well sites in a surface coal mine, Clay and Vigo Counties, Ind.

[Analyses by Amax Coal Co. (A) and U.S. Geological Survey (U); g, gram; meq, milliequivalent]

Depth of sample (feet below land surface)	Sulfur (percent by weight)	Potential acidity (meq H^{+1}/100 g)	Analysis by
	Well R1B		
10	0.24	-----	A
30	.21	-----	A
40	.21	-----	A
50	.18	-----	A
60	.43	-----	A
70	1.02	-----	A
80	.62	-----	A
90	.35	-----	A
100	.38	-----	A
110	.87	-----	A
120	3.80	162.0	U
120	3.91	-----	A
130	2.90	110.6	U
130	2.88	-----	A
140	6.06	148.3	U
	Well R2B		
10	.56	-----	A
20	.47	-----	A
30	.31	-----	A
40	1.20	-----	A
50	.47	-----	A
60	.54	-----	A
70	.48	-----	A
80	.37	-----	A
90	2.56	14.1	U
100	1.72	73.2	U
	Well R3A		
65	.28	13.7	U
75	4.82	68.6	U

Table 3.--Percent sulfur by weight and potential acidity of reclaimed cast overburden sample at well sites in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Depth of sample (feet below land surface)	Sulfur (percent by weight)	Potential acidity (meq H^{+1}/100 g)	Analysis by
	Well R3B		
10	1.70	------	A
20	.21	------	A
30	.68	------	A
40	.15	------	A
50	.20	------	A
60	1.14	------	A
70	1.07	------	A
90	2.01	83.7	U
100	1.18	6.4	U
	Well R4A		
10	15.87	3.72	A
20	4.42	1.5	A
30	8.33	------	A
40	10.31	------	A
50	10.10	221.4	U
60	6.20	239.5	U
70	.73	------	A
80	1.40	------	A
90	1.80	------	A
	Well R4B		
10	9.36	------	A
20	5.61	------	A
30	6.61	------	A
40	1.65	------	A
50	6.70	------	A
60	.64	------	A
70	.46	21.7	U
80	3.20	120.2	U
80	3.05	------	A

Table 3.--Percent sulfur by weight and potential acidity of reclaimed cast overburden sample at well sites in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Depth of sample (feet below surface)	Sulfur (percent by weight)	Potential acidity (meq H^{+1}/100 g)	Analysis by
	Well R5A		
90	1.35	61.0	U
	Well R5B		
110	2.18	66.5	U
125	.90	23.3	U
	Well R6A		
80	0.74	34.3	U
90	1.69	62.0	U
	Well R6B		
10	0.14	-----	A
20	.46	-----	A
30	.37	-----	A
40	.17	-----	A
50	2.88	-----	A
70	.20	-----	A
80	.15	-----	A
90	.37	-----	A
100	.20	-----	A
110	.21	-----	A
120	0	8.75	U
130	.53	1.10	U
	Well R7A		
55	1.90	72.8	U
65	.43	17.4	U
	Well R7B		
10	3.91	-----	A
20	.59	-----	A
30	.23	-----	A
40	2.54	-----	A
50	.26	-----	A

Table 3.--Percent sulfur by weight and potential acidity of reclaimed cast overburden sample at well sites in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Depth of sample (feet below land surface)	Sulfur (percent by weight)	Potential acidity (meq H^{+1}/100 g)	Analysis by
	Well R7B--Continued		
60	.36	----	A
70	.30	10.6	U
80	1.69	27.0	U
	Well R8B		
90	1.70	69.0	U
100	.32	8.69	U
	Well R8A		
70	2.10	75.3	U
80	.93	35.2	U
	Well R9A		
50	0.79	41.3	U
60	.71	30.9	U
	Well R9B		
60	0.32	15.0	U
80	1.34	59.6	U
	Well R10A		
50	0.37	16.9	U
60	1.60	33.6	U
	Well R11A		
60	0.63	27.3	U
70	1.20	45.9	U
	Well R11B		
10	0.43	----	A
20	.72	----	A
30	.48	----	A
40	.81	----	A
50	1.85	----	A

Table 3.--Percent sulfur by weight and potential acidity of reclaimed cast overburden sample at well sites in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Depth of sample (feet below land surface)	Sulfur (percent by weight)	Potential acidity (meq H^{+1}/100 g)	Analysis by
Well R11B--Continued			
60	1.40	68.1	U
70	2.60	97.3	U
70	2.76	----	A
Well R12A			
55	2.09	18.3	U
Well R12B			
80	1.62	0.82	U
Well R13B			
20	0.23	9.2	U
Well R14B			
20	0.07	7.00	U
30	.09	3.14	U

Table 4.--Summary statistics of water levels in wells in and around a surface coal mine, Clay and Vigo Counties, Ind., April 1978 through February 1980

[Well numbers plotted in figure 2; elevations in feet; ft, foot; N, number of measurements; $\bar{X}$, mean; Med, median; Min, minimum; Max, maximum CV, coefficient of variation; National Geodetic Vertical datum of 1929]

Well	N	$\bar{X}$	Med	Min	Max	CV
Wells in reclaimed cast overburden screened 20-40 ft below the water table						
R3A	20	561.31	559.49	545.60	578.82	1.5
R4A	19	577.29	578.09	567.80	582.66	.70
R5A	19	578.53	577.03	574.27	589.34	.71
R6A	19	579.24	78.16	573.71	586.29	.56
R7A	19	566.44	564.86	555.60	579.04	1.1
R8A	19	573.75	572.28	565.87	579.72	.59
R9A	18	576.73	576.52	572.87	581.63	.43
R11A	18	580.76	580.70	578.52	583.93	.29
R12A	20	597.50	597.03	595.90	600.93	.25
Wells in reclaimed cast overburden, screened on the floor of the mine						
R1B	19	534.37	533.64	532.91	537.65	0.28
R2B	19	544.59	545.03	533.29	552.61	1.1
R3B	20	561.37	559.53	545.58	580.10	1.5
R4B	19	573.92	575.72	566.86	579.39	.65
R5B	19	578.15	577.03	573.25	587.72	.64
R6B	19	579.27	578.44	574.73	586.30	.56
R7B	19	564.79	562.52	556.10	579.82	1.2
R8B	19	573.42	572.35	567.74	579.74	.55
R9B	19	577.52	576.63	573.22	582.10	.44
R10B	19	578.53	578.44	576.33	580.83	.25
R11B	18	580.58	580.42	578.55	583.91	.28
R12B	20	596.76	596.66	591.31	604.03	.48
R13B	19	638.21	638.13	637.20	640.43	.14
Wells screened in sandstone or sandy shale of the Staunton Formation below the Seelyville Coal(III) horizon						
R1C	11	546.11	542.22	537.60	580.19	2.2
R3C	17	508.58	504.01	495.66	554.75	3.3
R5C	29	559.05	559.14	557.52	560.19	1.4
R7C	19	540.92	544.77	521.90	548.18	1.4
R9C	19	569.22	569.06	565.31	578.84	.46
R11C	18	539.26	535.65	525.92	578.51	2.3
R5C	19	559.05	559.14	577.52	560.19	.11
Background wells screened in sand and (or) gravel						
B1A	19	626.18	619.92	614.56	627.07	0.65
B2A	18	597.65	598.21	591.99	600.81	.43
B3A	29	611.68	612.07	604.68	615.23	.47
B5A	19	575.00	575.86	571.76	576.94	.30
B6A	19	611.66	611.86	610.55	612.38	.09
B7A	19	662.90	663.96	658.08	664.59	.34
B8A	18	639.62	639.42	636.82	641.14	.19
Background wells screened in sandstone of the Linton Formation above Seelyville Coal (III)						
B1B	18	616.11	615.58	610.94	626.46	0.65
B2B	19	595.41	595.81	590.40	600.30	.42
B3B	17	527.56	526.85	525.93	533.18	.38
B5B	19	563.79	565.00	557.91	566.24	.42
B6B	18	611.83	612.10	609.84	613.75	.17
B7B	19	660.68	660.12	657.36	660.60	.12
B8B	19	619.46	620.53	605.61	630.34	.97

Table 5.--Elevations of tops of water wells in and around a surface coal mine, Clay and Vigo Counties, Ind., September 1978

[ft, foot; data collected by U.S. Geological Survey]

Well	Elevation (ft)	Well	Elevation (ft)	Well	Elevation (ft)
B1A	631.084	R2B	644.215	R10B	606.351
B1B	630.963	R3A	607.503	R11A	619.634
B2A	601.967	R3B	608.192	R11B	619.324
B2B	601.185	R4A	600.873	R12A	631.619
B3A	618.510	R4B	596.907	R12B	630.604
B3B	617.270	R5A	639.466	R13B	646.690
B5A	590.866	R5B	639.599	R14B	671.77
B5B	590.668	R6A	636.520	B5C	590.297
B6A	614.462	R6B	636.459	R1C	642.276
B6B	615.672	R7A	592.181	R3C	608.389
B7A	668.177	R7B	592.393	R5C	636.156
B7B	667.671	R8A	625.340	R7C	590.999
B8A	643.592	B8B	624.399	R9C	610.482
B8B	643.624	R9A	611.180	R11C	619.763
B1B	644.215	R9B	610.904		

Table 6.--Analyses of water samples from 5-inch-diameter well (R10B) for verification of ground-water sampling methods in a surface coal mine, Clay and Vigo Counites, Ind.

[Well site plotted in figure 2; concentrations in milligrams per liter unless otherwise stated; °C, degree Celsius; cm, centimeter; data collected and analyzed by U.S. Geological Survey]

Variables			Variables		
Sampling date	9-28-79	9-29-79	Sampling date	9-28-79	9-29-79
Water temperature[1] (°C)	13.5	13.6	Organic carbon	6.0	4.0
pH[1]	6.8	6.3	Phosphorus, as P	.0	.0
Eh[1] (millivolts)	224	229			
Specific conductance[1] (micromho per centimeter at 25° C)	4,360	4,380	(The following metal and trace-element concentrations are in micrograms per liter.)		
Dissolved solids at 180° C	3,790	3,770	Aluminum	0	0
Hardness, noncarbonate	2,000	1,900	Iron	16,000	16,000
Hardness, total	2,600	2,500	Manganese	3,100	3,500
Alkalinity, total as $CaCO_3$	610	620	Arsenic	3	5
Dissolved oxygen	.0	.0	Beryllium	0	0
Silica	18	18	Boron	570	550
Sodium	85	80	Cadmium	1	0
Potassium	8.6	8.8	Chromium	1	1
Calcium	570	520	Copper	1	2
Magnesium	290	300	Lead	5	2
Chloride	4.7	4.7	Mercury	.5	.5
Fluoride	.1	.2	Nickel	0	12
Sulfate	2,100	2,100	Selenium	0	0
			Zinc	50	80

[1]Instrument was lowered to well screen for measuring these variables.

Table 7.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden 20-40 ft below the water table in a surface coal mine, Clay and Vigo Counties, Ind.

[Constituents dissolved unless otherwise stated; well numbers plotted in figure 2; °C, degree Celsius; mV, millivolt; µmho/cm, micromho per centimeter; mg/L, milligram per liter; data collected and analyzed by U.S. Geological Survey]

Sampling date	Water temp (°C)	pH	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Dissolved solids at 180° C (mg/L)	Hardness noncarb. (mg/L)	Hardness carbonate (mg/L)	Total alkalinity as $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)	Silica (mg/L)
Well R3A										
7-20-78	14.5	6.8	132	4,800	4,030	2,000	2,600	580	0.1	17
9-29-78	15.0	6.4	180	4,600	4,030	2,100	2,700	590	.0	16
5-21-79	15.4	6.7	138	4,380	3,820	1,900	2,500	610	.8	18
8 -1-79	15.0	6.7	152	4,080	3,840	1,800	2,400	590	.0	18
10-31-79	15.0	6.3	220	4,220	4,040	1,400	1,900	580	.0	17
Mean	15.0	---	---	4,420	3,950	1,840	2,420	590	---	17
Median	15.0	6.7	---	4,380	4,030	1,900	2,500	590	---	17
Standard dev.	.3	---	---	289	112	270	311	12	---	.8
Maximum	15.4	6.8	---	4,800	4,040	2,100	2,700	610	---	18
Minimum	14.5	6.3	---	4,080	3,820	1,400	1,900	580	---	16
Well R4A										
7-27-78	14.2	6.6	106	4,000	4,210	1,400	1,700	280	0.0	9.6
9-28-78	14.0	7.1	106	3,380	3,320	1,500	1,900	320	.1	11
5-17-79	14.6	6.7	122	3,400	3,180	1,600	1,900	340	.1	13
8 -9-79	14.7	7.2	172	3,310	2,900	1,200	1,500	330	.1	12
Mean	14.4	---	126	3,520	3,400	1,400	1,800	318	0.1	11.4
Median	14.3	6.9	114	3,400	3,250	1,300	1,800	320	.1	11.5
Standard dev.	.3	---	31	321	570	170	190	26	.0	1.5
Maximum	14.7	7.2	172	4,000	4,210	1,600	1,900	340	.1	13
Minimum	14.0	6.6	106	3,310	2,900	1,200	1,500	280	.0	9.6
Well R5A										
7-19-78	13.7	6.8	120	4,460	3,800	2,000	2,300	290	0.0	15
9-28-78	13.7	---	158	4,460	3,730	1,700	2,200	470	.0	16
9-29-78	13.5	6.5	260	4,340	2,610	580	1,200	650	.0	17
5-22-79	14.2	6.8	156	3,400	2,160	370	1,000	670	.0	17
8 -8-79	15.1	7.0	210	3,920	3,570	1,400	1,900	530	.0	17
10-30-79	14.0	6.5	272	3,840	3,290	870	1,400	550	.0	17
Mean	14.0	---	---	4,100	3,190	-----	-----	---	---	16
Median	13.9	6.8	---	4,130	3,420	-----	-----	---	---	17
Standard dev.	.6	---	---	467	666	-----	-----	---	---	.8
Maximum	15.1	7.0	---	4,660	3,800	-----	-----	---	---	17
Minimum	13.5	6.5	---	3,400	2,160	-----	-----	---	---	15

Table 7.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden 20-40 ft below the water table in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Organic carbon (mg/L)	Organic carbon suspended (mg/L)	Phosphorus as P (mg/L)
					Well R3A					
7-20-78	210	15.0	530	300	5.3	0.1	2,400	10.0	---	0.02
9-29-78	200	13.0	550	310	4.2	.2	2,300	2.7	---	.01
5-21-79	160	14.0	510	290	5.1	.2	2,100	----	---	.01
8 -1-79	150	12.0	510	280	5.0	.2	1,800	----	---	.01
10-31-79	190	12.0	250	320	3.9	.2	1,900	----	---	----
Mean	182	13.2	---	300	4.7	0.2	2,100	----	---	0.01
Median	175	13.0	---	300	5.1	.2	2,100	----	---	.01
Standard dev.	26	1.3	---	16	.6	.0	255	----	---	.01
Maximum	210	15.0	---	320	5.1	.2	2,400	----	---	.02
Minimum	150	12.0	---	280	3.9	.1	1,800	----	---	.01
					Well R4A					
7-27-78	340	11.0	450	130	3.7	0.3	2,000	6.9	---	0.00
9-28-78	240	9.6	510	140	4.2	.3	1,900	5.4	---	.00
5-17-79	160	9.1	530	150	4.1	.1	1,800	7.2	---	----
8 -9-79	250	10.0	420	120	3.4	.2	1,700	7.3	1.4	.00
Mean	---	9.9	480	140	---	---	1,850	---	---	----
Median	---	9.8	480	140	---	---	1,850	---	---	----
Standard dev.	---	.8	51	13	---	---	130	---	---	----
Maximum	---	11.0	530	150	---	---	2,000	---	---	----
Minimum	---	9.1	420	120	---	---	1,700	---	---	----
					Well R5A					
7-19-78	240	13.0	490	260	4.0	0.1	2,300	2.3	---	0.00
9-28-78	230	14.0	470	240	3.6	.2	2,000	3.9	---	.01
9-29-78	330	11.0	260	140	3.5	.2	1,200	2.8	---	.00
5-22-79	320	12.0	220	120	3.7	.3	1,000	----	---	.01
8 -8-79	280	14.0	410	210	3.9	.2	1,600	9.3	.6	.01
10-30-79	290	13.0	240	200	3.9	.2	1,800	----	---	.01
Mean	280	12.8	---	---	3.8	---	-----	----	---	----
Median	280	13.0	---	---	3.8	---	-----	----	---	----
Standard dev.	41	1.2	---	---	.2	---	-----	----	---	----
Maximum	330	14.0	---	---	4	---	-----	----	---	----
Minimum	230	11.0	---	---	4	---	-----	----	---	----

Table 7.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden 20-40 ft below the water table in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Water temp (°C)	pH	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Dissolved solids at 180° C (mg/L)	Hardness noncarb. (mg/L)	Hardness carbonate (mg/L)	Total alkalinity as $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)	Silica (mg/L)
					Well R6A					
6-14-78	15.8	6.6	200	4,200	4,160	2,300	2,700	430	0.0	13
9-28-78	15.5	6.9	170	4,430	3,970	2,100	2,500	420	.1	13
5-15-79	16.1	6.8	---	3,480	3,930	2,200	2,600	390	.2	13
8 -2-79	15.3	6.7	230	3,540	3,850	2,100	2,500	390	.3	13
11 -1-79	15.5	6.4	260	4,100	3,860	1,500	1,900	400	.0	13
Mean	15.6	---	215	3,950	3,950	2,000	2,440	406	---	13
Median	15.5	6.7	215	4,100	3,900	2,100	2,500	400	---	13
Standard dev.	.3	---	39	420	125	313	313	18	---	0
Maximum	16.1	6.9	260	4,430	4,160	2,300	2,700	430	---	13
Minimum	15.3	6.4	170	3,480	3,850	1,500	1,900	390	---	13
					Well R7A					
6-15-78	15.6	6.7	26	3,400	3,280	1,500	2,100	570	0.1	14
10 -2-78	16.0	6.9	221	3,910	3,340	1,600	2,100	550	.0	13
5-16-79	15.9	7.6	55	3,910	3,420	1,600	2,200	550	.0	13
8 -7-79	15.0	6.7	160	3,500	3,090	1,500	2,000	540	.0	13
Mean	15.6	---	---	3,680	3,280	1,550	2,100	553	---	13
Median	15.8	6.8	---	3,700	3,280	1,550	2,100	550	---	13
Standard dev.	.5	---	---	269	141	58	82	13	---	.5
Maximum	16.0	7.6	---	3,910	3,420	1,600	2,200	570	---	14
Minimum	15.0	6.7	---	3,400	3,090	1,500	2,000	540	---	13
					Well R8A					
7-27-78	15.8	6.1	198	4,810	3,420	2,100	2,700	580	0.1	16
10 -2-78	16.0	6.6	346	4,700	4,130	2,100	2,700	590	.1	16
5-22-79	15.7	6.7	100	4,300	4,160	2,100	2,700	600	.0	18
8 -7-79	16.2	6.6	240	4,400	4,190	2,100	2,700	580	.0	18
10-31-79	16.0	6.5	215	4,440	4,270	1,500	2,200	620	.0	17
Mean	15.9	---	220	4,530	4,034	1,980	2,600	594	---	17
Median	16.0	6.6	206	4,440	4,160	2,100	2,700	590	---	17
Standard dev.	.2	---	88	215	347	268	224	17	---	1
Maximum	16.2	6.7	240	4,810	4,270	2,100	2,700	620	---	18
Minimum	15.7	6.1	100	4,300	3,420	1,500	2,200	580	---	16

Table 7.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden 20-40 ft below the water table in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Organic carbon (mg/L)	Organic carbon suspended (mg/L)	Phosphorus as P (mg/L)
					Well R6A					
6-14-78	150	15.0	570	320	4.6	0.2	2,300	1.2	---	0.02
9-28-78	250	13.0	480	310	7.7	.2	2,400	7.3	---	.00
5-15-79	110	13.0	530	310	7.9	.1	2,300	3.9	---	----
8 -2-79	110	13.0	520	300	8.1	.2	2,200	----	---	.01
11-1-79	120	13.0	260	310	7.9	.2	2,000	----	---	.00
Mean	128	13.4	---	310	7.2	0.2	2,240	---	---	----
Median	120	13.0	---	310	7.7	.2	2,300	---	---	----
Standard dev.	20	.9	---	7	1.5	.0	152	---	---	----
Maximum	150	15.0	---	320	7.9	.2	2,400	---	---	----
Minimum	1,110	13.0	---	300	4.6	.1	2,000	---	---	----
					Well R7A					
5-15-78	150	7.0	500	200	4.2	0.3	1,700	13.0	---	0.00
10-2-78	140	8.8	490	220	3.8	.3	2,100	12.0	---	.00
5-16-79	150	8.2	500	230	3.8	.2	1,900	5.1	---	----
8 -7-79	130	7.9	470	200	3.7	.4	1,700	5.4	---	.01
Mean	143	8.0	490	213	3.9	0.3	1,850	----	---	----
Median	145	8.0	495	210	3.8	.3	1,800	----	---	----
Standard dev.	10	.8	14	15	.2	.1	191	----	---	----
Maximum	150	8.8	500	230	4.2	.4	2,100	----	---	----
Minimum	130	7.0	470	200	3.7	.2	1,700	----	---	----
					Well R8A					
7-27-78	180	15.0	570	310	8.4	0.2	2,700	4.5	---	0.00
10 -2-78	230	15.0	560	320	9.0	.2	2,400	4.2	---	.00
5-22-79	190	15.0	550	330	7.0	.2	2,400	----	---	.00
8 -7-79	170	13.0	560	310	6.9	.3	2,000	8.3	1.4	.01
10-31-79	190	14.0	290	350	8.0	.3	2,100	----	---	.00
Mean	192	14.4	506	324	7.9	.2	2,320	----	---	----
Median	190	15.0	560	320	8.0	.2	2,400	----	---	----
Standard dev.	23	.9	121	17	.9	.1	277	----	---	----
Maximum	230	15.0	570	350	9.0	.3	2,700	----	---	----
Minimum	170	13.0	290	310	6.9	.2	2,000	----	---	----

Table 7.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden 20-40 ft below the water table in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Water temp (°C)	pH	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Dissolved solids at 180° C (mg/L)	Hardness noncarb. (mg/L)	Hardness carbonate (mg/L)	Total alkalinity as $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)	Silica (mg/L)
					Well R9A					
7-19-78	13.8	7.1	70	3,880	3,060	1,500	2,100	590	0.5	16
10 -2-78	13.4	6.5	232	3,700	3,070	1,400	2,000	600	---	16
					Well R11A					
7-27-78	14.2	6.4	180	3,420	2,900	1,500	2,100	560	0.1	19
9-28-78	13.2	6.6	258	3,600	2,950	1,600	2,100	570	.3	19
8 -8-79	14.5	6.7	240	3,100	2,810	1,300	1,900	560	.0	19
Mean	14.0	---	226	3,370	2,890	1,470	2,030	563	---	19
Median	14.2	6.6	240	3,420	2,900	1,500	2,100	560	---	19
Standard dev.	.7	---	41	253	71	153	115	6	---	0
Maximum	14.5	6.7	258	3,600	2,950	1,600	2,100	570	---	19
Minimum	13.2	6.4	180	3,100	2,810	1,300	1,900	560	---	19
					Well R12A					
7-20-78	14.9	6.8	80	1,410	837	230	720	490	0.1	26
10-3-78	14.7	6.9	379	1,630	962	---	780	530	1.0	25
5-17-79	15.0	6.8	91	1,500	998	120	680	560	.1	24
7-31-79	14.5	6.7	152	1,530	995	200	750	550	.0	27
10-30-79	14.7	6.7	200	1,720	997	290	710	420	.0	23
Mean	14.8	---	---	1,560	958	---	728	510	---	25
Median	14.7	6.8	---	1,530	995	---	720	530	---	24
Standard dev.	.2	---	---	120	69	---	38	57	---	1.6
Maximum	15.0	6.9	---	1,720	998	---	780	560	---	27
Minimum	14.5	6.7	---	1,410	837	---	680	420	---	23

Table 7.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden 20-40 ft below the water table in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Organic carbon (mg/L)	Organic carbon suspended (mg/L)	Phosphorus as P (mg/L)
					Well R9A					
7-19-78	120	9.0	460	220	4.8	0.2	1,600	7.8	---	0.01
10 -2-78	150	8.6	450	220	4.1	.2	1,600	11.0	---	.00
					Well R11A					
7-27-78	37	8.0	470	220	4.4	0.2	1,500	4.6	---	0.00
9-28-78	44	6.8	480	230	3.8	.2	1,500	3.2	---	.01
8 -8-79	43	12.0	430	200	4.0	.2	1,400	17.0	1.0	.02
Mean	41	----	460	217	4.0	---	1,470	----	---	----
Median	43	----	470	220	4.0	---	1,500	----	---	----
Standard dev.	4	----	26	15	.3	---	58	----	---	----
Maximum	44	----	480	230	4.4	---	1,500	----	---	----
Minimum	37	----	430	200	3.8	---	1,400	----	---	----
					Well R12A					
7-20-78	55	10.0	160	78	4.4	0.1	280	12.0	---	0.01
10 -3-78	50	8.0	180	80	4.2	.2	290	12.0	---	.00
5-17-79	50	7.5	160	68	4.3	.1	290	6.5	---	----
7-31-79	50	7.4	180	74	4.4	.2	300	----	---	.02
10-30-79	55	7.1	170	70	4.5	.2	330	----	---	.00
Mean	52	8.0	170	74	4.4	---	298	----	---	----
Median	50	7.4	165	72	4.3	---	290	----	---	----
Standard dev.	3	1.2	10	5	.1	---	19	----	---	----
Maximum	55	10.0	180	80	4.5	---	330	----	---	----
Minimum	50	7.1	160	68	4.2	---	280	----	---	----

Table 8.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.

[Constituents dissolved unless otherwise stated: well numbers plotted in figure 2; °C, degree Celsius; mV, millivolt; µmho/cm, micromho per centimeter; mg/L, milligram per liter; data collected and analyzed by U.S. Geological Survey]

Sampling date	Water temp (°C)	pH	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Dissolved solids at 180° C (mg/L)	Hardness noncarb. (mg/L)	Hardness carbonate (mg/L)	Total alkalinity as $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)	Silica (mg/L)
Well R1B										
7-21-78	14.8	6.9	86	4,240	3,270	1,200	1,700	450	0.4	16
10 -3-78	14.8	7.0	143	4,000	3,420	-----	1,800	650	.0	17
5-18-79	15.2	7.2	40	3,880	3,440	1,300	1,800	480	.1	18
8 -8-79	16.0	7.2	160	3,700	3,370	1,300	1,800	480	.8	17
Mean	15.2	---	107	3,960	3,375	1,270	1,780	515	---	17
Median	15.0	7.1	114	3,940	3,895	1,300	1,800	480	---	17
Standard dev.	.6	---	55	226	76	58	50	91	---	.8
Maximum	16.0	7.2	160	4,240	3,440	1,300	1,800	650	---	18
Minimum	14.8	6.9	40	3,700	3,270	1,200	1,700	450	---	16
Well R2B										
7-24-78	15.0	7.4	76	3,440	3,060	1,100	1,600	460	0.1	17
10 -3-78	14.9	7.2	170	3,680	3,240	1,300	1,700	470	.0	14
5-21-79	14.5	7.4	95	3,280	3,230	1,200	1,800	640	.0	18
7-31-79	15.4	6.8	224	3,300	3,120	1,300	1,800	530	.1	18
Mean	14.9	---	---	3,430	3,160	1,220	1,720	525	---	17
Median	14.7	7.3	---	3,310	3,170	1,250	1,750	500	---	18
Standard dev.	.4	---	---	184	87	96	96	83	---	1.9
Maximum	15.4	7.4	---	3,680	3,240	1,300	1,800	640	---	18
Minimum	14.5	6.8	---	3,280	3,060	1,100	1,600	460	---	14
Well R3B										
7-20-78	14.8	6.4	136	4,810	4,180	2,100	2,600	510	0.1	16
9-29-78	15.2	6.3	211	4,820	4,160	2,000	2,600	580	.0	16
5-21-79	15.3	6.5	260	4,600	4,300	2,200	2,900	620	.0	15
8 -1-79	15.5	6.7	280	4,400	4,040	2,000	2,600	590	.0	16
10-31-79	15.5	6.4	244	4,650	3,900	1,500	2,000	580	.0	17
Mean	15.3	---	226	4,660	4,116	1,960	2,540	576	---	16
Median	15.3	6.4	244	4,650	4,160	2,000	2,600	580	---	16
Standard dev.	.3	---	56	173	152	270	329	40	---	.7
Maximum	15.5	6.7	280	4,820	4,300	2,200	2,900	620	---	17
Minimum	14.8	6.4	136	4,400	3,900	1,500	2,000	510	---	15

Table 8.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Organic carbon (mg/L)	Organic carbon susp. (mg/L)	Phosphorus as P (mg/L)
					Well R1B					
7-21-78	320	14.0	360	190	4.5	0.1	1,800	7.1	---	0.00
10-3-78	280	.8	400	200	3.3	.1	2,000	6.2	---	.00
5-18-79	300	12.0	380	200	3.4	.1	1,900	3.2	---	----
8 -8-79	280	11.0	390	190	4.0	.1	1,900	19.0	.7	.01
Mean	295	----	383	195	3.8	0.1	1,900	----	---	----
Median	290	----	385	195	3.7	.1	1,900	----	---	----
Standard dev.	19	----	17	6	.6	.0	82	----	---	----
Maximum	320	----	400	200	4.5	.1	2,000	----	---	----
Minimum	280	----	360	190	3.3	.1	1,800	----	---	----
					Well R2B					
7-24-78	270	13.0	360	170	4.2	0.2	1,700	4.4	---	0.00
10 -3-78	340	12.0	380	190	3.5	.2	1,900	----	---	.00
5-21-79	240	10.0	410	190	3.9	.2	1,600	----	---	.00
7-31-79	210	10.0	420	190	4.3	.2	1,700	----	---	.01
Mean	265	11.3	393	185	4.0	0.2	1,725	----	---	----
Median	255	11.0	392	190	4.0	.2	1,700	----	---	----
Standard dev.	56	1.5	28	10	.4	.0	126	----	---	----
Maximum	340	13.0	420	190	4.3	.2	1,900	----	---	----
Minimum	210	10.0	360	170	3.5	.2	1,600	----	---	----
					Well R3B					
7-20-78	200	15.0	560	300	5.4	0.2	2,300	1.9	---	0.01
9-29-78	270	13.0	540	300	4.3	.2	2,400	2.4	---	.01
5-21-79	190	15.0	550	360	4.3	.2	2,500	----	---	.00
8 -1-79	170	13.0	520	310	5.0	.2	2,200	----	---	.01
10-31-79	190	13.0	290	320	4.6	.3	1,900	----	---	.00
Mean	204	13.8	492	318	4.7	0.2	2,260	----	---	----
Median	190	13.0	540	310	4.6	.2	2,300	----	---	----
Standard dev.	38	1.1	114	25	.5	.0	230	----	---	----
Maximum	270	15.0	560	360	5.4	.3	2,500	----	---	----
Minimum	170	13.0	290	300	4.3	.2	1,900	----	---	----

Table 8.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Water temp (°C)	pH	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Dissolved solids at 180° C (mg/L)	Hardness noncarb. (mg/L)	Hardness carbonate (mg/L)	Total alkalinity as $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)	Silica (mg/L)
					Well R4B					
7-27-78	17.2	6.4	140	4,960	3,810	1,000	1,500	470	0.0	13
9-28-78	16.9	6.9	150	4,980	3,850	1,000	1,500	490	.0	13
5-17-79	17.0	6.5	120	5,130	4,640	1,700	2,200	510	.0	15
8 -9-79	17.5	6.9	210	4,900	2,710	1,700	2,200	520	.0	15
10-30-79	16.9	6.4	260	5,020	4,540	1,100	1,600	530	.0	15
Mean	17.1	---	---	5,000	3,910	-----	1,800	504	---	14
Median	17.0	6.5	---	4,980	3,850	-----	1,600	510	---	15
Standard dev.	.3	---	---	86	772	-----	367	24	---	1.1
Maximum	17.5	6.9	---	5,130	4,640	-----	2,200	530	---	15
Minimum	16.9	6.4	---	4,900	2,710	-----	1,500	470	---	13
					Well R5B					
7-19-78	13.7	7.1	120	4,730	3,190	320	870	550	0.0	15
9-28-78	13.8	7.3	289	4,680	3,230	330	890	560	.8	15
5-22-79	13.6	6.9	125	4,050	3,350	510	1,000	530	.0	15
8 -8-79	14.5	7.2	214	4,310	3,360	580	1,100	500	.1	16
Mean	13.9	---	187	4,440	3,280	---	965	535	---	15
Median	13.7	7.1	170	4,500	3,290	---	945	540	---	15
Standard dev.	.4	---	81	322	85	---	107	26	---	.5
Maximum	14.5	7.3	289	4,730	3,360	---	1,100	560	---	16
Minimum	13.6	6.9	120	4,050	3,190	---	870	500	---	15
					Well R6B					
6-14-78	15.2	6.6	208	4,200	4,110	2,300	2,800	430	0.1	14
9-29-78	15.3	6.7	212	4,500	3,990	2,100	2,600	440	.0	14
5-15-79	15.6	6.6	---	4,100	4,040	2,300	2,700	460	.2	15
8 -2-79	15.4	6.7	242	3,660	4,030	2,100	2,600	480	.0	15
11-1-79	15.3	6.4	280	4,200	4,010	1,600	2,100	450	.0	16
Mean	15.4	---	236	4,130	4,040	2,080	2,560	452	---	14.8
Median	15.3	6.6	227	4,150	4,030	2,100	2,600	450	---	15.0
Standard dev.	.2	---	36	304	46	286	270	19	---	.8
Maximum	15.6	6.8	280	4,500	4,110	2,300	2,800	480	---	16
Minimum	15.2	6.4	200	3,660	3,990	1,600	2,100	430	---	14

Table 8.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Organic carbon (mg/L)	Organic carbon susp. (mg/L)	Phosphorus as P (mg/L)
					Well R4B					
7-27-78	520	12.0	360	150	4.1	0.3	2,200	3.3	---	0.00
9-28-78	600	10.0	350	150	4.0	.3	2,100	3.8	---	.00
5-17-79	500	12.0	490	230	3.8	.2	2,500	----	---	----
8 -9-79	500	8.8	500	230	4.4	.3	2,400	11.0	.4	.00
10-30-79	450	12.0	260	240	4.5	.3	2,200	----	---	.01
Mean	514	11.0	392	200	4.1	0.3	2,280	----	---	----
Median	500	12.0	360	230	4.1	.3	2,200	----	---	----
Standard dev.	55	1.5	102	46	0	.0	164	----	---	----
Maximum	600	12.0	500	240	4.5	.3	2,500	----	---	----
Minimum	450	8.8	260	150	3.8	.2	2,100	----	---	----
					Well R5B					
7-19-78	720	12.0	210	85	3.5	0.2	1,800	3.2	---	0.01
9-28-78	750	15.0	210	89	4.0	.2	1,800	4.5	---	.01
5-22-79	580	15.0	250	100	3.7	.2	1,800	----	---	.00
8 -8-79	200	13.0	250	110	3.9	.2	1,600	5.2	.3	.00
Mean	---	13.8	230	96	3.8	0.2	1,750	4.3	---	----
Median	---	14.0	230	94	3.8	.2	1,800	4.5	---	----
Standard dev.	---	1.5	23	11	.2	.0	100	1.0	---	----
Maximum	---	15.0	250	110	4.0	.2	1,800	5.2	---	----
Minimum	---	12.0	210	85	3.5	.2	1,600	3.2	---	----
					Well R6B					
6-14-78	140	15.0	580	320	5.5	0.2	2,400	1.7	---	0.00
9-29-78	160	15.0	520	310	4.7	.2	2,400	6.3	---	.00
5-15-79	120	14.0	540	340	6.6	.1	2,700	2.1	---	----
8 -2-79	110	14.0	520	320	7.0	.2	2,000	----	---	.01
11 -1-79	120	14.0	270	340	6.9	.2	2,000	----	---	.00
Mean	130	14.4	---	326	6.1	0.2	2,200	----	---	----
Median	120	14.0	---	320	6.6	.2	2,200	----	---	----
Standard dev.	20	.5	---	13	1.0	.04	200	----	---	----
Maximum	160	15.0	---	340	7.0	.2	2,400	----	---	----
Minimum	110	14.0	---	310	4.7	.1	2,800	----	---	----

Table 8.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Water temp (°C)	pH	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Dissolved solids at 180° C (mg/L)	Hardness noncarb. (mg/L)	Hardness carbonate (mg/L)	Total alkalinity as $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)	Silica (mg/L)
					Well R7B					
6-15-78	15.0	6.7	190	2,380	1,980	1,000	1,400	390	0.1	12
10 -2-78	14.6	6.7	157	3,960	3,160	1,600	2,100	520	.0	13
5-16-79	15.0	6.8	85	3,950	3,450	1,700	2,200	490	.3	14
8 -7-79	15.0	6.6	220	3,900	3,900	1,800	2,300	510	.0	14
Mean	14.9	---	---	3,550	-----	1,530	2,000	478	---	13
Median	14.8	6.7	---	3,930	-----	1,650	2,150	500	---	13
Standard dev.	.2	---	---	779	-----	359	408	60	---	1
Maximum	15.0	6.8	---	3,960	-----	1,800	2,300	520	---	14
Minimum	14.6	6.6	---	3,380	-----	1,000	1,400	390	---	12
					Well R8B					
7-27-78	16.1	6.1	154	4,820	4,180	2,100	2,700	590	0.1	16
10 -2-78	16.1	6.5	350	4,730	4,130	2,000	2,600	580	.0	16
5-22-79	15.9	6.5	147	4,310	4,290	2,200	2,800	590	.0	17
8 -7-79	16.4	6.6	228	4,600	4,220	2,100	2,700	580	.0	17
10-31-79	15.4	6.4	240	4,680	4,270	1,800	2,100	290	.0	17
Mean	16.0	---	224	4,630	4,218	2,040	2,580	526	---	17
Median	16.1	6.5	228	4,680	4,220	2,100	2,700	580	---	17
Standard dev.	.4	---	82	195	65	152	277	132	---	.5
Maximum	16.4	6.6	350	4,820	4,290	2,200	2,800	590	---	17
Minimum	15.4	6.1	147	4,310	4,130	1,800	2,100	290	---	16
					Well R9B					
7-19-78	14.2	6.6	22	3,920	2,820	1,300	1,800	530	0.0	19
9-29-78	14.5	6.7	234	3,690	2,920	1,100	1,700	590	.0	18
5-17-79	14.5	7.0	258	3,260	2,890	1,100	1,700	610	3.6	19
8 -9-79	14.8	7.2	211	3,280	2,820	1,000	1,600	610	3.6	19
Mean	14.5	---	---	3,540	2,860	1,120	1,700	585	---	19
Median	14.5	6.8	---	3,890	3,860	1,100	1,700	600	---	19
Standard dev.	.2	---	---	323	51	126	82	38	---	.5
Maximum	14.8	7.2	---	3,920	2,920	1,300	1,800	610	---	19
Minimum	14.2	6.6	---	3,260	2,820	1,000	1,600	530	---	18

Table 8.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Organic carbon (mg/L)	Organic carbon susp. (mg/L)	Phosphorus as P (mg/L)
					Well R7B					
6-15-78	70	6.6	340	140	2.5	0.3	1,100	2.4	---	0.00
10 -2-78	150	9.0	470	220	3.3	.3	1,700	9.1	---	.01
5-16-79	130	8.5	480	250	3.2	.2	1,900	3.2	---	----
8 -7-79	140	9.3	510	260	3.4	.3	1,800	8.3	0.4	----
Mean	---	8.3	450	218	3.1	---	1,620	----	---	----
Median	---	8.7	475	235	3.2	---	1,750	----	---	----
Standard dev.	---	1.2	75	54	.4	---	359	----	---	----
Maximum	---	9.3	510	260	3.4	---	1,900	----	---	----
Minimum	---	6.6	340	140	2.5	---	1,100	----	---	----
					Well R8B					
7-27-78	200	14.0	570	300	11	0.2	2,600	6.5	---	0.01
10-22-78	210	14.0	550	300	12	.2	2,300	----	---	.00
5-22-79	210	15.0	580	320	12	.2	2,400	----	---	.00
8 -7-79	210	14.0	560	310	13	.3	2,100	3.5	.4	.03
10-31-79	210	14.0	260	340	14	.3	2,100	----	---	.03
Mean	208	14.2	---	314	12	---	2,300	----	---	----
Median	210	14.0	---	310	12	---	2,300	----	---	----
Standard dev.	4	.4	---	17	1	---	212	----	---	----
Maximum	210	15.0	---	340	14	---	2,600	----	---	----
Minimum	200	14.0	---	300	11	---	2,100	----	---	----
					Well R9B					
7-19-78	180	10.0	410	200	3.8	0.1	1,700	16.0	---	0.01
9-29-78	210	8.0	390	180	4.6	.2	1,400	10.0	---	.00
5-17-79	220	6.6	370	180	4.5	.2	1,500	5.4	---	----
8 -9-79	210	6.2	370	170	4.3	.3	1,300	3.7	.3	.00
Mean	205	7.7	385	183	4.3	---	1,480	----	---	----
Median	210	7.3	380	180	4.4	---	1,450	----	---	----
Standard dev.	17	1.7	19	13	.36	---	171	----	---	----
Maximum	220	10.0	410	200	4.6	---	1,300	----	---	----
Minimum	180	6.2	370	170	3.8	---	1,300	----	---	----

Table 8.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Water temp (°C)	pH	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Dissolved solids at 180° C (mg/L)	Hardness noncarb. (mg/L)	Hardness carbonate (mg/L)	Total alkalinity as $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)	Silica (mg/L)
					Well R10B					
7-24-78	13.5	6.4	160	3,990	3,860	2,100	2,800	610	0.1	17
9-28-78	13.5	6.7	224	4,360	3,790	2,000	2,600	610	.0	18
9-29-78	13.6	6.3	229	4,380	3,770	1,900	2,500	620	.1	18
5-16-79	13.8	7.2	162	3,950	3,740	1,900	2,500	590	.1	19
7-31-79	14.0	6.8	232	3,800	3,750	1,900	2,500	590	.0	18
10-29-79	13.4	6.0	280	4,200	3,670	1,500	2,000	560	.0	18
Mean	13.6	---	214	4,110	3,760	1,880	2,480	597	---	18
Median	13.5	6.6	227	4,130	3,760	1,900	2,500	600	---	18
Standard dev.	.2	---	46	236	62	204	264	22	---	.6
Maximum	14.0	7.2	280	4,380	3,860	2,100	2,800	620	---	19
Minimum	13.4	6.0	160	3,800	3,670	1,500	2,000	560	---	17
					Well R11B					
7-27-78	13.8	6.6	120	3,240	2,470	1,300	1,800	480	0.1	21
9-28-78	13.5	6.8	161	3,420	2,810	1,500	2,100	580	.0	20
8 -2-79	14.2	6.8	192	2,920	2,790	1,400	2,000	550	.0	19
Mean	13.8	---	158	3,190	2,690	1,400	1,967	537	---	20
Median	13.5	6.8	161	3,420	3,790	1,400	2,000	550	---	20
Standard dev.	.4	---	36	253	191	100	153	51	---	1
Maximum	14.2	6.8	192	3,420	2,810	1,500	2,100	580	---	21
Minimum	13.5	6.6	120	2,920	2,470	1,300	1,800	480	---	19

Table 8.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Organic carbon (mg/L)	Organic carbon susp. (mg/L)	Phosphorus as P (mg/L)
					Well R10B					
7-24-78	75	9.0	610	300	4.7	0.2	2,000	6.9	---	0.01
9-28-78	85	8.6	570	290	4.7	.1	2,100	6.0	---	.00
9-29-78	80	8.8	520	300	4.7	.2	2,100	----	---	.01
5-16-79	75	7.1	540	270	4.5	.1	2,100	3.9	---	.00
7-31-79	80	8.0	540	280	5.0	.2	2,100	----	---	.01
10-29-79	80	8.2	340	290	4.3	.2	1,700	----	---	.00
Mean	79	8.3	520	288	4.6	0.2	2,020	----	---	----
Median	80	8.1	540	285	4.7	.2	2,100	----	---	----
Standard dev.	3	.7	94	12	.2	.05	160	----	---	----
Maximum	80	9.0	610	300	5.0	.2	2,100	----	---	----
Minimum	75	7.1	340	270	4.3	.1	1,700	----	---	----
					Well R11B					
7-27-78	37	11.0	350	200	4.6	0.2	1,300	19.0	---	0.01
9-28-78	40	9.2	460	220	4.0	.2	1,500	7.1	---	.01
8 -8-79	40	6.5	470	200	3.8	.2	1,300	12.0	0.3	.00
Mean	39	----	437	207	4.1	0.2	1,360	----	0.3	----
Median	40	----	460	200	4.0	.2	1,300	----	.3	----
Standard dev.	2	----	49	12	.4	.0	115	----	---	----
Maximum	40	----	470	220	4.6	.2	1,500	----	.3	----
Minimum	37	----	380	200	4.0	.2	1,300	----	.3	----

Table 8.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Water temp (°C)	pH	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Dissolved solids at 180° C (mg/L)	Hardness noncarb. (mg/L)	Hardness carbonate (mg/L)	Total alkalinity as $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)	Silica (mg/L)
					Well R12B					
7-20-78	14.6	6.9	88	1,820	1,450	550	970	420	0.0	21
10 -3-78	14.7	7.1	431	2,020	1,420	-----	1,000	510	.0	21
5-17-79	15.5	7.0	100	1,570	1,490	500	930	430	.1	21
8 -2-79	15.5	7.0	142	1,880	1,460	510	950	440	.1	20
Mean	15.1	---	190	1,820	1,460	520	963	450	---	21
Median	15.1	7.0	121	1,850	1,440	510	960	430	---	21
Standard dev.	.5	---	162	188	29	26	30	41	---	.5
Maximum	15.5	7.1	431	2,020	1,490	550	1,000	510	---	21
Minimum	14.6	6.9	80	1,570	1,420	500	930	420	---	20
					Well R13B					
6-16-78	12.0	6.6	210	2,740	2,240	1,300	1,700	390	0.5	15
5-17-79	11.2	6.5	140	2,410	2,060	890	1,600	690	.2	18
8 -2-79	13.7	6.6	228	2,300	2,090	870	1,600	700	.0	19
Mean	12.3	---	193	2,480	2,130	1,020	1,630	---	---	17
Median	12.0	6.6	210	2,410	2,060	890	1,600	---	---	15
Standard dev.	1.3	---	46	229	96	243	58	---	---	2
Maximum	13.7	6.7	228	2,740	2,240	1,300	1,700	---	---	19
Minimum	11.2	6.5	140	2,300	2,060	870	1,600	---	---	10

Table 8.--Field and laboratory measurements of water quality and related properties of water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Organic carbon (mg/L)	Organic carbon susp. (mg/L)	Phosphorus as P (mg/L)
					Well R12B					
7-20-78	75	7.0	240	90	6.6	0.1	640	5.6	---	0.00
10 -3-78	80	5.3	250	100	6.5	.1	660	11.0	---	.00
5-17-79	71	5.2	230	86	6.4	.1	690	10.0	---	----
8 -2-79	67	5.0	240	84	6.6	.1	640	----	---	.03
Mean	73	5.6	240	90	6.5	0.1	658	----	---	----
Median	75	5.2	240	87	6.6	.1	650	----	---	----
Standard dev.	6	.9	8	7	.1	.0	24	----	---	----
Maximum	80	7.0	250	100	7	.1	690	----	---	----
Minimum	67	5.0	230	84	6	.1	640	----	---	----
					Well R13B					
6-16-78	55	4.6	380	190	1.2	0.2	1,300	20.0	---	0.00
5-17-79	27	2.7	370	160	13	.1	930	4.9	---	----
8 -2-79	30	2.6	380	150	12	.1	870	----	---	.02
Mean	--	----	377	167	----	---	1,030	----	---	----
Median	--	----	380	160	----	---	930	----	---	----
Standard dev.	--	----	6	21	----	---	233	----	---	----
Maximum	--	----	380	190	----	---	1,300	----	---	----
Minimum	--	----	370	150	----	---	870	----	---	----

Table 9.--Field and laboratory measurements of water quality and related properties of water from wells screened in sandstone or sandy shale below the Seelyville coal (III) horizon of the Stauton Formation, in and around a surface coal mine, Clay and Vigo Counties, Ind.

[Constituents dissolved unless otherwise stated; well numbers plotted in figure 2; °C, degree Celsius, mV, millivolt; µmho/cm, micromho per centimeter; mg/L, milligram per liter; data collected by U.S. Geological Survey]

Sampling date	Water temp. (°C)	pH	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Dissolved solids at 180° C (mg/L)	Hardness noncarb. (mg/L)	Hardness carb. (mg/L)	Total alkalinity as $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)	Silica (mg/L)
					Well R1C					
6-28-78	14.0	7.6	77	2,540	2,800	3	400	400	-	9.9
					Well R5C					
6-28-78	13.7	8.7	-16	2,360	1,780	0	66	310	-	7.8
4-26-79	14.3	7.8	190	2,700	1,870	0	150	310	-	9.2
8-16-79	14.0	7.8	200	2,020	1,890	0	160	330	-	9.4
Mean	14.0	----	---	2,360	1,850	-	---	317	-	8.8
Median	14.3	7.8	---	2,360	1,870	-	---	310	-	9.2
Standard dev.	.3	----	---	340	59	-	---	12	-	.0
Maximum	14.3	8.7	---	2,700	1,890	-	---	330	-	9.4
Minimum	13.7	7.8	---	2,020	1,780	-	---	310	-	7.8
					Well R7C					
6-28-78	15.6	8.3	-64	2,280	1,430	0	54	920	-	11
4-26-79	15.2	8.1	60	2,020	1,295	0	29	760	-	11
8-16-79	15.2	8.4	200	1,940	1,330	0	66	950	-	11
Mean	15.3	---	---	2,080	1,350	-	---	877	-	11
Median	15.2	8.3	---	2,020	1,330	-	---	920	-	11
Standard dev.	.2	----	---	178	70	-	---	102	-	0
Maximum	15.6	8.4	---	2,280	1,430	-	---	950	-	11
Minimum	15.2	8.1	---	1,940	1,300	-	---	760	-	11
					Well R9C					
6-28-78	14.1	8.2	20	1,760	1,210	0	38	910	-	8.0
10-20-78	14.3	8.3	56	1,900	1,180	0	29	940	-	6.3
4-25-79	14.4	8.4	45	1,820	1,180	0	27	940	-	7.5
8-17-79	14.5	8.4	220	1,700	1,160	0	20	960	-	7.2
Mean	14.3	----	---	1,800	1,180	-	29	938	-	7.2
Median	14.3	8.3	---	1,790	1,180	-	28	940	-	7.4
Standard dev.	.2	----	---	85	21	-	7	21	-	.7
Maximum	14.5	8.4	---	1,900	1,210	-	38	960	-	8.0
Minimum	14.1	8.2	---	1,700	1,160	-	20	910	-	6.3
					Well B5C					
6-21-78	12.8	8.6	-12	1,200	609	0	7	670	-	7.3
10-19-78	12.5	8.6	80	1,230	744	0	6	660	-	7.7
4-24-79	13.6	8.9	157	1,220	751	0	5	660	-	7.3
8-15-79	12.9	8.8	490	1,000	747	0	5	660	-	7.6
Mean	12.9	----	---	1,160	713	-	6	663	-	7.5
Median	12.8	8.7	---	1,210	744	-	6	660	-	7.4
Standard dev.	.5	----	---	109	69	-	1	5	-	.2
Maximum	13.6	8.9	---	1,230	751	-	7	670	-	7.7
Minimum	12.5	8.6	---	1,000	609	-	5	660	-	7.3

Table 9.--Field and laboratory measurements of water quality and related properties of water from wells screened in sandstone or sandy shale below the Seelyville coal (III) horizon of the Stauton Formation, in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Organic carbon (mg/L)	Organic carbon, susp. (mg/L)	Phosphorus as P (mg/L)
					Well R1C					
6-28-78	750	12.0	87	45	2.7	0.2	1,700	----	---	0.00
					Well R5C					
6-28-78	600	4.1	16	6.3	2.7	0.4	1,000	----	---	0.00
4-26-79	580	4.9	35	14	2.7	.4	1,000	15.0	---	----
8-16-79	550	4.7	38	17	2.7	.4	990	17.0	1.2	.05
Mean	577	4.6	----	----	2.7	0.4	997	16.0	---	----
Median	565	4.7	----	----	2.7	.4	1,000	16.0	---	----
Standard dev.	25	.4	----	----	0	.0	6	1.4	---	----
Maximum	600	4.9	----	----	2.7	.4	1,000	17.0	---	----
Minimum	550	4.1	----	----	2.7	.4	990	15.0	---	----
					Well R7C					
6-28-78	560	4.0	10	7	39	4.4	380	7.1	---	0.05
4-26-79	500	4.3	6.5	3	45	4.6	180	22.0	---	----
8-16-79	560	5.1	14	7.6	55	5.0	140	18.0	3.7	.08
Mean	540	4.5	----	----	46	4.7	-------	----	---	----
Median	550	4.3	----	----	45	4.6	-------	----	---	----
Standard dev.	35	.6	----	----	8	.3	-------	----	---	----
Maximum	560	5.1	----	----	55	5.0	-------	----	---	----
Minimum	500	4.0	----	----	39	4.4	-------	----	---	----
					Well R9C					
6-28-78	480	4.1	7.8	4.6	62	6.2	88	----	---	0.04
10-20-78	500	3.3	6.4	3.2	53	5.3	27	4.8	---	.04
4-25-79	460	3.7	6.3	2.7	64	6.5	40	12.0	---	.04
8-17-79	520	3.4	5.0	1.8	62	6.6	23	12.0	2.5	.06
Mean	490	3.6	6.3	----	60	6.1	-------	----	---	0.05
Median	490	3.4	6.3	----	62	6.3	-------	----	---	.04
Standard dev.	26	.4	1.1	----	5	.6	-------	----	---	.01
Maximum	520	4.1	7.8	----	64	6.6	-------	----	---	.06
Minimum	460	3.3	5	----	53	5.3	-------	----	---	.04
					Well B5C					
6-21-78	330	2.3	1.9	0.6	17	5.2	7	5.2	---	0.07
10-19-78	350	1.5	1.5	.5	16	5.3	3.1	12.0	---	.06
4-24-79	320	1.8	1.2	.4	18	5.3	3.5	27.0	---	.08
8-15-79	360	1.7	1.5	.3	15	5.2	5.9	26.0	1.1	.07
Mean	340	1.8	1.5	.5	17	5.2	-------	----	---	0.07
Median	340	1.7	1.7	.4	16	5.2	-------	----	---	.07
Standard dev.	18	.3	.3	.1	1	.1	-------	----	---	.01
Maximum	360	2.3	1.9	.6	18	5.3	-------	----	---	.08
Minimum	320	1.5	1.2	.3	15	5.2	-------	----	---	.06

Table 10.--Field and laboratory measurements of water quality and related properties of water from background wells screened in sand and (or) gravel around a surface coal mine, Clay and Vigo Counties, Ind.

[Constituents dissolved unless otherwise stated: well numbers plotted in figure 2; °C, degree Celsius; mV, millivolt; µmho/cm, micromho per centimeter; mg/L, milligram per liter; data collected and analyzed by U.S. Geological Survey]

Sampling date	Water temp. (° C)	pH	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Dissolved solids at 180° C (mg/L)	Hardness noncarb. (mg/L)	Hardness carb. (mg/L)	Total alkalinity as $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)	Silica (mg/L)
					Well B1A					
6-21-78	11.8	7.0	350	480	277	58	200	140	-	10
10-25-78	11.1	7.7	429	452	351	23	310	290	-	15
4-25-79	11.5	7.5	480	410	227	41	160	120	-	13
8-15-79	12.2	6.6	560	632	232	28	150	120	-	19
Mean	11.6	---	455	494	272	---	---	---	-	----
Median	11.6	7.2	454	467	254	---	---	---	-	----
Standard dev.	.5	---	88	97	57	---	---	---	-	----
Maximum	12.2	7.7	560	632	351	---	---	---	-	----
Minimum	11.1	6.6	350	410	227	---	---	---	-	----
					Well B2A					
6-21-78	11.1	7.0	58	530	297	6	280	270	-	18
10-25-78	14.1	---	---	514	281	0	270	280	-	20
4-25-79	11.5	7.4	204	521	290	0	250	280	-	19
8-15-79	13.2	7.4	210	530	301	110	260	150	-	20
Mean	12.5	---	---	524	292	---	265	---	-	19
Median	11.5	7.2	---	525	293	---	265	---	-	20
Standard dev.	1.4	---	---	8	9	---	13	---	-	1
Maximum	14.1	7.4	---	530	301	---	280	---	-	20
Minimum	11.1	7.1	---	514	281	---	250	---	-	18
					Well B3A					
6-28-78	12.5	7.7	150	582	374	68	300	230	-	13
10-24-78	14.1	6.8	---	389	282	35	250	220	-	18
4-25-79	11.2	7.5	260	733	301	44	240	200	-	15
8-15-79	13.7	7.4	360	538	302	36	250	210	-	17
Mean	12.9	---	---	561	315	---	260	215	-	16
Median	13.1	7.4	---	560	301	---	250	215	-	16
Standard dev.	1.3	---	---	142	41	---	27	13	-	2.2
Maximum	14.1	7.7	---	733	374	---	300	230	-	18
Minimum	11.2	6.8	---	389	282	---	240	200	-	13
					Well B5A					
6-20-78	12.8	7.6	10	400	457	0	210	340	-	9.8
10-19-78	12.7	7.5	93	498	399	0	210	350	-	11.0
4-24-79	13.0	7.8	14	196	360	0	160	310	-	11.0
8-15-79	12.7	8.9	142	469	359	0	160	320	-	11.0
Mean	12.7	---	---	466	394	---	185	330	-	10.7
Median	12.8	7.7	---	482	376	---	185	330	-	11.0
Standard dev.	.2	---	---	46	46	---	29	18	-	.6
Maximum	13.0	8.9	---	498	457	---	210	350	-	11.0
Minimum	12.5	7.5	---	400	359	---	160	310	-	9.8

Table 10.--Field and laboratory measurements of water quality and related properties of water from background wells screened in sand and (or) gravel around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Organic carbon (mg/L)	Organic carbon, susp. (mg/L)	Phosphorus as P (mg/L)
					Well B1A					
6-21-78	10	0.4	56	14	6.3	0.3	44	4.6	---	0.01
10-25-78	15	1.3	79	28	7.6	.3	28	6.5	---	.01
4-25-79	11	.2	43	13	6.9	.2	41	4.1	---	.03
8-15-79	12	.1	41	11	6.4	.1	38	----	---	.00
Mean	12	---	--	--	6.8	---	38	5.1	---	----
Median	12	---	--	--	6.6	---	38	4.6	---	----
Standard dev.	2	---	--	--	.6	---	7	1.3	---	----
Maximum	15	---	--	--	8	---	44	6.5	---	----
Minimum	10	---	--	--	6	---	28	4.1	---	----
					Well B2A					
6-21-78	10	.6	71	24	0.9	0.3	2.8	3.0	---	0.00
10-25-78	11	.7	68	25	.9	.3	3.3	3.1	---	.01
4-25-79	10	.5	63	22	.8	.3	2.6	19.0	---	.00
8-15-79	11	.4	67	22	1.0	.3	3.5	14.0	0.2	.00
Mean	11	.5	67	23	0.9	0.3	3.0	----	---	----
Median	10	.6	68	23	.9	.3	3.0	----	---	----
Standard dev.	1	.1	3	2	.1	.0	.4	----	---	----
Maximum	11	.7	71	25	1.0	.3	3.3	----	---	----
Minimum	10	.4	63	22	.8	.3	2.6	----	---	----
					Well B3A					
6-28-78	16	1.6	78	25	19	0.3	64	----	---	0.01
10-24-78	11	.7	64	23	32	.3	17	2.1	---	.00
4-25-79	11	.6	63	21	31	.3	23	5.6	---	----
8-15-79	11	.4	64	21	30	.2	18	2.9	.3	.00
Mean	12	---	67	23	28	---	----	----	---	----
Median	11	---	64	21	30	---	----	----	---	----
Standard dev.	3	---	7	2	6	---	----	----	---	----
Maximum	16	---	78	25	32	---	----	----	---	----
Minimum	11	---	63	21	19	---	----	----	---	----
					Well B5A					
6-20-78	70	2.7	50	21	2.2	1.4	17	----	---	0.02
10-19-78	75	1.9	48	23	2.3	1.3	24	12.0	---	.03
4-24-79	73	1.9	35	17	2.0	1.5	13	11.0	---	----
8-15.79	71	1.5	37	17	2.3	1.4	10	15.0	.2	.24
Mean	72	2.0	43	20	2.2	1.4	----	12.7	---	----
Median	72	1.9	42	19	2.2	1.4	----	11.0	---	----
Standard dev.	2	.5	8	3	.1	.1	----	2.1	---	----
Maximum	75	2.7	50	23	2.3	1.5	----	15.0	---	----
Minimum	70	1.5	35	17	2.0	1.3	----	11.0	---	----

Table 10.--Field and laboratory measurements of water quality and related properties of water from background wells screened in sand and (or) gravel around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Water temp. (°C)	ph	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Dissolved solids at 180° C (mg/L)	Hardness noncarb. (mg/L)	Hardness carb. (mg/L)	Total alkalinity as $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)	Silica (mg/L)
					Well B6A					
6-29-78	12.5	7.1	55	690	383	0	190	350	-	14
10-25-78	11.1	7.4	28	678	403	0	180	370	-	15
4-24-79	13.2	7.6	80	694	402	0	160	380	-	15
8-16-79	12.5	8.2	100	560	408	0	160	380	-	15
Mean	12.3	---	---	656	399	--	173	370	-	15
Median	12.5	7.5	---	684	402	--	170	375	-	15
Standard dev.	.9	---	---	64	11	--	15	14	-	.5
Maximum	13.2	8.2	---	694	408	--	190	380	-	15
Minimum	11.1	7.1	---	560	383	--	160	350	-	14
					Well B7A					
6-22-78	11.0	7.6	143	660	372	56	320	260	-	16
10-25-78	13.5	7.3	270	653	393	57	330	270	-	17
4-25-79	11.5	7.3	248	696	432	42	310	270	-	17
8-16-79	12.5	8.1	200	690	455	47	320	270	-	18
Mean	12.1	---	---	675	413	51	320	268	-	17
Median	12.0	7.4	---	671	412	51	320	270	-	17
Standard dev.	1.1	---	---	21	37	7	8	5	-	.8
Maximum	13.5	8.1	---	696	455	57	330	270	-	18
Minimum	11.0	7.3	---	653	372	42	310	260	-	16
					Well B8A					
6-21-78	12.3	7.6	78	710	452	0	200	390	-	11
10-19-78	12.4	7.9	70	696	428	0	210	390	-	11
4-24-79	12.9	7.8	60	289	177	11	120	110	-	7.2
8-13-79	12.6	6.4	270	285	173	16	110	90	-	7.8
Mean	12.5	---	---	---	---	--	---	---	-	9.2
Median	12.5	7.7	---	---	---	--	---	---	-	9.4
Standard dev.	.3	---	---	---	---	--	---	---	-	2
Maximum	12.9	7.9	---	---	---	--	---	---	-	11
Minimum	12.3	6.4	---	---	---	--	---	---	-	7.2

Table 10.--Field and laboratory measurements of water quality and related properties of water from background wells screened in sand and (or) gravel around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Organic carbon (mg/L)	Organic carbon, susp. (mg/L)	Phosphorus as P (mg/L)
					Well B6A					
6-29-78	110	3.0	45	20	4.4	0.9	12	----	---	0.01
10-25-78	95	2.5	42	19	2.7	1.0	3.3	7.2	---	.05
4-24-79	90	2.7	37	17	4.2	1.1	1.7	9.6	---	.01
8-16-79	93	2.4	38	17	4.2	1.1	6.6	4.5	---	.00
Mean	97	2.6	41	18	3.8	1.0	-----	7.1	---	----
Median	94	2.6	40	18	4.4	1.0	-----	7.2	---	----
Standard dev.	9	.3	4	2	.8	.1	-----	2.6	---	----
Maximum	110	3.0	45	20	2.7	1.1	-----	9.6	---	----
Minimum	90	2.4	37	17	4.4	.9	-----	4.5	---	----
					Well B7A					
6-22-78	24	.4	77	30	5.4	0.3	85	1.0	---	0.00
10-25-78	27	.6	78	32	6.1	.2	80	1.6	---	.03
4-25-79	27	.4	74	31	5.7	.2	100	5.3	---	.00
8-16-79	29	.4	76	31	6.2	.2	100	9.6	.1	.00
Mean	27	.4	76	31	5.8	0.2	-----	----	---	----
Median	27	.4	76	31	5.9	.2	-----	----	---	----
Standard dev.	2	.1	2	1	.4	.05	-----	----	---	----
Maximum	29	.6	78	32	6.2	.3	-----	----	---	----
Minimum	24	.4	74	30	5.4	.2	-----	----	---	----
					Well B8A					
6-21-78	85	2.0	48	20	2.5	1.1	2.6	15.0	---	0.32
0-19-78	85	1.8	47	22	2.7	1.1	4.2	29.0	---	.13
4-24-79	6.7	3.7	37	7	4.2	.4	25	13.0	---	.15
8-13-79	6	3.5	36	5.8	5	.4	19	----	---	.13
Mean	---	---	42	----	---	---	-----	----	---	----
Median	---	---	42	----	---	---	-----	----	---	----
Standard dev.	---	---	6	----	---	---	-----	----	---	----
Maximum	---	---	48	----	---	---	-----	----	---	----
Minimum	---	---	36	----	---	---	-----	----	---	----

Table 11.--Field and laboratory measurements of water quality and related properties of water from background wells screened in sandstone of the Linton Formation above Seelyville coal (III) of Staunton Formation around a surface coal mine, Clay and Vigo Counties, Ind.

[Constituents dissolved unless otherwise stated: well numbers plotted in figure 2; °C, degree Celsius; mV, millivolt; µmho/cm, micromho per centimeter; mg/L, milligram per liter; data collected and analyzed by U.S. Geological Survey]

Sampling date	Water temp. (°C)	pH	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Dissolved solids at 180° C (mg/L)	Hardness noncarb. (mg/L)	Hardness carb. (mg/L)	Total alkalinity as $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)	Silica (mg/L)
					Well B1B					
6-21-78	12.3	7.0	52	600	331	15	260	250	-	13.0
4-25-79	11.8	7.5	262	623	342	0	280	280	-	17.0
8-14-79	12.4	6.9	202	652	360	4	290	290	-	18.0
Mean	12.2	---	---	625	344	---	277	273	-	16.0
Median	11.8	7.0	---	623	342	---	270	280	-	17.0
Standard dev.	.3	---	---	26	15	---	15	21	-	2.6
Maximum	12.4	7.5	---	652	360	---	290	290	-	18.0
Minimum	11.8	6.9	---	600	331	---	260	250	-	13.0
					Well B2B					
6-21-78	13.0	7.5	34	618	263	0	280	290	-	26.0
10-19-78	13.0	7.3	150	560	306	4	290	290	-	27.0
4-25-79	13.2	7.4	233	560	328	0	260	290	-	27.0
8-15-79	12.5	7.2	200	560	328	0	270	290	-	27.0
Mean	12.9	---	---	575	306	---	275	290	-	27.0
Median	13.1	7.4	---	560	317	---	275	290	-	27.0
Standard dev.	.3	---	---	29	31	---	13	0	-	.5
Maximum	13.2	7.5	---	618	328	---	290	290	-	27.0
Minimum	12.5	7.2	---	560	263	---	260	290	-	26.0
					Well B5B					
6-22-78	12.8	7.8	60	805	562	0	35	470	-	8.4
10-19-78	12.5	8.6	80	756	568	0	31	530	-	8.7
4-24-79	----	8.7	48	786	573	0	23	490	-	8.2
8-15-79	15.4	7.8	202	820	577	0	20	460	-	8.4
Mean	13.6	---	---	792	570	---	27	488	-	8.4
Median	12.8	8.3	---	780	570	---	27	480	-	8.4
Standard dev.	1.6	---	---	28	6	---	7	31	-	.2
Maximum	15.4	8.7	---	820	577	---	35	530	-	8.7
Minimum	12.5	7.8	---	756	562	---	20	460	-	8.2
					Well B6B					
6-29-78	12.6	7.9	100	1,280	759	0	83	420	-	6.8
4-24-79	13.0	8.6	210	1,450	528	0	100	380	-	11.0
8-16-79	12.8	8.8	162	1,000	441	0	130	380	-	12.0
Mean	12.8	---	---	1,240	576	---	104	390	-	9.9
Median	13.0	8.6	---	1,280	528	---	100	380	-	11.0
Standard dev.	.2	---	---	227	164	---	24	23	-	2.8
Maximum	13.0	8.8	---	1,450	759	---	130	420	-	12.0
Minimum	12.6	7.9	---	1,000	441	---	83	380	-	6.8

Table 11.--Field and laboratory measurements of water quality and related properties of water from background wells screened in sandstone of the Linton Formation above Seelyville coal (III) of Staunton Formation around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Organic carbon (mg/L)	Organic carbon, susp. (mg/L)	Phosphorus as P (mg/L)
					Well B1B					
6-21-78	14	1.9	68	23	7.6	0.5	31	7.8	---	0.02
4-25-79	14	1.0	69	25	7.4	.3	30	4.8	---	.00
8-14-79	16	.8	75	26	7.4	.2	32	16.0	---	.04
Mean	15	---	71	25	7.5	---	31	----	---	----
Median	14	---	69	25	7.4	---	31	----	---	----
Standard dev.	1	---	4	2	1.2	---	1	----	---	----
Maximum	16	---	75	26	7.6	---	32	----	---	----
Minimum	14	---	68	23	7.4	---	30	----	---	----
					Well B2B					
6-21-78	11	0.9	74	24	0.9	0.3	3.2	4.2	---	0.00
10-19-78	12	.9	75	26	1.0	.3	6.6	2.2	---	.01
4-25-79	12	1.0	68	23	.7	.2	13	7.2	---	.00
8-15-79	13	.8	72	23	1.0	.3	14	3.4	0.1	.01
Mean	12	0.9	72	24	0.9	---	-----	---	---	----
Median	12	.9	73	24	1.0	---	-----	---	---	----
Standard dev.	1	.1	3	1	.1	---	-----	---	---	----
Maximum	13	1.0	75	26	1.0	---	-----	---	---	----
Minimum	11	.8	68	23	.7	---	-----	---	---	----
					Well B5B					
6-22-78	220	2.8	9	3	4.3	2.8	16	11.0	---	0.06
10-19-78	270	1.9	7.8	2.7	5	2.8	11	8.1	---	.05
4-24-79	230	2.7	5.9	2.0	4.7	3.0	4.7	11.0	---	.30
8-15-79	230	1.9	5.4	1.7	5.4	2.8	6.3	14.0	---	.06
Mean	238	2.3	7.0	2.4	4.8	2.8	-----	11.0	---	----
Median	230	1.9	6	2	4.8	2.8	-----	11.0	---	----
Standard dev.	22	.5	1.7	.6	.5	.1	-----	2.4	---	----
Maximum	270	2.8	9	3	5.4	3.0	-----	14.0	---	----
Minimum	220	1.9	5.4	1.7	4.3	2.8	-----	8.1	---	----
					Well B6B					
6-29-78	270	3.9	20	8	12	2.9	190	----	---	0.01
4-24-79	170	2.6	25	9.8	9.4	1.7	11	14.0	---	----
8-16-79	120	1.9	34	12	4.5	1.0	19	2.2	1.4	.03
Mean	---	---	-----	9.9	----	---	-----	----	---	----
Median	---	---	-----	9.8	----	---	-----	----	---	----
Standard dev.	---	---	-----	2.0	----	---	-----	----	---	----
Maximum	---	---	-----	12	----	---	-----	----	---	----
Minimum	---	---	-----	8.0	----	---	-----	----	---	----

Table 11.--Field and laboratory measurements of water quality and related properties of water from background wells screened in sandstone of the Linton Formation above Seelyville coal (III) of Staunton Formation around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Water temp. (°C)	pH	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Dissolved solids at 180° C (mg/L)	Hardness noncarb. (mg/L)	Hardness carb. (mg/L)	Total alkalinity as $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)	Silica (mg/L)
					Well B7B					
6-22-78	12.7	7.2	110	780	540	190	490	300	-	19
10-25-78	12.5	6.9	168	721	585	110	500	390	-	20
4-26-79	13.0	6.8	286	984	608	84	460	380	-	19
8-16-79	12.2	7.8	112	930	614	56	460	400	-	20
Mean	12.6	---	---	854	587	---	478	368	-	20
Median	12.6	7.0	---	786	596	---	475	380	-	20
Standard dev.	.3	---	---	124	34	---	21	46	-	.6
Maximum	13.0	7.8	---	984	614	---	500	400	-	20
Minimum	12.2	6.8	---	721	540	---	460	300	-	19
					Well B8B					
6-29-78	14.0	7.6	75	700	388	0	160	310	-	8.7

Table 11.--Field and laboratory measurements of water quality and related properties of water from background wells screened in sandstone of the Linton Formation above Seelyville coal (III) of Staunton Formation around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate (mg/L)	Organic carbon (mg/L)	Organic carbon, susp. (mg/L)	Phosphorus as P (mg/L)
					Well B7B					
6-22-78	21	1.7	120	47	6.7	0.2	150	3.8	---	0.00
10-25-78	22	1.2	120	49	7.4	.2	130	2.8	---	.02
4-26-79	23	1.3	110	46	7	.3	140	14.0	---	----
8-16-79	23	1.1	110	44	6.9	.2	130	22.0	0.4	.02
Mean	22	---	120	47	6.0	0.2	140	----	---	----
Median	22	1.2	120	46	7.4	.2	130	----	---	----
Standard dev.	1	---	6	2	.3	.05	10	----	---	----
Maximum	23	1.7	120	49	7.4	.3	150	----	---	----
Minimum	21	1.1	110	44	6.7	.2	130	----	---	----
					Well B8B					
6-29-78	100	4.4	35	17	5.7	.5	9.1	----	---	.01

Table 12.--Concentrations of metals and trace elements in water from wells screened in reclaimed cast overburden 20-40 ft below the water table in a surface coal mine, Clay and Vigo Counties, Ind.

[Constituents dissolved unless otherwise stated: concentrations in micrograms per liter; well numbers plotted in figure 2; data collected and analyzed by U.S. Geological Survey]

Sampling date	Aluminum	Iron	Manganese	Arsenic	Beryllium	Boron (total)	Cadmium
			Well R3A				
7-20-78	20	3,700	1,800	1	0	-----	0
9-29-78	0	7,300	2,200	5	0	890	1
5-21-79	---	240	2,900	2	0	850	0
8 -1-79	30	13,000	2,500	1	0	690	1
10-31-79	---	5,300	1,800	-	-	560	-
			Well R4A				
7-27-78	0	15,000	4,700	4	0	-----	0
9-28-78	0	19,000	7,600	3	0	490	0
5-17-79	---	10,000	320	4	0	470	0
8 -9-79	100	8,600	6,600	5	0	570	0
			Well R5A				
7-19-78	10	5,200	890	6	0	-----	1
9-28-78	0	6,300	840	6	0	1,500	0
9-29-78	80	100	510	1	0	1,800	1
5-22-79	---	2,600	350	6	0	1,900	0
8 -8-79	100	3,700	600	6	0	1,400	0
10-30-79	---	4,000	560	-	-	1,000	-
			Well R6A				
6-14-78	20	3,300	2,600	5	0	-----	2
9-28-78	10	2,500	2,800	4	0	580	1
5-15-79	---	2,200	2,000	5	0	390	1
8 -2-79	20	3,300	3,500	3	0	430	0
11 -1-79	---	2,400	3,000	-	-	730	-
			Well R7A				
6-15-78	10	6,400	1,800	5	0	-----	0
10-27-78	0	5,500	2,300	0	0	500	1
5-16-79	---	5,800	1,600	3	0	780	1
8 -7-79	200	4,700	1,600	3	0	430	4

Table 12.--Concentrations of metals and trace elements in water from wells screened in reclaimed cast overburden 20-40 ft below the water table in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Zinc
			Well R3A				
7-20-78	1	0	3	0.5	2	0	0
9-29-78	1	0	1	.5	75	0	30
5-21-79	20	7	7	---	11	-	0
8 -1-79	10	0	12	---	7	0	20
10-31-79	--	-	--	---	--	-	--
			Well R4A				
7-27-78	0	0	2	0.5	3	0	10
9-28-78	2	0	2	.5	9	0	30
5-17-79	10	0	0	---	15	0	10
8-9-79	10	2	7	.5	5	0	30
			Well R5A				
7-19-78	0	0	1	0.5	1	0	120
9-28-78	2	1	5	.5	6	0	30
9-29-78	1	1	3	.5	6	0	170
5-22-79	10	0	10	.5	6	0	50
8 -8-79	10	1	8	---	3	0	50
10-30-79	--	-	--	---	---	-	---
			Well R6A				
6-14-78	2	2	31	0.5	64	0	70
9-28-78	1	3	2	.5	140	0	100
5-15-79	10	2	6	---	140	0	90
11 -1-79	--	-	--	---	---	-	---
			Well R7A				
6-15-78	0	1	6	0.5	17	0	50
10-27-78	0	1	3	.5	33	0	40
5-16-79	10	1	4	---	39	0	40
8 -7-79	10	1	17	.5	22	0	40

Table 12.--Concentrations of metals and trace elements in water from wells screened in reclaimed cast overburden 20-40 ft below the water table in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Aluminum	Iron	Manganese	Arsenic	Beryllium	Boron (total)	Cadmium
			Well R8A				
7-27-78	30	3,200	880	8	0	-----	1
10-2-78	0	8,700	880	10	0	1,200	1
5-22-79	---	60	980	4	0	1,000	1
8 -7-79	200	3,300	960	4	0	1,100	1
10-31-79	---	7,200	560	--	-	1,500	-
			Well R9A				
7-19-78	0	2,000	2,400	3	0	-----	0
10-2-78	0	100	2,100	1	0	1,000	1
			Well R11A				
7-27-78	0	15,000	1,400	8	0	-----	0
9-28-78	0	9,200	1,400	7	0	370	1
8 -8-79	200	6,700	1,500	8	9	300	1
			Well R12A				
7-20-78	40	0	160	1	0	-----	0
10 -3-78	20	50	230	1	0	240	0
5-17-79	---	4,300	220	3	0	370	4
7-31-79	---	8,500	270	2	0	180	1
10-30-79	---	930	320	-	-	550	-

Table 12.--Concentrations of metals and trace elements in water from wells screened in reclaimed cast overburden 20-40 ft below the water table in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Zinc
			Well R8A				
7-27-78	0	0	2	0.5	41	0	30
10-2-78	1	2	2	.5	41	0	70
5-22-79	40	4	8	---	30	0	30
8 -7-79	10	2	10	.5	50	0	50
10-31-79	--	-	--	---	--	-	---
			Well R9A				
7-19-78	0	0	0	0.5	11	0	320
10 -2-78	1	2	4	.5	13	0	10
			Well R11A				
7-27-78	0	0	0	0.5	8	0	0
9-28-78	1	1	2	.5	10	0	20
8 -8-79	10	2	8	.5	7	0	20
			Well R12A				
7-20-78	0	0	5	0.5	1	0	40
10 -3-78	2	1	1	.5	5	0	30
5-17-79	10	1	0	---	6	0	10
7-31-79	10	1	3	---	5	0	20
10-30-79	--	-	-	---	--	-	--

Table 13.--Concentrations of metals and trace elements in water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.

[Constituents dissolved unless otherwise stated; concentrations in micrograms per liter; well numbers plotted in figure 2; data collected and analyzed by U.S. Geological Survey]

Sampling date	Aluminum	Iron	Manganese	Arsenic	Beryllium	Boron (total)	Cadmium
			Well R1B				
7-21-78	30	3,300	760	9	0	-----	14
10 -3-78	20	3,300	900	10	0	-----	1
5-18-79	---	4,500	820	13	0	570	2
8 -8-79	100	3,900	830	13	0	620	18
			Well R2B				
7-24-78	0	2,400	140	4	0	-----	1
10 -3-78	0	280	150	3	0	1,100	1
5-21-79	---	1,300	260	4	0	780	0
7-31-79	0	730	230	2	0	820	0
			Well R3B				
7-20-78	10	30,000	1,800	5	0	-----	0
9-29-78	0	9,400	1,600	7	0	880	1
5-21-79	---	5,800	2,100	7	0	650	2
8 -1-79	20	5,000	2,200	4	0	640	1
10-31-79	---	6,600	1,800	-	-	490	-
			Well R4B				
7-27-78	0	19,000	1,300	2	0	-----	0
9-28-78	0	10,000	1,100	4	0	1,100	1
5-17-79	---	12,000	1,200	5	0	770	0
8 -9-79	200	9,800	1,500	5	0	990	0
10-30-79	---	14,000	1,200	-	-	1,500	-
			Well R5B				
7-19-78	10	4,000	390	5	0	-----	0
9-28-78	0	40	380	3	0	1,800	1
5-22-79	---	10	470	5	0	1,900	0
8 -8-79	200	2,500	410	4	0	1,800	1

Table 13.--Concentrations of metals and trace elements in water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Zinc
			Well R1B				
7-21-78	0	0	250	0.5	4	0	0
10 -3-78	0	1	3	.5	10	0	40
5-18-79	10	0	37	---	5	-	10
8 -8-79	10	1	140	---	5	0	40
			Well R2B				
7-24-78	1	0	6	0.5	2	0	20
10 -3-78	1	1	1	.5	10	0	10
5-21-79	40	0	6	---	5	0	0
7-31-79	10	0	3	---	6	0	40
			Well R3B				
7-20-78	0	0	1	0.5	8	0	100
9-29-78	3	0	2	.5	64	0	40
5-21-79	30	1	12	---	80	0	40
8 -1-79	10	0	15	---	50	0	60
10-31-79	--	-	--	---	--	-	---
			Well R4B				
7-27-78	1	1	2	0.5	7	0	20
9-28-78	2	0	2	.5	19	0	30
5-17-79	10	1	5	---	24	0	30
8 -9-79	10	1	2	.5	11	0	40
10-30-79	--	-	--	---	--	-	---
			Well R5B				
7-19-78	0	0	4	0.5	0	0	180
9-28-78	1	2	7	.5	9	0	40
5-22-79	20	1	6	---	3	0	0
8 -8-79	10	1	15	---	2	-	30

Table 13.--Concentrations of metals and trace elements in water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Aluminum	Iron	Manganese	Arsenic	Beryllium	Boron (total)	Cadmium
			Well R6B				
6-14-78	20	4,500	2,400	10	0	-----	0
9-29-78	0	560	2,400	2	0	600	1
5-15-79	---	5,000	1,800	9	0	520	1
8 -2-79	30	5,500	2,400	11	0	500	0
11 -1-79	---	6,000	2,300	--	-	1,000	-
			Well R7B				
6-15-78	20	5,000	1,200	6	0	-----	0
10 -2-78	0	8,900	1,700	4	0	490	1
5-16-79	---	7,700	1,400	5	0	410	0
8 -7-79	200	7,800	-----	--	-	430	-
			Well R8B				
7-27-78	10	2,400	1,000	11	0	-----	1
10 -2-78	0	9,000	1,000	8	0	1,200	1
5-22-79	---	9,600	1,100	10	0	960	0
8 -7-79	100	9,200	1,000	9	0	1,100	0
10-31-79	---	10,000	940	--	-	950	-
			Well R9B				
7-19-78	20	160	870	2	0	-----	0
9-29-78	0	6,400	1,100	11	0	1,000	0
5-17-79	---	5,100	920	11	0	400	0
8 -9-79	100	2,900	890	10	0	870	0
			Well R10B				
7-24-78	10	18,000	3,500	3	0	-----	1
9-28-78	0	16,000	3,100	3	0	570	1
9-29-78	0	16,000	3,500	5	0	550	0
5-16-79	---	17,000	2,000	3	0	440	0
7-31-79	10	19,000	3,600	3	0	450	0
10-29-79	---	21,000	3,400	--	-	230	---
			Well R11B				
7-27-78	20	20	600	2	0	-----	0
9-28-78	0	16,000	1,200	5	0	350	1
8 -8-79	100	5,700	1,500	10	0	280	0

Table 13.--Concentrations of metals and trace elements in water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Zinc
				Well R6B			
6-14-78	0	0	2	0.5	84	0	110
9-29-78	1	1	1	.5	110	0	100
5-15-79	10	0	2	---	110	0	50
8 -2-79	20	1	6	---	94	0	50
11 -1-79	--	-	-	---	--	-	---
				Well R7B			
6-15-78	0	2	0	0.5	22	0	40
10 -2-78	0	1	2	.5	36	0	40
5-16-79	10	2	3	---	51	0	30
8 -7-79	--	-	-	---	---	-	---
				Well R8B			
7-27-78	0	0	1	0.5	13	0	30
10 -2-78	0	1	2	.5	17	0	40
5-22-79	40	1	8	---	16	0	20
8 -7-79	10	3	8	.5	15	0	50
10-31-79	---	-	-	---	---	-	---
				Well R9B			
7-19-78	1	0	1	0.5	0	0	500
9-29-78	0	1	1	.5	6	0	20
5-17-79	10	0	2	---	10	0	20
8 -9-79	10	1	4	.5	10	0	30
				Well R10B			
7-24-78	0	1	2	0.5	7	0	150
9-28-78	1	1	5	.5	7	0	50
9-29-78	1	2	2	.5	12	0	80
5-16-79	20	1	6	---	8	0	50
7-31-79	10	2	5	---	6	0	70
10-29-79	--	-	-	---	--	-	---
				Well R11B			
7-27-78	1	0	2	0.5	9	0	40
9-28-78	1	2	1	.5	9	0	30
8 -8-79	10	1	5	.5	4	0	30

Table 13.--Concentrations of metals and trace elements in water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Aluminum	Iron	Manganese	Arsenic	Beryllium	Boron (total)	Cadmium
			Well R12B				
7-20-78	20	2,600	830	9	0	---	0
10 -3-78	20	20	1,100	2	0	380	0
5-17-79	--	4,900	920	6	0	360	0
8 -2-79	30	1,700	940	6	0	370	2
			Well R13B				
6-16-78	30	0	4,000	2	0	---	3
5-17-79	--	7,100	2,200	5	0	190	1
8 -2-79	10	9,100	3,000	8	0	40	0

Table 13.--Concentrations of metals and trace elements in water from wells screened in reclaimed cast overburden on the floor of a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Zinc
				Well R12B			
7-20-81	0	1	3	0.5	0	0	10
10 -3-78	2	1	4	.5	3	0	20
5-17-79	10	1	2	---	8	0	10
8 -2-79	10	1	11	---	6	0	20
				Well R13B			
6-16-78	2	0	40	0.5	2	0	30
5-17-79	10	1	2	---	39	0	20
8 -2-79	10	1	6	---	31	0	30

Table 14.--Concentrations of metals and trace elements in water from wells screened in sandstone or sandy shale below the Seelyville coal (III) horizon of the Staunton Formation in and around a surface coal mine, Clay and Vigo Counties, Ind.

[Constituents dissolved unless otherwise stated; concentrations in micrograms per liter; well numbers plotted in figure 2; data collected and analyzed by U.S. Geological Survey]

Sampling date	Aluminum	Iron	Manganese	Arsenic	Beryllium	Boron (total)	Cadmium
			Well R1C				
6-28-78	60	50	200	4	0	730	0
			Well R5C				
6-28-78	30	40	10	1	0	650	0
4-26-79	--	20	150	1	0	600	0
8-16-79	30	100	160	1	0	680	2
			Well R7C				
6-28-78	50	50	60	0	10	---	0
4-26-79	--	30	30	2	0	900	0
8-16-79	60	40	20	1	0	80	0
			Well R9C				
6-28-78	---	20	10	1	0	-----	-
10-20-78	20	20	10	1	0	790	1
4-25-79	---	10	20	2	0	850	0
8-17-79	100	40	10	2	0	880	0
			Well B5C				
6-21-78	270	350	10	5	0	1,100	1
10-19-78	100	30	0	1	0	1,000	1
4-24-79	---	0	3	1	0	500	0
8-15-79	40	10	6	1	0	1,100	1

Table 14.--Concentrations of metals and trace elements in water from wells screened in sandstone or sandy shale below the Seelyville coal (III) horizon of the Staunton Formation in and around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Zinc
				Well R1C			
6-28-78	0	0	5	1.1	5	3	100
				Well R5C			
6-28-78	0	0	2	0.5	2	0	30
4-26-79	10	0	5	---	0	0	0
8-16-79	10	0	10	.5	1	0	10
				Well R7C			
6-28-78	2	2	0	0.5	5	0	0
4-26-79	10	0	5	---	0	0	0
8-16-79	10	4	2	.5	1	0	10
				Well R9C			
6-28-78	0	0	4	<0.5	2	0	10
10-20-78	1	2	9	.5	2	0	20
4-25-79	10	1	3	----	0	0	10
8-17-79	10	1	5	<.5	4	0	20
				Well B5C			
6-21-78	1	2	17	0.5	0	0	10
10-19-78	3	2	8	.5	2	0	0
4-24-79	<10	0	5	---	0	0	0
8-15-79	<10	1	20	.5	1	0	0

Table 15.--Concentrations of metals and trace elements in water from background wells screened in sand and (or) gravel around a surface coal mine, Clay and Vigo Counties, Ind.

[Constituents dissolved unless otherwise stated; concentrations in micrograms per liter; well numbers plotted in figure 2; data collected and analyzed by U.S. Geological Survey]

Sampling date	Aluminum	Iron	Manganese	Arsenic	Beryllium	Boron (total)	Cadmium
			Well B1A				
6-21-78	40	50	170	1	0	20	1
10-25-78	20	110	4,600	5	0	40	0
4-25-79	--	0	10	1	0	0	0
8-15-79	0	0	3	1	0	4	1
			Well B2A				
6-21-78	40	0	1,100	6	0	20	0
10-25-78	20	740	950	3	0	20	1
4-25-79	--	680	840	2	0	50	0
8-15-79	0	490	1,000	3	0	0	1
			Well B3A				
6-28-78	20	10	510	2	0	730	0
10-24-78	30	80	420	3	0	20	0
4-25-79	---	110	320	3	0	20	0
8-15-79	20	200	440	2	0	0	2
			Well B5A				
6-20-78	150	230	90	16	0	170	0
10-19-78	20	40	190	24	0	40	0
4-24-79	---	130	130	28	0	150	0
8-15-79	10	1,100	60	33	0	190	0
			Well B6A				
6-29-78	30	20	150	1	0	460	0
10-25-78	10	20	120	1	0	510	1
4-24-79	---	10	80	1	0	510	0
8-16-79	2	20	80	1	0	550	0

Table 15.--Concentrations of metals and trace elements in water from background wells screened in sand and (or) gravel around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Zinc
				Well B1A			
6-21-78	2	2	3	<0.5	1	0	10
10-25-78	1	1	3	<.5	4	0	10
4-25-79	10	0	1	---	0	0	0
8-15-79	10	1	4	<.5	0	0	3
				Well B2A			
6-21-78	0	2	2	<0.5	0	0	10
10-25-78	1	0	8	<.5	2	0	10
4-25-79	10	0	4	---	0	0	50
8-15-79	10	0	5	<.5	2	0	8
				Well B3A			
6-28-78	0	2	4	<0.5	4	0	30
10-24-78	0	0	4	<.5	1	0	20
4-25-79	10	0	5	---	0	0	0
8-15-79	10	0	24	<.5	0	0	1
				Well B5A			
6-20-78	1	3	1	<0.5	3	0	10
10-19-78	1	0	9	<.5	4	0	10
4-24-79	10	0	6	---	0	0	10
8-15-79	10	1	1	<.5	0	0	50
				Well B6A			
6-29-78	0	0	3	<0.5	1	0	10
10-25-78	1	0	11	<.5	1	0	10
4-24-79	10	0	4	---	0	0	0
8-16-79	10	0	4	<.5	3	0	5

Table 15.--Concentrations of metals and trace elements in water from background wells screened in sand and (or) gravel around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Aluminum	Iron	Manganese	Arsenic	Beryllium	Boron (total)	Cadmium
			Well B7A				
6-22-78	20	10	220	4	0	20	0
10-25-78	20	30	250	1	0	470	0
4-25-79	--	10	180	3	0	4	0
8-16-79	0	90	230	3	0	0	3
			Well B8A				
6-21-78	30	280	80	47	0	160	0
10-19-78	20	70	70	29	0	190	1
4-24-79	--	90	220	20	0	70	0
8-13-79	--	30	150	11	0	---	1

Table 15.--Concentrations of metals and trace elements in water from background wells screened in sand and (or) gravel around a surface coal minc, Clay and Vigo Counties, Ind.--Continued

Sampling date	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Zinc
			Well B7A				
6-22-78	0	0	1	<0.5	1	0	10
10-25-78	1	0	8	<.5	5	0	10
4-25-79	10	0	4	<.5	1	0	0
8-16-79	10	0	16	<.5	0	0	2
			Well B8A				
6-21-78	4	0	1	<0.5	0	0	20
10-19-78	1	0	5	<.5	2	0	20
4-24-79	10	1	3	---	0	0	0
8-13-79	10	2	7	<.5	2	0	5

Table 16.--Concentrations of metals and trace elements in water from background wells screened in sandstone of the Linton Formation above Seelyville coal (III) of Staunton Formaton around a surface coal mine, Clay and Vigo Counties, Ind.

[Constituents dissolved unless otherwise stated; concentrations in micrograms per liter; well numbers plotted in figure 2; data collected and analyzed by U.S. Geological Survey]

Sampling date	Aluminum	Iron	Manganese	Arsenic	Beryllium	Boron (total)	Cadmium
			Well B1B				
6-21-78	20	330	4,800	8	0	20	0
4-25-79	---	200	2,600	3	0	6	0
8-14-79	200	3,900	2,700	9	0	20	0
			Well B2B				
6-21-78	40	50	390	3	0	20	0
10-19-78	10	160	380	0	0	40	1
4-25-79	---	100	380	2	0	2	0
8-15-79	10	720	370	1	0	0	0
			Well B5B				
6-22-78	30	30	20	3	0	890	0
10-19-78	20	60	30	2	0	890	1
4-24-79	---	10	20	2	0	730	0
8-15-79	140	140	30	3	0	900	1
			Well B6B				
6-29-78	30	80	30	1	0	1,000	0
4-24-79	--	0	10	2	0	660	0
8-16-79	20	0	10	3	0	580	2
			Well B7B				
6-22-78	30	40	350	2	0	40	0
10-25-78	20	510	250	1	0	210	0
4-26-79	--	30	330	2	0	50	0
8-16-79	0	990	270	2	0	30	2
			Well B8B				
6-29-78	40	10	110	3	0	630	0

Table 16.--Concentrations of metals and trace elements in water from background wells, screened in sandstone of the Linton Formation above Seelyville coal (III) around a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Sampling date	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Zinc
			Well B1B				
6-21-78	3	1	2	<0.5	2	0	10
4-25-79	10	3	5	---	1	0	0
8-14-79	<10	0	7	<.5	0	0	9
			Well B2B				
6-21-78	0	0	2	<0.5	0	0	20
10-19-78	2	1	15	<.5	2	0	10
4-25-79	10	0	3	---	0	0	10
8-15-79	10	0	1	<.5	0	0	2
			Well B5B				
6-22-78	0	1	0	0.5	2	0	10
10-19-78	2	0	11	<.5	1	0	10
4-24-79	<10	0	6	---	1	0	0
8-15-79	10	2	2	<.5	1	0	5
			Well B6B				
6-29-78	0	0	5	<0.5	2	0	20
4-24-79	<10	0	3	---	0	0	0
8-16-79	10	0	7	<.5	0	0	5
			Well B7B				
6-22-78	0	0	0	<0.5	0	0	20
10-25-78	2	0	1	<.5	3	0	10
4-26-79	10	0	3	---	1	0	10
8-16-79	10	1	28	<.5	1	0	7
			Well B8B				
6-29-78	0	0	4	<0.5	3	0	10

Table 17.--Concentrations of ferrous iron and dissolved oxygen in water from selected 5-inch-diameter wells in a surface coal mine, Clay and Vigo Counties, Ind.

[Well sites plotted in figure 2; µg/L, microgram per liter; mg/L, milligram per liter; analyses by U.S. Geological Survey]

Well	May 1979		August 1979[1]		October 1979	
	Ferrous iron (µg/L)	Dissolved oxygen (mg/L)	Ferrous iron (µg/L)	Dissolved oxygen (mg/L)	Ferrous iron (µg/L)	Dissolved oxygen (mg/L)
Wells in reclaimed cast overburden, screened 20-40 ft below the water table						
R3A	-----	---	8,400	0.0	------	---
			8,400	.0		
R4A	6,900	0.0	------	---	------	---
R5A	1,400	.0	4,100	.0	4,000	0.0
R7A	-----	---	1,300	.0	------	---
			1,300	.0		
R8A	5,600	.0	------	---	7,500	.0
R11A	-----	.0	11,000	.0	------	---
R12A	-----	.0	4,300	.0	3,300	.0
			4,300	.0		
Wells in reclaimed cast overburden, screened on the floor of the mine						
R1B	------	---	5,300	0.0	------	---
			5,400	.0		
R3B	2,500	0.0	------	---	------	---
R4B	------	.0	11,000	.0	14,000	0.0
			13,000	.0		
R5B	------	---	------	---	------	---
R6B	4,200	.0	4,900	.0	------	---
			4,800	.0		
R7B	------	---	8,200	.0	------	---
		8,000	.0			
R8B	6,400	.0	11,000	.0	10,000	.0
R9B	------	---	------	---	------	---
R10B	19,000	.0	19,000	.0	19,000	.0
			19,000	.0		
R11B	1,600	.0	------	---	------	---
R13B	8,600	.0	9,100	.0	------	---
			9,300			

[1]Two water samples were collected with a Foerst sampler from most wells, twelve determinations of ferrous iron were made of each sample, and an average concentration of these 12 determinations was reported. For oxygen, duplicate determinations were run, and the average of the determinations was reported. Methods used were modifications of methods by Sandell (1959, p. 537-542).

Table 18.--Instantaneous discharge measurements at streamflow gaging sites 3, 5, and 12 near a surface coal mine, Clay and Vigo Counties, Ind.

[Measurements in cubic foot per second; site numbers plotted in figure 2; measurements by U.S. Geological Survey]

Date	Time[1]	Instantaneous discharge	Date	Time	Instantaneous discharge
Site 3 at Honey Creek					
11-16-77	0935	11	11-17-78	1355	2.1
11-18-77	1230	.36	12-13-78	1610	.26
1 -5-78	1350	.15	1-18-79	1740	.26
3 -7-78	ice cover		2-21-79	1445	5.7
3-14-78	ice cover		3-24-79	1330	7.9
5-16-78	1350	2.0	4-26-79	1515	1.5
6 -1-78	1140	.25	5-26-79	1300	.06
7-20-78	1225	.15	7 -3-79	1700	.04
8-24-78	1355	.06	8-16-79	0900	.25
10 -4-78	1105	.03	9-20-79	1530	.03
10-24-78	1255	.02	10-10-79	1605	.03
Statistical data:		Number of measurements			20
		Maximum			10.8
		Minimum			0.02
Site 5 at Honey Creek					
9-29-77	1020	0.12	12-12-78	1300	1.3
11-16-77	1215	23	1-9-78	1430	3.4
11-17-77	1240	7.1	2-21-79	1310	9.1
9-29-77	1240	7.1	3-24-79	1200	2.2
1-5-78	1120	21	4-26-79	1300	11
3-22-78	1015	19	5-26-79	1030	4.5
3-29-78	1010	5.6	7-3-79	1440	2.8
5-16-78	1200	7.6	8-14-79	1450	3.6
6-1-78	1030	.0	9-20-79	1610	2.5
7-19-78	1400	.0	10-10-79	1235	6.1
8-24-78	0920	2.1	11-07-79	0950	3.9
9-27-78	1225	.0	12-05-79	0920	2.4
10-4-78	0940	.0	1-17-80	1230	8.1
10-24-78	1340	.0	2-27-80	1037	6.9
11-17-78	1105	16			
Statistical data:		Number of measurements			30
		Maximum			23
		Minimum			0.0

Table 18.--Instantaneous discharge measurements at streamflow gaging sites 3, 5, and 12 near a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Date	Time[1]	Instantaneous discharge	Date	Time	Instantaneous discharge
Site 12 at North Branch Honey Creek					
9-29-77	1435	0.02	1-19-79	1325	1.4
11-16-77	1045	37	2-21-79	1205	5.3
11-17-77	1610	3.0	3-24-79	1110	21
1-5-78	1245	.67	4-26-79	1130	3.6
3-22-78	1205	6.6	5-26-79	1420	.62
3-29-78	1500	3.5	7-3-79	1215	1.9
5-16-78	1530	5.8	8-14-79	----	2.3
6-1-78	1100	.23	9-21-79	0954	.47
7-20-78	1105	.14	10-10-79	0925	.27
8-24-78	1015	.00	11- 7-79	1046	.36
10- 4-78	----	.00	12- 5-79	1038	2.5
11-17-78	1245	9	1-7-80	1000	5.5
12-12-78	1125	1.1	2-28-80	1111	2.9

Statistical data: Number of measurements 26
Maximum 37.2
Minimum .00

[1]For example, 1435 is 2:35 p.m., eastern standard time.

Table 19.--Mean daily discharge[1] at stream site 5 near a surface coal mine, Clay and Vigo Counties, Ind.

[Data collected and analyzed by U.S. Geological Survey; discharge, in cubic foot per second]

1978 Water Year

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	15	0.20	0.00	2.5	---	-----	4.7	18	0.20	---	---	---
2	9.3	1.4	1.0	2.4	---	-----	4.4	18	.00	---	---	---
3	2.6	.20	3.0	2.3	---	-----	2.8	18	.00	---	---	---
4	1.4	.20	4.3	2.2	---	-----	.00	18	.00	---	---	---
5	3.1	1.2	27	2.1	---	-----	1.0	18	.00	---	---	---
6	2.2	1.6	21	2.0	---	-----	2.9	18	.00	---	---	---
7	1.5	.40	7.6	3.2	---	-----	3.1	18	.00	---	---	---
8	7.6	.20	5.5	4.2	---	-----	3.0	18	.00	---	---	---
9	5.9	.30	8.6	3.0	---	-----	4.1	18	.00	---	---	---
10	2.4	1.4	6.6	1.8	---	-----	2.0	18	.00	---	---	---
11	2.0	1.0	4.4	1.5	---	-----	4.0	18	.00	---	---	---
12	2.0	.70	3.6	1.4	---	-----	3.0	18	.00	---	---	---
13	1.2	1.4	27	1.4	---	-----	1.9	18	.00	---	---	---
14	1.2	.70	160	1.3	---	160	2.5	18	.00	---	---	---
15	3.0	.10	30	1.3	---	68	3.1	18	.00	---	---	---
16	3.3	21	12	1.2	---	35	4.1	6.2	.00	---	---	---
17	1.1	8.6	9.5	1.2	---	31	2.2	4.4	.00	---	---	---
18	1.1	2.4	6.4	1.2	---	17	2.9	2.6	.00	---	---	---
19	2.0	.40	4.8	1.2	---	19	12	1.7	.50	.00	---	---
20	1.8	.20	4.3	1.2	---	19	18	.40	.70	---	---	---
21	.80	.20	3.7	1.2	---	36	18	1.3	.70	---	---	---
22	2.7	.00	3.4	1.1	---	20	18	1.3	.70	---	---	---
23	3.1	.00	2.8	1.1	---	11	18	7.4	---	---	---	---
24	3.0	.00	2.6	1.1	---	28	18	19	---	---	---	---
25	1.3	.00	2.6	1.1	---	58	18	5.6	---	---	---	---
26	1.7	.00	2.4	---	---	24	18	2.5	---	---	---	---
27	2.4	.00	2.3	---	---	9.3	18	1.3	---	---	---	.00
28	1.3	.00	2.3	---	---	5.5	18	.30	---	---	---	.00
29	2.9	.00	2.3	---	---	5.3	18	2.1	---	---	---	.00
30	2.6	.40	2.4	---	---	5.0	18	2.3	---	---	---	.00
31	.60	-----	2.5	---	---	4.9	----	.60	---	---	---	---
Total	92.10	45.00	381.40	---	---	-----	261.70	329.00	---	---	---	---
Mean	2.97	1.50	12.3	---	---	-----	8.72	10.6	---	---	---	---
Max	15	21	160	---	---	-----	18	19	---	---	---	---
Min	.60	.00	.00	---	---	-----	.00	.30	---	---	---	---

Table 19.--Mean daily discharge at stream site 5 near a surface coal mine, Clay and Vigo Counties, Ind.--Continued

1979 water year

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	0.00	0.20	2.8	30	5.6	----	---	5.5	5.9	3.2	-----	3.8
2	.00	.40	3.4	10	3.8	----	---	6.4	5.8	2.3	-----	5.3
3	.00	1.1	9.3	4.4	3.3	----	---	7.2	5.3	2.2	-----	5.5
4	.00	1.4	8.1	3.8	2.8	----	---	7.0	3.1	4.3	-----	3.4
5	.50	2.2	5.3	3.4	2.3	----	---	8.4	2.8	2.1	-----	3.0
6	.70	1.5	3.8	3.1	2.0	----	---	6.9	3.7	.70	-----	4.9
7	.60	1.2	3.6	2.9	2.0	----	---	3.9	4.3	1.8	-----	4.9
8	2.5	1.4	7.7	2.6	2.0	----	---	1.7	4.6	1.9	-----	4.4
9	1.1	1.5	7.7	2.4	2.0	----	---	1.3	5.3	1.0	-----	5.2
10	.00	1.4	5.0	2.3	2.0	----	---	.50	6.6	1.6	-----	3.5
11	.00	2.8	2.4	2.3	2.0	----	---	.40	4.2	2.5	-----	3.9
12	1.9	3.9	1.5	2.3	2.0	----	---	1.4	1.4	1.9	-----	4.4
13	5.6	1.7	1.6	3.4	2.0	----	---	4.4	3.8	6.9	-----	4.2
14	6.0	1.2	1.8	3.5	2.2	----	---	2.6	3.6	7.4	3.3	4.1
15	4.9	3.8	2.0	2.0	2.6	----	---	1.4	3.6	8.0	4.0	5.0
16	2.0	2.9	3.2	1.7	3.1	----	---	2.4	3.8	3.9	4.0	4.1
17	.10	8.6	3.3	3.0	2.9	----	---	3.6	4.7	1.4	3.9	1.5
18	.00	9.9	1.3	3.9	2.2	----	---	4.1	2.3	2.6	5.1	.00
19	.20	5.8	.60	3.3	2.0	----	---	6.2	.60	3.2	230	.00
20	2.1	1.8	2.2	3.8	1.9	----	---	9.3	1.7	1.2	130	2.4
21	3.9	1.1	4.4	4.0	9.5	----	---	4.6	3.8	1.5	74	3.5
22	3.4	1.3	3.0	3.0	---	----	---	4.1	3.9	4.8	23	1.8
23	1.4	3.1	2.7	3.4	---	19	---	4.0	3.9	3.0	14	3.3
24	.00	2.3	3.9	8.2	---	15	---	3.9	4.3	2.0	8.4	1.8
25	1.3	2.2	3.4	7.4	---	6.7	---	4.1	2.9	5.8	7.4	2.0
26	1.4	3.5	2.6	6.8	---	4.9	9.3	4.6	2.8	6.3	9.0	3.1
27	.20	1.9	.80	6.0	---	5.9	8.8	7.2	2.5	4.4	6.9	3.3
28	1.1	.40	.00	4.4	---	14	8.8	6.9	2.7	31	6.7	3.3
29	1.9	.80	.80	4.0	---	----	9.3	3.9	1.1	----	6.9	4.9
30	.90	1.2	2.0	3.8	---	----	5.9	3.4	.90	----	5.5	4.2
31	.10	-----	29	4.6	---	----	---	4.9	------	----	2.5	---
Total	43.80	72.50	129.20	150.6	---	----	---	136.20	107.40	----	-----	104.70
Mean	1.41	2.42	4.17	4.86	---	----	---	4.39	3.58	----	-----	3.49
Max	6.0	9.9	29	30	---	----	---	9.3	6.6	----	-----	5.5
Min	.00	.20	.00	1.7	---	----	---	.40	.60	----	-----	.00

[1]Values 20 ft^3/s or greater are estimated.

Table 20.--Mean daily discharge[1] at stream site 12 near a surface coal mine, Clay and Vigo Counties, Ind.

[Data collected and analyzed by U.S. Geological Survey; discharge in cubic foot per second]

1978 water year

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	11	----	23	0.83	0.42	0.61	2.9	2.3	0.23	0.06	0.13	0.07
2	1.4	----	3.9	.64	.39	.66	2.6	2.3	.25	.27	55	.05
3	.97	----	4.2	.59	.38	.72	2.6	2.1	.23	.23	1.8	.02
4	.84	----	2.2	.59	.37	.72	2.6	11	.21	.16	.31	.00
5	.77	----	83	.64	.36	.62	2.6	5.8	.23	.12	.19	.00
6	.84	----	8.3	.68	.35	.58	6.4	3.1	.21	.09	.14	.00
7	.88	----	3.6	.70	.34	.58	4.0	6.5	.29	.06	.17	.00
8	4.3	----	6.3	1.1	.34	.60	3.2	5.4	.24	.11	.13	.00
9	1.4	----	21	1.1	.34	.83	3.0	3.1	.21	5.3	.11	.00
10	.97	----	4.0	.70	.36	1.8	3.1	2.7	.19	.39	.13	.00
11	.93	----	2.3	.48	.40	4.0	6.6	2.7	.19	.29	.14	.00
12	.93	----	2.2	.44	.42	10	3.2	15	.19	.23	.23	.00
13	1.0	----	140	.43	.46	20	2.8	96	.17	9.8	.13	.00
14	1.0	----	210	.42	.48	300	2.6	7.4	.16	.47	.11	.00
15	1.0	----	11	.41	.48	58	2.5	6.4	.16	.92	.11	.00
16	1.0	----	7.0	.40	.46	40	2.4	5.8	.16	.31	.13	.00
17	1.0	----	4.5	.39	.43	30	2.4	2.6	.14	.21	.09	.00
18	-----	----	2.7	.39	.42	21	3.6	2.1	1.9	.16	.09	.00
19	-----	----	1.7	.38	.40	18	25	1.9	1.5	.14	.11	.00
20	-----	----	1.5	.38	.40	12	8.0	1.7	.35	.13	.06	.00
21	-----	----	1.2	.39	.39	32	3.8	1.6	.29	.11	.00	.00
22	-----	----	1.1	.39	.36	14	3.2	1.5	.25	.09	.00	.00
23	-----	1.5	1.0	.40	.35	39	3.6	12	.23	.07	.00	.00
24	-----	1.5	1.1	.42	.34	42	4.0	3.3	.21	.54	.00	.00
25	-----	1.4	1.0	.48	.36	18	6.6	1.6	.19	.17	.00	.00
26	-----	1.2	.84	.58	.42	9.0	3.7	1.1	.17	.17	.00	.00
27	-----	1.2	.72	.58	.48	6.0	3.0	.76	.13	.17	.70	.00
28	-----	1.2	.66	.54	.54	3.9	2.7	.58	.09	.11	3.6	.00
29	-----	1.1	.72	.50	----	3.5	2.6	.46	.07	.07	.11	.00
30	-----	14	.72	.48	----	3.1	2.6	.34	.06	.93	.66	.00
31	-----	----	.78	.44	----	3.1	----	.24	----	.21	.25	.00
Total	-----	----	549.24	16.89	11.24	694.32	127.9	209.38	8.90	22.09	64.63	.14
Mean	-----	----	17.7	.54	.40	22.3	4.26	6.75	.30	.71	2.08	.005
Max	-----	----	210	1.1	.54	300	25	96	1.9	9.8	55	.07
Min	-----	----	.66	.38	.34	.58	2.4	.24	.06	.06	.00	.00

Table 20.--Mean daily discharges at stream site 12 near a surface coal mine, Clay and Vigo Counties, Ind.--Continued

1979 water year

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	0.00	.00	0.93	34	1.1	26	14	2.1	0.68	0.90	150	0.50
2	.00	.00	.94	4.8	1.0	33	20	2.1	.64	1.7	17	.68
3	.00	.00	12	2.5	.98	77	5.8	2.2	.53	1.4	17	.53
4	.00	.00	4.5	2.1	.94	180	20	1.9	.64	1.4	7.0	.72
5	.00	.00	2.2	1.7	.90	13	9.6	1.8	.60	1.8	6.0	.64
6	.00	.00	1.9	1.6	.84	10	4.4	1.6	.76	.98	11	.72
7	.00	.00	3.3	1.4	.80	8.9	3.7	1.5	.92	1.0	4.0	1.9
8	.00	.00	11	1.3	.76	6.6	38	1.3	1.6	1.3	3.2	.96
9	.00	.00	3.1	1.2	.73	6.0	32	1.1	1.3	1.1	2.7	.68
10	.00	.00	1.5	1.2	.67	3.5	6.4	1.1	.72	1.1	17	.92
11	.02	.00	1.5	1.2	.67	3.5	33	1.1	.64	1.1	17	.96
12	.36	.00	1.2	1.4	.65	3.3	130	1.3	.64	1.3	3.6	.60
13	1.5	.00	1.0	1.7	.64	3.8	7.8	1.3	.60	3.4	2.9	.44
14	.61	1.1	1.0	1.7	.65	6.6	6.0	1.1	.76	4.0	2.1	.58
15	.48	1.2	1.0	1.4	1.0	3.0	4.9	1.0	.68	1.7	1.7	.54
16	.45	1.1	1.0	1.2	1.5	2.9	3.6	.72	.64	1.2	1.7	.44
17	.41	5.2	.95	2.3	1.5	2.9	3.6	.57	.97	1.3	2.9	.64
18	.36	1.6	.95	1.8	1.4	3.4	3.3	.68	.84	1.1	2.0	.41
19	.32	1.1	1.0	1.3	1.1	20	2.8	1.3	.75	1.1	300	.44
20	.28	.94	2.5	1.2	1.0	11	2.7	1.2	.80	1.0	57	.50
21	.24	.89	2.7	1.3	5.0	7.6	2.6	.84	.88	1.0	21	.54
22	.20	.88	1.6	1.2	8.0	5.1	2.1	.76	.80	1.2	16	.47
23	.17	1.1	1.4	1.5	250	32	1.9	.68	1.0	1.2	6.0	.36
24	.13	.98	1.2	16	10	20	2.7	.57	1.0	1.6	3.3	.41
25	.11	.89	1.1	12	5.5	6.6	5.3	.57	.84	2.6	1.7	.36
26	.13	1.1	1.0	3.7	3.2	4.7	3.9	.68	.80	10	1.4	.29
27	.10	1.1	.94	2.4	3.2	4.5	3.5	1.1	.96	5.4	1.3	.36
28	.08	.98	.90	1.9	2.7	8.0	3.4	.68	.96	250	1.6	.14
29	.05	.93	1.0	1.4	------	30	2.5	.60	.80	30	1.1	.39
30	.02	.93	1.5	1.3	------	30	2.3	.57	.74	9.8	1.0	.47
31	.02	-----	60	1.2	------	10	-----	.68	-----	7.6	.72	-----
Total	6.04	22.02	126.71	110.9	306.46	586.7	377.8	34.70	24.49	350.58	684.92	17.59
Mean	.19	.73	4.09	3.58	10.9	18.9	12.6	1.12	.82	11.3	22.1	.59
Max	1.5	5.2	60	34	250	182	130	2.2	1.6	250	300	1.9
Min	.00	.00	.90	1.2	.64	2.9	1.9	.57	.53	.90	.72	.14

[1]Values 40ft^3/s or greater are estimated.

Table 21.--Field measurements of water-quality and related properties of water at reconnaissance sites on streams draining agricultural and forested lands affected by a surface coal mine, Clay and Vigo Counties, Ind.

[Site numbers plotted in figure 2; ft^3/s, cubic foot per second: °C, degree Celsius; mV, millivolt; µmho/cm, micromho per centimeter; mg/L, milligram per liter; data collected by U.S. Geological Survey]

Sampling date	Instantaneous discharge (ft^3/s)	Water temp (°C)	pH	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Diss. oxygen (mg/L)	Diss. oxygen (percent saturation)
Site 2A at Honey Creek tributary							
13-15-78	0.5	12.5	7.5	+340	1,350	9.6	88
7-25-78	---	22.3	7.2	+286	2,250	8.7	98
10-24-78	NO FLOW						
2-22-79	.1	1.3	8.2	+348	810	15.4	107
8-16-79	---	19.4	7.8	+390	1,800	6.6	70
Site 13 at North Branch Honey Creek							
9-29-77	.01	16.9	6.1	----	3,340	10.2	103
11-18-77	3.0	4.9	7.6	----	444	12.8	98
3-22-78	<.1	7.4	7.4	----	-----	6.5	53
Site 14 at North Branch Honey Creek							
9-29-77	.3	19.1	7.5	----	2,160	9.1	96
3-22-78	15	5.3	6.7	----	-----	6.1	47
5-15-78	-----	13.8	6.8	----	620	10.7	101
7-25-78	2.5	265	7.8	+348	2,400	9.4	116
10-24-78	3.0	11.2	7.5	+470	4,150	13.8	122
12-12-78	6.0	1.8	7.8	+240	3,740	14.0	99
5 -8-79	2.9	29.6	7.4	----	2,460	9.0	115
5-23-79	.8	22.2	8.0	+310	2,820	10.8	120
8-15-79	-----	26	8.8	+382	2,480	8.0	95
10-16-79	.33	12.7	7.9	+400	4,100	----	---
1-17-80	-----	6.4	7.6	----	3,910	10.7	85
Site 16 at Stone Quarry Branch tributary							
9-29-77	0.2	18.9	7.5	----	1,610	9.6	101
3-15-78	8.0	11.4	7.7	+410	390	9.5	85
10-24-78	NO FLOW						
Site 17 at Stone Quarry Branch							
11-18-78	1.0	----	---	----	-----	---	---
3-28-78	2.0	9.4	7.8	----	790	9.5	81
10-24-78	.1	9.0	7.3	+390	2,350	10.2	88
8-16-79	----	26.0	7.7	+395	2,300	8.5	101
10-10-79	.02	12.5	7.9	+410	2,520	8.6	80
11-17-79	.5	7.3	6.9	----	2,000	10.0	82
12- 5-79	----	2.7	7.4	+250	1,820	11.6	84
1-17-80	----	5.9	7.2	----	768	10.0	79

Table 22.--Field measurements of water-quality and related properties of water at reconnaissance sites on streams draining agricultural and forested lands unaffected by a surface coal mine, Clay and Vigo Counties, Ind.

[Site numbers plotted in figure 2; ft^3/s, cubic foot per second; °C, degree Celsius; mV, millivolt; µmho/cm, micromho per centimeter; mg/L, milligram per liter; data collected by U.S. Geological Survey]

Sampling date	Instantaneous discharge (ft^3/s)	Water temp (°C)	pH	Eh (mV)	Specific conductance (µmho/cm at 25° C)	Diss. oxygen (mg/L)	Diss. oxygen (percent saturation)
Site 1A at Lost Creek tributary							
3-22-78	1.3	9.1	7.3	----	---	----	---
3-28-77	1.0	6.7	7.4	----	442	----	---
5-15-78	1.3	11.7	7.1	+230	350	----	---
5-24-78	.8	18.5	7.2	----	359	9.1	95
7-25-78	.3	23.0	7.1	+346	372	----	---
10-24-78	NO FLOW						
2-22-79	-----	.6	7.3	+425	280	----	---
8-16-79	-----	21.0	8.2	+380	60	----	---
10-10-79	NO FLOW						
Site 2 at Lost Creek tributary							
11-17-77	0.1	9.7	7.6	----	385	10.3	88
3-15-78	.6	11.7	7.4	+390	392	9.4	84
3-18-78	12	13.4	7.5	----	396	5.1	48
7-25-78	NO FLOW						
10-24-78	NO FLOW						
2-22-79	.3	.2	8.0	+380	305	11.8	79
8-16-79	NO FLOW						
10-10-79	NO FLOW						
Site 7 at North Branch Honey Creek							
11-17-77	0.02	8.6	7.7	----	487	11.0	92
3-28-78	.1	13.5	7.6	----	550	3.5	33
5-15-78	.6	11.7	7.6	+430	370	9.9	88
7-18-78	NO FLOW						
10-24-78	NO FLOW						
8-16-79	-----	18	7.8	+425	730	8.9	92
12-5-79	-----	3	7.6	+353	610	12.1	88
2-27-79	.02	1.4	7.8	+224	360	----	--
Site 8 at North Branch Honey Creek							
11-17-77	0.5	9.7	7.5	----	349	10.6	97
3-25-78	.4	10.9	7.6	----	408	4.3	40
3-28-78	.7	10.4	7.5	370	305	9.3	86
7-19-78	NO FLOW						
10-24-78	NO FLOW						
2-22-79	7.5	.2	7.8	424	618	12.2	106
8-16-79	----	15.5	7.6	378	365	6.9	60
Site 18 at North Branch Honey Creek							
3-28-78	0.2	5.2	7.2	----	379	6.3	51
7-25-78	NO FLOW						
8-16-78	----	18.5	7.3	----	465	4.3	43
Site 10A at North Branch Honey Creek							
3-22-78	1.5	13.2	7.5	----	408	4.5	44
Site 11 at North Branch Honey Creek							
11-17-77	0.2	11.2	6.8	----	490	8.4	74
3-28-78	3.4	7.3	6.6	----	569	7.0	57
5-15-78	.5	11.0	6.4	+370	517	7.8	69
7-25-78	.1	21.2	6.4	+370	518	6.4	70
10-24-78	NO FLOW						
8-16-79	----	19.0	8.6	+410	562	4.0	42
10-10-79	NO FLOW						
Site 15 at Stone Quarry Branch tributary							
9-29-77	0.02	15.8	7.5	----	238	10.1	100
11-18-78	1.1	5.9	6.9	----	267	----	---
2-22-78	0.39	.5	7.6	425	200	----	---
3-28-78	2.2	4.5	6.4	----	---	----	---
5-15-78	4.8	14.0	7.4	+350	300	----	---
7-25-78	0.1	25.0	6.8	+320	290	----	---
12-12-78	1.5	2.5	7.2	+420	744	----	---
5-23-79	NO FLOW						
8-16-79	----	18.5	7.6	+360	340	----	---
12-5-79	.05	3.6	7.8	+280	260	----	---
1-17-80	.01	5.3	7.9	----	265	11.2	87
Site 20 at Big Slough							
9-29-77	0.02	16.3	7.7	----	456	10.0	100
11-18-78	.98	6.2	7.1	----	413	----	---
3-28-78	.07	5.9	7.5	----	390	----	---
5-15-78	2.61	10.4	7.4	+435	338	----	---
7-25-78	.02	23.8	6.3	+354	508	----	---
10-24-78	NO FLOW						
2-21-79	3.0	.2	8.2	+430	180	----	---
5-23-79	0.01	14.7	7.5	+315	460	----	---
8-16-79	----	18.6	7.6	+385	460	----	---
10-10-79	NO FLOW						
Site 21 at Big Slough							
7-20-78	0.1	30.5	7.5	+305	595	----	---
2-22-79	8.9	.4	8.2	+532	210	----	---
5-23-79	.3	17.5	7.7	+332	480	11.7	119
8-16-79	.23	24	7.7	+370	460	9.8	113
10-10-79	NO FLOW						
11-7-79	.1	7.6	7.7	+270	600	13.3	109
12-5-79	.71	4.9	7.7	+290	492	12.2	93
1-17-80	2.4	5.3	7.3	----	387	10.9	78
2-27-80	3.0	2.6	7.7	+201	420	----	---
Site 22 at Big Brush							
3-22-78	0.4	5.7	7.6	----	---	10.0	67
7-20-78	NO FLOW						
10-24-78	NO FLOW						
8-26-79	NO FLOW						
10-10-79	NO FLOW						
Site 23 at Brush Creek							
5-15-78	1.8	10.3	7.5	+408	278	9.5	83
7-20-78	NO FLOW						
10-24-78	NO FLOW						
8-16-79	----	19.5	7.7	+400	408	9.3	99

Table 23.--Field and laboratory measurements of water quality and related properties of water at sites on streams draining agricultural and forested lands affected by a surface coal mine, Clay and Vigo, Counties, Ind.

[Constituents dissolved unless otherwise stated: site numbers plotted in figure 2; ft^3/s, cubic foot per second; °C, degree Celsius; NF, no flow; mg/L, milligram per liter; mV, millivolt; µmho/cm, micromho per centimeter; samples collected and analyzed by U.S. Geological Survey]

	Site 1 at Sulphur Creek tributary					Site 14 at Honey Creek tributary near Riley, Ind.	
Sampling date	11-17-77	3-29-78	5-16-78	7-21-78	10-21-78	5-8-79	10-16-79
Sampling time[1]	1625	1645	1700	1000	--------	1700	1000
Instantaneous discharge (ft^3/s)	0.41	0.99	4.8	0.38	0.03	2.9	.33
Water temperature (°C)	9.0	13.2	15.4	24.8	11.6	29.6	12.7
pH	7.4	7.7	7.7	8.0	7.8	7.4	7.9
Eh (mV)	--------	--------	--------	340	464	-------	-------
Specific conductance (µmho/cm at 25° C)	1,130	3,100	2,530	3,500	3,400	2,460	4,100
Dissolved solids, residue at 180° C (mg/L)	1,090	1,950	2,470	3,140	--------	2,490	415
Hardness, noncarbonate (mg/L)	500	920	1,400	1,700	--------	1,300	1,000
Hardness, total (mg/L)	630	1,000	1,600	1,900	--------	1,500	1,300
Alkalinity as $CaCO_3$ (mg/L)	130	120	240	210	--------	110	210
Acidity (mg/L)	.0	.0	.0	.2	--------	.0	.0
Dissolved oxygen (mg/L)	10.7	5.0	8.3	7.6	8.6	9.0	10.0
Silica (mg/L)	-------	10	11	7.6	--------	2.7	4.3
Sodium (mg/L)	72	75	110	140	--------	130	430
Potassium (mg/L)	12	4.8	8.7	11	--------	9.4	21
Calcium (mg/L)	170	260	370	440	--------	300	220
Magnesium (mg/L)	51	96	170	200	--------	170	170
Chloride (mg/L)	9.3	3.8	5.0	3.2	--------	2.7	5.8
Fluoride (mg/L)	.2	.2	.3	.2	--------	.2	.4
Sulfate (mg/L)	560	1,500	1,400	1,900	--------	1,600	2,000
Organic carbon (mg/L)	23	--------	3.0	5.4	--------	-------	20
Organic carbon, suspended (mg/L)	.6	1.2	2.6	-------	--------	-------	.7
Phosphorus as P (mg/L)	--------	.00	.00	.01	--------	.1	-------

Table 23.--Field and laboratory measurements, of water quality and related properties of water at sites on streams draining agricultural and forested lands affected by a surface coal mine, Clay and Vigo, Counties, Ind.--Continued

Site 18 at Stone Quarry Branch													
Sampling date	9-29-77	11-18-77	3-29-78	5-16-78	7-19-78	10-24-78	12-2-78	2-24-79	5-23-79	8-16-79	10-10-79	11-11-79	12-15-79
Sampling time[1]	1125	1110	1300	1010	1630	1515	1535	1415	1115	1550	----	-------	-------
Instantaneous discharge (ft^3/s)	0.6	1.9	3.0	7.6	0.6	0.08	0.77	10.0	0.3	3.1	NF	0.3	0.9
Water temperature (°C)	15.2	5.2	12.0	13.0	27.3	10.0	1.2	.2	16.5	21.6	NF	7.2	4.1
pH	7.9	7.9	7.8	7.8	7.6	7.5	8.0	7.9	8.1	7.8	NF	7.6	7.8
Eh (mV)	-------	-----	-----	------	289	470	368	456	320	400	NF	310	160
Specific conductance (µmho/cm at 25° C)	3,240	444	860	350	912	2,400	700	950	2,400	1,880	NF	1,840	1,610
Dissolved solids, residue at 180° C (mg/L)	3,240	310	479	230	515	1,670	409	641	2,600	2,050	NF	-------	-------
Hardness, noncarbonate (mg/L)	1,600	110	230	59	240	580	130	270	1,200	1,200	NF	-------	640
Hardness, total (mg/L)	1,900	210	330	140	340	730	240	360	1,500	1,000	NF	-------	730
Alkalinity as $CaCO_3$ (mg/L)	320	98	98	81	100	150	110	82	280	77	NF	-------	94
Acidity (mg/L)	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0	NF	-------	.0
Dissolved oxygen (mg/L)	9.8	13	5.6	9.4	------	8.9	14	15.4	9.5	7.8	NF	-------	7.8
Silica (mg/L)	-------	-----	6.6	7.5	4.7	2.6	13	5.8	6.6	5.3	NF	-------	8.0
Sodium (mg/L)	280	11	18	5.9	26	190	34	44	160	180	NF	-------	77
Potassium (mg/L)	16	6.4	4.2	4.1	4.8	10	6	4.6	13	9.5	NF	-------	7
Calcium (mg/L)	410	54	77	38	81	160	59	78	330	250	NF	-------	180
Magnesium (mg/L)	210	18	33	11	33	80	22	39	170	91	NF	-------	80
Chloride (mg/L)	4.7	13	9.4	11	12	8.8	13	9.5	7.7	5.0	NF	-------	15
Fluoride (mg/L)	.2	.2	.2	.2	.3	.5	.1	.2	.2	.3	NF	-------	.4
Sulfate (mg/L)	2,300	110	230	59	250	850	170	310	1,400	1,000	NF	-------	800
Organic carbon (mg/L)	-------	-----	-----	16	6.6	3.1	6.0	6.5	4.6	1.8	NF	-------	-------
Organic carbon suspended (mg/L)	-------	6.8	-----	1.7	------	.8	------	------	.2	.4	NF	-------	-------
Phosphorus as P (mg/L)	-------	-----	4.2	.01	.01	.01	.01	.05	.0	.0	NF	-------	.0

[1]For example, 1625 is 4:25 p.m. eastern standard time.

Table 24.--Field and laboratory measurements, of water quality and related properties of water at sites on streams draining reclaimed land in a surface coal mine, Clay and Vigo, Counties, Ind.

[Constituents dissolved unless otherwise stated; site numbers plotted in figure 2; ft^3/s, cubic foot per second; °C, degree Celsius; NF, no flow; mg/L, milligram per liter; mV, millivolt; µmho/cm, micromho per centimeter; samples collected and analyzed by U.S. Geological Survey]

	Site 3 at Honey Creek									Site 4 at Honey Creek
Sampling date	11-18-77	5-16-78	7-20-78	10-25-78	12-13-78	2-21-79	5-23-79	8-16-79	10-10-79	8-16-79
Sampling time[1]	----	1435	1200	1250	1610	1525	1245	0850	----	0955
Instantaneous discharge (ft^3/s)	0.36	2.0	0.15	0.02	0.26	------	0.4	0.25	-------	9.6
Water temperature (°C)	7.3	16.2	26.5	10.7	3.0	0.2	16.7	16.6	12.2	17.5
pH	7.8	7.9	7.8	6.7	7.7	7.9	7.9	7.8	8.0	8.0
Eh (mV)	------	------	--------	513	--------	360	310	340	418	340
Specific conductance (µmho/cm at 25° C)	781	990	1,700	3,660	1,650	628	2,260	2,210	3,310	2,700
Dissolved solids, residue at 180° C (mg/L)	798	727	2,810	3,480	1,620	385	2,240	2,830	-------	3,140
Hardness, noncarbonate (mg/L)	450	360	840	2,100	800	210	1,200	1,700	-------	1,800
Hardness, total (mg/L)	630	500	1,000	2,600	1,100	290	1,600	1,800	-------	2,000
Alkalinity as $CaCO_3$ (mg/L)	160	140	170	500	330	86	360	440	-------	160
Acidity (mg/L)	.0	.0	.1	.0	.0	.0	.0	.0	-------	0
Dissolved oxygen (mg/L)	12.4	8.7	9.2	16.4	--------	15.4	13.2	7.4	16.5	8.5
Silica (mg/L)	------	6.8	8.4	14	8.7	4.6	9.1	13	-------	4.4
Sodium (mg/L)	10	8.6	19	48	21	5.9	29	32	-------	100
Potassium (mg/L)	5.0	4.5	8.5	10	5.6	3.2	7.1	9.3	-------	10
Calcium (mg/L)	170	120	260	550	270	79	340	310	-------	420
Magnesium (mg/L)	50	48	88	290	110	23	180	250	-------	230
Chloride (mg/L)	12	11	10	7.3	10	6.9	8.9	8.3	-------	8.3
Fluoride (mg/L)	.2	.2	.2	.1	.2	.1	.2	.2	-------	.3
Sulfate (mg/L)	380	350	760	2,000	830	180	1,200	1,600	-------	1,500
Organic carbon (mg/L)	------	4.9	9.4	4.7	3.7	4.6	4.8	5.7	-------	------
Organic carbon, suspended (mg/L)	.7	1.4	--------	.7	--------	-----	.3	.1	-------	.3
Phosphorus as P (mg/L)	-----	.00	.01	.01	.0	.02	.0	.0	-------	.0

Table 24.--Field and laboratory measurements of water quality and related properties of water at sites on streams draining reclaimed land in a surface coal mine, Clay and Vigo, Counties, Ind.--Continued

Site 5 at Honey Creek											
Sampling date	9-29-77	11-17-77	3-29-78	5-16-78	12-12-78	2-21-79	5-23-79	8-16-79	10-10-79	11-7-79	12-5-79
Sampling time[1]	1020	1240	1010	1215	1335	1220	1140	1600	1230	-------	-------
Instantaneous discharge	0.12	7.1	5.6	7.6	1.3	--------	-------	3.6	6.1	3.9	2.4
Water temperature (°C)	19.9	10.9	5.4	14.5	2.6	0.2	20.4	25	16.1	11.7	3.8
pH	7.7	7.7	7.6	8.1	8.2	8.0	8.0	7.8	8.1	8.0	8.7
Eh (mV)	--------	-------	--------	-------	508	442	310	395	210	340	300
Specific conductance (µmho/cm at 25° C)	2,400	1,750	1,300	1,400	1,980	1,000	2,500	2,400	3,000	3,200	2,120
Dissolved solids, residue at 180° C (mg/L)	2,120	2,140	818	1,040	2,370	809	2,510	1,980	2,940	-------	-------
Hardness, noncarbonate (mg/L)	1,400	1,300	470	590	3,000	460	1,500	1,200	1,600	-------	-------
Hardness, total (mg/L)	1,600	1,500	570	720	3,200	540	1,600	1,300	1,400	-------	-------
Alkalinity as $CaCO_3$ (mg/L)	110	160	110	130	200	78	180	140	190	-------	-------
Acidity (mg/L)		.0	.0	.0	.0	.0	.0	.0	.0	-------	-------
Dissolved oxygen (mg/L)	10.4	9.5	7.8	9.9	13.6	--------	10.4	12.8	9.1	10.0	13.0
Silica (mg/L)	--------	-------	6.3	4.6	6.3	3.0	4.7	5.6	6.8	-------	-------
Sodium (mg/L)	60	66	17	21	74	31	59	46	87	-------	-------
Potassium (mg/L)	9.6	9.6	2.9	4.3	9.6	4.7	8.2	7.4	10	-------	-------
Calcium (mg/L)	310	310	130	160	970	130	330	270	290	-------	-------
Magnesium (mg/L)	190	170	60	79	180	52	200	160	220	-------	-------
Chloride (mg/L)	8.7	11	22	15	14	25	13	8.3	11	-------	-------
Fluoride (mg/L)	.2	.3	.1	.2	.3	.1	.3	.2	.3	-------	-------
Sulfate (mg/L)	1,500	1,300	450	580	1,400	480	1,500	950	1,800	-------	-------
Organic carbon (mg/L)	--------	-------	--------	6.0	3.4	--------	9.5	4.8	5.0	-------	-------
Organic carbon, suspended (mg/L)	--------	2.8	1.2	2.1	--------	--------	-------	.6	.7	-------	-------
Phospohorus as P (mg/L)	--------	-------	.02	.0	.0	.03	.0	.0	.0	-------	-------

[1]For example, 1435 is 2:35 p.m. Eastern Standard Time.

Table 25.--Field and laboratory measurements of water quality and related properties of water at sites on streams affected by a transition in land use in and around an active surface coal mine, Clay and Vigo Counties, Ind.

[Constituents dissolved unless otherwise stated; site numbers plotted in figure 2; °C, degree Celsius; ft^3/s, cubic foot per second; mV, millivolt; µmho/cm, micromho per centimeter; data collected by U.S. Geological Survey; land use was agricultural and forested lands unaffected by mining operations before October 1978; after October 1978, the stream was affected by mining of the West Field; a settling pond was installed upstream from site 9 in September 1979]

	Site 9 at North Branch Honey Creek		Site 12 at North Branch Honey Creek										
Sampling date	5-23-79	8-16-79	9-29-77	11-17-77	3-29-78	5-16-78	7-20-78	12-27-78	2-21-79	5-23-79	8-14-79	10-10-79	12-5-79
Sampling time[1]	1400	1230	1435	1605	1445	1535	1130	1135	1130	1340	1800	0925	----
Instantaneous discharge, (ft^3/s)	0.61	1.2	0.2	3.0	3.5	5.8	.14	1.1	--------	.68	2.3	.27	2.5
Water temperature (°C)	20	22	19.5	9.5	11.4	14.4	23	.9	.2	16.5	20	8.3	3.3
pH	8.1	7.1	7.9	7.5	7.4	7.5	7.4	7.0	8.0	8.1	7.1	7.7	7.9
Eh (mV)	+310	+411	-----	-----	-----	-----	------	392	400	330	410	462	270
Specific conductance (µmho/cm at 25° C)	3,080	2,700	474	446	480	393	615	708	1,400	2,720	2,300	3,400	1,100
Dissolved solids, residue at 180° C (mg/L)	3,030	2,580	270	334	231	258	301	539	1,150	2,780	2,220	1,650	--------
Hardness, noncarbonate (mg/L)	1,600	1,300	31	100	80	71	46	220	450	1,400	1,100	1,200	370
Hardness, total (mg/L)	1,800	1,400	190	190	170	150	210	330	620	1,600	1,300	1,300	490
Alkalinity as $CaCO_3$ (mg/L)	240	83	160	90	90	81	160	110	170	240	230	170	120
Acidity (mg/L	.0	.0	.0	.0	.0	.0	.2	.0	.0	.0	.0	.0	.0
Dissolved oxygen (mg/L)	12.7	8.9	16.8	10.6	5.8	8.5	------	13.8	14.7	9.9	7.0	10.4	12.7
Silica (mg/L)	7.8	10	-----	-----	11	11	14	7.8	9.3	8.1	11.0	7.3	9.6
Sodium (mg/L)	180	110	14	11	7.7	8	13	28	83	160	140	220	7.7
Potassium (mg/L)	14	11	8.0	8	2.1	3	3.1	4.6	5.2	13	9.9	12	6.7
Calcium (mg/L)	410	280	50	52	44	41	56	84	150	360	300	240	120
Magnesium (mg/L)	190	160	17	15	15	12	16	30	60	170	140	180	47
Chloride (mg/L)	5.3	5.6	22	25	16	15	17	11	11	6.3	7.6	8.1	14
Fluoride (mg/L)	.2	.2	.1	.1	.1	.2	.2	.1	.1	.2	.2	.2	.2
Sulfate (mg/L)	1,800	1,500	38	75	71	61	41	250	640	1,600	1,000	1,900	430
Organic carbon (mg/L)	--------	-------	-----	25	-----	9.5	9.8	4.6	3.6	4.6	9.1	3.6	------
Organic carbon, suspended (mg/L)	--------	-------	-----	.8	1.7	1.3	------	-----	--------	.4	.2	1.5	------
Phosphorus as P (mg/L)	.0	.0	----	-----	.0	.0	.01	.0	.03	.01	.01	.01	.01

[1]For example, 1400 is 2:00 p.m. eastern standard time.

Table 26.--Field and laboratory measurements of water quality and related properties of water at sites on streams draining agricultural and forested lands unaffected by a surface coal mine, Clay and Vigo Counties, Ind.

[Constituents dissolved unless otherwise stated; site numbers plotted in figure 2; °C, degree Celsius; ft^3/s, cubic foot per second; mV, millivolt; µmho/cm, micromho per centimeter; NF, no flow; data collected by U.S. Geological Survey]

Site 1A at Lost Creek tributary			
Sampling date	5-24-78	Acidity (mg/L)	.0
Sampling time[1]	1315	Dissolved oxygen (mg/L)	9.1
Instantaneous discharge (ft^3/s)	.83	Silica (mg/L)	13
		Sodium (mg/L)	9
Water temperature (°C)	18.5		
		Potassium (mg/L)	2.6
pH	7.3		
		Calcium (mg/L)	36
Eh (mV)	-----		
		Magnesium (mg/L)	13
Specific conductance (µmho/cm at 25° C)	339	Chloride (mg/L)	17
Dissolved solids, residue at 180° C (mg/L)	244	Fluoride (mg/L)	.1
		Sulfate (mg/L)	59
Hardness, noncarbonate (mg/L)	72		
		Organic carbon (mg/L)	-----
Hardness, total (mg/L)	140		
		Organic carbon, suspended (mg/L)	-----
Alkalinity as $CaCO_3$ (mg/L)	71		
		Phosphorus as P (mg/L)	.01

Table 26.--Field and laboratory measurements of water quality and related properties of water at sites on streams draining agricultural and forested lands unaffected by a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Site 15 at Stone Quarry Branch			
Sampling date	9-29-77	Dissolved oxygen (mg/L)	10.1
Sampling time[1]	1550	Silica (mg/L)	----
Instantaneous discharge (ft^3/s)	.02	Sodium (mg/L)	5.3
Water temperature (°C)	15.8	Potassium (mg/L)	4.1
pH	7.5	Calcium (mg/L)	29
Eh (mV)	------	Magnesium (mg/L)	9
Specific conductance (µmho/cm at 25° C)	238	Chloride (mg/L)	5.6
Dissolved solids, residue at 180° C (mg/L)	136	Fluoride (mg/L)	.1
Hardness, noncarbonate (mg/L)	19	Sulfate (mg/L)	20
Hardness, total (mg/L)	110	Organic carbon (mg/L)	----
Alkalinity as $CaCO_3$ (mg/L)	90	Organic carbon, suspended (mg/L)	----
Acidity (mg/L)	.0	Phosphorus as P (mg/L)	----

Table 26.--Field and laboratory measurements of water quality and related properties of water at sites on streams draining agricultural and forested lands unaffected by a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Site 20 at Big Slough			
Sampling date	9-29-80	Acidity (mg/L)	.0
Sampling time[1]	1215	Dissolved oxygen (mg/L)	10
Instantaneous discharge (ft^3/s)	.02	Silica (mg/L)	6.3
		Sodium (mg/L)	16
Water temperature (°C)	16.3	Potassium (mg/L)	3.1
pH	7.7	Calcium (mg/L)	45
Eh (mV)	-----	Magnesium (mg/L)	18
Specific conductance (µmho/cm at 25° C)	456	Chloride	26
Dissolved solids, residue at 180° C (mg/L)	265	Fluoride (mg/L)	.1
		Sulfate (mg/L)	53
Hardness, noncarbonate (mg/L)	63	Organic carbon (mg/L)	----
Hardness, total (mg/L)	190	Organic carbon, suspended (mg/L)	----
Alkalinity as $CaCO_3$ (mg/L)	120	Phosphorus as P (mg/L)	----

Table 26.--Field and laboratory measurements of water quality and related properties of water at sites on streams draining agricultural and forested lands unaffected by a surface coal mine, Clay and Vigo Counties, Ind.--Continued

	Site 21 at Big Slough				
Sampling date	7-20-78	2-22-79	5-23-79	8-16-79	12-5-79
Sampling time[1]	1830	1030	1045	1700	1320
Instantaneous discharge, (ft^3/s)	0.1	8.9	0.3	0.23	0.71
Water temperature (°C)	30.5	.4	17.5	24	4.9
pH	7.5	8.2	7.7	7.7	7.7
Eh (mV)	305	532	332	370	290
Specific conductance (µmho/cm at 25° C)	595	210	480	460	492
Dissolved solids, residue at 180° C (mg/L)	252	120	308	294	------
Hardness, noncarbonate (mg/L)	50	38	65	59	92
Hardness, total (mg/L)	180	71	200	190	200
Alkalinity as $CaCO_3$ (mg/L)	130	33	140	130	110
Acidity (mg/L)	.1	.0	.0	.0	.0
Dissolved oxygen (mg/L)	------	------	11.7	9.8	12.2
Silica (mg/L)	14	6.3	8.6	16	16
Sodium (mg/L)	12	4.6	14	15	15
Potassium (mg/L)	2.7	4.0	1.7	2.0	2.6
Calcium (mg/L)	49	19	54	51	53
Magnesium (mg/L)	14	5.6	17	15	17
Chloride (mg/L)	18	12	17	18	25
Fluoride (mg/L)	.2	.1	.2	.2	.2
Sulfate (mg/L)	44	31	77	52	85
Organic carbon (mg/L)	9.0	5.4	5.1	5.7	------
Organic carbon, suspended (mg/L)	------	------	.8	.1	------
Phosphorus as P (mg/L)	.01	.15	.0	.06	.01

[1]For example, 1315 is 1:15 p.m. eastern standard time.

Table 27.--Concentrations of metals and trace elements in water at sites on streams draining agricultural and forested lands affected by a surface coal mine, Clay and Vigo Counties, Ind.

[Concentrations in micrograms per liter; diss., dissolved; tot., dissolved plus suspended phases; site numbers plotted in figure 2; data collected by U.S. Geological Survey]

Site 1 at Sulphur Creek tributary									
Sampling date	11-17-77	3-29-78	5-16-78	7-21-78	Sampling date	11-17-77	3-29-78	5-16-78	7-21-78
Aluminum, diss.	50	40	50	20	Chromium, diss.	0	-----	-----	0
Aluminum, tot.	210	3,330	730	270	Chromium, tot.	10	-----	-----	20
Iron, diss.	30	30	0	50	Copper, diss.	4	-----	-----	0
Iron, tot.	460	7,700	8,600	1,000	Copper, tot.	3	-----	-----	0
Manganese, diss.	51	3,600	3,100	3,000	Lead, diss.	0	-----	-----	5
Manganese, tot.	200	-----	-----	3,100	Lead, tot.	1	-----	-----	3
Arsenic, diss.	---	-----	-----	1	Mercury, diss.	---	-----	-----	.5
Arsenic, tot.	---	-----	-----	-------	Mercury, tot.	---	-----	-----	-------
Beryllium, diss.	3	-----	-----	0	Nickel, diss.	17	-----	-----	58
Beryllium, tot.	3	-----	-----	0	Nickel, tot.	19	-----	-----	-------
Boron, diss.	---	-----	-----	-------	Selenium, diss.	---	-----	-----	2
Boron, tot.	---	-----	-----	610	Selenium, tot.	---	-----	-----	-------
Cadmium, diss.	0	-----	-----	0	Zinc, diss.	10	-----	-----	0
Cadmium, tot.	0	-----	-----	0	Zinc, tot.	10	-----	-----	20

Table 27.--Concentrations of metals and trace elements in water at sites on streams draining agricultural and forested lands affected by a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Site 14 at Honey Creek tributary near Riley, Ind.					
Sampling date	5-8-79	10-16-79	Sampling date	5-8-79	10-16-79
Aluminum, diss.	---	-----	Chromium, diss.	----	----
Aluminum, tot.	120	40	Chromium, tot.	10	20
Iron, diss.	30	50	Copper, diss.	----	----
Iron, tot.	460	340	Copper, tot.	1	2
Manganese, diss.	100	1,100	Lead, diss.	----	----
Manganese, tot.	240	1,100	Lead, tot.	14	0
Arsenic, diss.	---	-----	Mercury, diss.	----	----
Arsenic, tot.	0	2	Mercury, tot.	<.5	.1
Beryllium, diss.	---	-----	Nickel, diss.	----	----
Beryllium, tot.	---	-----	Nickel, tot.	----	58
Boron, diss.	---	-----	Selenium, diss.	----	----
Boron, tot.	180	20	Selenium, tot.	1	1
Cadmium, diss.	---	-----	Zinc, diss.	----	----
Cadmium, tot.	1	0	Zinc, tot.	40	20

Table 27.--Concentrations of metals and trace elements in water at sites on streams draining agricultural and forested lands affected by a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Site 18 at Stone Quarry Branch											
Sampling date	9-29-77	11-18-77	3-29-78	5-16-78	7-19-78	10-24-78	12-2-78	2-21-79	5-23-79	8-16-79	12-5-79
Aluminum, diss.	10	80	40	40	30	10	0	0	10	60	40
Aluminum, tot.	40	280	3,000	1,500	140	50	320	0	30	160	800
Iron, diss.	10	50	40	90	80	10	10	40	100	1	380
Iron, tot.	60	780	3,200	1,800	490	110	1,100	3,700	130	420	4,100
Manganese, diss.	890	70	580	110	240	90	580	710	810	3,100	2,700
Manganese, tot.	910	180	-----	111	280	90	590	710	760	3,200	2,700
Arsenic, diss.	---	---	-----	-----	1	1	0	1	1	1	0
Arsenic, tot.	---	---	-----	-----	-----	-----	1	1	1	1	-------
Beryllium, diss.	---	---	-----	-----	0	0	0	0	0	0	0
Beryllium, tot.	---	---	-----	-----	0	0	0	0	0	0	0
Boron, diss.	---	---	-----	-----	-----	-----	-----	-----	-----	430	210
Boron, tot.	---	---	-----	-----	160	460	140	250	460	440	190
Cadmium, diss.	0	0	-----	-----	1	1	0	0	0	2	0
Cadmium, tot.	0	0	-----	-----	1	1	0	0	1	2	1
Chromium, diss.	0	2	-----	-----	1	2	0	0	10	10	10
Chromium, tot.	<10	<10	-----	-----	10	10	<10	10	30	20	10
Copper, diss.	0	4	-----	-----	1	1	2	1	1	3	2
Copper, tot.	0	3	-----	-----	3	1	3	4	2	5	7
Lead, diss.	0	0	-----	-----	0	11	3	0	4	8	7
Lead, tot.	3	1	-----	-----	0	10	4	0	7	7	0
Mercury, diss.	---	---	-----	-----	.5	<.5	<.5	<.5	-----	<.5	.3
Mercury, tot.	---	---	-----	-----	.5	<.5	<.5	<.5	<.5	<.5	-------
Nickel, diss.	210	12	-----	-----	47	46	45	38	88	180	310
Nickel, tot.	240	16	-----	-----	-----	60	77	56	110	190	310
Selenium, diss.	---	---	-----	-----	6	9	2	2	0	5	7
Selenium, tot.	---	---	-----	-----	-----	-----	2	2	1	5	-------
Zinc, diss.	10	0	-----	-----	10	10	0	0	0	60	70
Zinc, tot.	20	0	-----	-----	20	20	0	30	90	80	90

Table 28.--Concentration of metals and trace elements in water at sites on streams draining reclaimed lands in a surface coal mine, Clay and Vigo Counties, Ind.

[Concentrations in micrograms per liter; diss., dissolved; tot., dissolved plus suspended phases; site numbers plotted in figure 2; data collected by U.S. Geological Survey]

Site 3 at Honey Creek								
Sampling date	11-18-77	5-16-78	7-20-78	10-25-78	2-13-78	7-21-79	5-23-78	8-16-79
Aluminum, diss.	40	40	20	10	0	0	0	0
Aluminum, tot.	110	980	60	40	30	0	40	100
Iron, diss.	30	10	70	60	30	50	90	90
Iron, tot.	390	2,000	550	290	2,100	5,900	1,500	660
Manganese, diss.	230	310	1,600	5,400	2,200	390	2,800	230
Manganese, tot.	230	-----	1,700	5,500	2,200	420	3,300	3,300
Arsenic, diss.	---	-----	1	1	1	1	1	2
Arsenic, tot.	---	-----	-------	-------	1	1	2	2
Beryllium, diss.	---	-----	0	0	0	0	0	0
Beryllium, tot.	---	-----	0	0	0	0	0	0
Boron, diss.	0	-----	-------	-------	-------	-------	-------	310
Boron, tot.	0	-----	150	480	180	170	230	340
Cadmium, diss.	0	-----	1	0	0	0	1	1
Cadmium, tot.	0	-----	1	1	0	0	1	1
Chromium, diss.	0	-----	1	2	0	0	20	20
Chromium, tot.	<10	-----	10	10	20	10	30	20
Copper, diss.	0	-----	1	1	1	1	2	2
Copper, tot.	3	-----	3	1	2	5	3	3
Lead, diss.	0	-----	4	5	0	0	0	1
Lead, tot.	0	-----	2	6	2	2	4	5
Mercury, diss.	---	-----	.5	<.5	<.5	<.5	-------	<.5
Mercury, tot.	---	-----	-------	-------	<.5	<.5	<.5	<.5
Nickel, diss.	1	-----	11	35	3	2	14	14
Nickel, tot.	3	-----	-------	49	34	19	46	16
Selenium, diss.	---	-----	0	0	1	1	0	0
Selenium, tot.	---	-----	-------	-------	1	1	0	0
Zinc, diss.	10	-----	10	20	0	0	0	20
Zinc, tot.	10	-----	10	20	0	20	20	30

Table 28.--Concentrations of metals and and trace elements in water at sites on streams draining reclaimed lands in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Site 4 at Honey Creek			
Sampling date 8-16-79			
Aluminum, diss.	10	Chromium, diss.	10
Aluminum, tot.	50	Chromium, tot.	20
Iron, diss.	90	Copper, diss.	1
Iron, tot.	170	Copper, tot.	1
Manganese, diss.	260	Lead, diss.	3
Manganese, tot.	280	Lead, tot.	4
Arsenic, diss.	1	Mercury, diss.	<.5
Arsenic, tot.	1	Mercury, tot.	<.5
Beryllium, diss.	0	Nickel, diss.	24
Beryllium, tot.	0	Nickel, tot.	24
Boron, diss.	460	Selenium, diss.	0
Boron, tot.	460	Selenium, tot.	1
Cadmium, diss.	0	Zinc, diss.	10
Cadmium, tot.	1	Zinc, tot.	30

Table 28.--Concentrations of metals and trace elements in water at sites on streams draining reclaimed lands in a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Site 5 at Honey Creek									
Sampling date	9-29-77	11-17-77	3-29-78	5-16-78	12-12-78	2-21-79	5-23-79	8-16-79	10-10-79
Aluminum, diss.	20	60	40	30	10	0	10	10	40
Aluminum, tot.	130	330	280	360	110	0	380	80	60
Iron, diss.	10	20	90	20	20	50	40	60	60
Iron, tot.	200	600	510	630	360	2,600	870	190	170
Manganese, diss.	30	100	590	160	670	460	200	250	340
Manganese, tot.	50	140	---	---	680	450	260	1,000	480
Arsenic, diss.	---	---	---	---	1	1	1	1	2
Arsenic, tot.	---	---	---	---	1	1	1	1	3
Beryllium, diss.	---	---	---	---	0	0	0	0	0
Beryllium, tot.	---	---	---	---	0	0	0	0	0
Boron, diss.	---	---	---	---	-----	-------	-----	360	370
Boron, tot.	---	---	---	---	360	240	280	360	380
Cadmium, diss.	0	0	---	---	0	0	2	1	1
Cadmium, tot.	0	0	---	---	0	0	2	1	1
Chromium, diss.	0	1	---	---	0	0	20	10	20
Chromium, tot.	50	20	---	---	30	10	30	20	30
Copper, diss.	0	3	---	---	3	1	4	2	1
Copper, tot.	2	3	---	---	12	3	3	3	4
Lead, diss.	4	0	---	---	2	0	0	3	2
Lead, tot.	5	0	---	---	2	1	5	2	3
Mercury, diss.	---	---	---	---	<.5	<.5	-----	<.5	.1
Mercury, tot.	---	---	---	---	<.5	<.5	<.5	<.5	.1
Nickel, diss.	12	10	---	---	9	21	16	8	19
Nickel, tot.	12	10	---	---	42	29	34	11	22
Selenium, diss.	---	---	---	---	3	2	2	0	1
Selenium, tot.	---	---	---	---	3	2	2	2	3
Zinc, diss.	10	10	---	---	0	0	0	10	10
Zinc, tot.	20	10	---	---	0	20	110	60	40

Table 29.--Concentrations of metals and trace elements in water at sites on streams affected by a transition in land use in and around a surface coal mine, Clay and Vigo Counties, Ind.

[Concentrations in micrograms per liter; diss., dissolved; tot., dissolved plus suspended phases; site numbers plotted in figure 2; land use was agricultural and forested lands lands unaffected by mining before October 1978; after october 1978, the stream was affected by mining of the West Field; a settling pond was installed upstream from site 9 in September 1979; data collected by U.S. Geological Survey]

Site 9 at North Branch Honey Creek					
Sampling date	5-23-78	8-16-79	Sampling date	5-23-78	8-16-79
Aluminum, diss.	10	10	Chromium, diss.	20	10
Aluminum, total	60	220	Chromium, tot.	30	20
Iron, diss.	100	70	Copper, diss.	2	0
Iron, tot.	200	730	Copper, tot.	2	4
Manganese, diss.	1,300	1,800	Lead, diss.	4	1
Manganese, tot.	1,300	1,800	Lead, tot.	5	7
Arsenic, diss.	2	2	Mercury, diss.	----	<.5
Arsenic, tot.	2	2	Mercury, tot.	.5	<.5
Beryllium, diss.	0	0	Nickel, diss	200	110
Beryllium, tot.	0	0	Nickel, tot.	200	130
Boron, diss.	-----	720	Selenium, diss.	4	1
Boron, tot.	700	830	Selenium, tot.	4	1
Cadium, diss.	1	0	Zinc, diss.	0	10
Cadium, tot.	1	1	Zinc, tot.	10	50

Table 30.--Concentrations of metals and trace elements in water at sites on streams draining agricultural and forested land unaffected by a surface coal mine, Clay and Vigo Counties, Ind.

[Concentrations in micrograms per liter; diss., dissolved; tot., dissolved plus suspended phases: site numbers plotted in figure 2; data collected by U.S. Geological Survey]

Site 1 at Lost Creek Tributary	
Sampling date	5-24-78
Aluminum, diss.	40
Aluminum, tot.	90
Iron, diss.	100
Iron, tot.	780
Manganese, diss.	110

Site 15 at Stone Quarry Branch tributary			
Sampling date	9-29-77	Chromium, diss.	0
Aluminum, diss.	20	Chromium, tot.	0
Aluminum, tot.	180	Copper, diss.	0
Iron, diss.	110	Copper, tot.	5,000
Iron, tot.	250	Lead, diss.	3
Manganese, diss.	320	Lead, tot.	4
Arsenic, diss.	---	Mercury, diss.	-----
Arsenic, tot.	---	Mercury, tot.	-----
Beryllium, diss.	---	Nickel, diss.	6
Beryllium, tot.	---	Nickel, tot.	6
Boron, diss.	---	Selenium, diss.	-----
Boron, tot.	---	Selenium, tot.	-----
Cadmium, diss.	0	Zinc, diss.	0
Cadmium, tot.	0	Zinc, tot.	20

Site 20 at Big Slough			
Sampling date	9-29-77	Chromium, diss.	0
Aluminum, diss.	20	Chromium, tot.	<10
Aluminum, total	160	Copper, diss.	0
Iron, diss.	60	Copper, tot.	2
Iron, tot.	230	Lead, diss.	3
Manganese, diss.	50	Lead, tot.	3
Manganese, tot.	50	Mercury, diss.	---
Arsenic, diss.	---	Mercury, tot.	---
Arsenic, tot.	---	Nickel, diss	---
Beryllium, diss.	---	Nickel, tot.	---
Beryllium, tot.	---	Selenium, diss	---
Boron, diss.	---	Selenium, tot.	---
Boron, tot.	---	Zinc, diss.	10
Cadium, diss.	0	Zinc, tot.	10
Cadium, tot.	0		

Table 30.--Concentrations of metals and trace elements in water at sites on streams draining agricultural and forested lands unaffected by a surface coal mine, Clay and Vigo Counties, Ind.--Continued

Site 21 at Big Slough									
Sampling date	7-20-78	2-22-79	5-23-79	8-16-79	Sampling date	7-20-78	2-22-79	5-23-79	8-16-79
Aluminum, diss.	30	0	0	120	Chromium, diss.	1	0	20	10
Aluminum, tot.	90	0	100	3,700	Chromium, tot.	10	10	30	20
Iron, diss.	30	100	70	390	Copper, diss.	0	3	2	2
Iron, tot.	670	1,400	900	8,900	Copper, tot.	1	3	2	9
Manganese, diss.	320	170	490	760	Lead, diss.	2	0	2	4
Manganese, tot.	350	180	550	1,200	Lead, tot.	2	0	3	19
Arsenic, diss.	1	1	1	3	Mercury, diss.	.6	<.5	-----	<.5
Arsenic, tot.	-----	1	1	3	Mercury, tot.	-----	<.5	<.5	<.5
Beryllium, diss.	0	0	0	0	Nickel, diss.	1	4	5	2
Beryllium, tot.	0	0	0	0	Nickel, tot.	---	17	17	13
Boron, diss.	-----	-------	-----	40	Selenium, diss	0	0	0	0
Boron, tot.	80	180	30	0	Selenium, tot.	---	0	0	0
Cadmium, diss.	0	0	0	1	Zinc, diss.	10	0	0	30
Cadmium, tot.	0	0	1	2	Zinc, tot.	10	40	20	60

Table 31.--Suspended sediment in water at at site 5 on Honey Creek in a surface coal mine, Clay and Vigo Counties, Ind., October 10, 1979

[mm, millimeter; mg/L, milligram per liter; g, gram; data collected by U.S. Geological Survey]

Site 5 at Honey Creek	
Weight of water-sediment mixture	613 g
Weight of silt and clay	0.1007 g
Weight of sand	0.2012 g
Concentration of sediment	492 mg/L
Percent sand	67
Percent finer than 0.062 mm	33

Table 32.--Concentrations of aluminum, iron, and manganese adsorbed on streambed samples from selected stream sites in and around a surface coal mine, Clay and Vigo Counties, Ind.

[Site numbers plotted in figure 2: concentrations in microgram per gram; data collected by U.S. Geological Survey]

Site	Stream name	Sampling date	Aluminum	Iron	Manganese
5	Honey Creek	10-10-79	2,000	4,300	---
12	North Branch Honey Creek	5-23-79	-----	8,600	240
		8-16-79	1,200	4,400	130
		10-10-79	1,000	1,100	---
		12-5-79	3,000	4,500	---
14	Honey Creek tributary	5-8-79	5,300	10,000	400
18	Stone Quarry Branch	12-5-79	4,000	3,700	---
21	Big Slough	12-5-79	680	2,700	---

Table 33.--Concentrations of metals and trace elements adsorbed on a stream bed sample collected at site 14 on Honey Creek tributary in a surface coal mine, Clay and Vigo Counties, Ind.

[Site number plotted in figure 2; concentrations in microgram per gram; data collected by U.S. Geological Survey]

Trace elements	Concentration	Trace elements	Concentration
Aluminum	5,300	Cobalt	<10
Iron	10,000	Copper	10
Manganese	400	Lead	10
Arsenic	2	Mercury	.14
Boron	11	Selenium	.0
Cadmium	<10	Zinc	40
Chromium	10		

Table 34.--Phytoplankton data for selected stream sites in a surface coal mine, Clay and Vigo Counties, Ind., September 29, 1977

[Site numbers plotted in figure 2; data collected by U.S. Geological Survey]

Organism	Cells per milliliter			
	Site 3	Site 5	Site 18	Site 20
Chlorophyta (green algae)				
Ankistrodesmus sp	-----	1,500	-----	-----
Closteriopsis sp	-----	23	-----	-----
Closterium sp	24	--------	-----	-----
Crucigenia sp	-----	--------	61	-----
Kirchneriella sp	-----	--------	61	-----
Chrysophyta (yellow-brown algae and diatoms)				
Caloneis sp	-----	--------	-----	14
Cymbella sp	32	--------	-----	21
Fragilaria sp	32	--------	-----	-----
Gomphena sp	16	--------	-----	41
Navicula sp	40	93	84	55
Nitzschia sp	8	370	750	76
Rhoicoshpenia sp	-----	--------	-----	14
Surirella sp	-----	--------	-----	28
Synedra sp	-----	47	8	-----
Cyanophyta (blue-green algae)				
Cyclindrospermum sp	-----	5,600	-----	-----
Lynbya sp	-----	6,100	-----	-----
Oscillatoria sp	-----	14,000	-----	-----
Euglenophyta (euglenoids)				
Tracelamonas sp	16	--------	-----	41
Total cell count (cells/mL)	170	28,000	900	290
Genera diversity index	2.7	1.8	.9	2.8

Table 34.--Phytoplankton data from selected stream sites near a surface coal mine, Clay and Vigo Counties, Ind., September 29, 1977-Continued

Organism	Cells per milliliter	
	Site 5	Site 12
Chlorophyta (green algae)		
Ankistrodesmus sp	1,200	-------
Chlamydomonas sp	110	-------
Chlorella sp	420	-------
Chlorococcum sp	210	-------
Platymonas sp	35	-------
Sceneoesmus sp	140	-------
Chrysophyta (yellow-brown algae and diatoms)		
Cocconeis sp	--------	20
Cyclotella sp	210	59
Navicula sp	180	120
Nitzschia sp	320	1,800
Synedra sp	35	-------
Crytophyta (Cryptomonads)		
Cryptomonas sp	740	39
Cyanophyta (blue-green algae)		
Anacystis sp	140	-------
Oscillatoria sp	11,000	-------
Schizothrix sp	3,900	200
Euglenophyta (euglenoids)		
Euglena sp	35	-------
Eutreptia sp	70	-------
Tracelamonas sp	--------	20
Total cell count (cells/mL)	18,000	2,200
Genera diversity index	2.1	1.2

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