SEDIMENT AND WATER-QUALITY DATA FOR THE WEST BRANCH AND EAST BRANCH SHADE RIVER BASINS, OHIO, 1983 WATER YEAR

By C. J. Oblinger Childress and Rick L. Jones

U.S. GEOLOGICAL SURVEY

Open-File Report 85-187

Columbus, Ohio

1985

UNITED STATES DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
Water Resources Division
U.S. Geological Survey
975 W. Third Avenue
Columbus, Ohio 43212

Copies of this report can
be purchased from:

Open-File Services Section
Western Distribution Branch
U.S. Geological Survey
Box 25425, Federal Center
Denver, Colorado 80225
(Telephone: (303) 234-5888)

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

For the convenience of readers who prefer to use metric (International System) units, conversion factors for inch-pound units used in this report are listed below:

Multiply inch-pound units	By	To obtain metric units
foot (ft)	0.3048	meter (m)
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.0283	cubic meter per second (m^3/s)
ton per day (ton/d)	0.9072	megagram per day (Mg/d)
ton per day per square mile ($ton/d/mi^2$)	0.3503	megagram per day per square kilometer ($Mg/d/km^2$)

SEDIMENT AND WATER-QUALITY DATA FOR THE WEST BRANCH AND EAST BRANCH SHADE RIVER BASINS, OHIO, 1983 WATER YEAR

By C. J. Oblinger Childress and Rick L. Jones

ABSTRACT

Sedimentation in and flooding of the West Branch Shade River and its tributaries have been major concerns of residents and State and local officials. The area was extensively surface mined for coal between the mid-1940's and the early 1960's. Reclamation efforts immediately after mining were unsuccessful. The results have been elevated sediment loads and the subsequent loss of channel conveyance.

Two sediment and stream-gaging stations were established on the West Branch Shade River and one station was established on the East Branch Shade River. These three stations will provide data to evaluate the effectiveness of current reclamation activities on reducing sediment loads.

From June through September 1983, suspended-sediment yield was 18 times higher in West Branch (218 tons/mi^2) than East Branch (12 tons/mi^2) Shade River. In addition, acidity is higher, pH is lower, and concentrations of dissolved sulfate and metals are higher in the West Branch Shade River basin than in the East Branch Shade River basin.

INTRODUCTION

Residents of the West Branch Shade River basin and local and State officials are concerned about sedimentation and flooding along the West Branch Shade River and its tributaries. The flooding may be due, in part, to loss of channel conveyance resulting from deposition of sediment from abandoned surface mines. The headwaters of the basin near the abandoned surface mines are most affected.

The area was surface mined for coal from the mid-1940's to the early 1960's. Although Ohio law required surface-mine reclamation, techniques used at that time often were not effective. As a result, much of the headwater area of West Branch Shade River is marked by disturbed land, highwalls, and spoil piles that are devoid of vegetation.

In addition to excessive sedimentation, degraded water quality in the West Branch Shade River and some of its tributaries is of concern (Ohio Board of Unreclaimed Strip Mine Lands, 1974).

The Ohio Department of Natural Resources, Division of Reclamation, and the U.S. Department of Agriculture, Soil Conservation Service, have begun reclaiming the mined areas. As reclamation proceeds, abandoned mines will be vegetated, slopes will be reduced, and the sediment load should be reduced. It is hoped that water quality also will improve.

Purpose and Scope

The purpose of the study is to present suspended-sediment and water-quality data for the West Branch Shade River basin. This report presents data collected during the first water year (May 5 through September 30, 1983) of a 4-year study.

Sediment, streamflow, and water-quality data are presented for two stations located on West Branch Shade River (one near the headwaters and the other at about mid-basin), and for a control station established near the mouth of East Branch Shade River (fig. 1). Nine stream-channel cross sections for the West Branch Shade River and its tributaries also are presented.

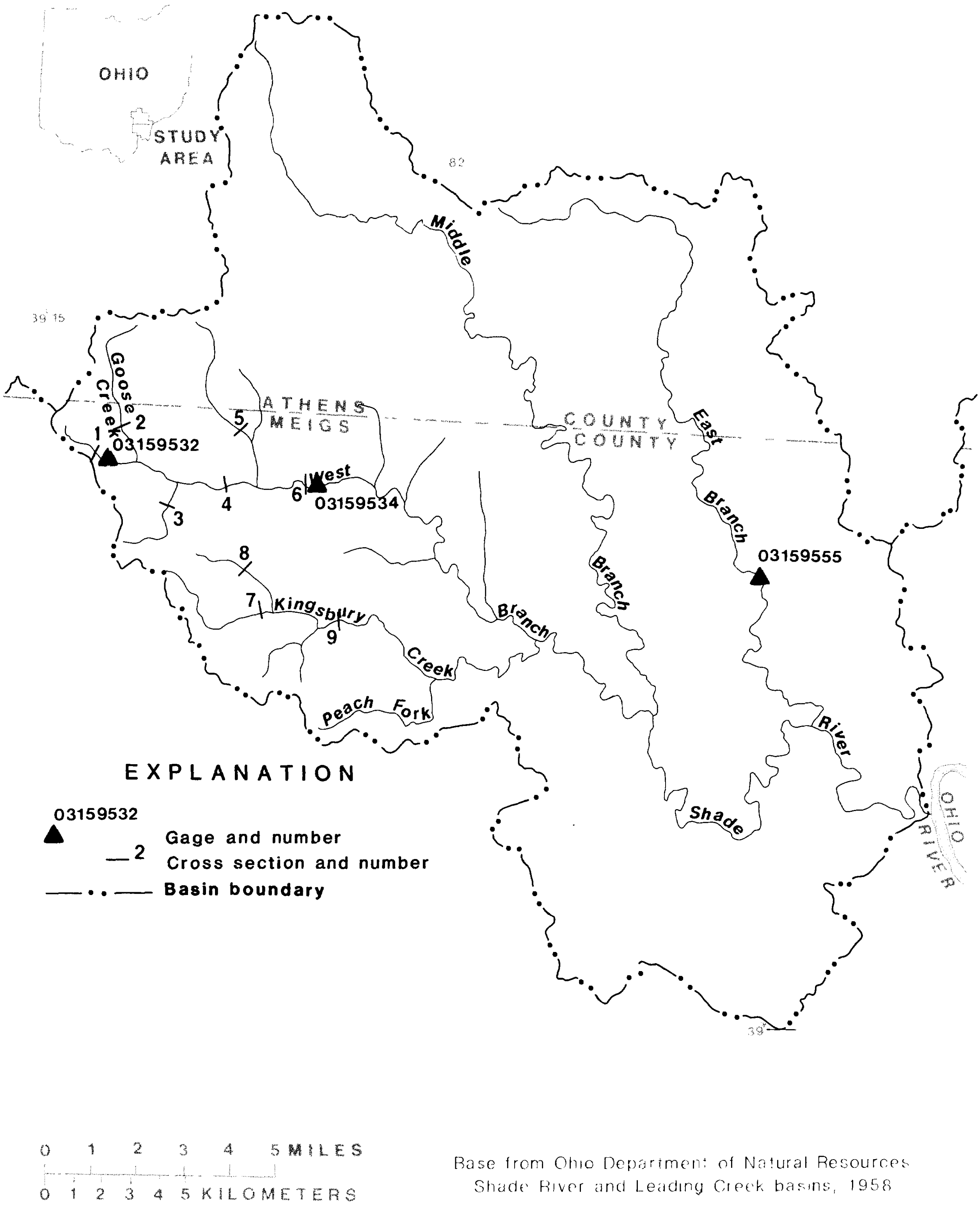
Description of the Shade River Basin

Shade River drains 221 square miles (mi^2), most of which is in eastern and north-central Meigs County in southeastern Ohio. It is tributary to the Ohio River. There are three main branches: West (drainage area, 71.3 mi^2), Middle (57.6 mi^2), and East (54.9 mi^2).

The Shade River basin is located in the unglaciated Appalachian Plateaus physiographic province (Fenneman, 1938). Because eastward-dipping strata underlie the basin, rocks of the Monongahela Formation of Pennsylvanian age crop out in the central part of Meigs County, and rocks of the Dunkard group of Pennsylvanian and Permian age crop out in the eastern third of the county (Brant and DeLong, 1960).

Annual precipitation has averaged 40.4 inches over an 18-year period at Carpenter, Ohio, located 4 miles west-southwest of the West Branch gage near Harrisonville (U.S. Department of Commerce, 1982). Annual precipitation in 1983 was 6.7 inches below normal, and precipitation for the period from May through September was 4.2 inches below normal. The mean annual temperature is 53.2 degrees F (U.S. Department of Commerce, 1983). In 1983, the mean temperature was 51.8 degrees F, 1.4 degrees below normal.

The channel of the East Branch Shade River is characterized by a series of pools and riffles typical of Ohio streams. The streambed material is primarily cobbles and sand.



Base from Ohio Department of Natural Resources
Shade River and Leading Creek basins, 1958

Figure 1.--Locations of gages and stream-channel cross sections.

The bed material in the West Branch Shade River is sand and silt. The channel is braided and lacks pool-and-riffle sequences. A braided channel can be a response to a sediment load that is too large to be handled by a single channel; therefore, it often is associated with an aggrading stream (Leopold and others, 1964).

Surface Mining and Reclamation in the West Branch Basin

Although coal mining was first reported in Meigs County in 1806, the first report of surface mining was not until 1940 (Collins, 1976). Most of the coal was extracted in the West Branch Shade River basin between the mid-1940's and the early 1960's by surface mining. There is currently no surface coal-mining in the West Branch basin within the study area or in the East Branch basin. Mining was most intense in the upper part of the West Branch basin; approximately 19 percent of the drainage area above the West Branch near Harrisonville (03159532) and 8 percent of the drainage area above the West Branch near Burlingham (03159555) has been surface mined (fig. 2).

During the period of intense mining, Ohio law required that surface mines be reclaimed by coal-mine operators. Reclamation generally consisted of regrading and planting. However, mine spoils frequently could not support new vegetation; the law did not require that the spoils be treated to improve plant survival. As a result, barren slopes redeveloped in some areas after reclamation and had no protection against erosion.

Reclamation of abandoned and unsuccessfully reclaimed mines was begun in 1981 by the U.S. Department of Agriculture, Soil Conservation Service, and the Ohio Department of Natural Resources, Division of Reclamation. Several areas were reclaimed by these agencies prior to this study (fig.2). Thirty acres were reclaimed immediately upstream of West Branch near Harrisonville in June 1983.

METHODS OF STUDY

Three continuous-record stream-gaging stations were constructed. Two are on the West Branch Shade River, near Burlingham (03159534) and near Harrisonville (03159532); the third (03159555), a control site, is located on the East Branch Shade River near Tuppers Plains (fig. 1). Drainage areas are 22.2, 0.99, and 37.5 square miles, respectively. Data collection began in May 1983 at East Branch and in June 1983 at both West Branch gages.

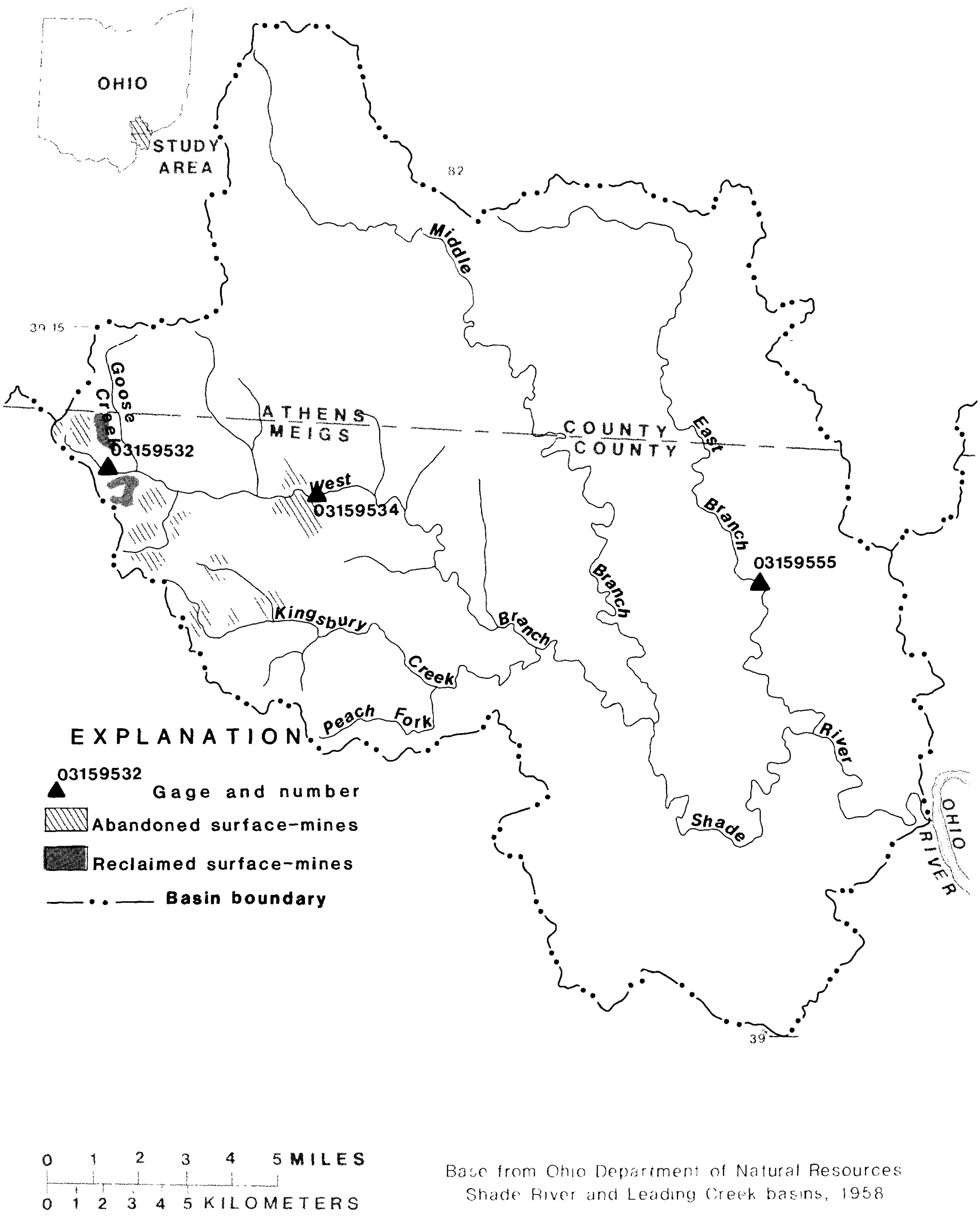


Figure 2.--Approximate location of abandoned and reclaimed surface mines in the West Branch basin.

West Branch near Burlingham and East Branch near Tuppers Plains are equipped with manometers to measure stage. Stage is recorded hourly during base flow and every 15 minutes during high flow. Stage also is recorded continuously on a strip-chart. Both stations are equipped with a wire-weight gage for an independent measure of stage. A U.S. Geological Survey PS-69 automatic sediment sampler collects suspended-sediment samples when the stage rises above a pre-set threshold at both stations.

West Branch Shade River near Harrisonville is equipped with a digital recorder to record stage at 5-minute intervals. Stage is measured with a float and stilling well. A Manning[1] automatic sampler is used to collect suspended-sediment samples. A float switch set 0.5 foot above the base-flow stage triggers the sampler, and samples are collected at half-hour intervals.

Because the automatic suspended-sediment samplers collect from a fixed point in the cross section, automatic sample concentrations were checked periodically against a manually collected depth-integrated sample. From the relation between the point sample and the depth-integrated sample, a correction coefficient was calculated and applied to all point-sample concentrations. The correction coefficient was 0.84 for West Branch Shade River at Burlingham, and was 1.0 for East Branch Shade River at Tuppers Plains.

Suspended-sediment samples were collected daily at East Branch by a local observer, except when discharge was near zero. The equal-transit-rate method (U.S. Geological Survey, 1977) was used. Samples were not collected daily at either of the West Branch sites during the first summer because stage was nearly always too low (less than 0.3 foot).

One bed-load sample was collected at West Branch near Burlingham to directly measure bed-load movement. The bed-load sample was collected with a Helley-Smith sampler (Emmett, 1980). The sampler is placed on the streambed where material moving along the bed passes through the 3-inch square opening and is trapped in a mesh bag.

Sediment samples were analyzed at the U.S. Geological Survey office in Columbus, Ohio. The concentration of suspended-sediment samples and the weight and particle-size distribution of bed-load samples were determined (Guy, 1969).

Stream cross sections were surveyed at nine locations in the West Branch basin (fig. 1). These data will be used to document changes in channel configuration due to deposition and (or) scour.

---

[1] Use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

The cross sections were first surveyed in July 1983. They will continue to be surveyed quarterly until September 1984, after which they will be surveyed twice a year.

A water-quality sample was collected at each of the three gages in June and July 1983 and analyzed at the U.S. Geological Survey laboratory in Doraville, Ga., for concentrations of total and dissolved aluminum, iron, and manganese and dissolved sulfate. Discharge, pH, alkalinity, and acidity were measured in the field. Alkalinity was measured by titrating to pH 4.5 (Skougstad and others, 1979). Samples for measurement of acidity were pretreated with hydrogen peroxide, heated, then titrated to pH 8.3 (American Public Health Association, 1975).

SEDIMENT DATA

Daily mean water discharge and suspended-sediment load at all three gages were zero for much of June through September 1983 because rainfall was well below normal. However, enough data were collected to develop a preliminary stage-discharge rating at West Branch near Burlingham and to confirm an existing rating for East Branch.

Suspended-sediment load for the period June through September 1983 was 4,828 tons at West Branch near Burlingham (table 1) and 461 tons at East Branch (table 2). West Branch transported nearly 11 times more suspended sediment than East Branch during this period. Suspended-sediment yield at East Branch was 12.3 tons per square mile (ton/mi^2), whereas the suspended-sediment yield at West Branch was 217 ton/mi^2 per square mile, nearly an 18-fold difference.

Total water discharge for the same period, in cubic feet per second-day (ft^3/s-d), was 656 at East Branch and 474 at West Branch, or a yield of 16 ft^3/s-d per square mile at East Branch and 22 ft^3/s-d per square mile at West Branch.

The number of high- and medium-flow measurements were not sufficient to develop a discharge rating at West Branch near Harrisonville. The low-flow discharge rating is complex because of the unstable active channel and the small drainage area. A small drainage area results in rapid stage changes that are difficult to measure accurately. Consequently, daily mean discharge and sediment load could not be calculated for this station.

Thirty acres upstream of West Branch near Harrisonville was reclaimed between June and September 1983. Samples collected from runoff during a storm on September 16, 1983, had high concentrations of suspended sediment. The concentration at a peak water discharge of 3.0 ft^3/s was 45,500 milligrams per liter.

Table 1.--Daily mean suspended-sediment concentration, daily mean suspended-sediment load, and daily mean water discharge, station 03159534 (West Branch Shade River near Burlingham, Ohio), from June through September, 1983

Day	JUNE Mean water discharge (ft^3/s)	JUNE Mean sediment concentration (mg/L)	JUNE Sediment load (ton)	JULY Mean water discharge (ft^3/s)	JULY Mean sediment concentration (mg/L)	JULY Sediment load (ton)
1	15	5	0.20	45	8130	1510
2	11	5	.15	6.4	353	8.8
3	18	2300	334	3.7	30	.30
4	60	6050	1100	3.9	219	5.9
5	22	413	29	5.8	134	2.2
6	15	1130	59	1.7	30	.14
7	12	275	11	1.3	30	.11
8	7.6	10	.21	1.0	28	.08
9	5.6	5	.08	.82	20	.04
10	5.2	5	.07	.73	20	.04
11	4.6	5	.06	.61	20	.03
12	4.5	5	.06	.55	20	.03
13	4.2	5	.06	.50	16	.02
14	4.1	5	.06	.51	15	.02
15	3.9	5	.05	.50	14	.02
16	3.8	5	.05	.49	12	.02
17	3.9	5	.05	.49	10	.01
18	4.7	5	.06	7.6	2170	93
19	18	2030	231	1.9	80	.48
20	15	820	38	1.2	20	.06
21	8.7	25	.59	1.0	15	.04
22	4.5	5	.06	.94	15	.04
23	3.4	5	.05	.91	10	.02
24	3.1	5	.04	42	4290	826
25	3.0	5	.04	9.3	1830	147
26	3.0	5	.04	7.0	1090	30
27	3.0	5	.04	2.3	15	.09
28	3.3	5	.04	1.4	15	.06
29	4.3	10	.12	.97	10	.03
30	13	1820	242	.76	10	.02
31	--	--	--	.60	10	.02
TOTAL	287.4	--	2046.18	151.88	--	2624.62

Table 1.--Daily mean suspended-sediment concentration, daily mean suspended-sediment load, and daily mean water discharge, station 03159534 (West Branch Shade River near Burlingham, Ohio), from June through September, 1983--Continued

Day	Mean water discharge (ft^3/s)	Mean sediment concentration (mg/L)	Sediment load (ton)	Mean water discharge (ft^3/s)	Mean sediment concentration (mg/L)	Sediment load (ton)
	AUGUST			SEPTEMBER		
1	21	7340	156	0.00	0	0.00
2	3.2	60	.60	.00	0	.00
3	1.6	10	.04	.00	0	.00
4	.97	10	.30	.00	0	.00
5	.68	5	.00	.00	0	.00
6	1.7	5	.02	.00	0	.00
7	.76	5	.01	.00	0	.00
8	.55	5	.00	.00	0	.00
9	.55	5	.00	.00	0	.00
10	.21	5	.00	.00	0	.00
11	.33	5	.00	.00	0	.00
12	1.1	5	.01	.00	0	.00
13	.38	5	.00	.00	0	.00
14	.21	5	.00	.00	0	.00
15	.18	5	.00	.05	5	.00
16	.14	5	.00	.10	5	.00
17	.12	5	.00	.15	5	.00
18	.12	5	.00	.06	5	.00
19	.10	5	.00	.05	5	.00
20	.03	5	.00	.05	5	.00
21	.02	5	.00	.21	5	.00
22	.02	5	.00	.14	5	.00
23	.00	0	.00	.06	5	.00
24	.00	0	.00	.04	5	.00
25	.00	0	.00	.04	5	.00
26	.00	0	.00	.00	0	.00
27	.00	0	.00	.00	0	.00
28	.00	0	.00	.00	0	.00
29	.00	0	.00	.00	0	.00
30	.00	0	.00	.00	0	.00
31	.00	0	.00	--	--	--
TOTAL	33.97	--	156.98	0.95	--	0.00
PERIOD	474.20		4827.78			

Table 2.--Daily mean suspended-sediment concentration, daily mean suspended-sediment load, and daily mean water discharge at station 03159555 (East Branch Shade River near Tuppers Plains, Ohio), from May through September, 1983

Day	Mean water discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment load (ton)	Mean water discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment load (ton)
	MAY			JUNE		
1	--	--	--	24	17	1.1
2	--	--	--	21	11	.62
3	--	--	--	30	41	7.1
4	--	--	--	84	37	9.8
5	--	--	--	48	25	3.2
6	--	--	--	30	25	2.0
7	--	--	--	47	50	6.3
8	--	--	--	26	13	.91
9	--	--	--	18	10	.49
10	--	--	--	14	10	.38
11	--	--	--	11	10	.30
12	--	--	--	8.8	10	.24
13	--	--	--	7.1	10	.19
14	--	--	--	6.1	10	.16
15	62	89	20	5.2	10	.14
16	235	199	120	4.7	10	.13
17	109	50	16	4.5	10	.12
18	60	15	2.4	4.3	10	.12
19	134	163	67	15	50	4.6
20	266	209	153	22	41	2.4
21	134	40	14	8.8	10	.24
22	262	373	338	6.6	10	.18
23	335	275	299	5.2	10	.14
24	101	45	12	4.1	10	.11
25	65	16	2.8	3.4	10	.09
26	46	11	1.4	2.8	10	.08
27	34	10	.92	2.3	10	.06
28	28	9	.68	2.7	10	.07
29	42	71	13	2.8	10	.08
30	71	110	21	2.8	10	.08
31	31	40	3.3	--	--	
TOTAL	2015	--	1084.50	472.2	--	41.43

Table 2.--Daily mean suspended-sediment concentration, daily-mean suspended-sediment load, and daily-mean water discharge at station 03159555 (East Branch Shade River near Tuppers Plains, Ohio), from May through September, 1983--Continued

Day	Mean water discharge (ft^3/s)	Mean sediment concentration (mg/L)	Sediment load (ton)	Mean water discharge (ft^3/s)	Mean sediment concentration (mg/L)	Sediment load (ton)	Mean water discharge (ft^3/s)	Mean sediment concentration (mg/L)	Sediment load (ton)
	JULY			AUGUST			SEPTEMBER		
1	3.0	13	0.11	2.1	62	0.35	0.00	0	0.00
2	3.4	10	.09	4.5	28	.34	.00	0	.00
3	1.3	10	.04	1.8	25	.12	.00	0	.00
4	2.2	14	.08	1.2	14	.05	.00	0	.00
5	3.4	27	.25	1.0	25	.07	.00	0	.00
6	2.7	25	.18	27	301	24	.00	0	.00
7	1.6	16	.07	5.0	156	2.1	.00	0	.00
8	1.2	18	.06	2.7	95	.69	.00	0	.00
9	.97	15	.04	1.8	50	.24	.00	0	.00
10	.73	17	.03	1.2	30	.10	.00	0	.00
11	.73	20	.04	.84	46	.10	.00	0	.00
12	.54	18	.03	.54	25	.04	.00	0	.00
13	.22	19	.01	1.1	57	.17	.00	0	.00
14	.22	15	.00	.63	55	.09	.00	0	.00
15	.19	15	.00	.30	32	.03	.00	0	.00
16	.12	16	.00	.19	34	.02	.00	0	.00
17	.10	14	.00	.14	20	.00	.00	0	.00
18	.22	21	.01	.10	19	.00	.00	0	.00
19	.47	26	.03	.10	16	.00	.00	0	.00
20	.47	17	.02	.14	20	.00	.00	0	.00
21	.47	20	.03	.26	25	.02	.00	0	.00
22	.47	16	.02	.16	21	.00	.00	0	.00
23	2.8	681	21	.00	0	.00	.00	0	.00
24	83	1590	364	.00	0	.00	.00	0	.00
25	8.2	135	3.0	.03	24	.00	.00	0	.00
26	4.4	68	.81	.02	23	.00	.00	0	.00
27	2.3	65	.40	.00	0	.00	.00	0	.00
28	1.8	42	.20	.00	0	.00	.00	0	.00
29	1.3	34	.12	.00	0	.00	.00	0	.00
30	1.1	28	.08	.00	0	.00	.00	0	.00
31	.84	22	.05	.00	0	.00	--	--	--
TOTAL	130.46	--	390.80	52.85	--	28.53	0.00	--	0.00
PERIOD	2670.51		1545.26						

The peak total instantaneous sediment discharge was 374 tons per day (ton/d); instantaneous bed-load discharge was 5.5 ton/d; instantaneous suspended-sediment discharge was 368 ton/d.

Cross sections at selected sites on West Branch Shade River and its tributaries are shown in figure 3. Figure 4 shows cross sections at selected sites on Kingsbury Creek (a major tributary to West Branch Shade River) and a tributary to Kingsbury Creek. Future surveys of these same cross sections will be used to determine if any net aggradation or degradation has occurred.

WATER-QUALITY DATA

Chemical analyses of water samples collected from each gage site during base flow are shown in table 3. Sulfate, acidity, and dissolved metals concentrations are significantly higher at the West Branch sites than at the control site (East Branch).

SUMMARY

From June through September of 1983, suspended-sediment yield was 18 times higher on the West Branch Shade River than the East Branch Shade River. In addition, acidity is higher, pH is lower, and dissolved sulfate and metals concentrations are higher than in the East Branch Shade River.

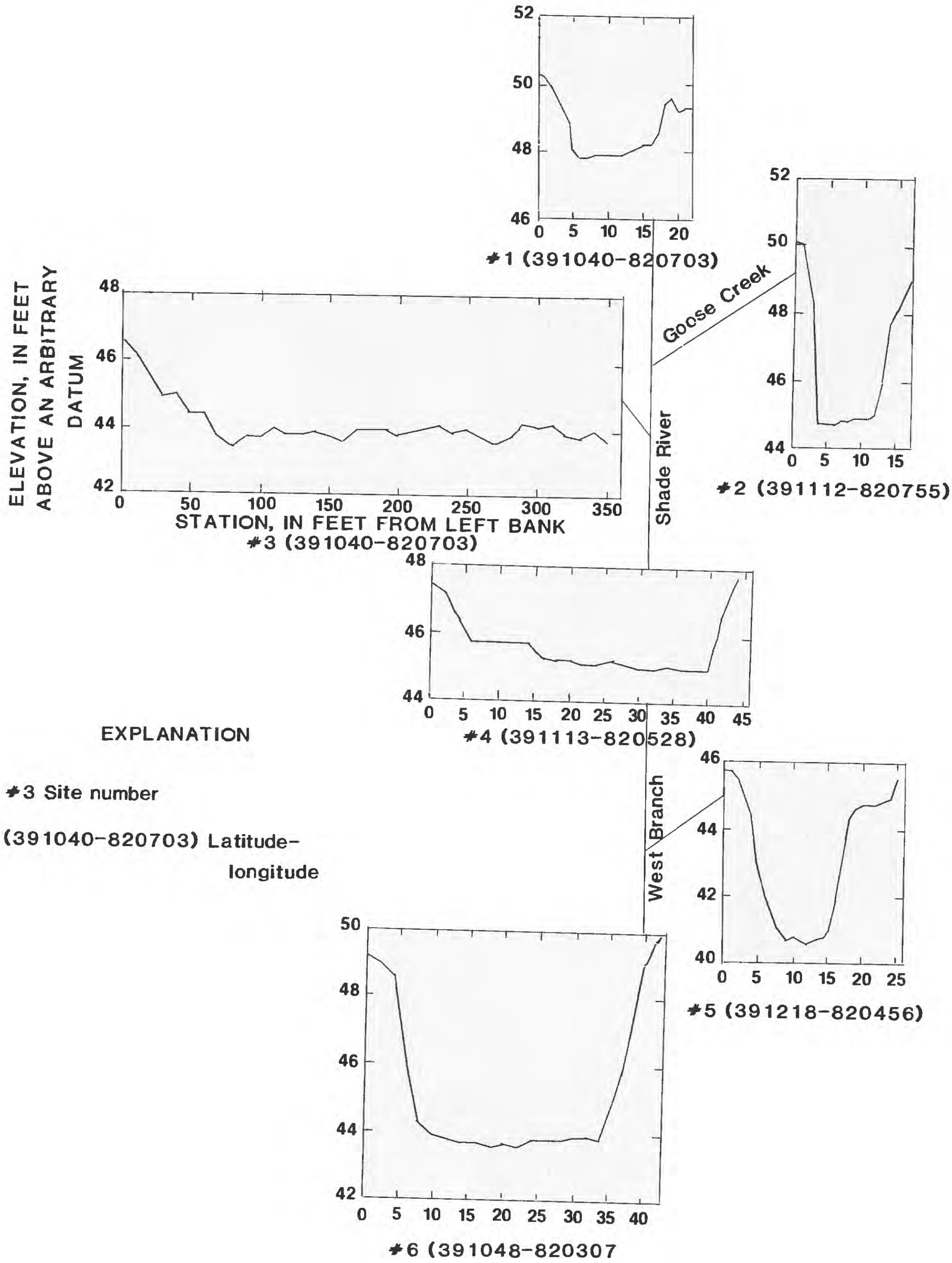


Figure 3.--Cross sections of West Branch Shade River and three of its tributaries, July 1983.

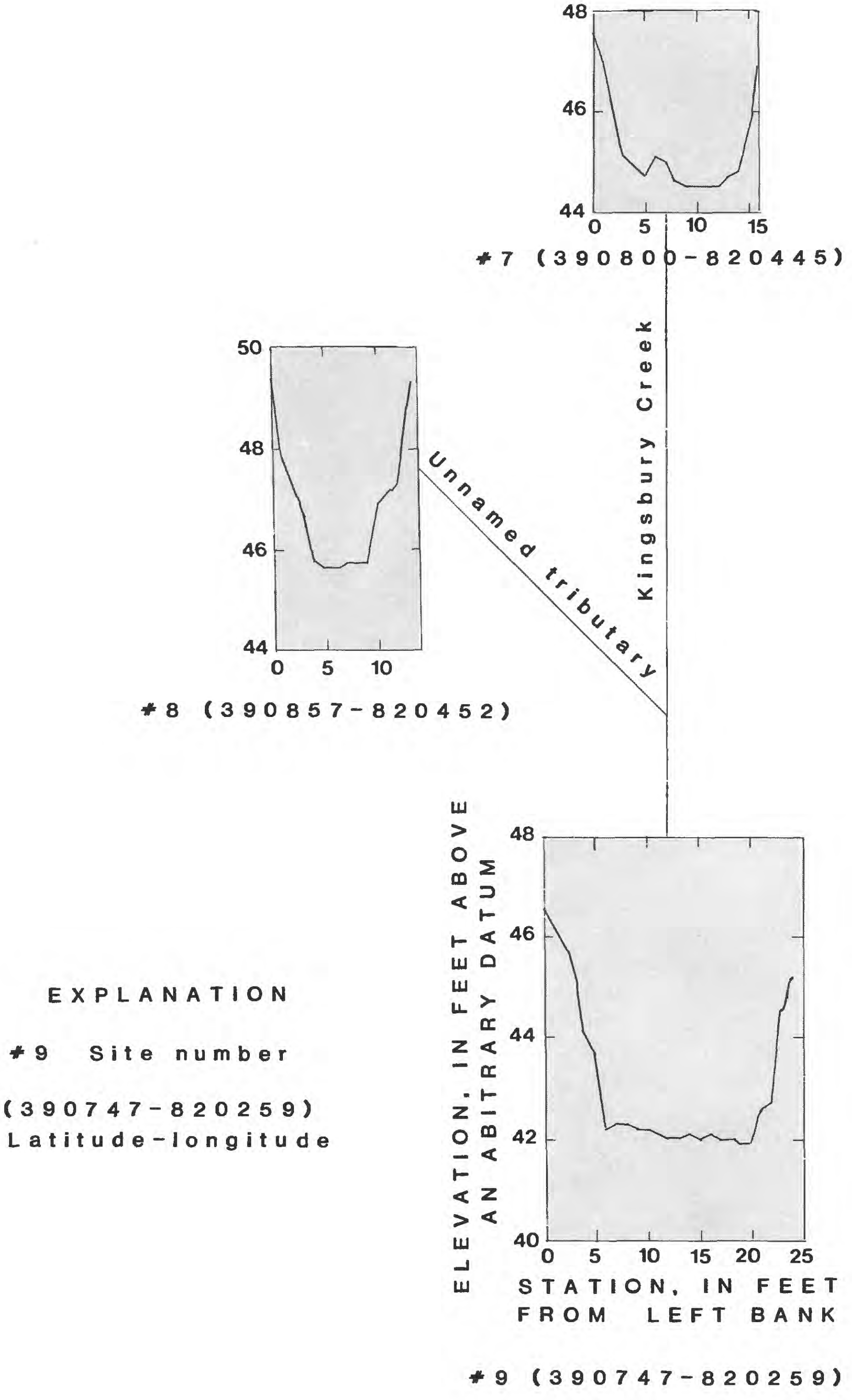


Figure 4.--Cross sections of Kingsbury Creek and an unnamed tributary to Kingsbury Creek, July 14, 1983.

Table 3.--Chemical analyses of water samples collected at each of the gaging stations

Station name	Temperature (°C)	Temperature, air (°C)	Streamflow, instantaneous (ft^3/s)	Specific conductance (µS/cm)	pH	Carbon dioxide, dissolved (mg/L as CO_2)
W. B. Shade R. near Harrisonville[1]	27.0	--	.07	1,020	4.2	--
W. B. Shade R. near Burlingham[1]	25.0	--	2.4	502	6.5	20
E. B. Shade R. near Tuppers Plains[2]	25.5	25.0	3.5	441	7.0	27

Station name	Acidity (mg/L as $CaCO_3$)	Alkalinity, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Iron, suspended recoverable (µg/L as Fe)	Iron, total recoverable (µg/L as Fe)	Iron, dissolved (µg/L as Fe)
W. B. Shade River near Harrisonville	199	0[4]	580	160	640	480
W. B. Shade R. near Burlingham	50	33	210	1,500	1,700	210
E. B. Shade R. near Tuppers Plains	0[3]	139	28	1,200	1,200	30

Station name	Manganese, suspended recoverable (µg/L as Mn)	Manganese, total recoverable (µg/L as Mn)	Manganese, dissolved (µg/L as Mn)	Aluminum, total recoverable (µg/L as Al)	Aluminum, dissolved (µg/L as Al)	Aluminum, suspended recoverable (µg/L as Al)
W. B. Shade R. near Harrisonville	0	12,000	12,000	1,000	1,000	0
W. B. Shade R. near Burlingham	0	3,300	3,300	1,000	<100	--
E. B. Shade R. near Tuppers Plains	60	400	340	700	300	400

[1]Sampled June 28, 1983.
[2]Sampled July 5, 1983.
[3]Acidity is assumed to be zero when the pH is 4.5 or less.
[4]Alkalinity is assumed to be zero when the pH is 7.0 or greater.

REFERENCES CITED

American Public Health Association, 1975, Standard methods for the analysis of water and wastewater, 14th edition: p. 275-277.

Brant, R. A., and DeLong, R. M., 1960, Coal resources of Ohio: Ohio Department of Natural Resources Bulletin 58, p. 89-93.

Collins, H. R., 1976, Coal production in Ohio -- 1800-1974: Ohio Department of Natural Resources Circular 44, p. 33.

Emmett, W. W., 1980, A field calibration of the sediment-trapping characteristics of the Helley-Smith bedload sampler: U.S. Geological Survey Professional Paper 1139, p. 2.

Fenneman, N. G., 1938, Physiography of eastern United States: New York, McGraw-Hill, 714 p.

Guy, H. P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. Cl, 58 p.

Leopold, L. B., Wolman, M. G., and Miller, J. P., 1964, Fluvial processes in geomorphology: San Francisco, W. H. Freeman, p. 290-295.

Ohio Board of Unreclaimed Strip Mine Lands, 1974, Land reborn: Ohio Department of Natural Resources, 91 p.

Skougstad, M. W., Fishman, M. J., Friedman, L. C., Erdmann, D. E., and Duncan, S. S., 1979, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. Al, 626 p.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1982, Climatological Data, Annual Summary, Ohio.

----- 1983, Climatological data (May through September) -- Ohio: v. 88, no. 5-9.

U.S. Geological Survey, Office of Water Data Coordination, 1977, Sediment, _in_ National handbook of recommended methods for water-data acquisition.

☆U.S.Government Printing Office: 1985 — 561-082/11911