SEDIMENTATION AND WATER QUALITY IN THE WEST BRANCH SHADE RIVER BASIN, OHIO, 1984 WATER YEAR

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

U.S. GEOLOGICAL SURVEY

Open-File Report 85-552

Prepared in cooperation with the

OHIO DEPARTMENT OF NATURAL RESOURCES,

DIVISION OF RECLAMATION

Columbus, Ohio

1985

UNITED STATES DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

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CONVERSION FACTORS

For the convenience of readers who may prefer to use metric (International System) units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply inch-pound unit	By	To obtain metric units
foot (ft)	0.3048	meter (m)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second-day (ft^3/s-d)	0.002447	cubic hectometer (hm^3)
ton	0.9072	megagram (Mg)
ton per acre-foot (ton/acre-ft)	0.07358	megagram per cubic hectometer (Mg/hm^3)

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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 West Branch Shade River in the area of past mining to provide data to evaluate the effectiveness of current reclamation activities on reducing sediment loads. A third station was established on the East Branch Shade River in an unmined area as a control.

From October 1983 through September 1984, the annual suspended-sediment yield per acre-foot of runoff was approximately two times as high for West Branch Shade River (0.51 ton per acre-foot of runoff) as for East Branch Shade River (0.28 ton per acre-foot). In addition, water quality of West Branch indicates that acidity is higher, pH is lower, and concentrations of dissolved sulfate and metals are higher than for East Branch.

The concentration of coal in bed material increased in the downstream direction along West Branch Shade River. The concentration downstream in the West Branch was more than 20 times greater than in the East Branch.

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. Headwaters 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 basin is marked by disturbed land, highwalls, and spoil piles that are devoid of vegetation. Reclamation was begun again in 1978 by various government agencies. The expected result is a reduction in sediment loading and possibly some improvement in water quality.

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).

Purpose and Scope

This report presents data collected during the second water year (October 1, 1983 to September 30, 1984) of a 4-year study. The purpose of the study is to measure the effects of abandoned-mine lands and their reclamation on sediment loading, channel cross-section configuration, and water quality of streams in the West Branch Shade River basin.

Sediment, streamflow, and water-quality data are presented for three gaging stations located on West and East Branches of the Shade River (fig. 1). Also presented are 10 stream-channel cross sections and data from 11 coal-separation sites on the West Branch Shade River, its tributaries, and the East Branch Shade River.

Description of the Study Area

A physical description of the study area, a brief history of surface coal mining in the area, and data from the first year of study were presented in a report by Childress and Jones (1985).

Approximately 450 acres of abandoned surface mines had been reclaimed in the West Branch Shade River basin by the end of 1984. The Ohio Department of Natural Resources, Division of Reclamation, funded reclamation of 100 acres in 1978, and 235 acres in the summer of 1984 (M. Farley, Ohio Department of Natural Resources, oral commun., 1984). The U.S. Department of Agriculture, Soil Conservation Service, funded reclamation of about 88 acres in 1982 and 30 acres in 1983 (Dean Hire, U.S. Soil Conservation Service, oral commun., 1984) (fig. 2). As reclamation proceeds, abandoned mines are revegetated and slopes are reduced.

METHODS OF STUDY

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

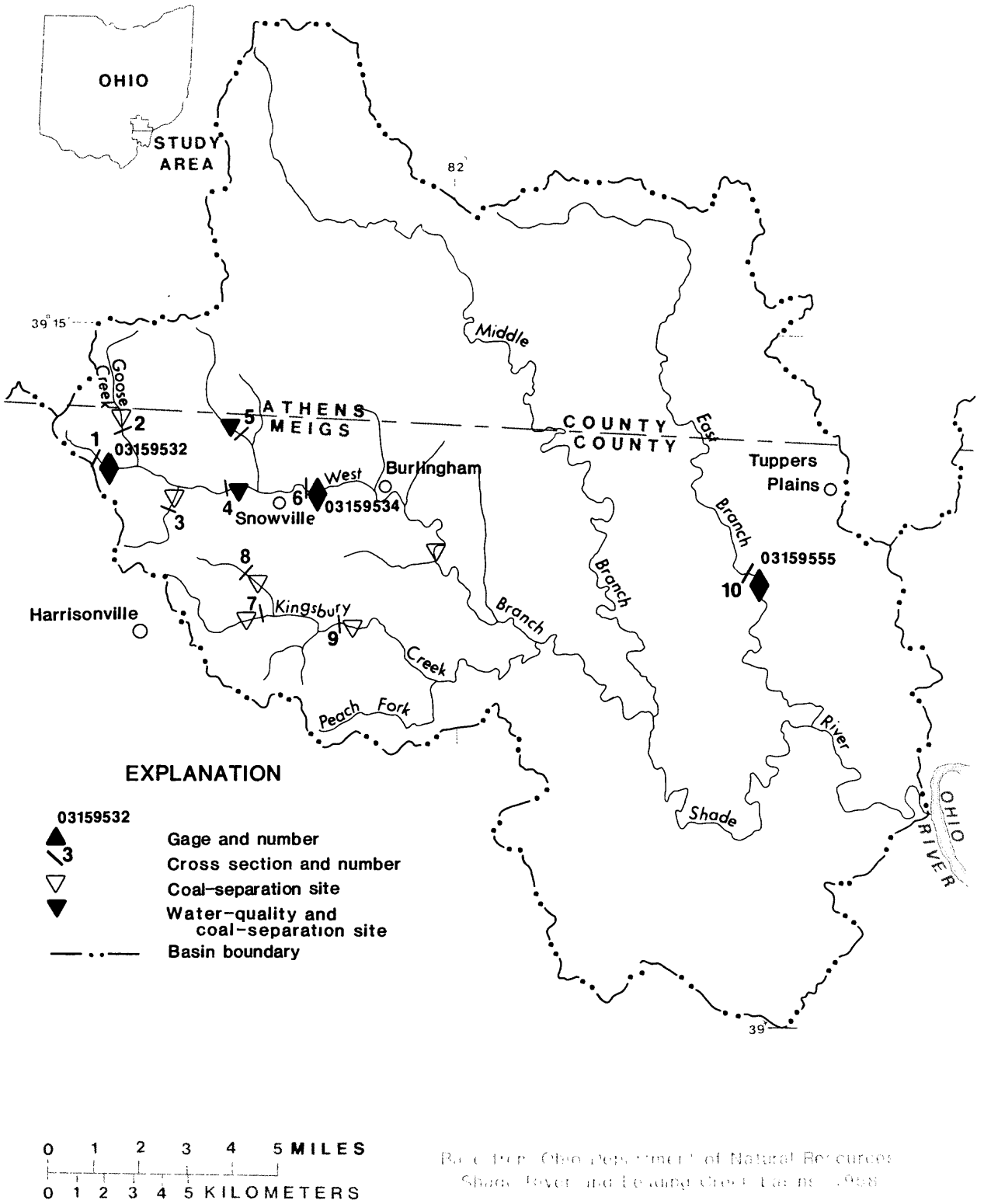
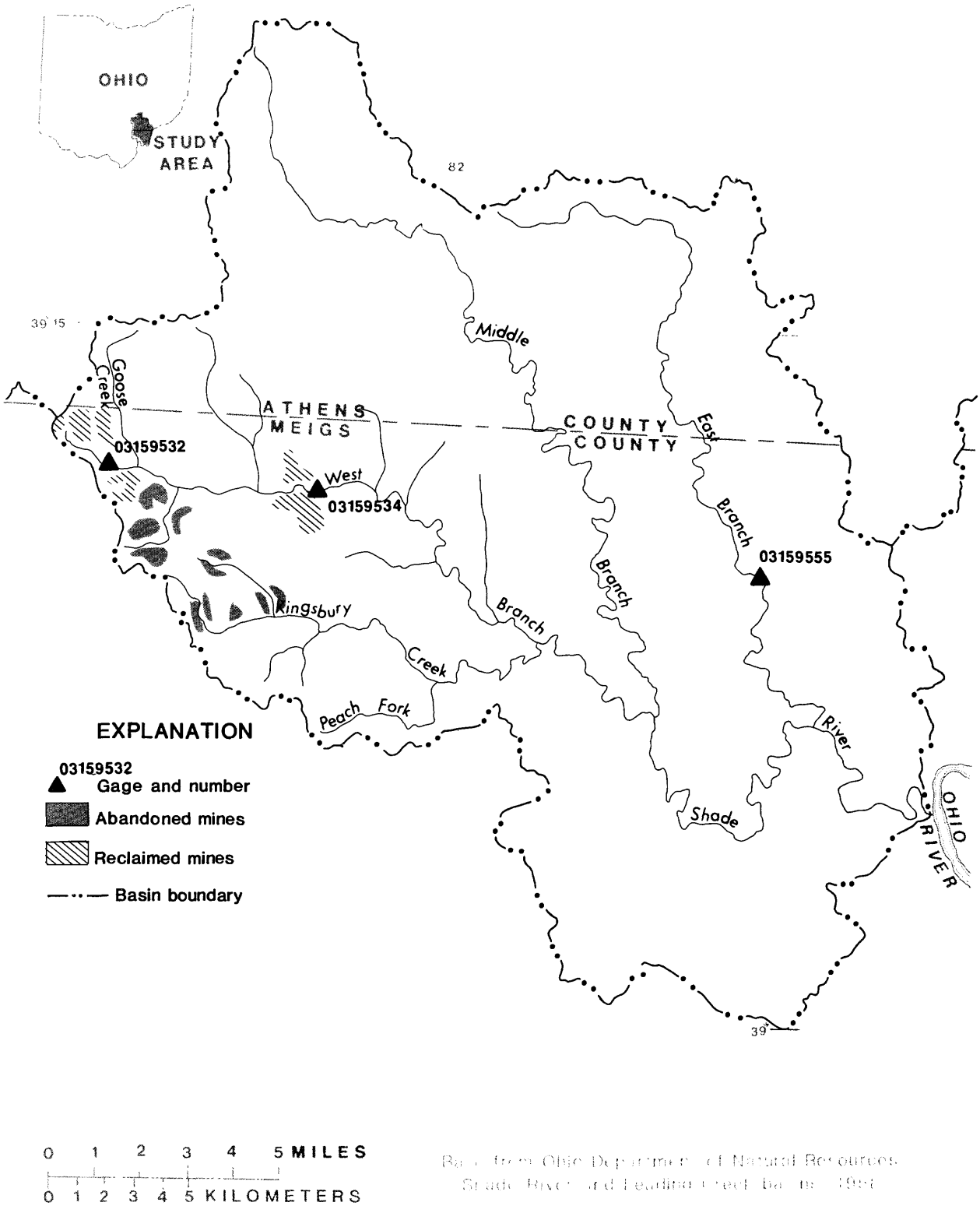


Figure 1.--Locations of gages, stream-channel cross sections, and water-quality and coal-separation sites.



Base from Ohio Department of Natural Resources
Shade River and Leading Creek basins, 1981

Figure 2.—Approximate location of abandoned and reclaimed surface coal mines in the West Branch basin (as of October 1984).

The West Branch station near Burlingham and the East Branch station 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 wire-weight gages for an independent measure of stage and a verificaiton of recorded stage. At each station, a U.S. Geological Survey PS-69 automatic sediment sampler collects suspended-sediment samples when the stage rises above a pre-set threshold.

The West Branch station 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 at Burlingham, and was 1.0 for East Branch.

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

Bedload samples were collected at West Branch near Burlingham to directly measure bedload movement. They were 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 bedload samples were determined by methods described by Guy (1969).

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

Stream cross sections were surveyed at nine locations in the West Branch basin and one location in the East Branch basin (fig. 1). These data are used to document changes in channel configuration due to deposition and (or) scour. The cross sections were first surveyed in July 1983, and were surveyed quarterly until September 1984. Thereafter, each will be surveyed twice a year.

A water-quality sample was collected at each of the three gaging stations and at two additional locations in the West Branch basin (fig. 1) in January or February, May, and June 1984. Samples were analyzed 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).

Samples for separation of coal from bed material were collected at 11 locations in June 1984 (fig. 1). Subsamples were collected from the bed at about 10 equidistant sites in a cross section at each location. Subsamples were composited for analysis.

Water-quality and coal-separation samples were analyzed at the U.S. Geological Survey laboratory in Doraville, Georgia.

SUSPENDED-SEDIMENT LOAD AND SEDIMENTATION

Total annual suspended-sediment load for the 1984 water year was 8,422 tons for the West Branch station near Burlingham and 7,712 tons for the East Branch (tables 1 and 2, at back of report). The daily suspended-sediment discharge for the 1984 water year is shown in table 1 for West Branch and in table 2 for East Branch.

Total water discharge for the same period was 8,337 cubic feet per second-day (ft^3/s-d) for West Branch and 13,958 ft^3/s-d for East Branch. From those two figures, the annual sediment yield was calculated to be 0.51 and 0.28 ton per acre-foot of runoff for the West and East Branches, respectively.

Results of bedload analyses are shown in table 3 (at back of report). Bedload was calculated as an instantaneous load in tons per day and as percent of the total instantaneous sediment load.

Each cross-section (fig. 1) was surveyed four times in the 1984 water year. Figures 3 through 5 compare cross sections surveyed in 1984 with the same cross section in July 1983 (except East Branch Shade River; the first cross-section survey there was in February 1984).

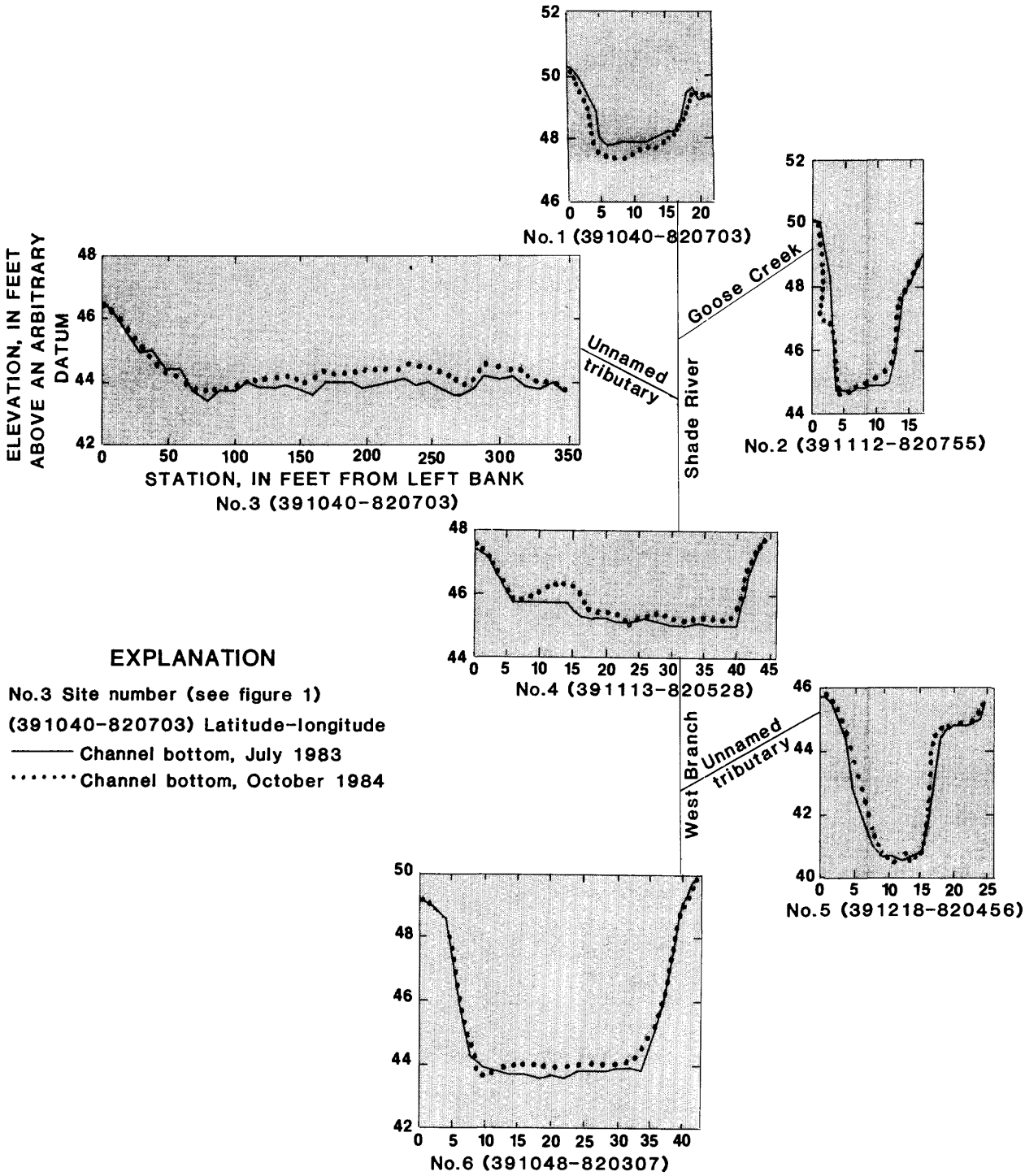

Figure 3.--Stream-channel cross sections of West Branch Shade River and three of its tributaries.

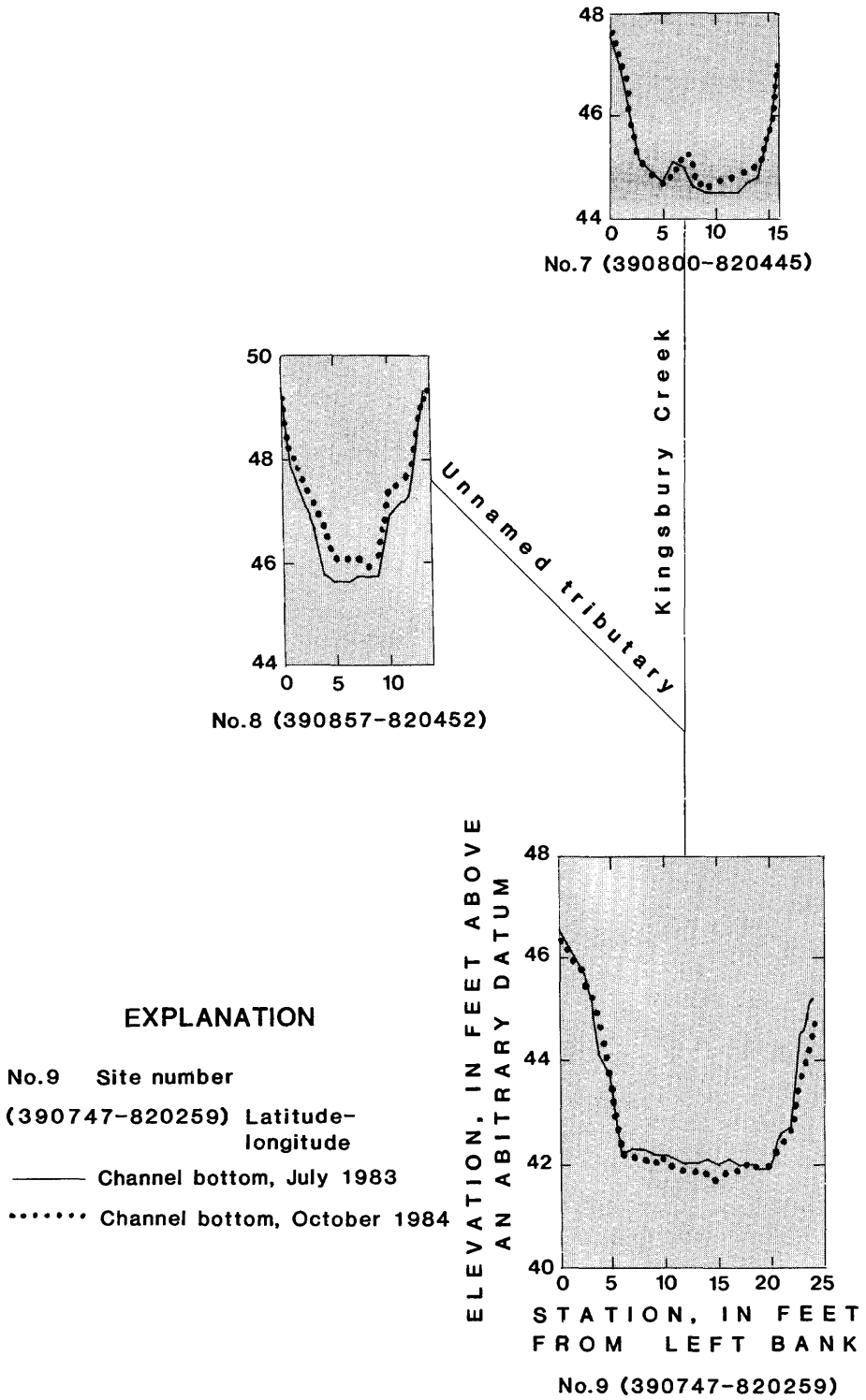

Figure 4.--Stream-channel cross sections of Kingsbury Creek and an unnamed tributary to Kingsbury Creek.

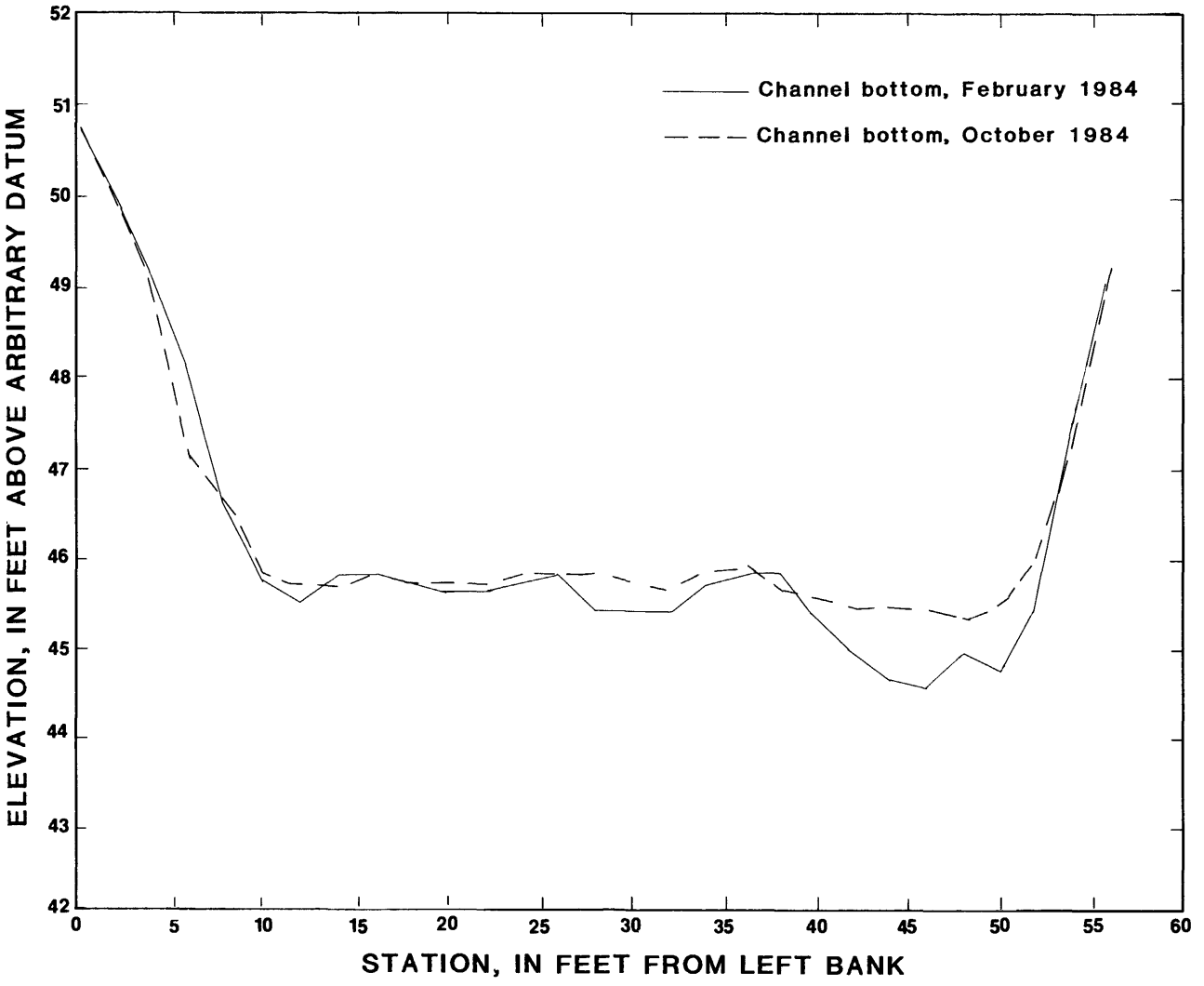

Figure 5.--Stream-channel cross section, East Branch Shade River (site 10, fig. 1; latitude, 39°08′29″; longitude, 81°52′39″)

The discharge rating at the West Branch gage near Harrisonville is complex because of the unstable channel and the small drainage area. A small drainage area results in rapid stage changes that make discharge measurement and suspended-sediment sample collection difficult. As a result, daily record of discharge and suspended-sediment concentration are not presented.

CHEMICAL QUALITY

Chemical analyses of water samples collected from five sites (fig. 1) are shown in table 4 (at back of report). Two of these sites drain unmined areas (East Branch and unnamed tributary to West Branch). Water quality for West Branch Shade River sites (mined) near Harrisonville, Snowville, and Burlingham indicates significantly higher sulfate, acidity, and dissolved metals concentrations than at the control sites (unmined).

COAL SEPARATION FROM BED MATERIAL

Results of the separation of coal from bed material are shown in table 5. The concentration of coal increased along the main stem of the West Branch in the downstream direction. Tributary concentrations ranged from 1.1 to 6.0 grams per kilogram (g/kg). Concentrations were low at East Branch Shade River (0.5 g/kg) and for the headwaters of the West Branch Shade River (0.2 g/kg) compared with 11 g/kg for the downstream station on the West Branch.

SUMMARY

From October 1983 through September 1984, the annual suspended-sediment yield per acre-foot of runoff was approximately two times as high for the West Branch Shade River as the East Branch Shade River. Water-quality data indicate that acidity, dissolved sulfate, and dissolved metals are higher and pH is lower in the mined basin than in nearby unmined basins. An analysis of bed material shows that the concentration of coal in bed material increases downstream in the West Branch basin. Furthermore, the concentration downstream in the West Branch is more than 20 times higher than for the East Branch.

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Table 1.--Daily mean water discharge, daily mean suspended-sediment concentration, and daily suspended-sediment discharge, at station 03159534 (West Branch Shade River near Burlingham, Ohio) during the 1984 water year

Day	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)
		OCTOBER			NOVEMBER			DECEMBER	
1	0.00	0	0.00	2.0	8	0.04	14	55	2.1
2	.00	0	.00	1.7	8	.04	13	49	1.7
3	.00	0	.00	5.0	8	.11	14	44	1.7
4	.00	0	.00	6.6	8	.14	121	364	120
5	.00	0	.00	6.0	8	.13	51	121	17
6	.00	0	.00	4.8	8	.10	80	196	48
7	.00	0	.00	3.1	8	.07	51	112	110
8	.00	0	.00	2.8	8	.06	30	47	3.8
9	.00	0	.00	2.6	8	.06	41	85	19
10	.00	0	.00	140	552	318	96	221	55
11	.04	4	.00	128	346	150	46	169	20
12	.18	4	.00	31	42	3.5	170	389	180
13	.18	1120	.88	17	10	.46	73	247	59
14	.08	71	.02	12	8	.26	47	117	14
15	.05	8	.00	36	110	15	42	69	7.7
16	.04	4	.00	50	128	17	29	27	2.1
17	.04	4	.00	37	76	7.6	23	17	1.1
18	.10	4	.00	21	59	3.3	17	15	.69
19	.10	4	.00	17	49	2.2	15	14	.57
20	.50	4	.00	15	45	1.8	13	13	.46
21	14	89	3.5	17	41	1.9	20	70	3.8
22	27	313	47	14	33	1.2	110	168	50
23	136	903	414	12	29	.94	90	55	13
24	107	416	191	12	25	.81	33	28	2.5
25	52	372	63	10	22	.59	21	20	1.1
26	15	67	2.7	8.2	18	.40	16	17	.73
27	9.2	17	.42	7.2	22	.43	14	16	.60
28	6.6	8	.14	107	288	90	12	16	.52
29	5.2	8	.11	35	101	9.5	11	16	.48
30	3.5	8	.08	19	67	3.4	11	15	.45
31	2.5	8	.05	---	---	---	11	14	.42
TOTAL	379.31	---	722.90	780.0	---	629.04	1335	---	737.52

Table 1.--Daily mean water discharge, daily mean suspended-sediment concentration, and daily suspended-sediment discharge, at station 03159534 (West Branch Shade River near Burlingham, Ohio) during the 1984 water year--Continued

Day	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)
		JANUARY			FEBRUARY			MARCH	
1	11	12	0.36	42	47	5.3	14	10	0.38
2	10	12	.32	44	26	3.1	14	10	.38
3	10	13	.35	42	60	6.8	26	11	.77
4	9.6	12	.31	33	39	3.5	34	17	1.6
5	9.4	12	.30	23	25	1.6	84	109	25
6	9.0	12	.29	19	22	1.1	75	25	5.1
7	8.6	12	.28	20	60	3.2	37	14	1.4
8	8.2	12	.27	23	63	3.9	29	13	1.0
9	7.8	12	.25	19	31	1.6	27	13	.95
10	7.6	11	.23	16	27	1.2	24	13	.84
11	7.4	13	.26	20	42	2.3	19	12	.62
12	7.2	15	.29	23	50	3.1	17	12	.55
13	7.0	15	.28	30	94	9.0	18	12	.58
14	6.8	16	.29	75	235	50	17	12	.55
15	6.8	16	.29	42	98	11	10	18	.49
16	6.6	18	.32	29	46	3.6	15	13	.53
17	6.2	16	.27	26	25	1.8	15	12	.49
18	5.8	16	.25	23	17	1.1	14	17	.64
19	5.2	16	.22	25	15	1.0	13	23	.81
20	4.7	14	.18	24	15	.97	15	23	.93
21	4.3	14	.16	20	13	.70	171	1150	565
22	4.0	14	.15	15	13	.53	75	356	74
23	50	13	1.8	17	14	.64	50	185	25
24	277	156	117	15	13	.53	28	42	3.2
25	157	84	36	16	13	.56	28	29	2.2
26	93	59	15	15	12	.49	30	24	1.9
27	70	57	11	14	12	.45	25	24	1.6
28	55	38	5.6	14	11	.42	234	755	545
29	45	24	2.9	14	11	.42	218	1030	649
30	41	20	2.2	---	---	---	74	332	69
31	39	19	2.0	---	---	---	44	157	19
TOTAL	990.2	---	199.42	738	---	119.91	1494	---	1998.51

Table 1.--Daily mean water discharge, daily mean suspended-sediment concentration, and daily suspended-sediment discharge, at station 03159534 (West Branch Shade River near Burlingham, Ohio) during the 1984 water year--Continued

Day	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)
		APRIL			MAY			JUNE	
1	33	60	5.4	20	59	3.1	21	320	17
2	26	48	3.4	18	46	2.2	16	99	4.0
3	40	210	52	38	417	42	12	29	.94
4	232	1080	706	42	143	19	7.8	15	.32
5	160	621	270	27	67	5.1	6.3	18	.31
6	98	466	99	33	153	15	4.8	21	.27
7	57	185	28	34	70	6.4	3.7	11	.11
8	40	88	9.5	35	92	11	3.5	53	4.7
9	32	67	5.8	37	152	15	3.0	8	.06
10	27	53	3.9	27	145	11	2.8	6	.05
11	22	39	2.3	21	44	2.5	2.8	7	.05
12	19	34	1.7	29	158	14	3.0	69	.77
13	20	34	1.8	22	43	2.6	1.8	17	.08
14	17	24	1.1	18	67	3.4	1.6	35	.15
15	16	24	1.0	16	95	4.3	1.7	37	.17
16	14	22	.83	15	77	2.5	1.6	13	.06
17	14	55	2.1	10	30	.81	1.4	13	.05
18	19	124	6.5	9.6	150	4.3	2.0	---	---
19	18	70	3.5	6.9	35	.69	3.3	73	.88
20	16	24	1.0	5.2	10	.14	1.6	17	.07
21	14	17	.64	5.8	73	1.6	1.8	40	.25
22	117	692	410	6.0	69	1.6	1.4	21	.08
23	107	399	126	13	132	5.9	1.4	15	.06
24	100	379	106	7.8	27	.57	14	203	9.3
25	55	158	25	8.5	88	2.7	3.3	241	2.1
26	40	52	5.6	4.3	11	.13	1.3	108	.38
27	44	118	13	3.9	8	.08	1.1	21	.06
28	35	116	11	103	2820	868	1.6	7	.03
29	27	42	3.1	184	397	204	2.8	76	1.6
30	26	42	2.9	41	189	21	3.0	169	1.4
31	---	---	---	29	569	42	---	---	---
TOTAL	1485	---	1908.07	870.0	---	1312.62	133.4	---	45.30

Table 1.--Daily mean water discharge, daily mean suspended-sediment concentration, and daily suspended-sediment discharge, at station 03159534 (West Branch Shade River near Burlingham, Ohio) during the 1984 water year--Continued

Day	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)
		JULY			AUGUST			SEPTEMBER	
1	23	237	13	1.0	27	0.07	0.00	0	0.00
2	5.2	88	1.3	1.0	13	.04	.00	0	.00
3	2.0	19	.10	1.0	8	.02	.00	0	.00
4	1.6	13	.06	1.7	7	.03	.00	0	.00
5	23	2120	257	4.6	6	.07	.00	0	.00
6	16	688	37	2.2	3	.02	.00	0	.00
7	4.3	106	1.2	2.0	3	.02	.00	0	.00
8	1.4	34	.13	1.8	3	.01	.00	0	.00
9	.68	13	.02	1.7	2	.00	.00	0	.00
10	.62	6	.01	1.8	2	.00	.00	0	.00
11	5.7	2990	123	3.5	2	.02	.00	0	.00
12	3.2	1600	21	1.8	2	.00	.00	0	.00
13	.45	6	.00	.89	2	.00	.00	0	.00
14	.04	3	.00	.40	2	.00	.00	0	.00
15	.01	2	.00	.21	2	.00	.00	0	.00
16	.00	0	.00	.08	2	.00	.00	0	.00
17	.00	0	.00	.02	2	.00	.00	0	.00
18	.00	0	.00	.01	2	.00	.00	0	.00
19	.00	0	.00	.01	0	.00	.00	0	.00
20	.00	0	.00	.00	0	.00	.00	0	.00
21	.00	0	.00	.00	0	.00	.00	0	.00
22	.00	0	.00	.00	0	.00	.00	0	.00
23	.00	0	.00	.00	0	.00	.00	0	.00
24	.00	0	.00	.00	0	.00	.00	0	.00
25	.01	0	.00	.00	0	.00	.00	0	.00
26	.21	6	.00	.00	0	.00	.00	0	.00
27	2.1	8	.05	.00	0	.00	.00	0	.00
28	10	2280	257	.00	0	.00	.00	0	.00
29	5.0	1590	37	.00	0	.00	.00	0	.00
30	1.1	95	.28	.00	0	.00	.00	0	.00
31	1.1	59	.18	.00	0	.00	---	---	---
TOTAL	106.72	---	748.33	25.72	---	0.30	0.00	---	0.00
YEAR	8337.35		8421.92						

Table 2.--Daily mean water discharge, daily mean suspended-sediment concentration, and daily suspended-sediment discharge, at station 03159555 (East Branch Shade River basin near Tuppers Plains, Ohio) during the 1984 water year

Day	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)
		OCTOBER			NOVEMBER			DECEMBER	
1	0.00	0	0.00	5.0	21	0.28	31	4	0.33
2	.00	0	.00	4.8	30	.39	24	3	.19
3	.00	0	.00	5.0	27	.36	22	3	.18
4	.00	0	.00	7.4	23	.46	180	91	49
5	.00	0	.00	6.4	14	.24	110	33	10
6	.00	0	.00	5.5	10	.15	131	61	24
7	.00	0	.00	4.6	10	.12	103	29	8.7
8	.00	0	.00	3.8	10	.10	65	12	2.1
9	.00	0	.00	3.3	11	.10	74	25	8.1
10	.00	0	.00	238	239	200	198	89	51
11	.00	0	.00	408	158	115	93	25	6.2
12	.00	0	.00	76	31	6.7	437	248	297
13	.00	0	.00	41	14	1.5	144	45	18
14	.40	24	.03	28	9	.68	90	23	5.6
15	.11	11	.00	118	75	36	92	30	7.4
16	1.0	13	.04	128	55	19	66	6	1.1
17	.84	16	.04	94	25	6.3	49	2	.26
18	.63	16	.03	57	14	2.2	40	2	.22
19	.63	18	.03	40	20	2.2	34	2	.18
20	.63	20	.03	32	20	1.7	26	2	.14
21	31	53	5.5	29	12	.94	25	3	.20
22	39	51	7.2	24	5	.32	306	254	211
23	254	480	393	21	3	.17	128	48	18
24	228	185	140	21	7	.40	70	9	1.7
25	118	68	26	19	8	.41	44	7	.83
26	27	22	1.6	16	5	.22	31	7	.59
27	19	15	.77	14	6	.23	26	13	.91
28	12	17	.55	155	106	48	22	27	1.6
29	9.1	20	.49	79	27	5.8	20	24	1.3
30	7.1	20	.38	47	7	.89	18	13	.63
31	5.5	18	.27	---	---	---	16	5	.22
TOTAL	753.94	---	575.96	1730.8	---	450.86	2715	---	726.68

Table 2.--Daily mean water discharge, daily mean suspended-sediment concentration, and daily suspended-sediment discharge, at station 03159555 (East Branch Shade River basin near Tuppers Plains, Ohio) during the 1984 water year--Continued

Day	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)
		JANUARY			FEBRUARY			MARCH	
1	15	4	0.16	42	14	1.6	83	30	6.7
2	14	3	.11	36	13	1.3	69	21	3.9
3	14	2	.08	36	17	1.7	59	19	3.0
4	14	2	.08	48	25	3.2	54	23	3.4
5	14	2	.08	40	18	1.9	95	95	24
6	14	3	.11	34	8	.73	119	119	39
7	14	2	.08	23	6	.37	76	23	4.7
8	14	3	.11	25	7	.47	60	8	1.3
9	15	3	.12	18	5	.24	38	19	2.0
10	14	3	.11	17	5	.23	33	23	1.9
11	14	3	.11	19	8	.41	35	15	1.4
12	13	5	.18	27	17	1.2	24	13	.84
13	13	4	.14	34	36	4.7	25	13	.88
14	13	3	.11	119	179	63	24	8	.52
15	12	4	.13	80	45	9.9	23	9	.56
16	12	4	.13	55	18	2.7	22	16	.95
17	11	5	.15	44	16	1.9	21	12	.68
18	10	7	.19	38	17	1.7	20	12	.65
19	8.0	7	.15	36	21	2.0	19	15	.77
20	7.0	7	.13	38	14	1.4	18	36	2.0
21	6.6	8	.14	33	7	.62	410	905	1040
22	6.2	6	.10	29	6	.47	172	128	61
23	6.0	6	.10	27	6	.44	116	50	16
24	172	139	96	24	9	.58	79	31	6.6
25	196	125	74	23	10	.62	66	28	5.0
26	101	58	16	20	10	.54	82	45	10
27	66	31	5.5	18	10	.49	76	32	6.6
28	51	18	2.5	178	512	350	167	176	139
29	43	13	1.5	154	138	63	262	305	234
30	38	11	1.1	---	---	---	119	63	20
31	43	13	1.5	---	---	---	80	30	6.5
TOTAL	983.8	---	200.90	1315	---	517.41	2546	---	1643.85

Table 2.--Daily mean water discharge, daily mean suspended-sediment concentration, and daily suspended-sediment discharge, at station 03159555 (East Branch Shade River basin near Tuppers Plains, Ohio) during the 1984 water year--Continued

Day	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)
		APRIL			MAY			JUNE	
1	60	20	3.2	26	20	1.4	26	22	1.5
2	47	15	1.9	22	20	1.2	19	28	1.4
3	53	36	6.8	26	35	2.8	15	27	1.1
4	414	531	572	45	80	11	12	22	.71
5	274	229	181	31	20	1.7	9.5	17	.44
6	126	65	22	32	23	2.0	7.9	14	.30
7	94	33	8.4	36	22	2.1	6.6	13	.23
8	67	22	4.0	36	32	3.6	5.7	19	.29
9	53	21	3.0	58	55	13	5.0	24	.32
10	43	20	2.3	39	16	1.7	4.3	19	.22
11	37	20	2.0	31	11	.92	3.7	17	.17
12	33	16	1.4	49	76	26	3.1	23	.19
13	31	12	1.0	41	27	3.0	2.8	23	.17
14	28	13	.98	31	15	1.3	2.3	27	.17
15	28	17	1.3	25	15	1.0	2.0	25	.14
16	29	14	1.1	20	17	.92	1.5	27	.11
17	29	22	1.7	18	18	.87	1.5	34	.14
18	48	26	3.4	15	19	.77	1.5	33	.13
19	57	24	3.7	14	20	.76	2.0	32	.17
20	42	17	1.9	12	20	.65	1.7	25	.11
21	35	10	.95	10	21	.57	1.7	16	.07
22	216	371	384	9.1	23	.57	1.4	17	.06
23	217	208	136	13	30	1.1	1.4	22	.08
24	158	66	28	12	39	1.3	1.5	30	.12
25	93	30	7.5	8.2	25	.55	3.4	40	.37
26	64	20	3.5	7.1	25	.48	2.1	19	.11
27	51	20	2.8	6.6	25	.45	1.5	28	.11
28	45	20	2.4	33	933	1350	1.2	20	.06
29	36	17	1.7	161	344	634	1.7	45	.26
30	32	20	1.7	76	57	13	1.3	46	.15
31	---	---	---	40	27	2.9	---	---	---
TOTAL	2540	---	1391.63	983.0	---	2081.61	150.3	---	9.40

Table 2.--Daily mean water discharge, daily mean suspended-sediment concentration, and daily suspended-sediment discharge, at station 03159555 (East Branch Shade River basin near Tuppers Plains, Ohio) during the 1984 water year--Continued

Day	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)	Mean discharge (ft^3/s)	Mean sediment concen-tration (mg/L)	Sediment discharge (ton/d)
		JULY			AUGUST			SEPTEMBER	
1	9.8	74	1.7	1.2	18	0.06	.35	18	0.02
2	5.7	38	.58	1.2	24	.10	.35	19	.02
3	3.0	30	.24	9.1	83	2.1	.30	23	.02
4	2.0	18	.10	34	260	53	.30	23	.02
5	1.8	12	.06	45	323	41	.26	22	.02
6	7.4	54	.85	15	63	2.6	.22	22	.01
7	4.1	19	.21	7.1	75	1.4	.19	22	.01
8	2.8	15	.11	7.6	66	1.4	.19	21	.01
9	1.9	13	.07	5.0	41	.55	.19	21	.01
10	1.4	12	.05	3.3	30	.27	.16	21	.00
11	2.4	33	.33	3.9	31	.33	.16	20	.00
12	4.8	64	.83	3.1	22	.18	.16	20	.00
13	2.2	42	.25	2.2	18	.11	.14	20	.00
14	1.4	33	.12	1.9	15	.08	.12	19	.00
15	1.1	25	.07	1.6	14	.06	.30	19	.02
16	.97	20	.05	1.4	16	.06	.26	19	.01
17	.84	16	.04	1.2	20	.06	.22	19	.01
18	.54	14	.02	1.0	18	.05	.19	19	.00
19	.54	12	.02	3.3	39	.28	.16	18	.00
20	.47	11	.01	2.0	20	.11	.16	18	.00
21	.47	10	.01	1.4	20	.08	.16	18	.00
22	.47	11	.01	1.2	20	.06	.14	18	.00
23	.40	11	.01	1.2	20	.06	.12	18	.00
24	.40	11	.01	1.1	19	.06	.12	17	.00
25	.40	10	.01	1.4	16	.06	.12	17	.00
26	.40	10	.01	1.2	18	.06	.12	17	.00
27	1.2	11	.04	1.0	21	.06	.06	17	.00
28	1.7	11	.05	.63	18	.03	.06	17	.00
29	9.1	137	3.3	.54	21	.03	.06	17	.00
30	2.8	24	.18	.30	25	.02	.06	16	.00
31	1.5	17	.07	.35	21	.02	---	---	---
TOTAL	74.00	---	9.41	160.42	---	104.34	5.40	---	0.18
YEAR	13957.66		7712.23						

Table 3.--Instantaneous bedload and suspended-sediment load for the Shade River stations

Station	Date	Water discharge (ft^3/s)	Instantaneous bedload (ton/d)	Instantaneous suspended sediment (ton/d)	Percent of total load
West Branch Shade River near Harrisonville (03159532)	10-24-83	5.3	2.4	60	4
	10-24-83	21.1	20.6	308	6
	11-10-83	21.5	16.4	99	14
	2-01-84	1.8	0.7	.05	93
	3-28-84	3.2	0.7	34	2
	5-03-84	4.0	1.2	43	3
West Branch Shade River near Burlingham (03159534)	10-24-83	40.8	28.9	41	41
	2-01-84	10.8	7.0	1.8	79
	2-15-84	36.8	26.8	10.4	72
	4-16-84	13.6	24	0.8	97
	5-03-84	66	6.0	144	4
East Branch Shade River near Tuppers Plains (03159555)	2-15-84	72.9	0.9	6.9	13

Table 4.--Water-quality analyses of samples collected at each of the gaging stations

03159532 -- West Branch Shade River near Harrisonville, Ohio

Date	Time	Temperature (°C)	Streamflow, instantaneous ft^3/s	Specific conductance (µS/cm)	pH	Alkalinity, field (mg/L as $CaCO_3$)	Sulfate dissolved (mg/L as as SO_4)	Iron, suspended recoverable (µg/L as Fe)	Iron, total recoverable (µg/L as Fe)
Jan. 16, 1984	1600	0.0	0.33	560	5.1	3	300	900	2900
May 22, 1984	0800	16.5	.20	572	4.1	--	290	--	1400

Date	Time	Iron, dissolved (µg/L as Fe)	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)	Acidity (mg/L as H)	Drainage area (mi^2)
Jan. 16, 1984	1600	2000	0	5800	5800	7000	6900	100	1.9	0.99
May 22, 1984	0800	30	--	5300	5200	4600	4300	--	1.0	.99

Table 4.--Water-quality analyses of samples collected at each of the gaging stations--Continued

391103082045600 -- Unnamed tributary to West Branch Shade River near Burlingham, Ohio

Date	Time	Temperature (°C)	Streamflow, instantaneous ft^3/s	Specific conductance (µS/cm)	pH	Alkalinity, field (mg/L as $CaCO_3$)	Sulfate dissolved (mg/L as as SO_4)	Iron, suspended recoverable (µg/L as Fe)	Iron, total recoverable (µg/L as Fe)
Feb. 02, 1984	1300	0.0	7.8	247	7.1	48	64	30	90
May 21, 1984	1615	22.0	1.4	270	7.3	67	61	--	250
June 27, 1984	1510	--	--	--	--	--	--	--	--

Date	Time	Iron dissolved (µg/L as Fe)	Maganese, 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)	Acidity (mg/L as H)	Drainage area (mi^2)
Feb. 02, 1984	1300	60	50	150	100	200	200	0	0.1	--
May 21, 1984	1615	40	--	70	60	100	100	--	--	--
June 27, 1984	1510	--	--	--	--	--	--	--	--	--

Table 4.--Water-quality analyses of samples collected at each of the gaging stations--Continued

391009082053600 -- West Branch Shade River near Burlingham, (Snowville) Ohio

Date	Time	Temperature (°C)	Streamflow, instantaneous ft^3/s	Specific conductance (µS/cm)	pH	Alkalinity, field (mg/L as $CaCO_3$)	Sulfate dissolved (mg/L as as SO_4)	Iron, suspended recoverable (µg/L as Fe)	Iron, total recoverable (µg/L as Fe)
Jan. 16, 1984	1500	0.0	2.8	513	5.4	3	240	420	960
May 22, 1984	0900	18.5	1.9	451	5.5	7	200	--	550
June 27, 1984	1500	--	--	--	--	--	--	--	--

		Iron, dissolved (µg/L as Fe)	Maganese, 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)	Acidity (mg/L as H)	Drainage area (mi^2)
Jan 16, 1984	1200	540	0	4600	4600	2900	2300	600	0.4	10.2
May 21, 1984	1450	60	--	3800	2200	1600	300	--	.3	10.2
June 27, 1984	1115	--	--	--	--	--	--	--	--	10.2

Table 4.--Water-quality analyses of samples collected at each of the gaging stations--Continued

03159534 -- West Branch Shade River near Burlingham, Ohio

Date	Time	Temperature (°C)	Streamflow, instantaneous ft^3/s	Specific conductance (µS/cm)	pH	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)
Jan. 16, 1984	1200	0.5	6.7	455	5.8	18	200	200	1400
May 22, 1984	1450	24.5	5.4	411	6.7	30	170	--	670
June 27, 1984	1115	--	--	--	--	--	--	--	--

Date	Time	Iron, dissolved (µg/L as Fe)	Maganese, 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)	Acidity (mg/L as H)	Drainage area (mi^2)
Jan 16, 1984	1200	1200	0	3300	3300	1000	100	--	0.1	22.2
May 21, 1984	1450	670	650	--	2200	400	100	--	.1	22.2
June 27, 1984	1115	--	--	--	--	--	--	--	--	22.2

Table 4.--Water-quality analyses of samples collected at each of the gaging stations--Continued

03159555 -- East Branch Shade River near Tuppers Plains, Ohio

Date	Time	Temperature (°C)	Streamflow, instantaneous ft^3/s	Specific conductance (µS/cm)	pH	Alkalinity, field (mg/L as $CaCO_3$)	Sulfate dissolved (mg/L as as SO_4)	Iron, suspended recoverable (µg/L as Fe)	Iron, total recoverable (µg/L as Fe)
Jan. 17, 1984	0930	0.0	11	355	7.8	110	44	70	130
May 21, 1984	1245	20.0	11	392	7.8	134	40	--	760
June 27, 1984	1610	--	--	--	--	--	--	--	--

		Iron, dissolved (µg/L as Fe)	Maganese, 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)	Acidity (mg/L as H)	Drainage area (mi^2)
Jan 17, 1984	0930	60	0	160	160	100	100	--	--	37.5
May 21, 1984	1245	50	--	230	160	200	100	--	--	37.5
June 27, 1984	1610	--	--	--	--	--	--	--	--	37.5

Table 5.--Coal-separation analyses

[g/kg, grams of coal per kilogram of sediment. Asterisks indicate streams draining unmined basins. Boxed-in numbers are concentrations at main-stem sites]

Station name	Latitude-longitude	Concentration (g/kg)
West Branch Shade River basin		
West Branch Shade River near Harrisonville (03159532)-------	391040-820814	0.2
Unnamed tributary to West Branch Shade River near Harrisonville	390940-820705	1.7
Goose Creek----------	391116-820758	2.9
West Branch Shade River near Burlingham (Snowville)--------	391009-820536	1.4
Unnamed tributary to West Branch Shade River near Burlingham---	391103-820456	1.1*
West Branch Shade River near Burlingham (03159534)---------	391014-820304	3.3
West Branch Shade river---------	390852-820036	11.0
Kingsbury Creek near Harrisonville----------	390752-820448	6.0
Unnamed tributary to Kingsbury Creek near Harrisonville------	390832-820451	1.2
Kingsbury Creek near Burlingham-	390742-820259	2.7
East Branch Shade River basin		
East Branch Shade River near Tuppers Plains (03159555)-----	390829-815239	0.5*

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