LAKE ERIE TRIBUTARY LOADING STUDIES

1987 WATER YEAR

DRAFT REPORT

Submitted in Partial Fulfillment of
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Great Lakes National Program Office
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Chicago, Illinois 60604

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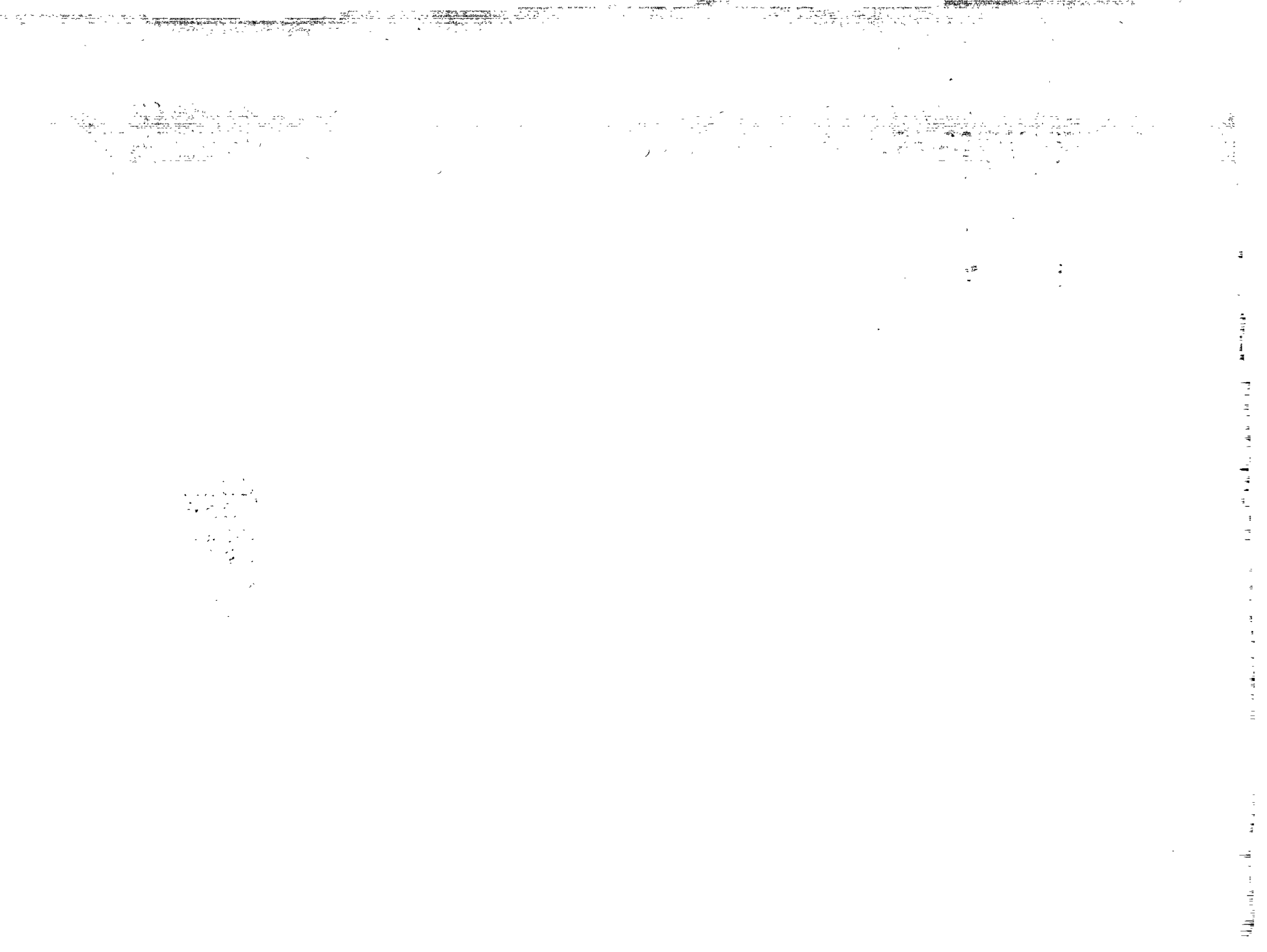

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BACKGROUND

For the portion of the 1987 water year extending from May 1, 1987 through August 31, 1987, the Great Lakes National Program Office provided partial support (Grant R005967-01) for the sediment, nutrient, and pesticide monitoring program at six long term river transport stations in the Lake Erie Basin. Additional support for the operation of this program, both during the above time period and during the balance of the water year, was provided by the State of Ohio and by manufacturers of pesticides and soaps and detergents. Parallel monitoring is also underway at a seventh station, a tributary to Lost Creek in Defiance County, with support from the U. S. Soil Conservation Service.

The program conducted during the 1987 water year is part of a large scale, long term agricultural ecosystem study in the Lake Erie Basin.[1] The EPA's Great Lakes National Program Office also provided partial support for these research and monitoring efforts during the five year interval beginning with the 1982 water year. On an annual basis, the program provides detailed information on nutrient, sediment and pesticide loading into Lake Erie from its major tributaries, as called for in the Great Lakes Surveillance Plan.[2] Beginning with the 1988 water year, support from the State of Ohio was increased, and portions of the program were incorporated into an expanded cooperative tributary loading program involving the U. S. Geological Survey, the State of Ohio (through the Ohio Department of Natural Resources) and Heidelberg College.

The reporting program associated with the above research and monitoring activities involves several formats. At approximately four year intervals, major interpretive reports are prepared.[1,3] The data also serve as a basis for numerous journal publications[4,5,6,7] and published symposia papers.[8,9,10,11,12,13] For years between the major interpretive reports, the grant reports consist primarily of data summaries, as produced by existing programs for calculating loads and various types of average concentrations. This type of data report was produced for the 1986 water year,[14] and is the type prescribed in the proposals associated with this 1987 water year EPA grant.

Consequently, this report will consist primarily of data summaries in the form of tables, figures, and appendices. The reader is referred to our most recent interpretive report for detailed discussions of field collection, chemical analyses, and data analysis procedures, as well as for discussions of the characteristics of agricultural nonpoint pollution illustrated by these studies[4].

STUDY LOCATIONS

The locations of the six sampling stations included in this study, as well as that for the tributary to Lost Creek, are shown in Figure 1. All seven of the stations are located at U. S. Geological Survey stream gaging stations. The U. S. Geological Survey station number at each site is also shown in Figure 1. Additional information regarding each station, as well as precise coordinates for each station, are published in Volume 2 of the *Water Resources Data, Ohio , Water Year 1987*, as published by the U. S. Geological Survey. The chemical concentration data for each station is stored in the STORET data base under the U.S. Geological Survey station number and the Heidelberg College Water Quality Laboratory agency code.

NUTRIENT AND SEDIMENT LOADS

MONTHLY AND ANNUAL LOADS

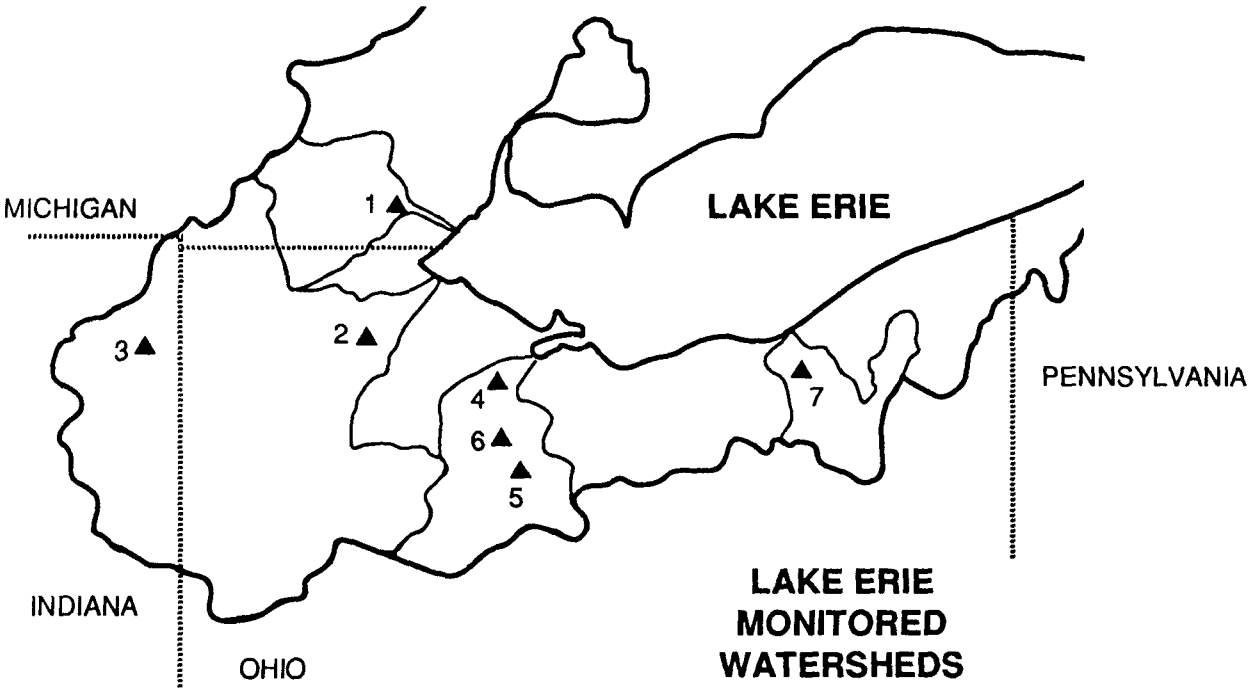
The monthly and annual loads of sediments and major nutrients for the seven stations are shown in Appendix 1. Annual chemographs and hydrographs are shown on the page facing the corresponding monthly loading tables.

TIME WEIGHTED AND FLOW WEIGHTED CONCENTRATIONS

The time weighted mean concentrations (TWMC) and flow weighted mean concentrations (FWMC) for the 1987 water year for the major parameters at each station are shown in Table 1. FWMC's exceed TWMC's for parameters whose concentrations are higher during high flow conditions than during low flow conditions. For all stations and parameters listed, except for soluble reactive phosphorus and nitrates at the Cuyahoga River station, FWMC's exceed TWMC's. The higher low flow concentrations of soluble reactive phosphorus and nitrates at the Cuyahoga station can be attributed to significant point sources of these substances in the Cuyahoga River Basin.

COMPARISON BETWEEN 1987 ANNUAL LOADS AND LONG TERM AVERAGE ANNUAL LOADS

In Table 2, the annual loads for the major parameters for the 1987 water year are compared with the average annual loads observed for the indicated period of record for each station. For virtually all cases, the 1987 loads were less than the long term average loads. It should also be noted that the annual discharges at each station were also lower



1 River Raisin near Monroe (USGS 04176500)
2 Maumee River at Bowling Green (USGS 04193500)
3 Lost Creek near Defiance (USGS 04185440)
4 Sandusky River at Fremont (USGS 04198000)
5 Honey Creek at Melmore (USGS 04197100)
6 Rock Creek at Tiffin (USGS 04197170)
7 Cuyahoga River at Independence (USGS 04208000)

Figure 1. Locations of sampling stations in the Lake Erie tributary monitoring program.

Table 1. Comparisons of time weighted mean concentrations (TWMC) and flux weighted mean concentrations (FWMC) for sediments and nutrients at Lake Erie Basin transport stations.

Station	SS, mg/L		TP, mg/L		SRP, mg/L		NO23-N, mg/L		TKN, mg/L	
	TWMC	FWMC	TWMC	FWMC	TWMC	FWMC	TWMC	FWMC	TWMC	FWMC
Maumee River	69.7	129	0.215	0.299	0.057	0.075	5.12	6.51	1.54	1.78
Sandusky River	93.6	155	0.202	0.288	0.044	0.051	3.42	4.57	1.33	1.62
Cuyahoga River	77.3	168	0.258	0.320	0.083	0.067	2.15	1.69	1.20	1.41
Raisin River	28.3	44	0.110	0.135	0.027	0.047	3.04	3.95	1.16	1.31
Honey Creek	57.4	133	0.206	0.379	0.061	0.080	4.05	5.26	1.27	1.96
Rock Creek	44.7	152	0.157	0.384	0.034	0.057	2.18	2.54	1.11	2.09
Lost Creek	37.5	197	0.144	0.384	0.029	0.061	2.79	5.14	1.24	2.78

Table 2. Comparison of 1987 water year nutrient and sediment loads (in metric tons) with long term average loads for Lake Erie tributaries.

Station	Drainage Area (mi^2)	Years of Record	Sediment		Total Phosphorus		NO23-N		TKN		Chloride	
			1987	Avg	1987	Avg	1987	Avg	1987	Avg	1987	Avg
Maumee R.	6330	9	436,000	1,053,000	1,010	2,290	21,900	25,700	6,040	9,340*	112,300	142,900*
Sandusky R.	1251	13	195,000	265,000	377	499	4,800	5,170	1,960	2,040*	24,320	28,800*
Raisin R.	1042	6	25,100	55,500	78	161	2,270	2,820	750	950	23,800	24,220
Cuyahoga R.	707	6	137,780	190,690	269	392	1,440	1,690	1,200	1,330	75,290	88,870
Honey Cr.	149	12	14,060	23,250	40	50	557	606	207	221*	2,160	2,410*
Rock Cr.	34.6	4	3,410	6,740	8	13	68	93	44	58	511	600
Lost Cr.	4.23	---	682	---	1	---	13	---	9	---	49	---

* 6 year average

than the long term average. It is likely that the lower stream flows were associated with rainfall patterns and that these lower stream discharges are primarily responsible for the lower than average annual loading.

In Figures 2-4, the seasonal and annual loads and discharges are shown for the Maumee and Sandusky rivers and for Honey Creek. These figures illustrate the extensive variability associated with sediment and nutrient export from these rivers. Recent studies by Richards[15] identify several of these tributaries as prime examples of event response tributaries.

PESTICIDE CONCENTRATIONS AND LOADS

PESTICIDE CONCENTRATIONS IN INDIVIDUAL SAMPLES

The pesticide concentration data for individual samples for each station are presented in Appendix 3. That appendix also contains a description of the analytical methods used for pesticide analysis.

PESTICIDE LOADS

The pesticide loads transported at each of the sampling stations are presented in Appendix 2.

TIME WEIGHTED MEAN CONCENTRATIONS (TWMC'S) OF PESTICIDES

The TWMC's, along with the 50th, 90th, and 95th percentile concentrations and the maximum concentrations at the transport stations are shown for each of the six major herbicides included in this study in Tables 3-8. The calculations include all samples collected between April 15 and August 15, 1987. The data in the tables have not been corrected for recoveries less than 100%. The average recovery for each herbicide is listed in a footnote for each table.

CONCENTRATION EXCEEDENCY CURVES FOR PESTICIDES

Concentration exceedency curves for the three herbicides used in the largest quantities and having the highest concentrations in stream systems (alachlor, metolachlor, and atrazine) are shown for the Maumee River (Figure 5), the Sandusky River (Figure 6) and Honey Creek (Figure 7). The use and interpretations of the pesticide concentration exceedency curves are presented elsewhere.[4]

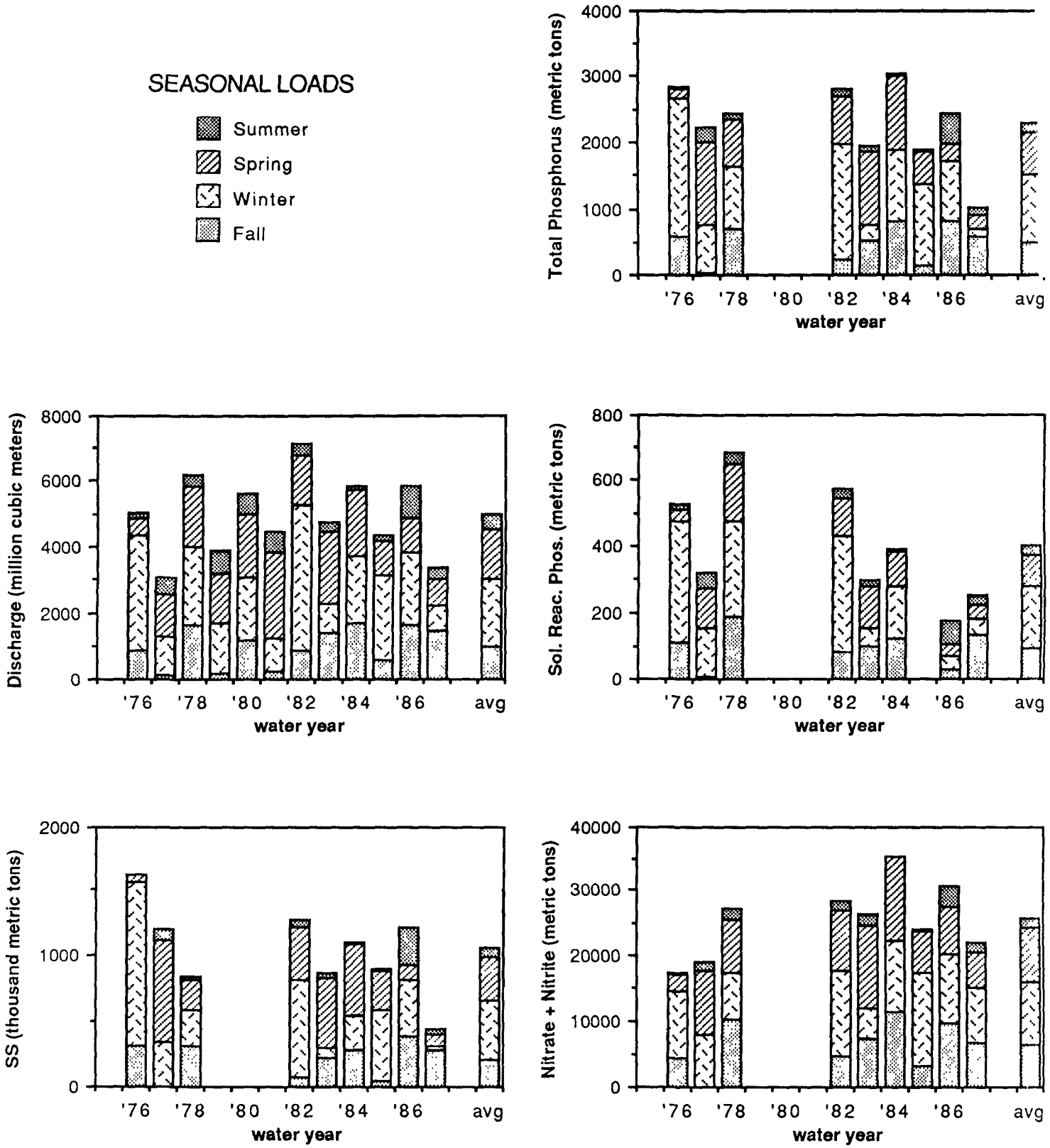


Figure 2. Annual variability and seasonal distribution of discharge and loading of SS, TP, SRP and Nitrate + Nitrite-Nitrogen at the Maumee River transport station.

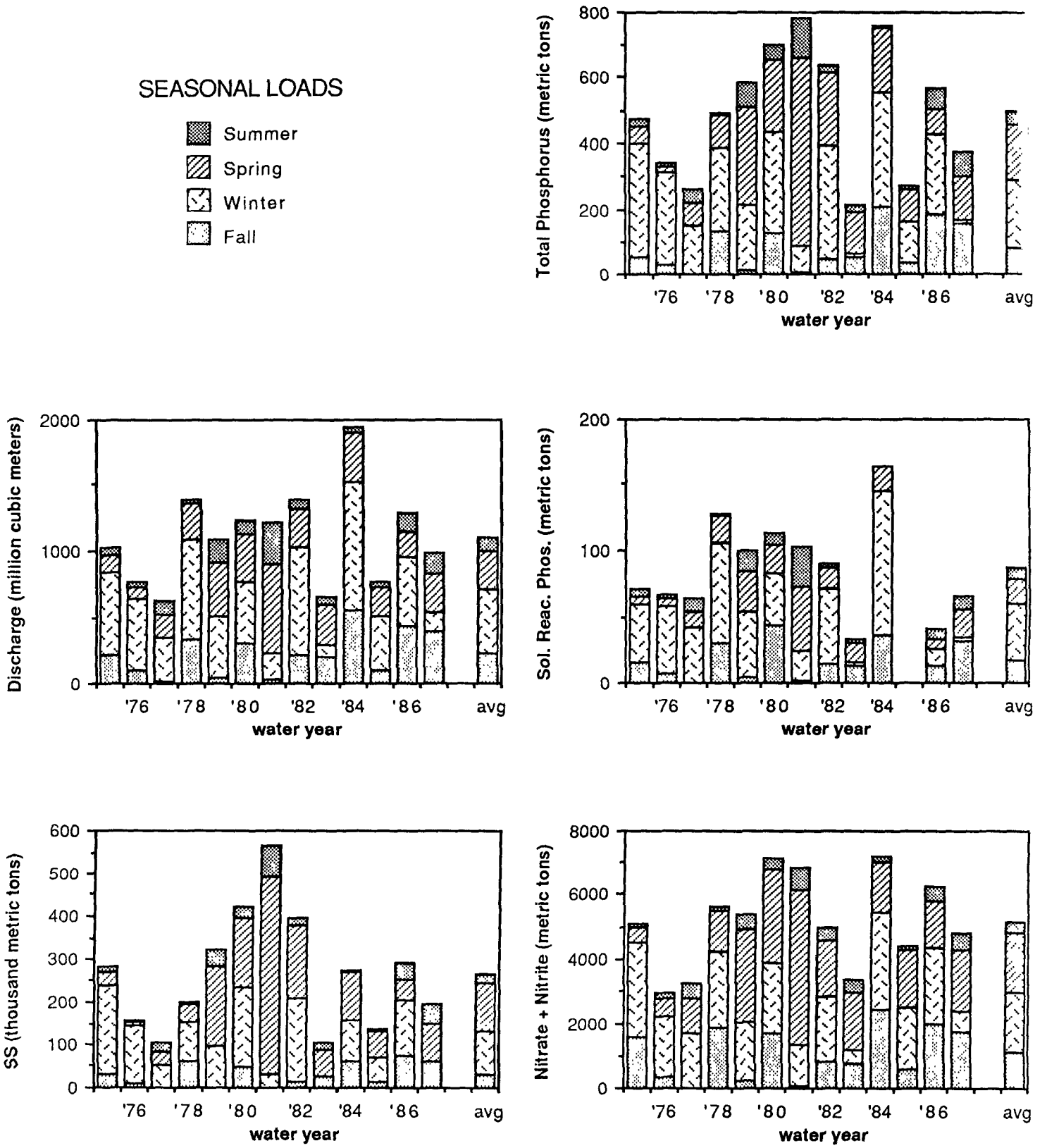


Figure 3. Annual variability and seasonal distribution of discharge and loading of SS, TP, SRP and Nitrate + Nitrite-Nitrogen at the Sandusky River transport station.

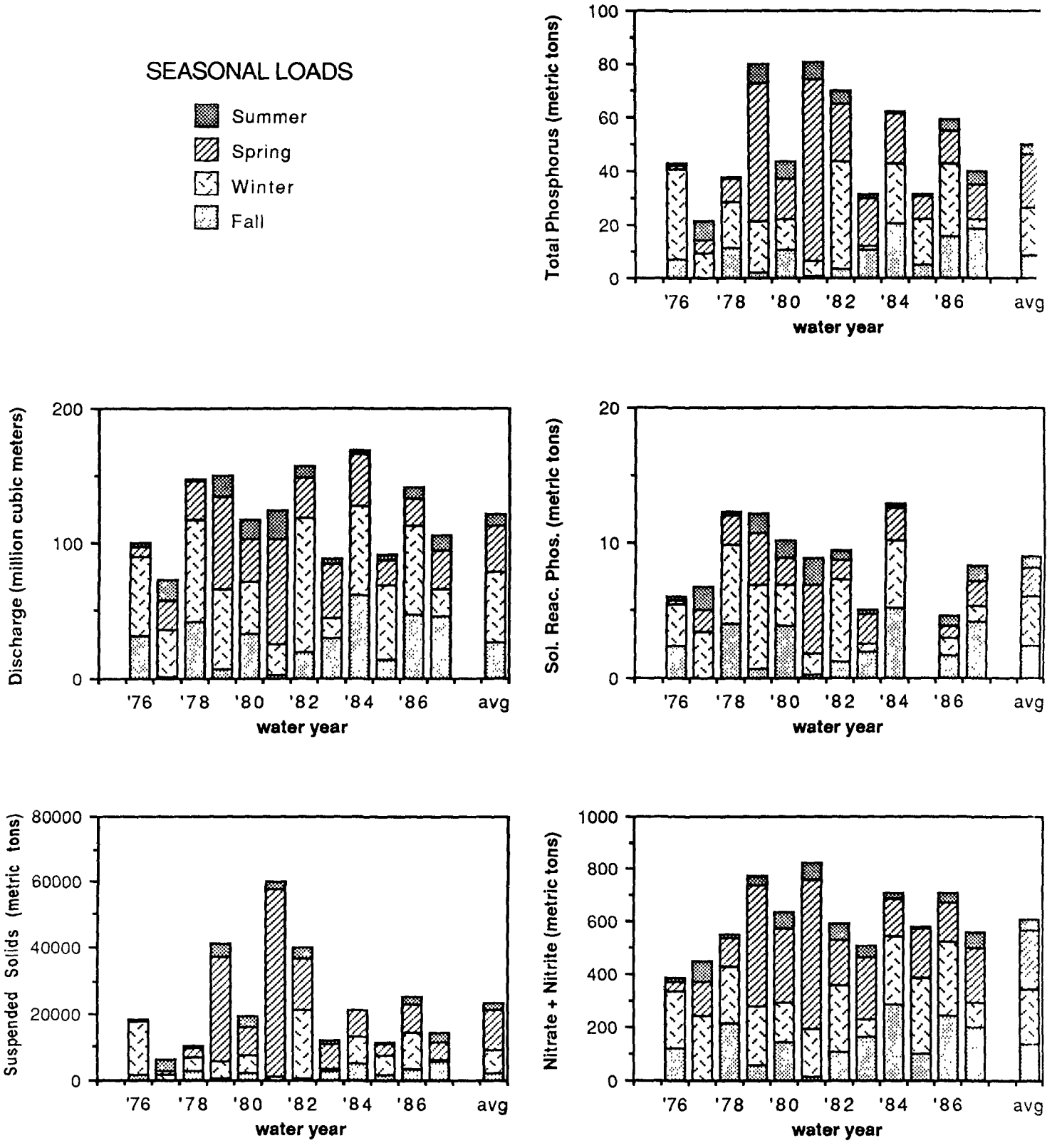


Figure 4. Annual variability and seasonal distribution of discharge and loading of SS, TP, SRP and Nitrate + Nitrite-Nitrogen at the Honey Creek transport station.

Table 3. Time weighted mean concentrations (TWMC), percentile concentrations and maximum levels for alachlor at seven stations.* Data include all samples collected between April 15 and August 15.

Station	N	TWMC µg/L	Percentile 50th µg/L	90th µg/L	95th µg/L	Maximum µg/L
Maumee R.	40	1.518	0.789	3.017	4.965	5.666
Sandusky R.	66	1.714	0.522	4.152	9.754	9.754
Raisin R.	7	0.734	0.020	1.771	1.771	2.017
Cuyahoga R.	6	0.233	0.020	0.020	0.939	0.939
Honey Cr.	103	2.901	0.410	6.076	9.384	54.866
Rock Cr.	64	0.592	0.282	1.377	2.158	16.883
Lost Cr.	87	0.925	0.180	1.690	3.231	20.189

* The average recovery for alachlor was 74%. The data in Table 3 are not corrected for recoveries of less than 100%.

Table 4. Time weighted mean concentrations (TWMC), percentile concentrations and maximum levels for metolachlor at seven stations.* Data include all samples collected between April 15 and August 15.

Station	N	TWMC µg/L	Percentile 50th µg/L	90th µg/L	95th µg/L	Maximum µg/L
Maumee R.	40	3.895	2.241	8.492	9.311	10.558
Sandusky R.	66	3.818	0.874	9.267	20.113	20.113
Raisin R.	7	0.595	0.020	1.008	1.008	2.104
Cuyahoga R.	6	1.549	0.000	3.084	4.435	4.435
Honey Cr.	103	3.968	1.638	10.457	13.704	23.761
Rock Cr.	64	2.119	0.558	4.645	7.594	18.657
Lost Cr.	87	2.248	0.636	4.954	7.945	53.959

* The average recovery for metolachlor was 77%. The data in Table 4 are not corrected for recoveries of less than 100%.

Table 5. Time weighted mean concentrations (TWMC), percentile concentrations and maximum levels for atrazine at seven stations.* Data include all samples collected between April 15 and August 15.

Station	N	TWMC µg/L	Percentile 50th µg/L	90th µg/L	95th µg/L	Maximum µg/L
Maumee R.	40	4.764	3.459	9.217	9.476	9.916
Sandusky R.	66	3.853	1.583	10.732	16.449	16.449
Raisin R.	7	1.898	0.020	3.911	4.531	4.843
Cuyahoga R.	6	0.748	0.020	0.422	2.617	2.617
Honey Cr.	103	5.391	2.265	12.829	15.532	35.111
Rock Cr.	64	1.848	0.785	5.020	6.171	17.321
Lost Cr.	87	3.610	1.431	8.220	11.674	45.782

* The average recovery for atrazine was 76%. The data in Table 5 are not corrected for recoveries of less than 100%.

Table 6. Time weighted mean concentrations (TWMC), percentile concentrations and maximum levels for metribuzin at seven stations.* Data include all samples collected between April 15 and August 15.

Station	N	TWMC µg/L	Percentile 50th µg/L	90th µg/L	95th µg/L	Maximum µg/L
Maumee R.	40	0.747	0.346	2.149	2.324	2.872
Sandusky R.	66	0.861	0.102	3.682	4.054	4.054
Raisin R.	7	0.255	0.020	0.272	0.367	1.144
Cuyahoga R.	6	0.148	0.020	0.020	0.513	0.513
Honey Cr.	103	0.734	0.132	1.853	4.070	5.180
Rock Cr.	64	0.285	0.036	0.833	1.219	4.409
Lost Cr.	87	0.413	0.000	1.125	1.342	11.482

* The average recovery for metribuzin was 70%. The data in Table 6 are not corrected for recoveries of less than 100%.

Table 7. Time weighted mean concentrations (TWMC), percentile concentrations and maximum levels for cyanazine at seven stations.* Data include all samples collected between April 15 and August 15.

Station	N	TWMC µg/L	Percentile 50th µg/L	90th µg/L	95th µg/L	Maximum µg/L
Maumee R.	40	1.111	0.534	2.717	3.943	4.535
Sandusky R.	66	0.685	0.254	2.769	4.445	4.445
Raisin R.	7	0.343	0.020	0.782	0.782	1.430
Cuyahoga R.	6	0.088	0.020	0.027	0.141	0.273
Honey Cr.	103	1.009	0.330	2.040	2.677	14.730
Rock Cr.	64	0.147	0.000	0.327	0.599	3.266
Lost Cr.	87	1.556	0.253	3.047	9.184	18.317

* The average recovery for cyanazine was 62%. The data in Table 7 are not corrected for recoveries of less than 100%.

Table 8. Time weighted mean concentrations (TWMC), percentile concentrations and maximum levels for linuron at seven stations.* Data include all samples collected between April 15 and August 15.

Station	N	TWMC µg/L	Percentile 50th µg/L	90th µg/L	95th µg/L	Maximum µg/L
Maumee R.	40	0.428	0.000	0.481	3.473	3.473
Sandusky R.	66	0.093	0.000	0.020	1.465	2.574
Raisin R.	7	0.031	0.020	0.020	0.020	0.020
Cuyahoga R.	6	0.048	0.020	0.020	0.020	0.020
Honey Cr.	103	0.292	0.000	0.020	3.952	6.973
Rock Cr.	64	0.068	0.000	0.000	0.020	9.508
Lost Cr.	87	0.097	0.000	0.000	0.020	13.436

* Recovery data not yet available.

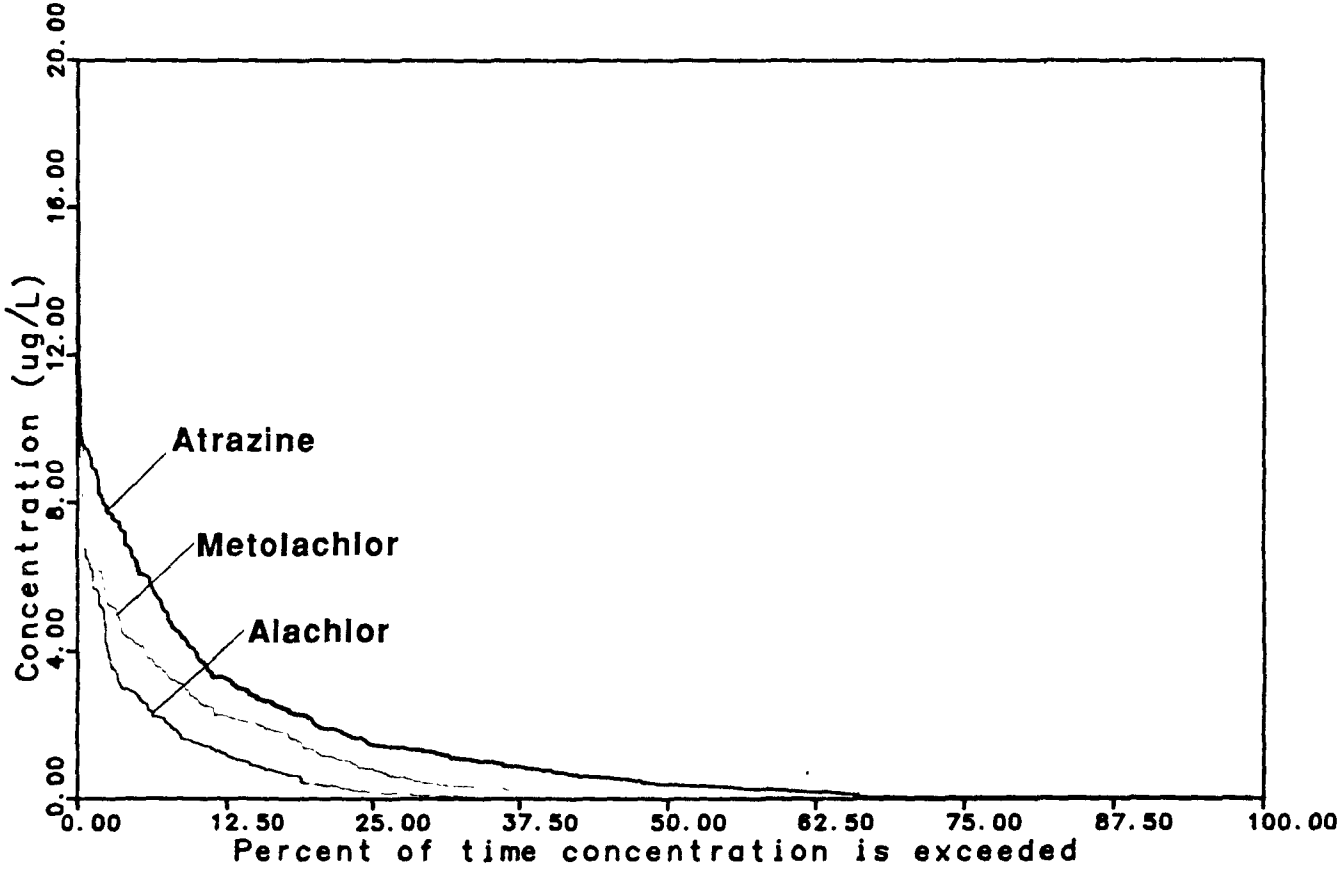


Figure 5. Concentration exceedency curves for three major herbicides in the Maumee River during the period from April 1983 through October 1987.

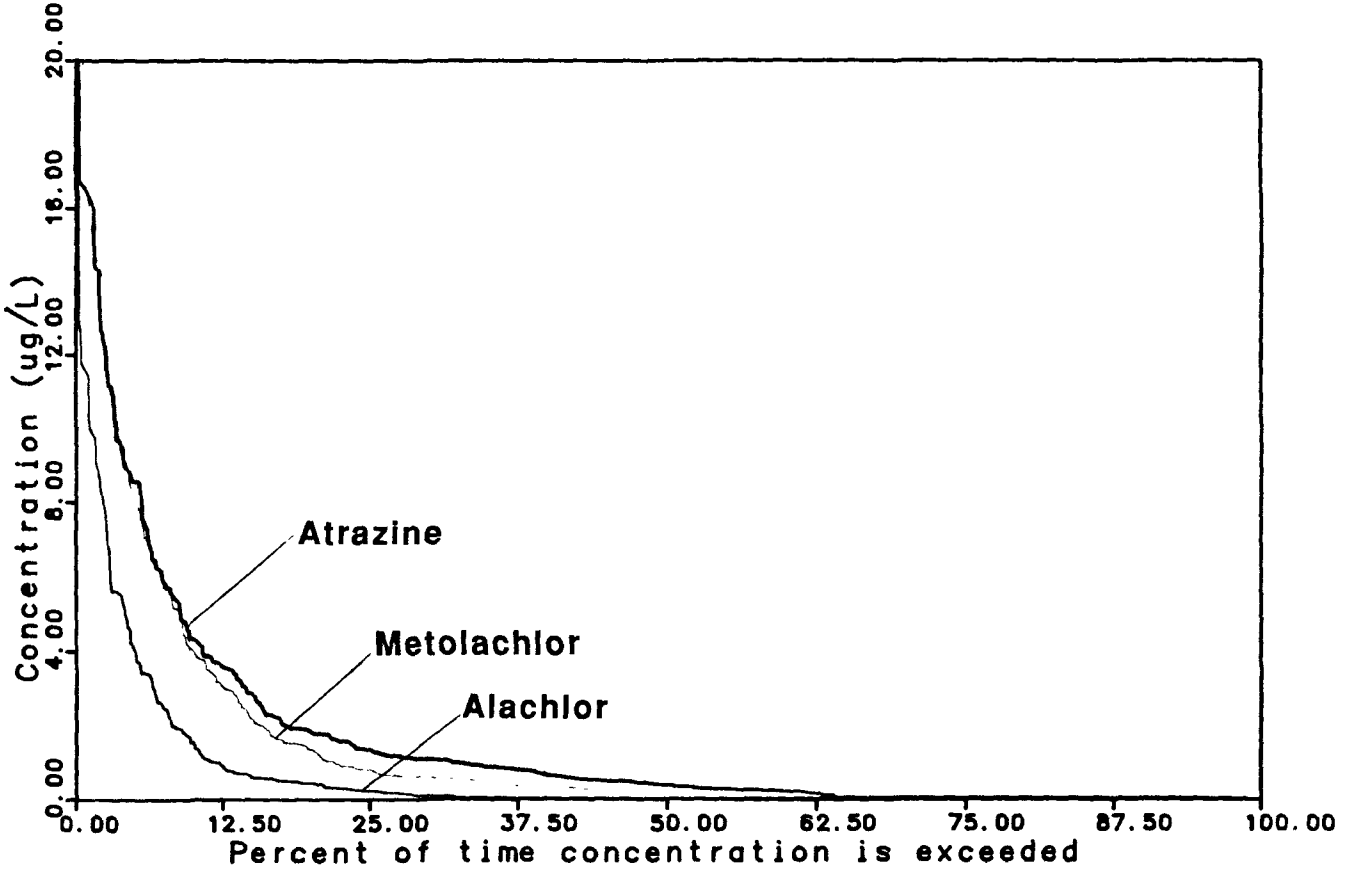


Figure 6. Concentration exceedency curves for three major herbicides in the Sandusky River during the period from April 1983 through October 1987.

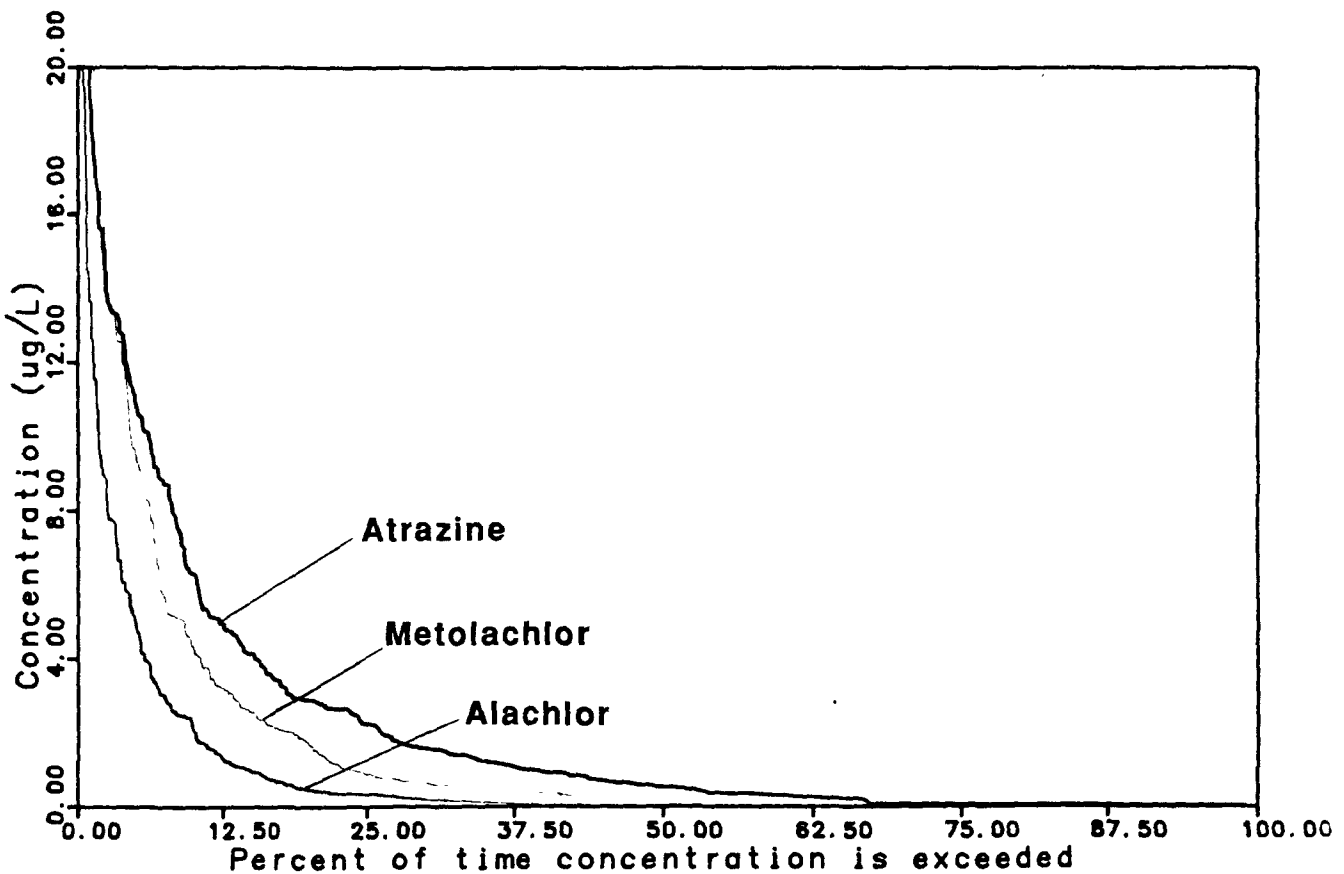


Figure 7. Concentration exceedency curves for three major herbicides in Honey Creek during the period from April 1983 through October 1987.

REFERENCES

1. Baker, D. B. 1988. Sediment, Nutrient and Pesticide Transport in Selected Lower Great Lakes Tributaries. EPA Report EPA-905/4-88-001, U. S. EPA Great Lakes National Program Office, Chicago. 225 p.

2. Great Lakes International Surveillance Plan (GLISP). 1986. International Joint Commission, Detroit. Part 5.

3. Baker, D. B. 1984. Fluvial transport and processing of sediments and nutrients in large agricultural river basins. U.S. Environ. Protection Agency, ERL, Athens, Georgia. EPA-600/3-83-054.

4. Richards, R. P. 1985. Monte Carlo studies of sampling strategies for estimating tributary loads: II. Effects on bias and precision due to differences among watershed sizes and the transported materials being monitored. U.S. EPA, Region V, Chicago.

5. Baker, D.B. 1985. Regional water quality impacts of intensive row-crop agriculture: a Lake Erie Basin case study. J. Soil and Water Conserv. 40:125-132.

6. Richards. R. P., J. W. Kramer, D. B. Baker, and K. A. Krieger. 1987. Pesticides in rainwater in the northeastern United States. Nature, Vol. 327, No. 6118, 14 May 1987.

7. Richards, R. P. 1985. Estimating the extent of reduction needed to statistically demonstrate reduced nonpoint phosphorus loading to Lake Erie. J. Great Lakes Res. 11 (2):110-116.

8. Baker, D. B. 1985b. Impacts of cropland runoff on nutrient and pesticide concentrations in river systems in The Offsite Costs of Soil Erosion. Proceedings of a symposium, May 1985. The Conservation Foundation, Washington, D.C. pp. 63-80.

9. Baker, D. B. 1987. Rural nonpoint pollution in the Lake Erie Basin: Overview. IN: Effects of Conservation Tillage on Groundwater Quality -- Nitrates and Pesticides. Lewis Pub., Chelsea, MI. pp. 65-91.

10. Baker, D.B., K. A. Krieger, R. P. Richards and J. W. Kramer. 1985a. Effects of intensive agricultural land use on regional water quality in northwestern Ohio. pp. 201-207. IN: U.S. EPA, Perspective on nonpoint source pollution. EPA 440/5-85-001.

11. Baker, D. B., K. A. Krieger, R. P. Richards and J. W. Kramer. 1985b. Gross erosion rates, sediment yields, and nutrient yields. IN: Perspective on nonpoint source pollution. EPA 440/5-85-001.

12. Baker, D.B. 1988. Farm chemicals in surface waters. IN: Water Quality: A Realistic Perspective. University of Michigan, Ann Arbor. pp. 219-234.

13. Richards, R. P. and D. B. Baker. 1988. Estimates of human exposure to pesticides through drinking water: A preliminary risk assessment. 26 p.

14. Baker, D. B. 1987. An integrated tributary loading program and conservation tillage assessment program for the Lower Great Lakes. 1986 Water Year Summary Report. Grant Number R005817-01-2. Great Lakes National Program Office, Chicago. 49 p.

15. Richards, R. P. 1988. Measures of flow variability and a new classification of Great Lakes tributaries. Report to U.S. EPA/GLNPO, 18 pp. plus figures and appendices.

LAKE ERIE TRIBUTARY LOADING STUDIES

APPENDIX 1

CONCENTRATIONS AND LOADS OF NUTRIENTS AND SEDIMENTS IN LAKE ERIE TRIBUTARIES

(1987 WATER YEAR)

Submitted in Partial Fulfillment of
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Great Lakes National Program Office
U. S. Environmental Protection Agency, Region 5
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Note: In this appendix, the concentrations and loads of nutrients and sediments are presented in the same format that was used in Appendix 1 of the 1988 report by Baker entitled *Sediment, Nutrient and Pesticide Transport in Selected Lower Great Lakes Tributaries* (EPA-905/4-88-001). The reader is referred to that document for details on the methods used to calculate monthly and annual loads of nutrients and sediments.

List of Tables

The following tables for the indicated stations include:

1. USGS discharge for each month and the entire water year.
2. The ratios of the monthly USGS discharge to the discharge observed in the monitoring program.
3. The number of samples analyzed each month.
4. The monthly and water year loads of suspended solids (SS), total phosphorus (TP), soluble reactive phosphorus (SRP), nitrate plus nitrite-nitrogen (NO23-N), total Kjeldahl nitrogen (TKN), and Chloride (Cl).

List of Figures

The following figures for the indicated stations include annual hydrographs, sedigraphs and chemographs for total phosphorus, soluble reactive phosphorus, nitrate plus nitrite-nitrogen, and conductivity.

Table 1. Monthly loads and discharge for the Maumee River for water year 1987. Discharge is given in million cubic meters, and loads are given in metric tons.

Month	USGS Discharge	Flow Ratio	N of Samples	SS	TP	SRP	NO23-N	TKN	CL
Oct	665.98	0.935	45	170404	322.6	79.43	1956	1588.0	13780.4
Nov	308.98	0.956	37	45058	107.2	22.65	2071	566.5	15717.6
Dec	485.19	1.009	26	53744	152.5	31.14	2598	890.2	14204.0
Jan	180.44	1.084	35	3873	26.9	12.85	761	191.4	7673.4
Feb	293.49	0.937	33	14151	48.5	18.46	1546	389.9	11716.8
Mar	289.97	0.947	39	21090	47.2	13.69	6010	468.4	9911.2
Apr	300.42	0.918	34	20004	50.0	11.48	1584	403.8	10388.9
May	279.35	0.927	38	35461	78.1	13.18	2316	562.8	9093.5
Jun	225.22	0.931	39	33092	69.0	16.22	1775	410.4	7089.9
Jul	262.80	0.978	35	33167	82.3	27.81	1236	435.6	7122.5
Aug	49.82	1.261	36	2887	19.2	3.34	13	42.0	2639.4
Sep	46.92	1.602	32	2587	10.7	1.61	31	91.5	2980.8
Totals	3388.58		429	435517	1014.1	251.88	21896	6040.5	112318.0

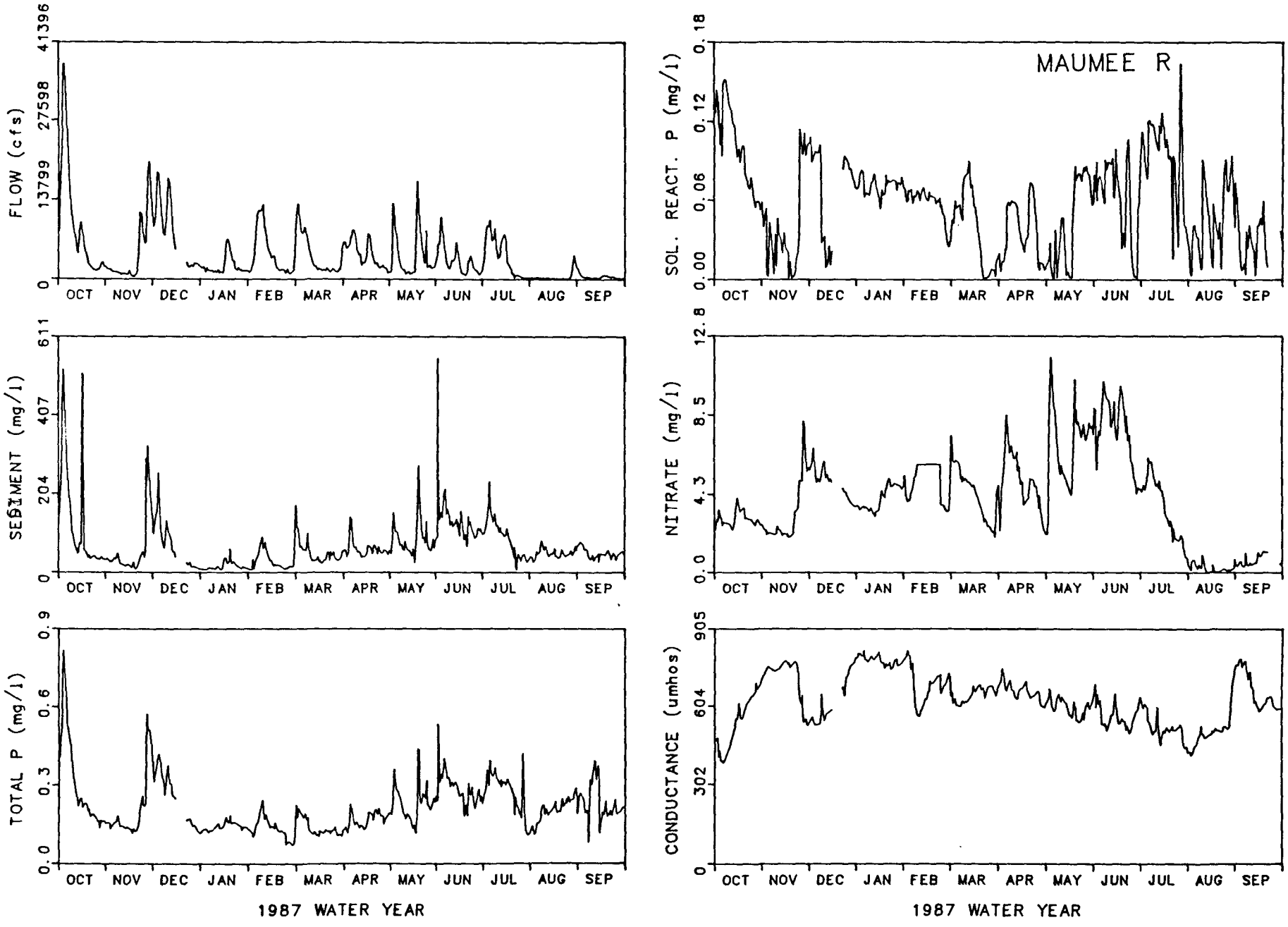

Figure 1. Annual hydrograph, sedigraph and nutrient chemograph for the Maumee River (USGS No. 04193500) during the 1987 water year.

Table 2. Monthly loads and discharge for the Sandusky River for water year 1987. Discharge is given in million cubic meters, and loads are given in metric tons.

Month	USGS Discharge	Flow Ratio	N of Samples	SS	TP	SRP	NO23-N	TKN	CL
Oct	118.58	---	0	17788	45.1	13.04	415	249.0	2371.7
Nov	121.78	1.950	20	24355	60.9	10.96	633	292.3	3409.8
Dec	152.08	2.057	18	16903	49.1	7.59	678	245.8	3709.7
Jan	42.25	0.258	33	231	2.9	1.45	158	32.7	1914.3
Feb	47.92	0.414	32	946	4.5	1.44	172	43.3	1781.7
Mar	49.87	1.045	35	1726	5.6	0.94	346	66.7	1821.2
Apr	171.96	1.002	40	26756	51.9	10.99	1117	339.3	4008.3
May	37.61	1.797	34	8116	12.2	2.16	176	70.3	1211.3
Jun	86.19	0.997	69	52731	70.2	6.96	622	300.4	1594.9
Jul	136.19	0.986	43	43863	71.6	9.46	468	301.6	1969.5
Aug	9.57	1.199	26	845	2.1	0.60	6	13.4	347.5
Sep	5.05	2.328	11	419	1.0	0.07	11	8.6	178.6
Totals	979.06		361	194678	376.9	65.65	4802	1963.4	24318.4

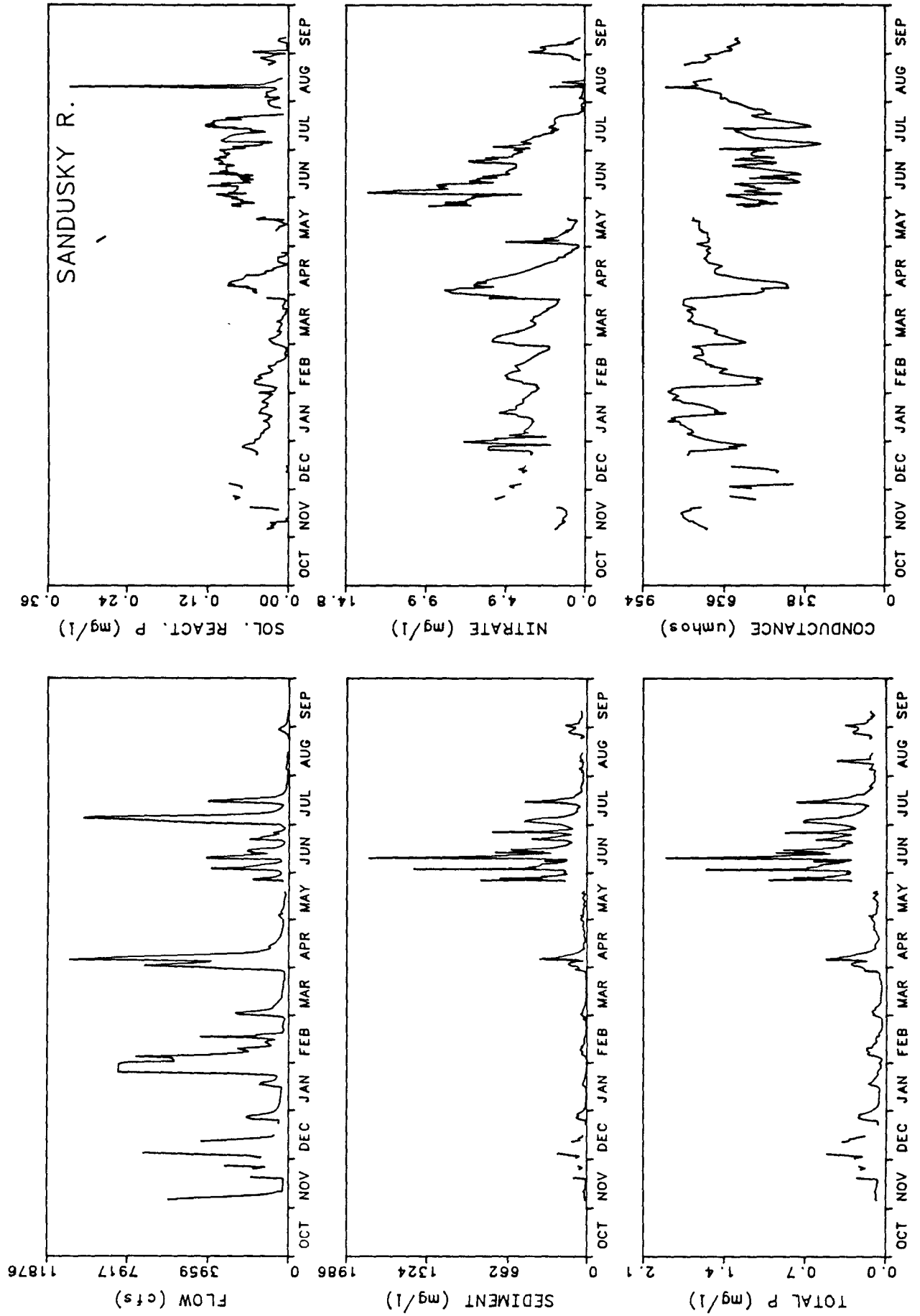

Figure 2. Annual hydrograph, sedigraph and nutrient chemograph for the Sandusky River (USGS No. 04198000) during the 1987 water year.

Table 3. Monthly loads and discharge for the River Raisin for water year 1987. Discharge is given in million cubic meters, and loads are given in metric tons.

Month	USGS Discharge	Flow Ratio	N of Samples	SS	TP	SRP	NO23-N	TKN	CL
Oct	121.35	1.305	24	10567	27.0	15.28	465	207.9	4139.4
Nov	42.80	1.148	25	1156	5.0	1.28	168	55.4	2187.7
Dec	81.87	1.422	24	1838	8.3	1.59	386	104.5	3292.3
Jan	38.99	1.258	26	271	2.1	0.74	141	34.8	1907.5
Feb	29.71	1.259	23	122	1.5	0.41	71	25.6	1570.6
Mar	75.82	1.201	26	3518	8.6	1.34	288	102.2	2758.6
Apr	69.95	1.198	25	1721	6.3	0.92	295	81.6	2707.0
May	27.71	1.246	25	676	3.1	0.40	76	36.8	1313.7
Jun	29.11	1.384	25	2740	7.1	1.79	208	47.7	1143.7
Jul	10.71	1.285	25	329	1.4	0.41	27	13.5	649.9
Aug	17.77	1.330	26	1300	4.5	0.33	66	12.8	973.4
Sep	22.50	1.224	26	887	3.0	0.76	77	27.1	1155.5
Totals	568.30		300	25124	77.9	25.25	2267	749.8	23799.1

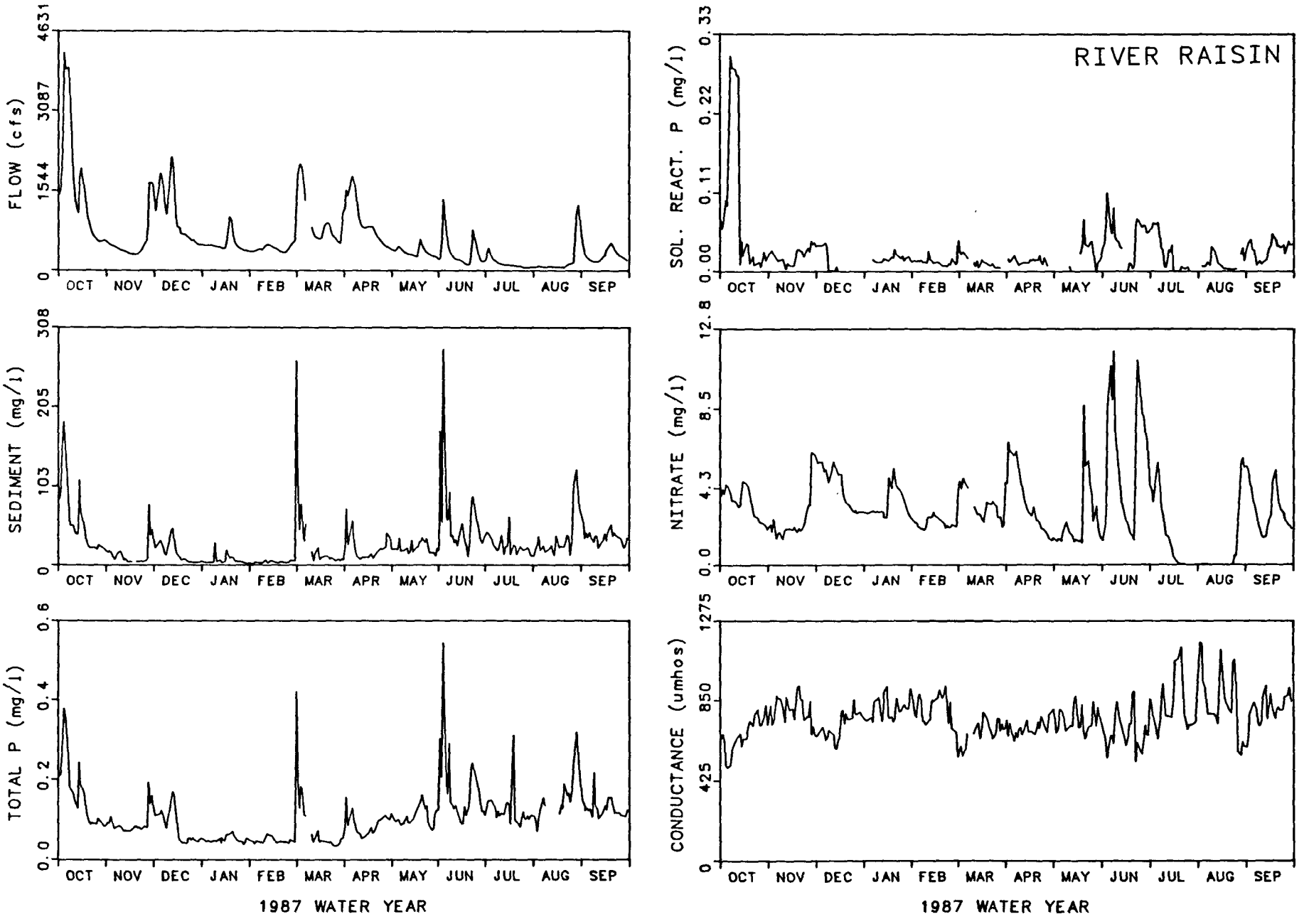

Figure 3. Annual hydrograph, sedigraph and nutrient chemograph for the River Raisin (USGS No. 04176500) during the 1987 water year.

Table 4. Monthly loads and discharge for the Cuyahoga River for water year 1987. Discharge is given in million cubic meters, and loads are given in metric tons.

Month	USGS Discharge	Flow Ratio	N of Samples	SS	TP	SRP	NO23-N	TKN	CL
Oct	77.09	1.067	32	12511	25.5	5.84	109	106.9	5102.8
Nov	58.58	0.933	37	9114	23.3	5.03	92	89.6	4292.8
Dec	116.49	1.061	33	8504	28.0	6.25	192	124.2	7125.4
Jan	61.03	1.297	28	1925	15.9	4.69	124	87.5	9252.1
Feb	46.01	1.940	17	810	8.1	3.29	92	59.3	8001.5
Mar	92.08	1.095	38	15230	25.4	4.40	135	149.8	8752.3
Apr	151.70	1.007	35	26253	46.1	6.16	198	212.5	13837.1
May	32.30	0.875	35	1222	7.0	2.28	82	35.5	3407.6
Jun	43.65	0.958	47	15313	23.5	4.85	105	89.9	3902.9
Jul	91.08	0.993	41	38653	41.1	5.90	119	156.9	4848.7
Aug	27.18	0.926	37	3374	8.6	2.74	80	25.7	2762.4
Sep	53.20	1.287	27	4870	16.8	5.52	111	66.7	3999.6
Totals	850.39		407	137778	269.2	56.96	1441	1204.5	75285.0

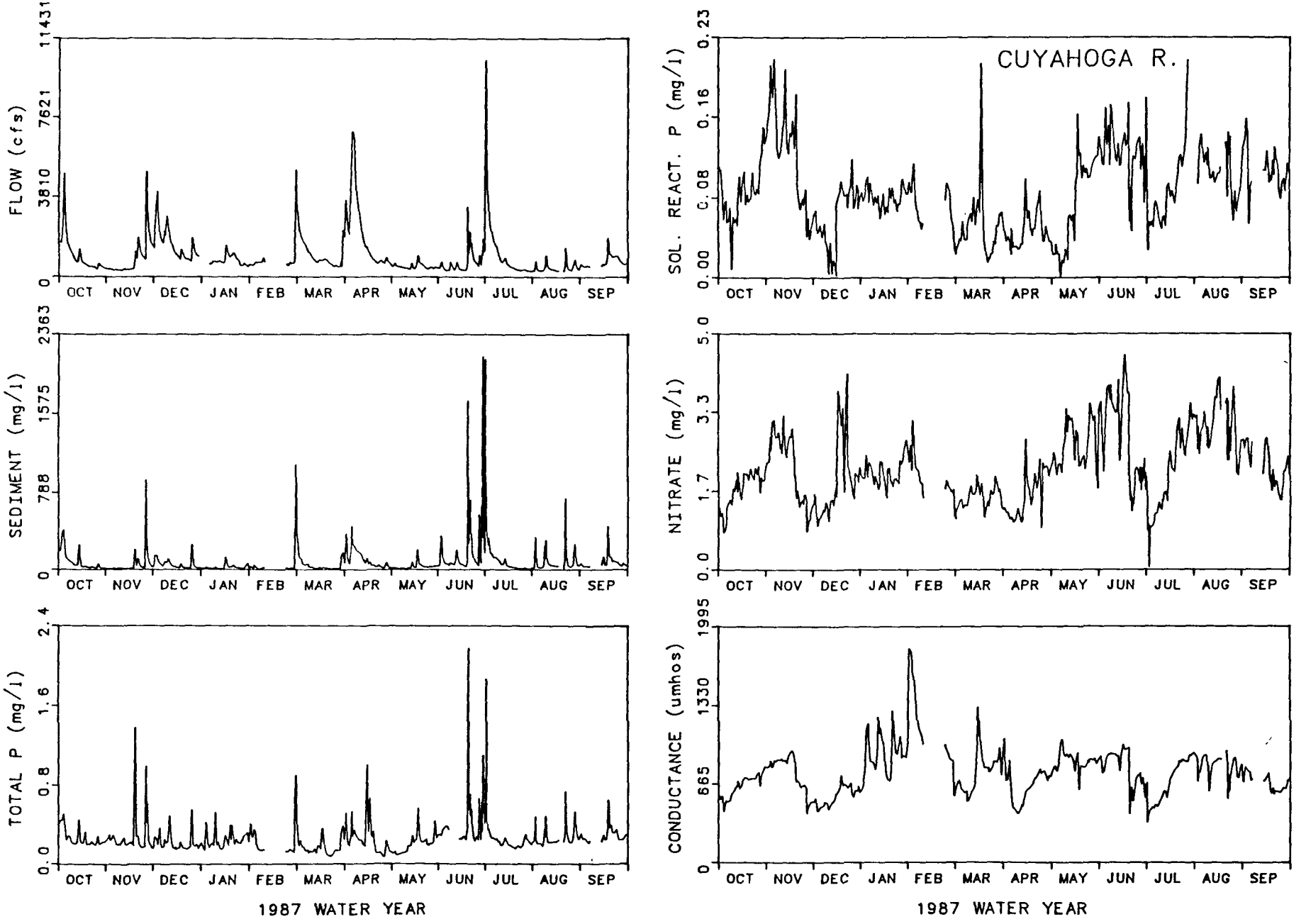

Figure 4. Annual hydrograph, sedigraph and nutrient chemograph for the Cuyahoga River (USGS No. 04208000) during the 1987 water year.

Table 5. Monthly loads and discharge for Honey Creek at Melmore for water year 1987. Discharge is given in million cubic meters, and loads are given in metric tons.

Month	USGS Discharge	Flow Ratio	N of Samples	SS	TP	SRP	NO23-N	TKN	CL
Oct	13.40	1.052	36	1473	4.8	1.67	46	28.5	228.1
Nov	13.29	1.023	47	2356	6.8	1.39	73	34.1	383.4
Dec	18.53	1.066	31	1896	7.1	1.10	81	37.0	377.4
Jan	4.91	1.074	36	102	0.7	0.44	25	6.1	140.1
Feb	8.11	1.058	30	278	1.3	0.41	34	9.6	168.5
Mar	7.09	1.709	30	370	1.3	0.28	37	11.1	182.1
Apr	22.13	0.972	37	3006	6.8	1.18	137	41.7	364.2
May	2.01	1.138	40	187	0.5	0.11	11	3.2	51.0
Jun	5.32	1.044	53	1953	5.6	0.54	56	15.0	104.0
Jul	9.41	1.184	34	2314	4.6	0.95	51	18.9	130.4
Aug	1.32	1.133	36	110	0.5	0.24	4	1.6	25.7
Sep	0.42	1.006	34	9	0.1	0.03	1	0.5	9.8
Totals	105.92		444	14055	39.9	8.35	557	207.3	2164.6

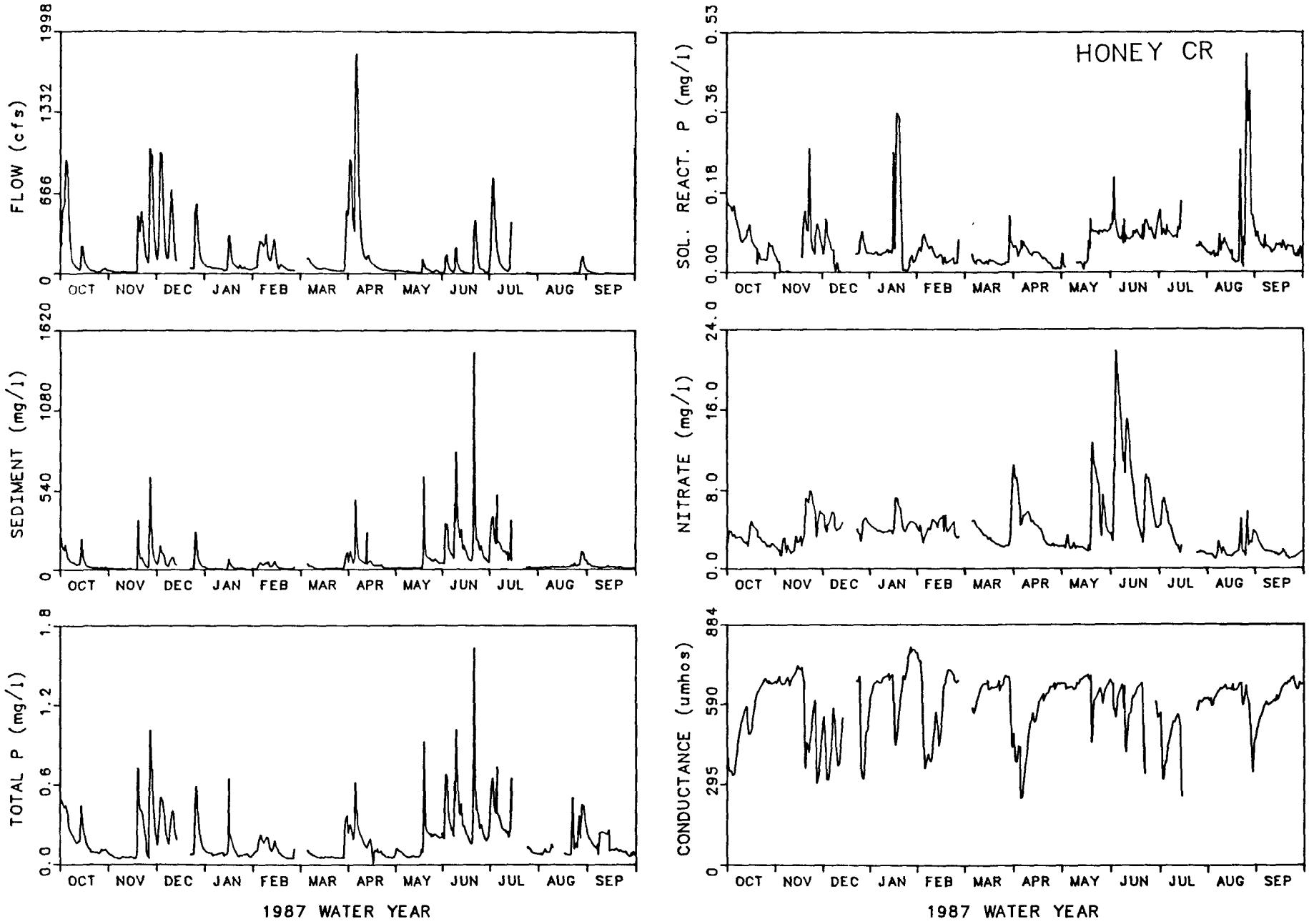

Figure 5. Annual hydrograph, sedigraph and nutrient chemograph for Honey Creek at Melmore (USGS No. 04197100) during the 1987 water year.

Table 6. Monthly loads and discharge for Rock Creek for water year 1987. Discharge is given in million cubic meters, and loads are given in metric tons.

Month	USGS Discharge	Flow Ratio	N of Samples	SS	TP	SRP	NO23-N	TKN	CL
Oct	3.60	1.281	34	491	1.32	0.371	6.5	7.29	67.0
Nov	3.65	1.148	58	960	2.15	0.188	11.2	10.80	85.8
Dec	4.53	1.231	30	692	1.82	0.201	11.7	9.41	80.3
Jan	1.11	1.024	39	37	0.13	0.026	3.2	1.16	33.7
Feb	2.04	1.138	30	92	0.31	0.075	5.1	2.36	42.7
Mar	1.47	1.001	37	71	0.18	0.021	3.9	1.83	40.8
Apr	4.61	1.067	60	700	1.21	0.139	19.7	8.22	87.3
May	0.60	0.998	35	22	0.05	0.008	0.4	0.40	19.0
Jun	0.79	0.969	76	138	0.25	0.033	3.9	1.21	20.7
Jul	0.87	1.401	36	197	0.32	0.053	2.8	1.37	20.0
Aug	0.23	1.007	33	7	0.03	0.009	0.1	0.11	7.3
Sep	0.19	0.805	26	3	0.02	0.006	0.1	0.11	6.6
Totals	23.69		494	3411	7.78	1.129	68.4	44.27	511.2

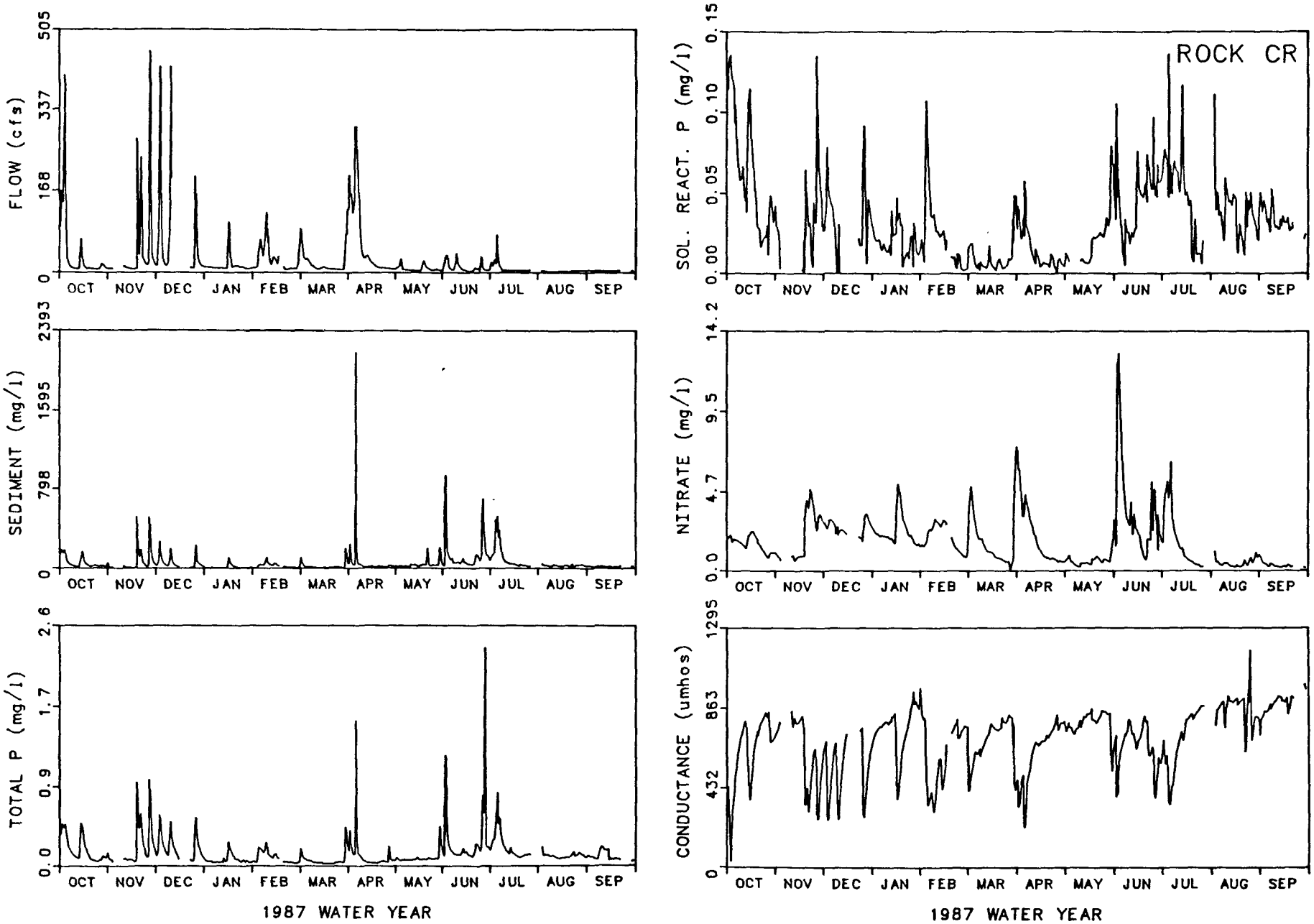

Figure 6. Annual hydrograph, sedigraph and nutrient chemograph for Rock Creek (USGS No. 04197170) during the 1987 water year.

Table 7. Monthly loads and discharge for the Lost Creek Tributary for water year 1987. Discharge is given in million cubic meters, and loads are given in metric tons.

Month	USGS Discharge	Flow Ratio	N of Samples	SS	TP	SRP	NO23	TKN	CL
Oct	0.96	6.202	19	288	0.49	0.034	1.8	2.76	10.3
Nov	0.26	1.026	49	12	0.06	0.016	1.0	0.49	5.7
Dec	0.33	1.428	46	17	0.09	0.011	1.1	0.64	6.9
Jan	0.14	0.979	28	7	0.03	0.004	0.6	0.16	2.8
Feb	0.22	0.961	32	6	0.05	0.017	0.8	0.43	3.7
Mar	0.28	0.912	54	50	0.09	0.011	1.4	0.87	4.4
Apr	0.14	0.988	34	4	0.02	0.004	0.4	0.23	2.5
May	0.49	0.987	80	198	0.28	0.030	3.9	2.30	8.8
Jun	0.08	0.889	47	28	0.04	0.005	1.1	0.23	1.6
Jul	0.15	0.664	53	72	0.12	0.012	0.8	0.48	2.0
Aug	0.01	0.620	28	<1	<0.01	<0.001	<0.1	0.01	0.1
Sep	0.01	0.320	34	<1	<0.01	<0.001	<0.1	0.01	0.2
Totals	3.07		504	682	1.26	0.144	13.0	8.61	49.1

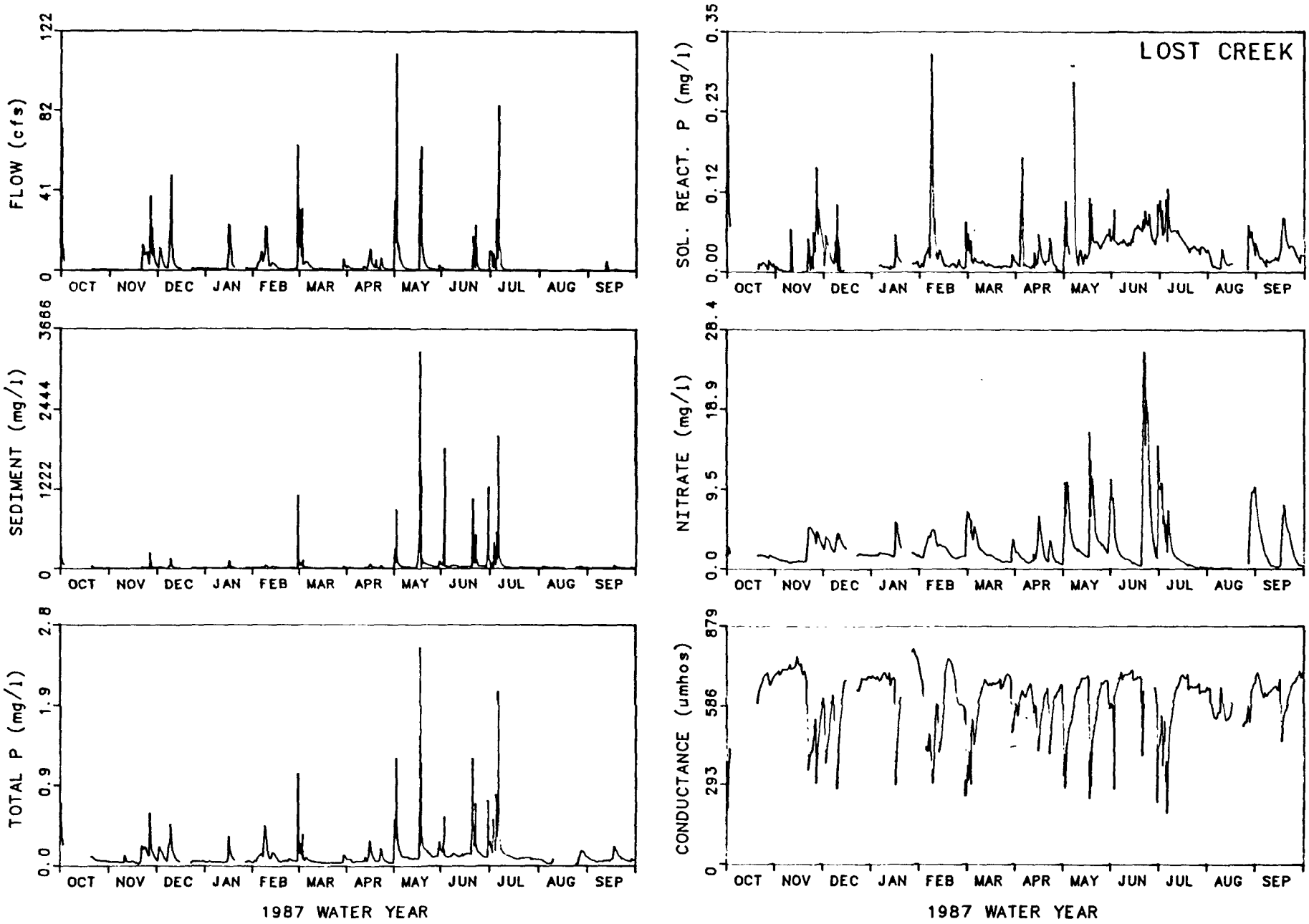

Figure 7. Annual hydrograph, sedigraph and nutrient chemograph for the Lost Creek Tributary (USGS No. 04185440) during the 1987 water year.

LAKE ERIE TRIBUTARY LOADING STUDIES

APPENDIX 2

PESTICIDE LOADS IN LAKE ERIE TRIBUTARIES

(1987 WATER YEAR)

Submitted in Partial Fulfillment of
Grant Number R005967-01

Great Lakes National Program Office
U. S. Environmental Protection Agency, Region 5
Chicago, Illinois 60604

Robert Beltran, Project Officer

January 1989

Prepared by:

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Note: In this appendix, the pesticides loads for Lake Erie tributaries are presented in the same format that was used in Appendix 2 of the 1988 report by Baker entitled *Sediment, Nutrient and Pesticide Transport in Selected Lower Great Lakes Tributaries* (EPA-905/4-88-001). The reader is referred to that document for details on the methods used to calculate pesticide loads for each station.

List of Tables

The following tables present the pesticide loads and unit area loads for each station.

Table 1: Pesticide loads for the Maumee River, USGS04193500, during the time interval 8704150000 to 8708150000, a span of 122 days, during which 40 pesticide samples were taken.

The time characterized by any pesticide sample was limited to 7 days.

The loads calculated in this manner are as follows:

Pesticide	Observed Load kg	Extrapolated Load kg	Unit area Load g/ha
Simazine	330.431	351.839	.214601
Carbofuran	1107.04	1178.76	.718976
Atrazine	4664.52	4966.71	3.02941
Terbufos	44.2636	47.1312	.287473E-01
Fonofos	368.569	392.447	.23937
Metribuzin	730.14	777.443	.474195
Alachlor	1552.14	1652.7	1.00805
Linuron	49.2537	52.4447	.319882E-01
Metolachlor	3937.41	4192.5	2.55718
Cyanazine	1113.6	1185.75	.723239
Pendimethalin	76.3805	81.3289	.496059E-01
EPTC	3.56784	3.79899	.231716E-02
DIA	42.2637	45.0019	.274485E-01
DEA	13.2938	14.155	.863374E-02
Ethoprop	219.693	233.926	.142681
Trifluralin	38.172	40.6451	.247911E-01
Phorate	222.32	236.723	.144387
Propoxur	42.0645	44.7897	.273191E-01
Aldicarb	0	0	0

The monitored time is 97.2361 days.
The monitored discharge is 377284 cfs-days, or 923.214 million cubic meters.

The total discharge during this time is 401727 cfs-days, or 983.026 million cubic meters, and is based on the most complete discharge record available in the computer. Due to differences in data and calculation approach, this discharge may differ from the USGS discharge for the same time period. The discharge record covers 121.125 days out of 122 with each flow measurement characterizing one day or less. 1 flow values out of 149 were missing.

The observed loads correspond to the time and discharge monitored. The extrapolated loads are calculated by multiplying the observed load by the ratio of the total discharge to the monitored discharge. The unit area load is the extrapolated load divided by the watershed area and re-expressed as grams per hectare.

The accuracy of the load estimates is dependent on the frequency and representativeness of the pesticide samples and the flow data. Infrequent pesticide samples are more often the limiting factor than is inadequate flow data.

Pesticide concentrations below detection limit are taken as 0.000 ug/L.

Table 2: Pesticide loads for the Sandusky River, USGS04198000, during the time interval 8704150000 to 8708150000, a span of 122 days, during which 65 pesticide samples were taken.

The time characterized by any pesticide sample was limited to 7 days.

The loads calculated in this manner are as follows:

Pesticide	Observed Load kg	Extrapolated Load kg	Unit area Load g/ha
Simazine	114.044	117.452	.362506
Carbofuran	767.7	790.639	2.44024
Atrazine	1077.16	1109.35	3.42391
Terbufos	0	0	0
Fonofos	68.2491	70.2884	.216939
Metribuzin	212.242	218.584	.67464
Alachlor	480.978	495.35	1.52886
Linuron	73.3624	75.5546	.233193
Metolachlor	1020.54	1051.03	3.24393
Cyanazine	86.3519	88.9321	.274482
Pendimethalin	23.5525	24.2562	.748649E-01
EPTC	2.51089	2.58592	.798123E-02
DIA	2.49424	2.56876	.792828E-02
DEA	3.16955	3.26426	.100749E-01
Ethoprop	24.2905	25.0163	.772108E-01
Trifluralin	2.17676	2.24181	.691915E-02
Phorate	1.23705	1.27401	.393213E-02
Propoxur	.516062	.531482	.164038E-02
Aldicarb	0	0	0

The monitored time is 103.649 days.
The monitored discharge is 105851 cfs-days, or 259.017 million cubic meters.

The total discharge during this time is 109014 cfs-days, or 266.756 million cubic meters, and is based on the most complete discharge record available in the computer. Due to differences in data and calculation approach, this discharge may differ from the USGS discharge for the same time period. The discharge record covers 113.625 days out of 122 with each flow measurement characterizing one day or less. 0 flow values out of 180 were missing.

The observed loads correspond to the time and discharge monitored. The extrapolated loads are calculated by multiplying the observed load by the ratio of the total discharge to the monitored discharge. The unit area load is the extrapolated load divided by the watershed area and re-expressed as grams per hectare.

The accuracy of the load estimates is dependent on the frequency and representativeness of the pesticide samples and the flow data. Infrequent pesticide samples are more often the limiting factor than is inadequate flow data.

Pesticide concentrations below detection limit are taken as 0.000 ug/L.

Table 3: Pesticide loads for the River Raisin, USGS04176500, during the time interval 8704150000 to 8708150000, a span of 122 days, during which 6 pesticide samples were taken.

The time characterized by any pesticide sample was limited to 7 days.

The loads calculated in this manner are as follows:

Pesticide	Observed Load kg	Extrapolated Load kg	Unit area Load g/ha
Simazine	2.13483	8.46509	.313638E-01
Carbofuran	9.45032	37.4726	.138839
Atrazine	65.1303	258.256	.956859
Terbufos	0	0	0
Fonofos	3.39069	13.4448	.498142E-01
Metribuzin	10.4976	41.6254	.154225
Alachlor	22.2597	88.2647	.327027
Linuron	0	0	0
Metolachlor	22.4832	89.1508	.33031
Cyanazine	10.0192	39.7285	.147197
Pendimethalin	3.84666	15.2529	.056513
EPTC	0	0	0
DIA	0	0	0
DEA	.103388	.409958	.151893E-02
Ethoprop	1.45543	5.77111	.213824E-01
Trifluralin	.125054E-01	.495867E-01	.183722E-03
Phorate	1.55067	6.14875	.227816E-01
Propoxur	.100043E-01	.396693E-01	.146978E-03
Aldicarb	0	0	0

The monitored time is 40 days.
The monitored discharge is 8064.62 cfs-days, or 19.7341 million cubic meters.

The total discharge during this time is 31978 cfs-days, or 78.2502 million cubic meters, and is based on the most complete discharge record available in the computer. Due to differences in data and calculation approach, this discharge may differ from the USGS discharge for the same time period. The discharge record covers 101.63 days out of 122 with each flow measurement characterizing one day or less. 0 flow values out of 102 were missing.

The observed loads correspond to the time and discharge monitored. The extrapolated loads are calculated by multiplying the observed load by the ratio of the total discharge to the monitored discharge. The unit area load is the extrapolated load divided by the watershed area and re-expressed as grams per hectare.

The accuracy of the load estimates is dependent on the frequency and representativeness of the pesticide samples and the flow data. Infrequent pesticide samples are more often the limiting factor than is inadequate flow data.

Pesticide concentrations below detection limit are taken as 0.000 ug/L.

Table 4: Pesticide loads for the Cuyahoga River, USGS04208000, during the time interval 8704150000 to 8708150000, a span of 122 days, during which 4 pesticide samples were taken.

The time characterized by any pesticide sample was limited to 7 days.

The loads calculated in this manner are as follows:

Pesticide	Observed Load kg	Extrapolated Load kg	Unit area Load g/ha
Simazine	10.673	28.6248	.156334
Carbofuran	10.3312	27.7081	.151328
Atrazine	64.6018	173.261	.946267
Terbufos	0	0	0
Fonofos	7.53734	20.2151	.110405
Metribuzin	6.80883	18.2612	.997336E-01
Alachlor	12.4538	33.4009	.182419
Linuron	0	0	0
Metolachlor	51.0571	136.935	.747869
Cyanazine	2.05774	5.51885	.301412E-01
Pendimethalin	.407366	1.09255	.596697E-02
EPTC	0	0	0
DIA	0	0	0
DEA	.581951E-01	.156079	.852424E-03
Ethoprop	.876423	2.35056	.128376E-01
Trifluralin	0	0	0
Phorate	0	0	0
Propoxur	0	0	0
Aldicarb	0	0	0

The monitored time is 21 days.
The monitored discharge is 33675.6 cfs-days, or 82.4043 million cubic meters.

The total discharge during this time is 90317.8 cfs-days, or 221.008 million cubic meters, and is based on the most complete discharge record available in the computer. Due to differences in data and calculation approach, this discharge may differ from the USGS discharge for the same time period. The discharge record covers 118.748 days out of 122 with each flow measurement characterizing one day or less. 0 flow values out of 157 were missing.

The observed loads correspond to the time and discharge monitored. The extrapolated loads are calculated by multiplying the observed load by the ratio of the total discharge to the monitored discharge. The unit area load is the extrapolated load divided by the watershed area and re-expressed as grams per hectare.

The accuracy of the load estimates is dependent on the frequency and representativeness of the pesticide samples and the flow data. Infrequent pesticide samples are more often the limiting factor than is inadequate flow data.

Pesticide concentrations below detection limit are taken as 0.000 ug/L.

Table 5: Pesticide loads for Honey Creek, USGS04197100,
during the time interval 8704150000 to 8708150000, a span of 122 days,
during which 102 pesticide samples were taken.

The time characterized by any pesticide sample was limited to 7 days.

The loads calculated in this manner are as follows:

Pesticide	Observed Load kg	Extrapolated Load kg	Unit area Load g/ha
Simazine	9.46856	9.05309	.234536
Carbofuran	11.0289	10.5449	.273185
Atrazine	116.142	111.046	2.87683
Terbufos	.141258E-01	.013506	.349896E-03
Fonofos	7.45817	7.13091	.184739
Metribuzin	11.2119	10.72	.277719
Alachlor	54.4497	52.0605	1.34872
Linuron	7.68909	7.3517	.190459
Metolachlor	65.1481	62.2895	1.61372
Cyanazine	14.9971	14.339	.371478
Pendimethalin	1.5841	1.51459	.392381E-01
EPTC	.151202	.144567	.374526E-02
DIA	.135681	.129728	.336082E-02
DEA	.340906E-02	.325947E-02	.844423E-04
Ethoprop	1.48242	1.41737	.367195E-01
Trifluralin	.272269	.260322	.67441E-02
Phorate	.217595	.208047	.538982E-02
Propoxur	.016867	.161269E-01	.417795E-03
Aldicarb	0	0	0

The monitored time is 102.875 days.
The monitored discharge is 7319.69 cfs-days, or 17.9113 million cubic meters.

The total discharge during this time is 6998.51 cfs-days,
or 17.1254 million cubic meters, and is based on the most complete
discharge record available in the computer. Due to differences in data and
calculation approach, this discharge may differ from the USGS discharge for
the same time period. The discharge record covers 114.25 days out of 122
with each flow measurement characterizing one day or less. 0 flow values
out of 162 were missing.

The observed loads correspond to the time and discharge monitored.
The extrapolated loads are calculated by multiplying the observed load
by the ratio of the total discharge to the monitored discharge.
The unit area load is the extrapolated load divided by the watershed
area and re-expressed as grams per hectare.

The accuracy of the load estimates is dependent on the frequency and
representativeness of the pesticide samples and the flow data.
Infrequent pesticide samples are more often the limiting factor than
is inadequate flow data.

Pesticide concentrations below detection limit are taken as 0.000 ug/L.

Table 6: Pesticide loads for Rock Creek, USGS04197170,
during the time interval 8704150000 to 8708150000, a span of 122 days,
during which 63 pesticide samples were taken.

The time characterized by any pesticide sample was limited to 7 days.

The loads calculated in this manner are as follows:

Pesticide	Observed Load kg	Extrapolated Load kg	Unit area Load g/ha
Simazine	44.6823	48.1543	5.37437
Carbofuran	.767647	.827297	.923323E-01
Atrazine	7.27584	7.84121	.875135
Terbufos	.016602	.017892	.199688E-02
Fonofos	.676009	.728539	.813101E-01
Metribuzin	1.22729	1.32265	.147617
Alachlor	2.76978	2.985	.333148
Linuron	.435409	.469243	.523708E-01
Metolachlor	7.51977	8.10409	.904475
Cyanazine	.576826	.621648	.693804E-01
Pendimethalin	.19034	.205131	.022894
EPTC	.109592	.118107	.131816E-01
DIA	.135325E-01	.145841E-01	.162768E-02
DEA	.367975E-01	.396568E-01	.442598E-02
Ethoprop	.106515	.114792	.128116E-01
Trifluralin	.232741E-01	.250826E-01	.27994E-02
Phorate	.977698E-01	.105367	.117597E-01
Propoxur	.174452E-01	.188008E-01	.20983E-02
Aldicarb	0	0	0

The monitored time is 106.311 days.
The monitored discharge is 979.083 cfs-days, or 2.39582 million cubic meters.

The total discharge during this time is 1055.16 cfs-days,
or 2.58198 million cubic meters, and is based on the most complete
discharge record available in the computer. Due to differences in data and
calculation approach, this discharge may differ from the USGS discharge for
the same time period. The discharge record covers 115.875 days out of 122
with each flow measurement characterizing one day or less. 0 flow values
out of 177 were missing.

The observed loads correspond to the time and discharge monitored.
The extrapolated loads are calculated by multiplying the observed load
by the ratio of the total discharge to the monitored discharge.
The unit area load is the extrapolated load divided by the watershed
area and re-expressed as grams per hectare.

The accuracy of the load estimates is dependent on the frequency and
representativeness of the pesticide samples and the flow data.
Infrequent pesticide samples are more often the limiting factor than
is inadequate flow data.

Pesticide concentrations below detection limit are taken as 0.000 ug/L.

Table 7: Pesticide loads for Lost Creek, USGS04185440,
during the time interval 8704150000 to 8708150000, a span of 122 days,
during which 86 pesticide samples were taken.

The time characterized by any pesticide sample was limited to 7 days.

The loads calculated in this manner are as follows:

Pesticide	Observed Load kg	Extrapolated Load kg	Unit area Load g/ha
Simazine	.194632	.207575	.244205
Carbofuran	2.18214	2.32725	2.73794
Atrazine	7.96431	8.49391	9.99284
Terbufos	.434511E-03	.463405E-03	.545182E-03
Fonofos	2.06286	2.20004	2.58828
Metribuzin	.970862	1.03542	1.21814
Alachlor	3.71565	3.96273	4.66203
Linuron	.399619	.426193	.501403
Metolachlor	5.52499	5.89239	6.93222
Cyanazine	3.26162	3.4785	4.09236
Pendimethalin	.162048	.172824	.203323
EPTC	.218514E-02	.233044E-02	.27417E-02
DIA	.132899E-01	.141736E-01	.166748E-01
DEA	.785868E-01	.838126E-01	.986031E-01
Ethoprop	.507588	.541341	.636872
Trifluralin	.304382E-02	.324622E-02	.381909E-02
Phorate	.022285	.237669E-01	.027961
Propoxur	.111922E-02	.119364E-02	.140429E-02
Aldicarb	0	0	0

The monitored time is 104.358 days.
The monitored discharge is 344.607 cfs-days, or .843253 million cubic meters.

The total discharge during this time is 367.522 cfs-days,
or .899327 million cubic meters, and is based on the most complete
discharge record available in the computer. Due to differences in data and
calculation approach, this discharge may differ from the USGS discharge for
the same time period. The discharge record covers 121.681 days out of 122
with each flow measurement characterizing one day or less. 0 flow values
out of 215 were missing.

The observed loads correspond to the time and discharge monitored.
The extrapolated loads are calculated by multiplying the observed load
by the ratio of the total discharge to the monitored discharge.
The unit area load is the extrapolated load divided by the watershed
area and re-expressed as grams per hectare.

The accuracy of the load estimates is dependent on the frequency and
representativeness of the pesticide samples and the flow data.
Infrequent pesticide samples are more often the limiting factor than
is inadequate flow data.

Pesticide concentrations below detection limit are taken as 0.000 ug/L.