AB-383

CONSTRUCTION PHASE

ECOLOGICAL MONITORING PROGRAM

MARBLE HILL NUCLEAR GENERATING STATION

UNITS 1 AND 2

FINAL REPORT

FEBRUARY-NOVEMBER 1981

VOLUME 1

FEBRUARY 1982

APPLIED BIOLOGY, INC.
ATLANTA, GEORGIA 30033

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TABLE OF CONVERSION FACTORS FOR METRIC UNITS

To convert	Multiply by	To obtain
centigrade (degrees)	(°C x 1.8) + 32	fahrenheit (degrees)
centigrade (degrees)	°C + 273.18	kelvin (degrees)
centimeters (cm)	3.937×10^{-1}	inches
centimeters (cm)	3.281×10^{-2}	feet
centimeters/second (cm/sec)	3.281×10^{-2}	feet per second
cubic centimeters (cm^3)	1.0×10^{-3}	liters
grams (g)	2.205×10^{-3}	pounds
grams (g)	3.527×10^{-2}	ounces (avoirdupois)
kilograms (kg)	1.0×10^{3}	grams
kilograms (kg)	2.2046	pounds
kilograms (kg)	3.5274×10^{1}	ounces (avoirdupois)
kilometers (km)	6.214×10^{-1}	miles (statute)
kilometers (km)	1.0×10^{6}	millimeters
liters (l)	1.0×10^{3}	cubic centimeters (cm^3)
liters (l)	2.642×10^{-1}	gallons (U.S. liquid)
meters (m)	3.281	feet
meters (m)	3.937×10^{1}	inches
meters (m)	1.094	yards
microns (μ)	1.0×10^{-6}	meters
milligrams (mg)	1.0×10^{-3}	grams
milligrams/liter (mg/l)	1.0	parts per million
milliliters (ml)	1.0×10^{-3}	liters (U.S. liquid)
millimeters (mm)	3.937×10^{-2}	inches
millimeters (mm)	3.281×10^{-3}	feet
square centimeters (cm^2)	1.550×10^{-1}	square inches
square meters (m^2)	1.076×10^{1}	square feet
square millimeters (mm^2)	1.55×10^{3}	square inches

INTRODUCTION

Public Service Company of Indiana, Inc. (PSI), contracted Applied Biology, Inc. (ABI), to conduct a construction phase ecological monitoring program at the Marble Hill Nuclear Generating Station-Units 1 and 2, located near New Washington, Indiana. This report presents the results of that monitoring program and the analyses of all ecological data collected between 23 March and 12 November 1981.

The objectives of this program were to 1) ascertain and document the existing ecological conditions in the immediate vicinity of the Marble Hill Nuclear Generating Station site and 2) provide reference information to be used in the assessment and minimization of the effect of plant construction and operation on the local environment.

To meet these objectives, Applied Biology, Inc., conducted a sampling program based on specifications formulated in the Construction Phase Ecological Monitoring Program of Sargent and Lundy Engineers' Specification Y-2961 dated 15 April 1976. During 1981, the plankton, periphyton, macroinvertebrate, fish and larval fish communities, as well as chemical and physical parameters, were sampled at five aquatic sampling stations.

AQUATIC MONITORING PROGRAM

The aquatic sampling stations (Stations 1, 3, 5, 6 and 8; Figure 1) were sampled in March, May, August and November 1981. Station 1, located in the Ohio River 183 m upstream of Big Saluda Creek, was selected to represent conditions above the intake of the proposed plant. Station 3 is located in the area of the proposed intake and discharge, where construction impacts are most likely to occur. Station 5 is the downstream station selected to represent conditions after complete mixing of the thermal plume. Stations 6 and 8 are located in creeks that drain the northern and eastern margins, respectively, of the plant site. Stations 1, 3, 5 and 6 were established at locations sampled in a baseline study conducted during 1974-1975. Station 8 was added in 1977 to study erosion from construction activities. Station numbers of the present study are consistent with those used in the baseline study (Stations 2, 4, 7, 9, 10, 11 and 12 were sampled during the baseline study and were not sampled in this study. Station 14 was sampled for fisheries data only starting in 1978 as a check on the typicality of data from Stations 1, 3 and 5. Sampling there was discontinued in 1981).

1981 ECOLOGICAL MONITORING PROGRAM

Sampling was performed as outlined by Sargent and Lundy's Specification Y-2961. Samples for each parameter were analyzed and the data reduced. Dates and purposes of all field trips and personnel involved are presented in Table 1. The 1981 monitoring program was essentially a continuation of monitoring conducted during 1977-1980.

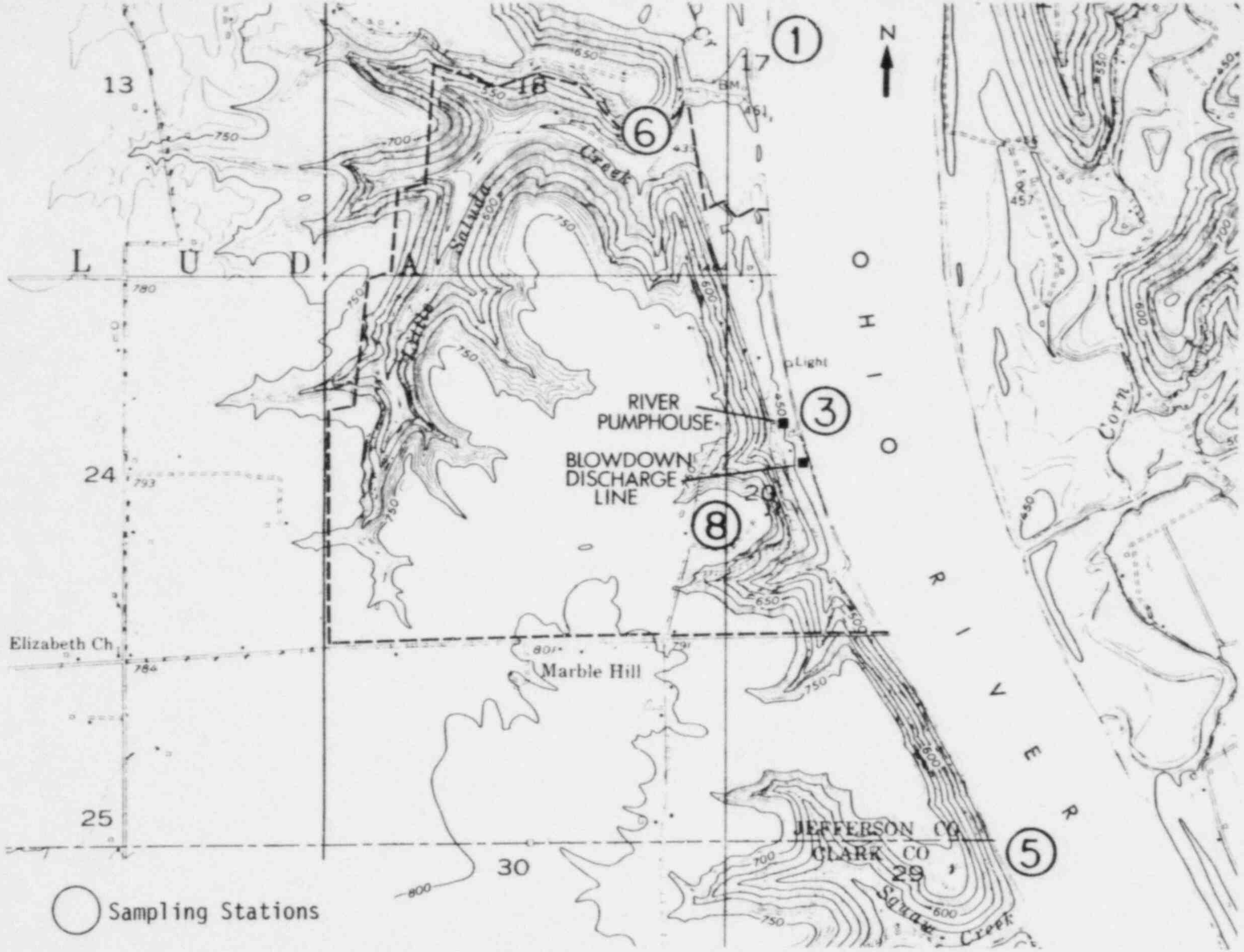

Figure 1. Marble Hill Nuclear Generating Station.

TABLE 1

FIELD WORK
MARBLE HILL PLANT SITE
MARCH - NOVEMBER 1981

Date	Purpose of field trip	ABI personnel
2 March	Placing of periphyton and macroinvertebrate samplers	W. Rhodes L. Mason
23-25 March	1st quarterly sampling	W. Rhodes P. Kinser R. Comegys
10 April	1st fish eggs and larvae collection	W. Rhodes R. Pierce G. Grunzel
24 April	2nd fish eggs and larvae collection	R. Pierce G. Grunzel
7 May	3rd fish eggs and larvae collection Placing of periphyton and macroinvertebrate samplers	R. Pierce G. Grunzel
14 May	4th fish eggs and larvae collection	R. Pierce G. Grunzel
21 May	5th fish eggs and larvae collection	R. Pierce G. Grunzel
25-27 May	2nd quarterly sampling 6th fish eggs and larvae collection	W. Rhodes P. Kinser C. Ellis
3 June	7th fish eggs and larvae collection	R. Pierce G. Grunzel
10 June	8th fish eggs and larvae collection	R. Pierce G. Grunzel
17 June	9th fish eggs and larvae collection	R. Pierce G. Grunzel
25 June	10th fish eggs and larvae collection	R. Pierce G. Grunzel

TABLE 1
(continued)
FIELD WORK
MARBLE HILL PLANT SITE
MARCH - NOVEMBER 1981

Date	Purpose of field trip	ABI personnel
2 July	11th fish eggs and larvae collection	R. Pierce G. Grunzel
9 July	12th fish eggs and larvae collection	R. Pierce G. Grunzel
20 July	Placing of periphyton and macroinvertebrate samplers	R. Pierce G. Grunzel
10-12 August	3rd quarterly sampling	W. Rhodes W. Sampson D. Strom
19 October	Placing of periphyton and macroinvertebrate samplers	R. Pierce F. Lewis
10-12 November	4th quarterly sampling	W. Rhodes R. Pierce F. Lewis

A. CHEMICAL AND PHYSICAL PARAMETERS

INTRODUCTION

This study was designed to monitor the chemical and physical parameters of the Ohio River and Little Saluda Creek near the Marble Hill Plant site. Monitoring of these parameters is especially important in the study of the biological community in aquatic environments because changes in these parameters can affect food chains. The purpose of monitoring was to: 1) determine whether the Marble Hill Plant construction affects the values of the chemical and physical parameters measured, 2) provide a more unified view of the aquatic habitat than would be obtained from sampling only the biotic components of the area, and 3) enable the examination of the relationship between the abiotic and biotic components of the aquatic environment.

Data taken at downstream sampling stations were compared with those taken at an upstream sampling station that served as a control station for the study (Figure 1). Furthermore, results of the study were compared with Ohio River Valley Water Sanitation Commission (ORSANCO) data and Indiana Water Quality Standards (1977) where applicable, and to 1977-1980 construction monitoring data (ABI, 1978, 1979, 1980, 1981).

MATERIALS AND METHODS

Duplicate subsurface water samples were collected at Stations 1, 3, 5 and 6 with a nonmetallic Kemmerer sampler. Water samples were preserved as prescribed by the EPA (1974) and analyzed according to Standard

Methods (APHA, 1980; Appendix Table A-1). Complete chemistry data may be found in Appendix Tables A-1 through A-5.

Current velocity, pH, dissolved oxygen, conductivity, water depth, water temperature, Secchi depth, and turbidity (Station 8 only) were measured on each sampling trip. In addition, quarterly sedimentation studies were conducted at Stations 6 and 8. Current velocity was determined with a General Oceanics Model 2030 digital flowmeter and Model 2035 flowmeter readout. Determinations of pH were made in the field with an Orion Model 407A pH meter. Water depth was measured with a Heathkit Model 1031 depth meter. Dissolved oxygen determinations were made using a YSI Model 54 oxygen meter. Conductivity was determined with a YSI Model 33 salinity-conductivity-temperature meter. Temperature was measured electronically with the oxygen and conductivity meters. Turbidity was determined in the laboratory with a Hach Model 2100A nephelometric turbidimeter. All meters were calibrated in the laboratory before each field use. Complete physical data may be found in Appendix Tables A-2 through A-9.

The 1981 results (average of two replicates) from Stations 1, 3 and 5 were graphically compared with 1977-1980 mean data derived from previous construction phase monitoring studies (Figures A-1 through A-22). Where available, 1977-1981 mean ORSANCO data were also compared. ORSANCO data from the ORSANCO sampling station (Mile Post 600.6 at Louisville, Kentucky) closest to the Marble Hill Plant site (Mile Post 570) were used for this comparison.

RESULTS OF WATER CHEMISTRY ANALYSIS

At the Ohio River stations, 1981 water chemistry data generally varied considerably among seasons but only slightly among stations. Chemical parameter values measured in 1981 were usually similar to those of 1977-1981 mean ORSANCO values.

Little Saluda Creek Station 6 water chemistry data obtained in 1981 were compared to mean data from previous construction phase monitoring results (ABI, 1978, 1979, 1980, 1981; Table A-1). Minimum and maximum values of each chemical parameter are presented for comparison.

Dissolved Oxygen

Similar to past years, Ohio River dissolved oxygen measurements during 1981 ranged from 6.6 to 10.7 mg/liter. Values were almost identical at all river stations within a sampling period, but they varied seasonally (Figure A-1). Dissolved oxygen values were highest in March and lowest in August and varied inversely with water temperatures. Measurements in Little Saluda Creek were generally higher than those for the Ohio River, ranging from 7.1 to 14.6 mg/liter (Table A-1). Regardless of the season, dissolved oxygen concentrations below 6.0 mg/liter have never been recorded at the Marble Hill site. This value is well above the minimum acceptable concentration of 4.0 mg/liter specified by Indiana Water Quality Standards (1977).

pH and Alkalinity

The pH values measured at the Marble Hill Plant site during 1981 ranged from 6.9 to 7.4 in the Ohio River and from 7.2 to 8.0 in Little Saluda Creek (Figure A-2, Table A-1). These values are within the 6.0 to 9.0 range recommended by Indiana Water Quality Standards.

Alkalinity, the measure of the carbonate and bicarbonate buffering capacity of water, ranged from 23.5 to 92.0 mg/liter in the Ohio River (Figure A-3). The EPA (1976) has established 20 mg/liter as the minimum total alkalinity necessary to support freshwater aquatic life. Little Saluda Creek had alkalinity values between 87.5 and 225.0 mg/liter, which were well above the minimum acceptance value (Table A-1). The higher alkalinity of the creek is probably a result of water leaching through the surrounding limestone.

Conductivity, Total Dissolved Solids and Total Suspended Solids

Conductivity is a measure of the dissociated ions in water, and total dissolved solids (TDS) is a measure of the dissociated ions plus all other dissolved solids. Conductivity values ranged from 205 to 479 μmhos/cm in the Ohio River and from 550 to 750 μmhos/cm in Little Saluda Creek (Figure A-4, Table A-1). Both ranges were similar to those reported in previous studies, but creek values were generally slightly higher during 1981. The TDS values ranged from 139 to 322 mg/liter in the Ohio River and from 395 to 612 mg/liter in Little Saluda Creek (Figure A-5, Table A-1). The range of values at all stations was similar to those observed in previous studies. For Station 8, TDS values ranged from 411 to 524 mg/liter during March and May. No water was available for sampling at Station 8 during August or November. Indiana Water Quality Standards (1977) specify that, for industrial water supplies, the dissolved solids from sources other than naturally occurring ones shall not exceed 1000 mg/liter at any time. This limit for dissolved solids was not exceeded at any station during 1981.

Total suspended solids (TSS) are insoluble particles suspended in the water column that increase turbidity and reduce light penetration. Total suspended solids values ranged from 7 to 36 mg/liter in the Ohio River, and the highest values were recorded in May (Figure A-6). Unusually low TSS values for March were probably a result of the lateness of the 1981 spring floods. Total suspended solids values for Little Saluda Creek Station 6 were between 1 and 20 mg/liter.

Biochemical Oxygen Demand, Chemical Oxygen Demand and Total Organic Carbon

Biochemical oxygen demand (BOD) is a measure of the biologically oxidizable material present in water, and chemical oxygen demand (COD) is a measure of the amount of material that can be oxidized by a chemically defined dichromate solution. Both of these parameters, as well as that for total organic carbon (TOC), indicate the concentration of organic waste material in water. BOD values for Ohio River stations ranged from 1.1 to 13.0 mg/liter (Figure A-7). COD values ranged from 5 to 13 mg/liter (Figure A-8), and TOC values ranged from 2.3 to 5.0 (Figure A-9). All of these parameters had values generally lower than observed in past monitoring, the only exception being very high BOD values in August. In Little Saluda Creek, BOD values ranged from 1.1 to 5.7 mg/liter, COD values ranged from 5.0 to 24.5 mg/liter, and TOC values ranged from 2.3 to 3.3 mg/liter (Table A-1). All of these values were well within the ranges of previous studies. Again, the only exception was high BOD values in August. Because these exceptional values occurred at all stations, they probably did not result from activity at the Marble Hill Plant site.

Phosphorus and Nitrogen

Phosphorus and nitrogen, which usually are the two limiting elements for primary production, were measured in the forms of total phosphorous, orthophosphate, nitrate nitrogen, ammonia and organic nitrogen.

To prevent biological nuisances such as plankton blooms, it has been suggested that total phosphorus concentrations should not exceed 0.10 mg/liter at any point within a flowing stream (MacKenthum, 1969). This limiting value for total phosphorus content was repeatedly exceeded at Stations 1, 3 and 5 in the Ohio River during 1981; however, no blooms were observed. Because values at Station 1, the control station, also exceeded recommended values, these high values were not attributed to construction at the Marble Hill site. Concentrations of total phosphorus in Little Saluda Creek exceeded 0.10 mg/liter only in May. For the Ohio River stations, total phosphorus values ranged from 0.09 to 0.99 mg/liter (Figure A-10), and orthophosphate values ranged from 0.04 to 0.08 mg/liter (Figure A-11). Both ranges were larger than those observed in previous monitoring. For Little Saluda Creek, total phosphorus values ranged from 0.04 to 0.12 mg/liter and orthophosphate values ranged from <0.01 to 0.03 mg/liter. All total phosphorus values were similar to values recorded by ORSANCO except in March when Little Saluda Creek values were much higher. This may be a result of the late spring flooding in 1981.

Nitrate nitrogen values for stations in the Ohio River and Little Saluda Creek ranged from 0.18 to 2.15 mg/liter during the year (Figure A-12, Table A-1), always exceeding the 0.1 mg/liter concentration limit necessary to inhibit growth of algae and plants (MacKenthum, 1969). Nitrate values were generally similar to means from previous years except in May when values were much higher. Again, late spring flooding in 1981 is probably the cause of this variation.

Ammonia nitrogen values ranged from <0.01 to 0.21 mg/liter for the Ohio River stations and from <0.01 to 0.02 mg/liter for Little Saluda Creek (Figure A-13, Table A-1). Values frequently exceeded 0.02 mg/liter of un-ionized ammonia, which is the maximum acceptable value for maintenance of freshwater life (EPA, 1976). These excessive values were also recorded at control Station 1; therefore, construction at the Marble Hill site was not their cause.

Organic nitrogen values ranged from 0.25 to 0.76 mg/liter for the Ohio River stations and from 0.35 to 0.65 mg/liter for Little Saluda Creek (Figure A-14, Table A-1). Both of these ranges were similar to those previously observed at the Marble Hill site.

Other Chemical Parameters

Quarterly values for silica, calcium and magnesium were similar among the three Ohio River stations (Figures A-15 through A-17), but they were usually lower than those for Little Saluda Creek (Table A-1). The higher concentrations of silica, calcium and magnesium were probably derived from minerals dissolving along the course of Little Saluda Creek.

Sodium values were lowest in March and highest in August and ranged from 9.3 to 25.3 mg/liter in the Ohio River (Figure A-18). Within the same sampling period there was little variation of sodium values at the Ohio River stations, except in May. In Little Saluda Creek, sodium concentrations were usually higher than Ohio River concentrations and ranged from 14.80 to 28.98 mg/liter (Table A-1).

The highest value of sulfate (102.6 mg/liter) measured during 1981 (Figure A-19) was well below the Indiana Water Quality Standards (1977) recommended maximum value of 250 mg/liter. There was little difference in sulfate values among Ohio River stations. Sulfate values for the Ohio River were usually lower than those for Little Saluda Creek, which were higher than in all previous monitoring in May, August and November.

The highest value of chloride (25.0 mg/liter) measured during 1981 (Figure A-20) was well below the Indiana Water Quality Standards recommended maximum of 250 mg/liter. As in previous years, Little Saluda Creek chloride values were higher than those for Ohio River stations, but they remained within the ranges reported by previous studies (Table A-1). Values always remained below 250 mg/liter.

Both free residual chlorine and chloramine values for the Ohio River and for Little Saluda Creek were less than 0.01 mg/liter during each quarter of 1981. Values for these parameters have never exceeded 0.01 mg/liter since monitoring began at the Marble Hill site in 1977.

Hexane soluble material levels were identical for the Ohio River and Little Saluda Creek, never exceeding the 5.0 mg/liter detection limit (Figure A-21, Table A-1). Phenol levels never exceeded 0.002 mg/liter either in the Ohio River or Little Saluda Creek (Figure A-22, Table A-1). Phenol values were always below ORSANCO's maximum recommended criterion (0.010 mg/liter) for the mainstream of the Ohio River. Indiana Water Quality Standards does not list any specific standard for phenol.

Natural Variation in Chemical Parameters

The dynamic nature of the Ohio River is often reflected by a wide variation in its chemical parameters. Such parameters are subject to varying seasonal fluctuations, depending on flow rates, as well as day-to-day variation in inputs of industrial or municipal effluents. The instantaneous measurement of these chemical parameters over the past five years serves only to record these irregularly occurring variations. Therefore, a pattern of variation noted in one year will not necessarily be repeated the next year.

The Ohio River is generally characterized in the spring by high water levels, fast currents, high turbidity levels and a great amount of debris. During the course of the year, water level and current speed fall to a minimum in August with a concomitant increase in water clarity. This pattern was observed in every year except in August 1980, when the river had a springtime appearance as a result of flooding in western Pennsylvania and West Virginia. Consequently, the levels of many chemical parameters in August 1980 differed from the levels recorded in preceding Augusts. In 1981, the onset of spring flooding occurred nearly two months later than in previous years and was generally more prolonged. Consequently, several chemical parameters had patterns of variation that differed from patterns established in 1977-1980 construction phase monitoring. It must be stressed, however, that on no occasion were water quality standards or recommendations exceeded at stations downstream of the plant without similar values being recorded at the control station upstream of the plant. Therefore, no variation in chemical parameters of the Ohio River could be attributed to construction at the Marble Hill site. While Little Saluda Creek is more susceptible to construction impacts than the Ohio River, it is also subject to the same amount of natural variability.

RESULTS OF PHYSICAL PARAMETER MEASUREMENTS

The following physical parameters were measured in conjunction with the water chemistry sample collections: water temperature, current velocity, water depth and Secchi depth. These parameters were measured at Stations 1, 3, 5 and 6. Turbidity measurements were made on water samples taken quarterly at Station 8. The results of these measurements were tabulated in Appendix Tables A-6 through A-9.

Water temperatures ranged from 7.0° to 28.1°C for Ohio River stations and from 9.6° to 22.2°C for Little Saluda Creek. These values were lower than the maximum temperature limits recommended by Indiana Water Quality Standards for the maintenance of a well-balanced warmwater fish community.

Water depth ranged from 4.0 to 5.6 m for Ohio River stations and from 0.2 to 0.5 m for Little Saluda Creek. Current velocity ranged from 12 to 55 cm/sec for Ohio River stations and was always <10 cm/sec for Little Saluda Creek. All values were similar to those recorded in previous monitoring.

Secchi depth ranged from 10 to 130 cm for Ohio River stations and the bottom was visible in Little Saluda Creek during each sampling. No correlation was observed between high current velocity and low Secchi depth.

Samples for turbidity measurements at Station 8 were collected only in March and May when there was water in the stream. The range of 4.7 to 192.5 nephelometric turbidity units (NTU) found in March and May, respectively, is within the range recorded during previous construction monitoring (ABI, 1978, 1979, 1980, 1981). This wide variation in turbidity was probably due to the intermittent nature of the stream and to the extreme effects of recent heavy rainfall and subsequent runoff.

SEDIMENTATION STUDIES

Sedimentation studies were conducted at Stations 6 and 8, which are located in streams that drain the plant site. This study was designed to estimate erosion by measuring the sediment accumulated at measured rods placed in the stream bed. Photographs were taken at two locations on each stream to visually evaluate changes in stream bed appearance over time (Figures A-23 through A-38). At Station 8, the upstream location was about midway up the east-facing slope adjacent to the plant site. The Station 8 downstream location was just below the road on the narrow floodplain of the Ohio River. Upstream and downstream sedimentation study rods at Station 6 were located upstream and downstream, respectively, of the small bridge that crosses Little Saluda Creek on the northern boundary of the plant site (Figure 1). Construction at the plant site took place continuously throughout the year.

Between November 1980 and March 1981, approximately 7.5 cm of sediment accumulated at the upstream study rod at Station 8 as a result of bank erosion along the entire length of the creek bed. Very little additional sediment accumulation was noted until August when another 2 cm of sediment was deposited. Significant erosion of the creek banks had again taken place allowing large rocks to fall into the creek bed. Subsequent water flow around the rocks exacerbated the bank erosion problem. No further sediment accumulation was noted for the remainder of the year. Erosion in the Station 8 creek is probably a result of accelerated runoff from the large construction parking lot and other cleared areas on the plant site. These areas do not appear to contribute sediment to the accumulations in Station 8 creek but simply allow runoff from a wider than usual area to flow down the creek and collapse the creek banks into the creek bed. These sediments do not flow into the Ohio River or even as far downslope as the downstream sedimentation study site. At this site, no sediment appears to have accumulated. Some erosion of the creek bed appears to have taken place but this is difficult to ascertain with certainty as no sedimentation study rod is in place at this site. Many attempts to keep a study rod in place here have failed because of the construction activity on the flood plain.

In Little Saluda Creek Station 6, no measurable sediment accumulations were observed at the upstream or downstream sedimentation study rods between November 1980 and March 1981. Between March and May, the late spring floods allowed overflow from the Ohio River to flood the creek. Although no measurable sediment accumulation was observed in the creek bed in May, the banks provided evidence that the creek had been overlain with sediment for a short time. This sediment accumulation removed the abundant algal growth observed in the creek in March (Figure A-31). Between May and August, 1.5 cm of sediment had accumulated at the upstream study rod and 1.0 cm at the downstream study rod probably as a result of heavy rains in June and July. These accumulations had been almost entirely washed away by November when extensive algal growth once again covered the rocks of the creek bed. Little Saluda Creek currently has virtually the same appearance it did in preconstruction times. Data collected during 1981 indicate that the creek has recovered the biological community structure that was lost during periods of heavy sediment input in 1978 to 1979.

CONCLUSIONS

Chemical and physical parameter values were similar at all the Ohio River stations during each of the quarterly sampling periods in 1981. They were similar to the values recorded during previous construction phase studies, although there were some exceptions. Construction at the Marble Hill site seems to have had no discernible effect on the chemical and physical parameters measured in this study. Most of the larger deviations between data collected in 1981 and data collected in previous studies occurred in March or May and were a result of the lateness of the spring flood in 1981.

Chemical parameter measurements indicate a degree of pollution at all the Ohio River stations, especially when compared to the station in Little Saluda Creek. In general, values for all parameters that indicate decreased water quality are higher in the Ohio River than in Little Saluda Creek; although, chemical and physical parameter values are usually within the range of water quality standards for the State of Indiana. Decreased water quality seems to be due to discharges upstream from the Marble Hill Plant site.

Sediment accumulations at Station 6 during 1981 were generally similar to those reported during 1980. At Station 6, sediment accumulations caused by construction activity appear to have stopped. The creek shows signs of returning to its preconstruction condition. Sediment accumulations from eroding stream banks continue to take place, however, at Station 8.

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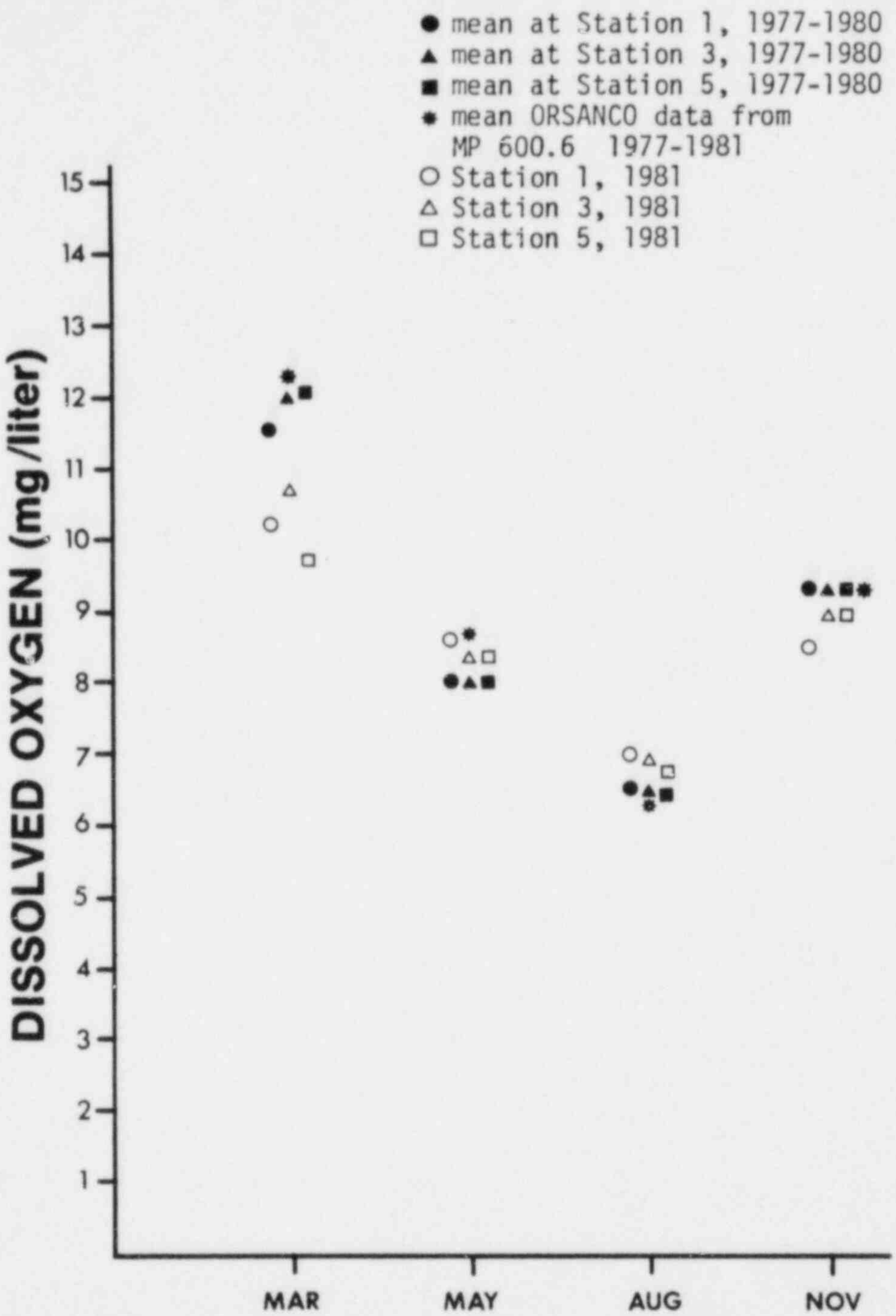

Figure A-1. Comparison of mean values from Stations 1, 3 and 5 (1977-1980), ORSANCO data and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

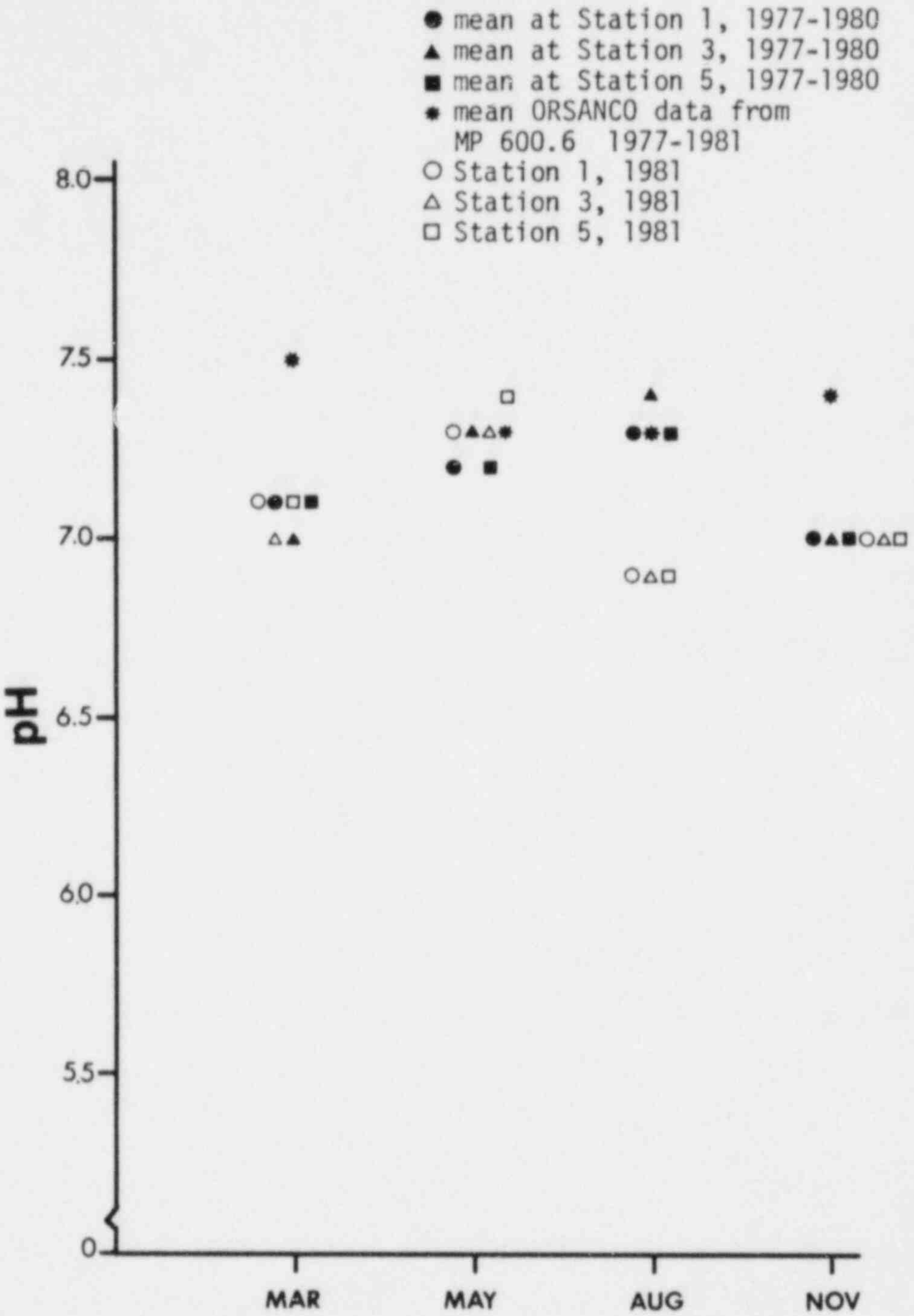

Figure A-2. Comparison of mean pH values from Stations 1, 3 and 5 (1977-1980), ORSANCO data and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

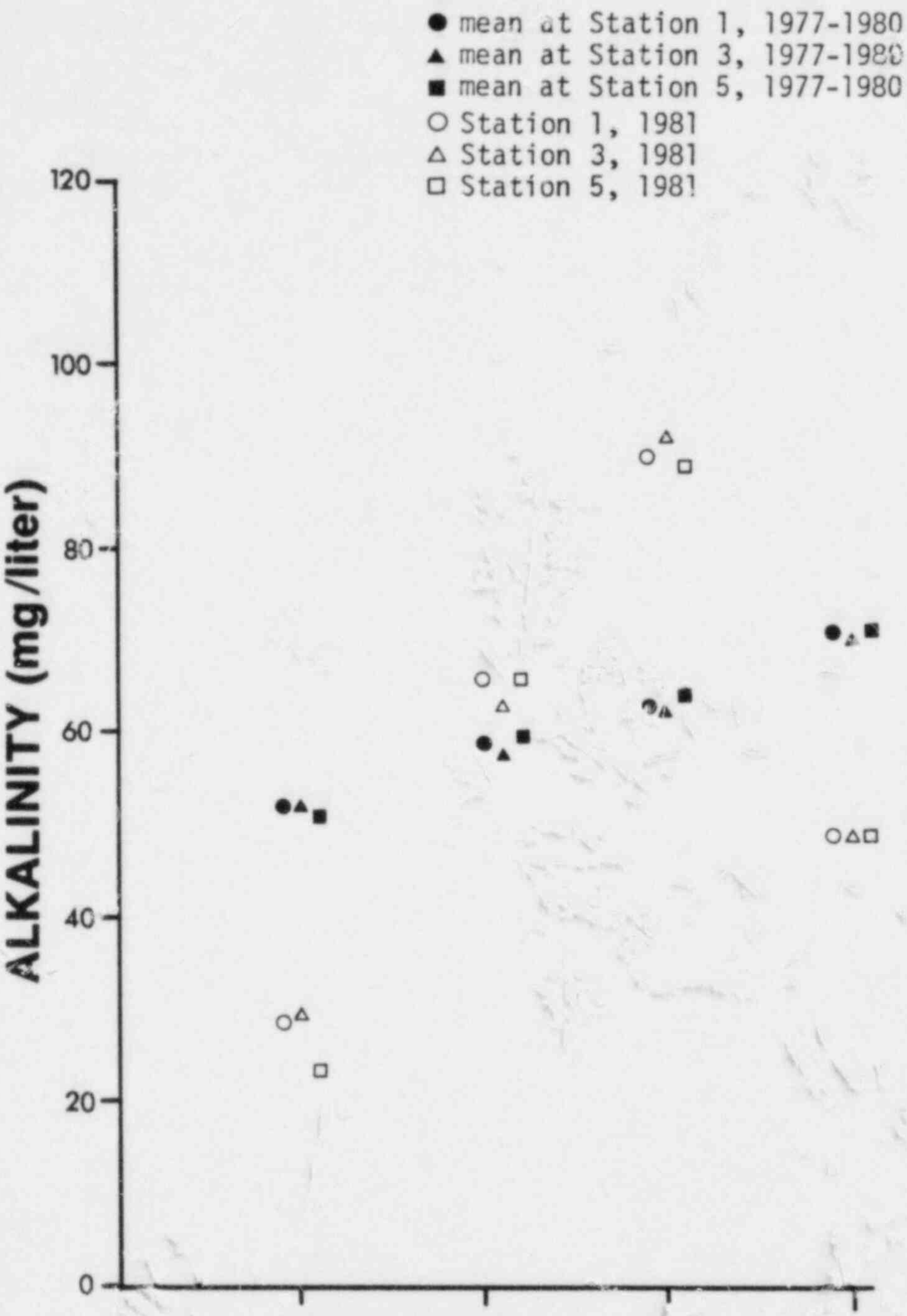

Figure A-3. Comparison of mean alkalinity values from Stations 1, 3 and 5 (1977-1980) and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

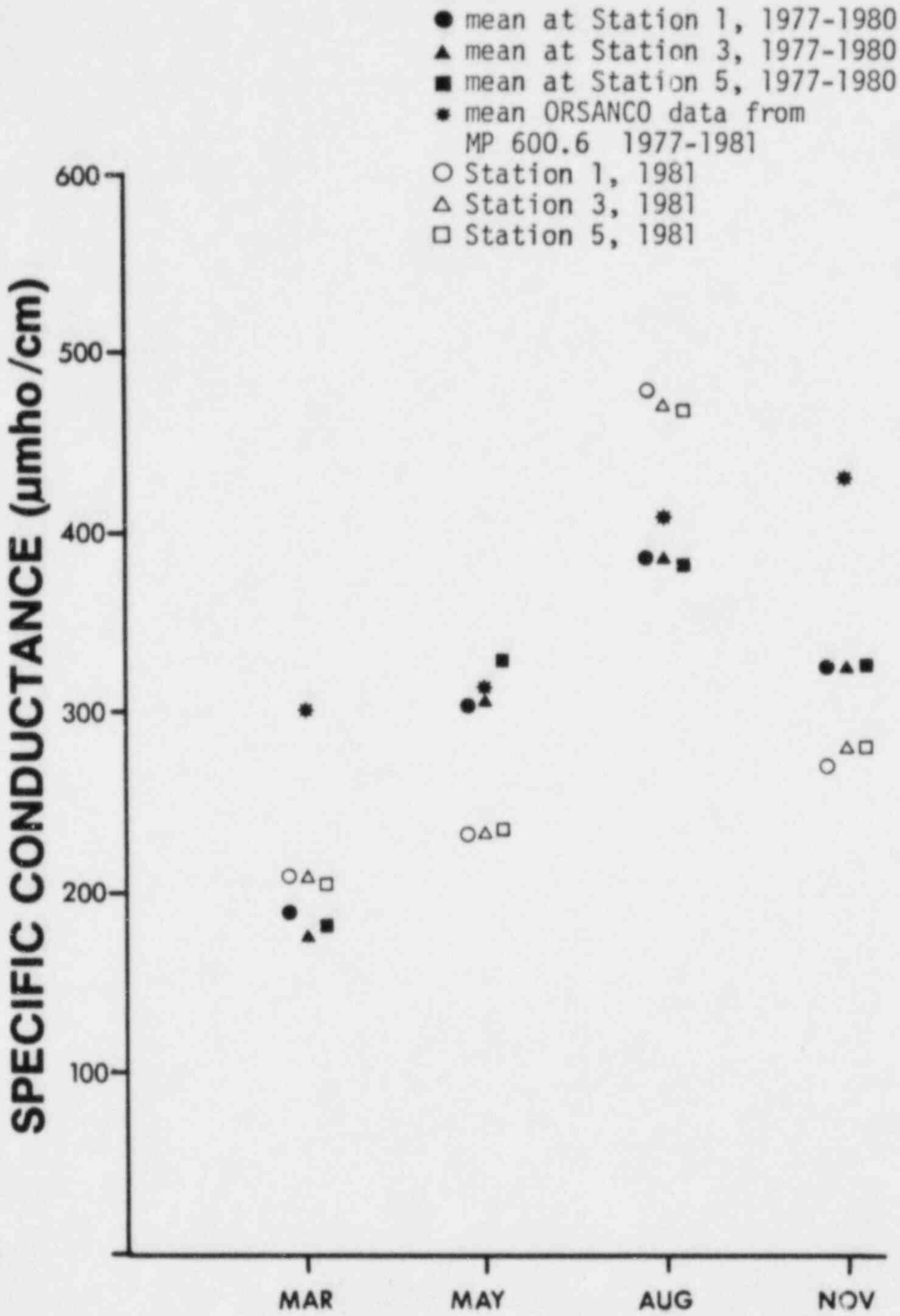

Figure A-4. Comparison of mean specific conductance values from Stations 1, 3 and 5 (1977-1980), ORSANCO data and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

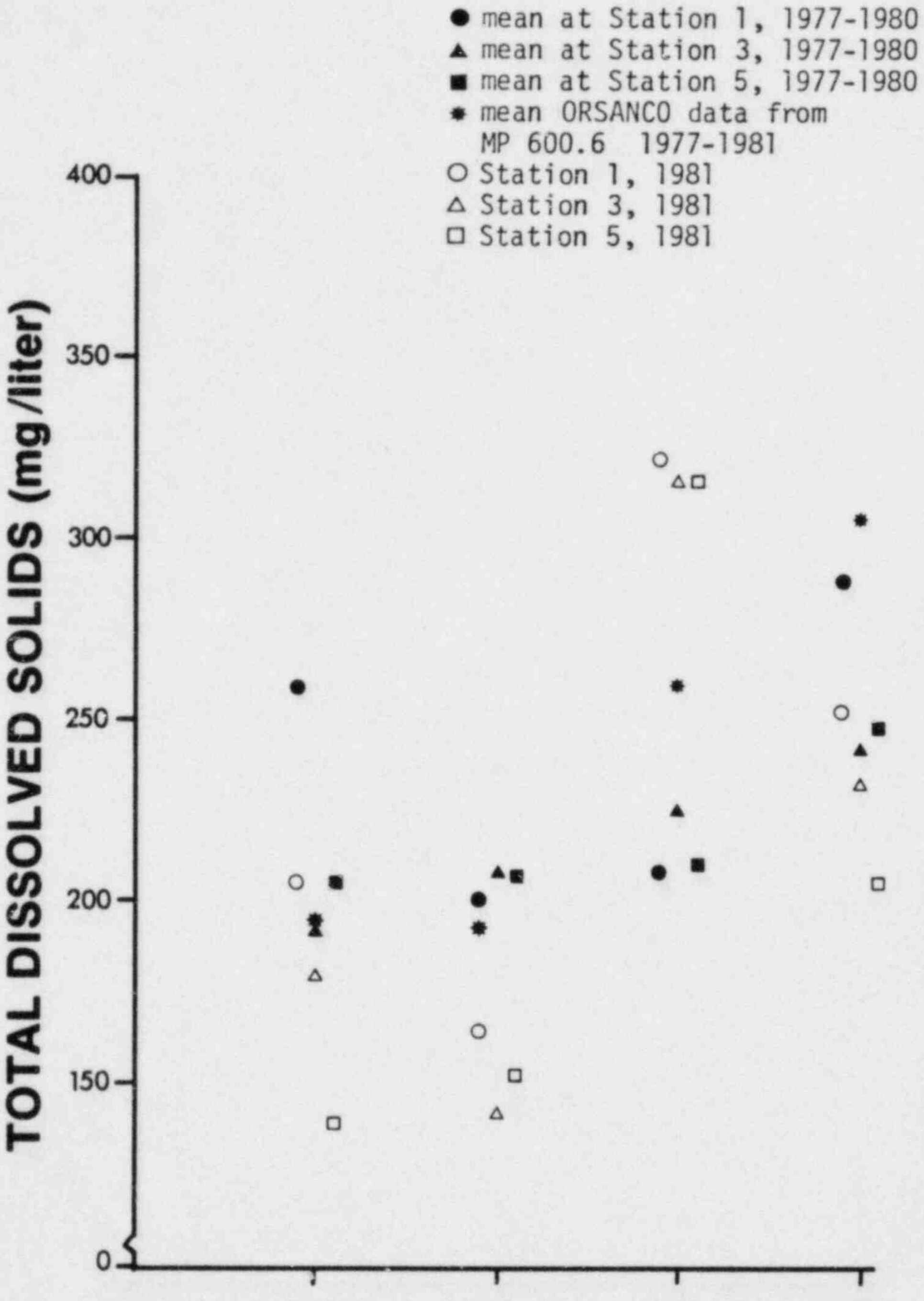

Figure A-5. Comparison of mean total dissolved solids values from Stations 1, 3 and 5 (1977-1980), ORSANCO data and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

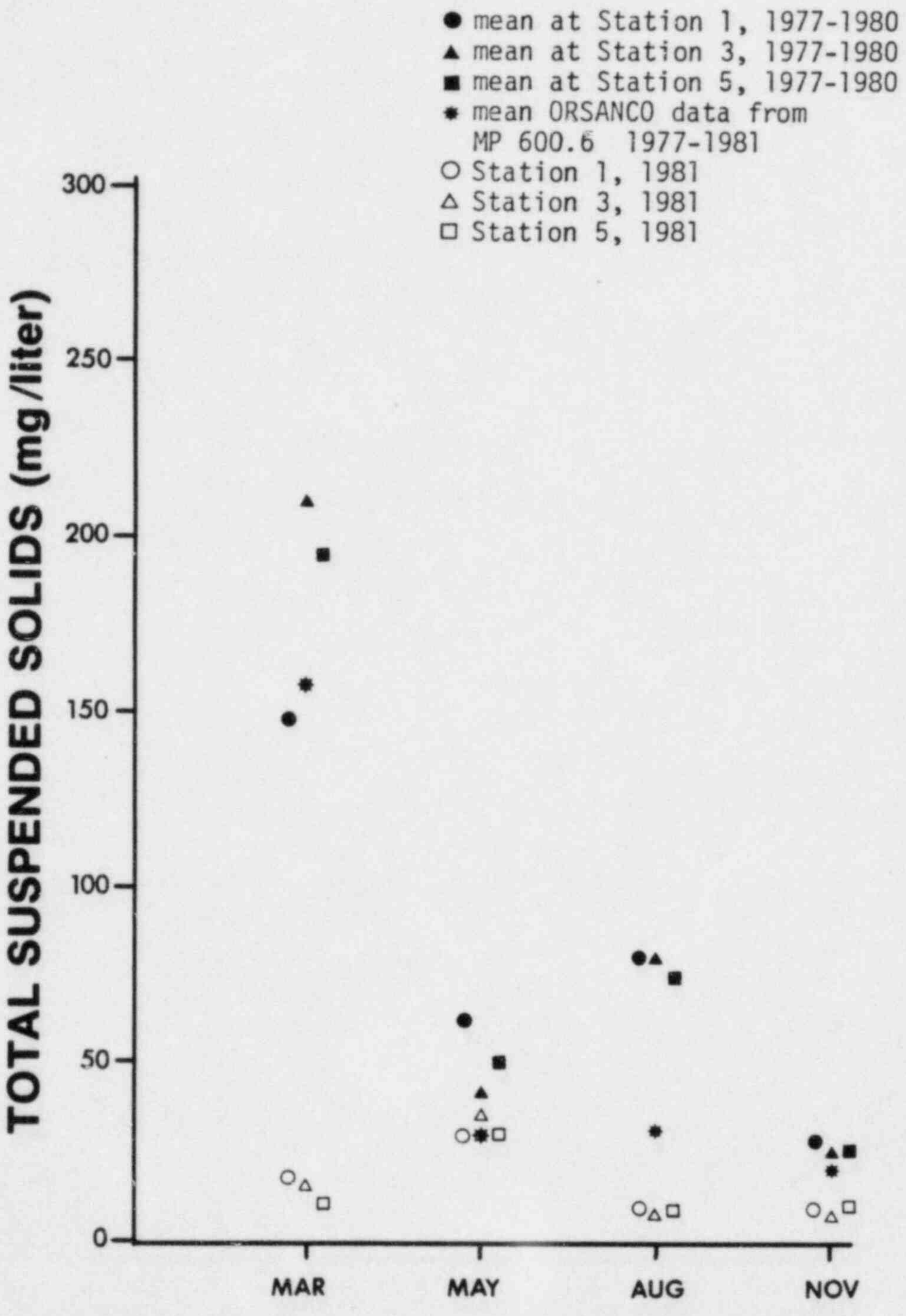

Figure A-6. Comparison of mean total suspended solids values from Stations 1, 3 and 5 (1977-1980), ORSANCO data and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

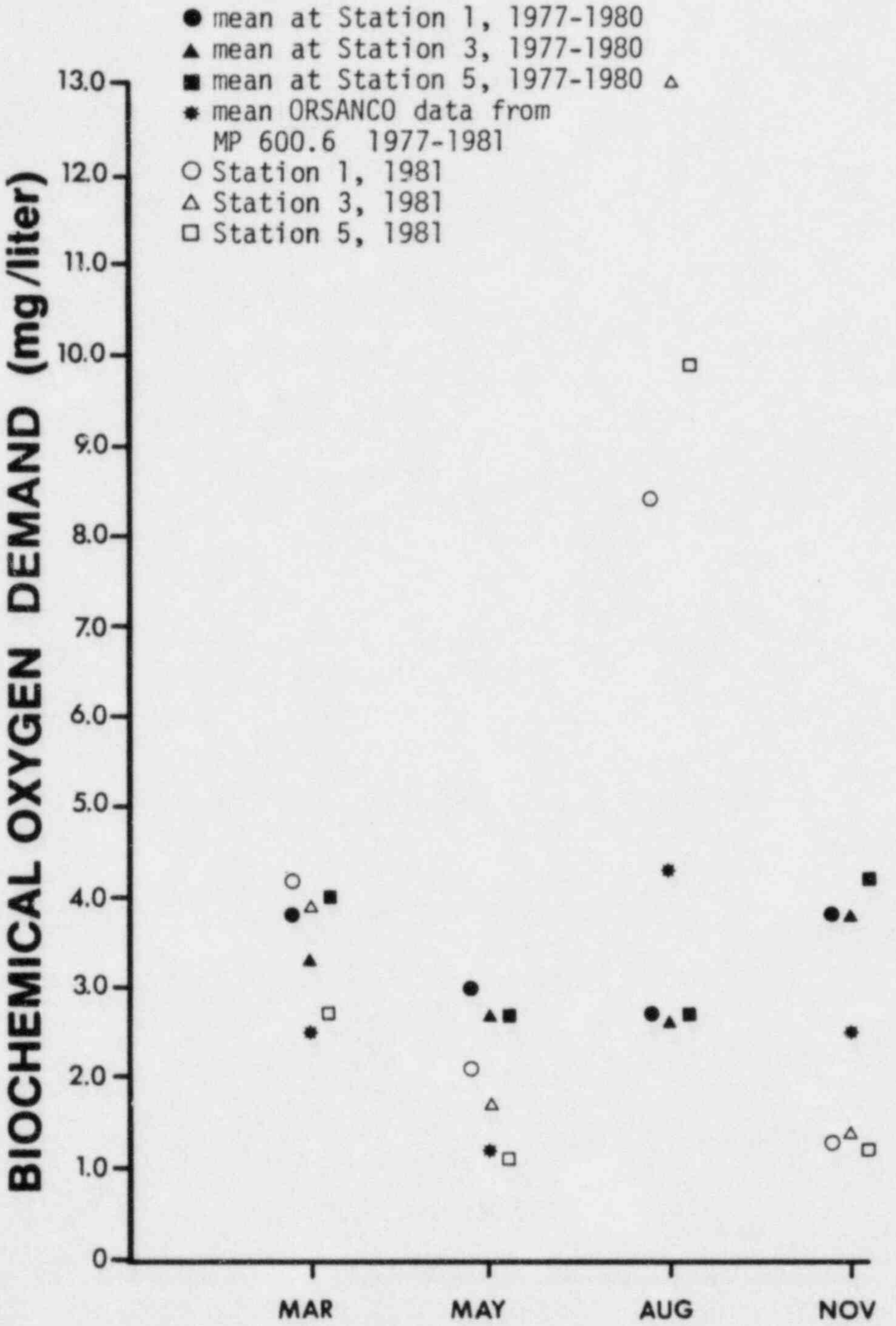

Figure A-7. Comparison of mean biochemical oxygen demand values from Stations 1, 3 and 5 (1977-1980), ORSANCO data and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

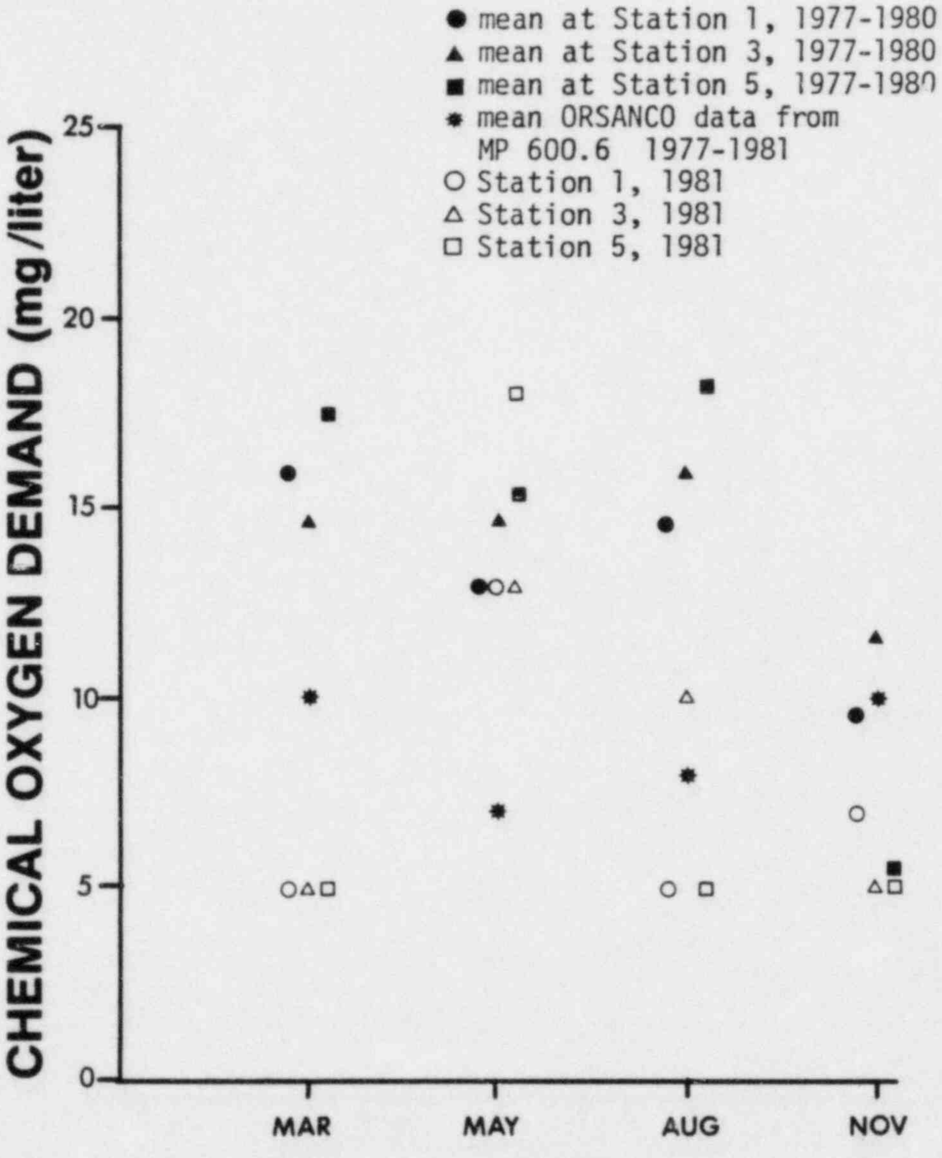

Figure A-8. Comparison of mean chemical oxygen demand values from Stations 1, 3 and 5 (1977-1980), ORSANCO data and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

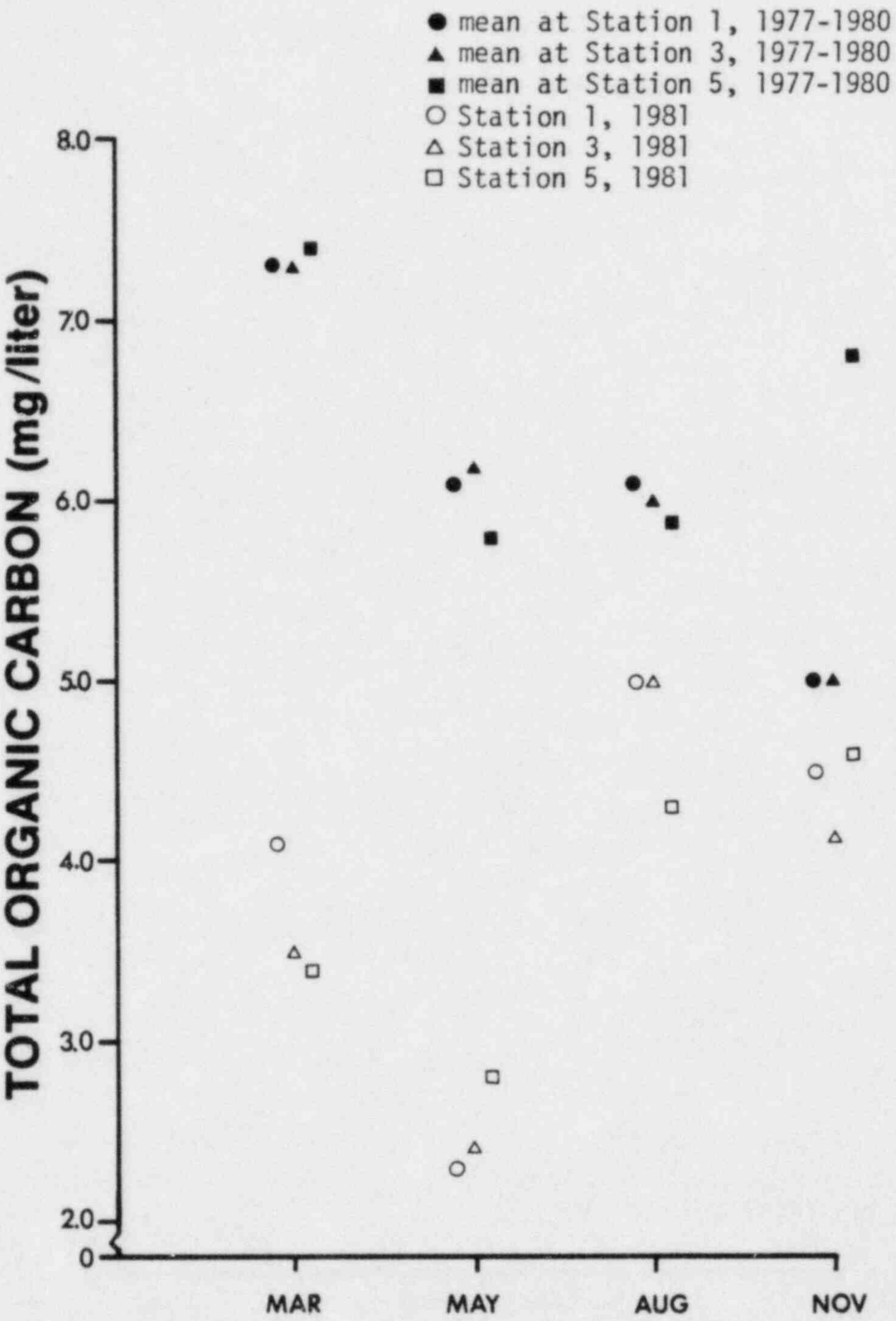

Figure A-9. Comparison of mean total organic carbon values from Stations 1, 3 and 5 (1977-1980) and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

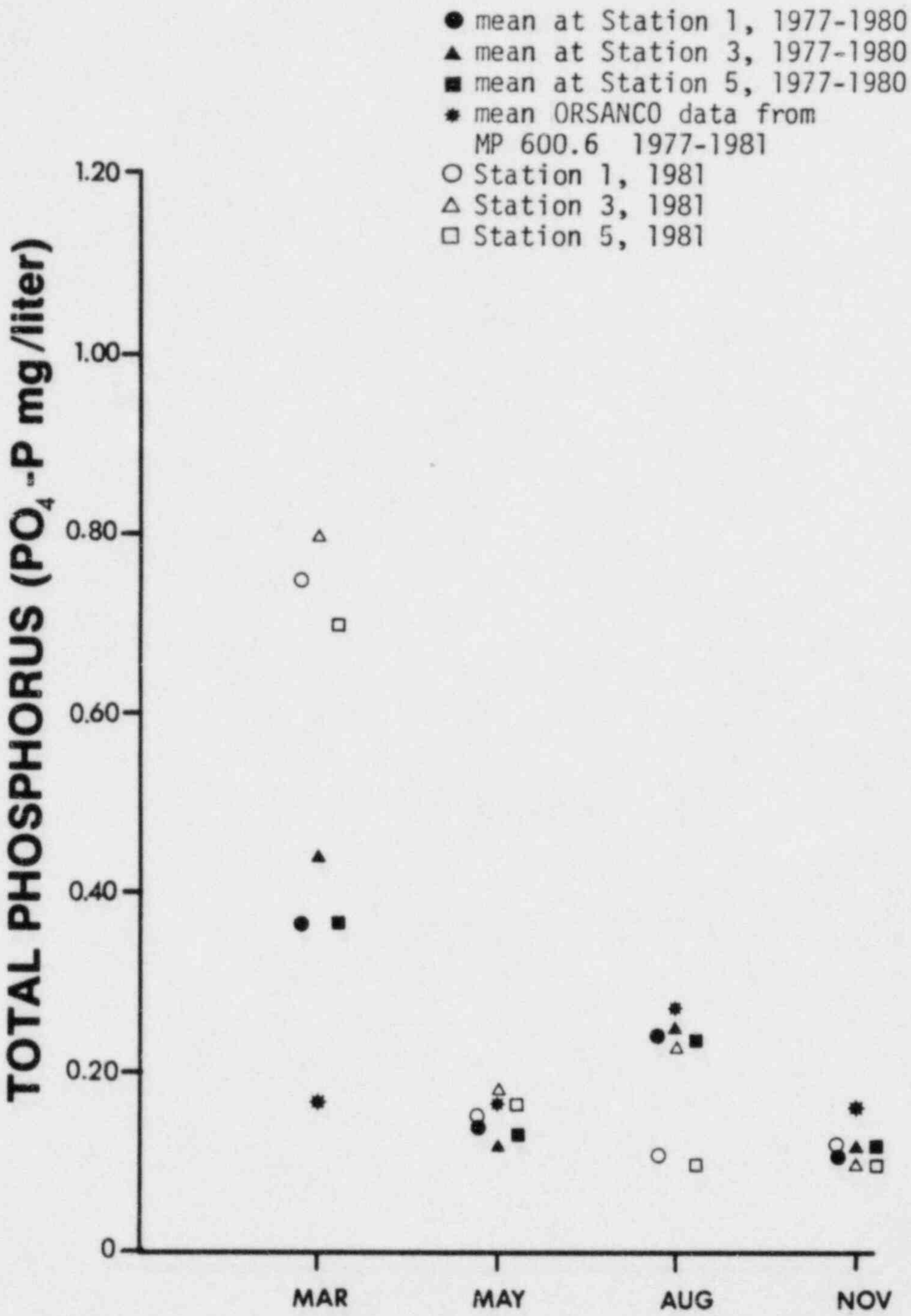

Figure A-10. Comparison of mean total phosphorus values from Stations 1, 3 and 5 (1977-1980), ORSANCO data and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

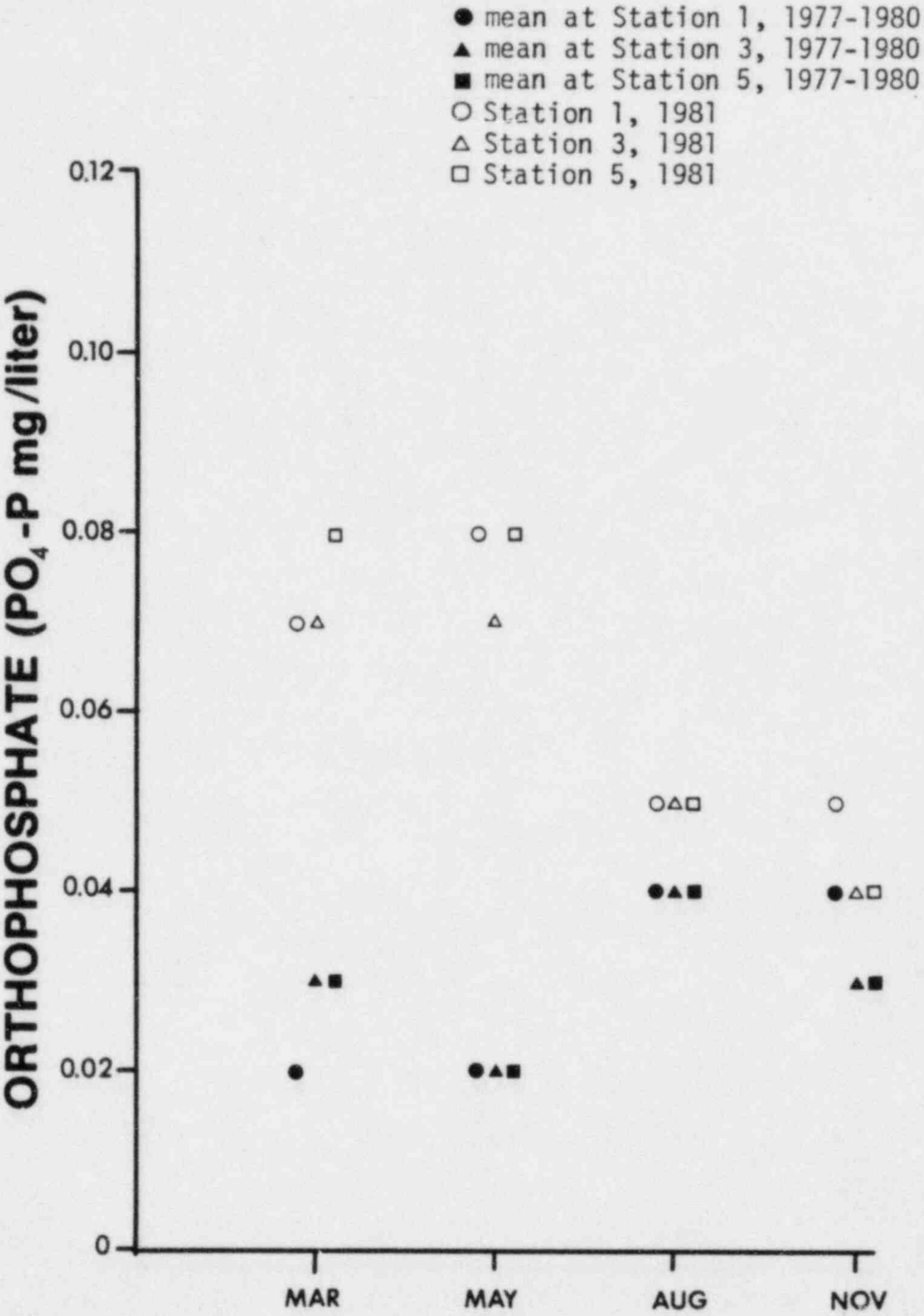

Figure A-11. Comparison of mean orthophosphate values from Stations 1, 3 and 5 (1977-1980) and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

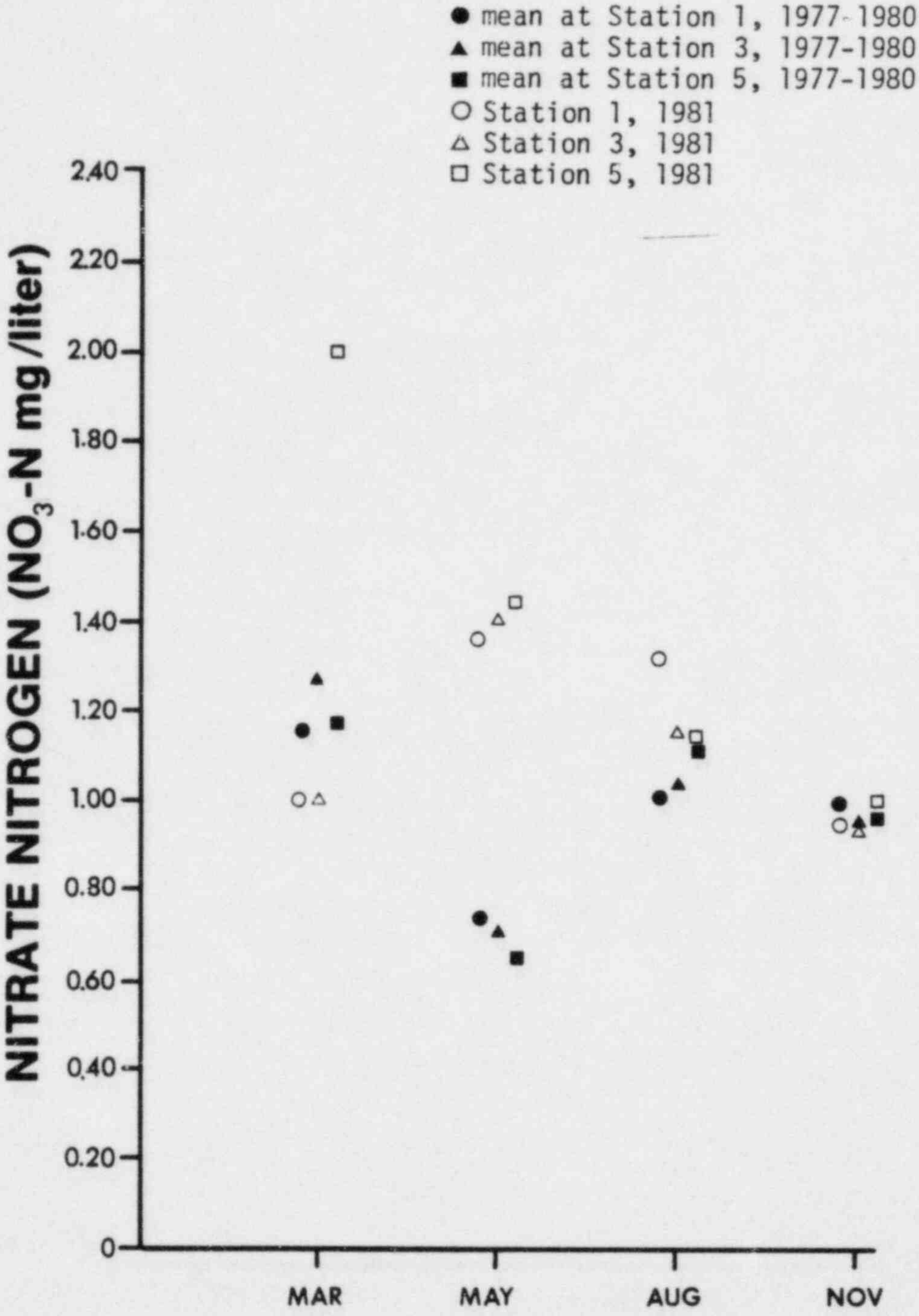

Figure A-12. Comparison of mean nitrate nitrogen values from Stations 1, 3 and 5 (1977-1980) and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

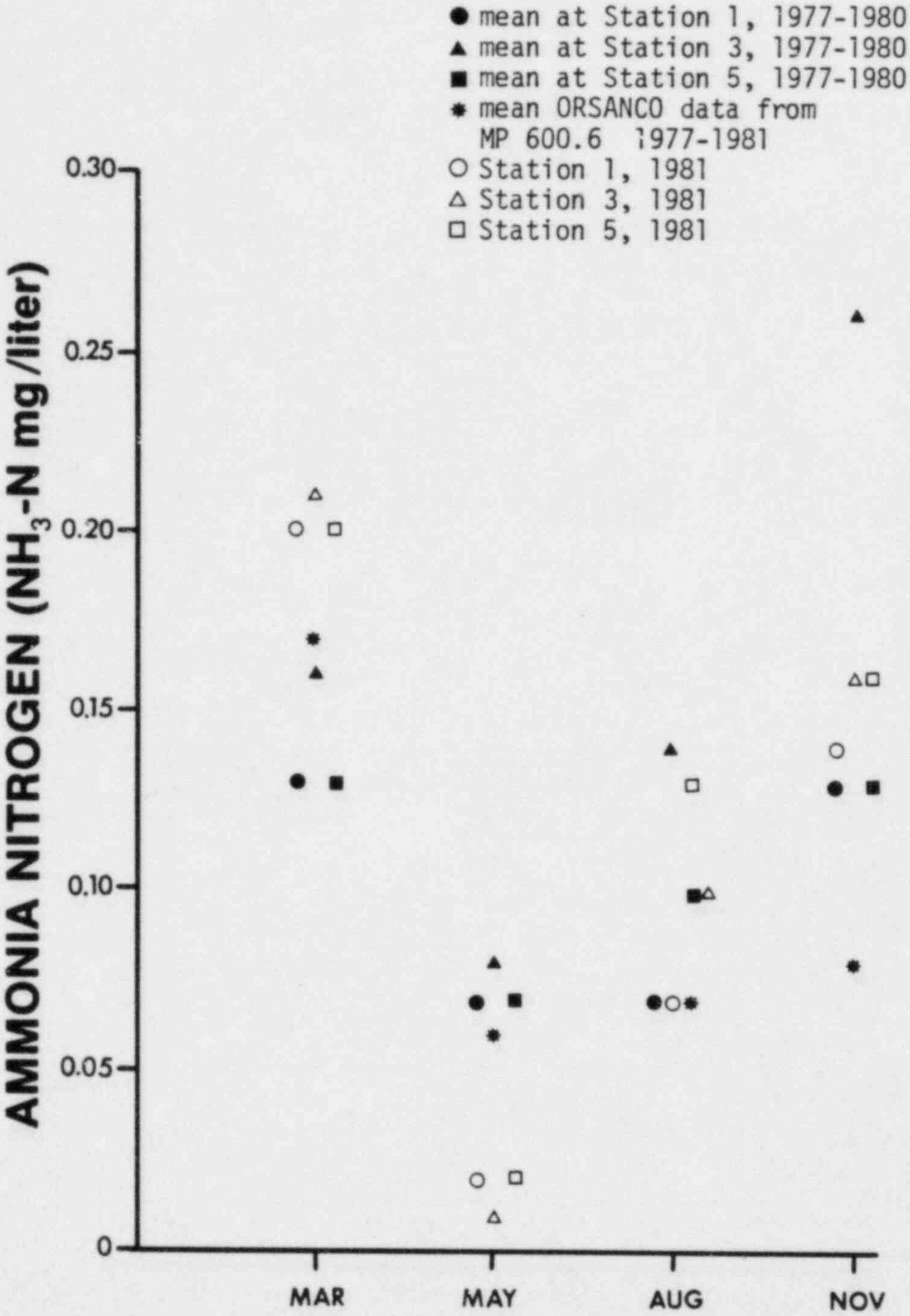

Figure A-13. Comparison of mean ammonia nitrogen values from Stations 1, 3 and 5 (1977-1980), ORSANCO data and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

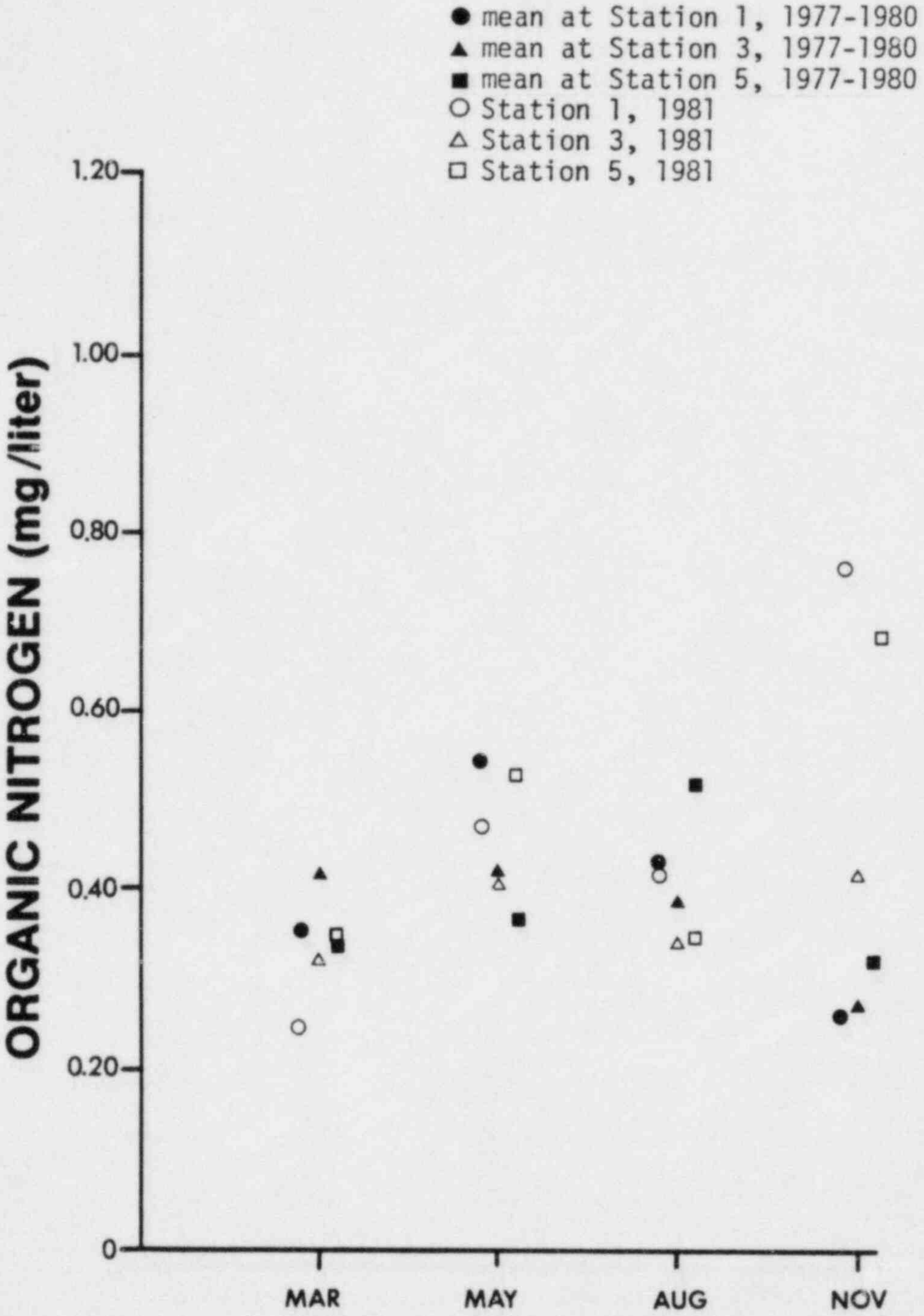

Figure A-14. Comparison of mean organic nitrogen values from Stations 1, 3 and 5 (1977-1980) and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

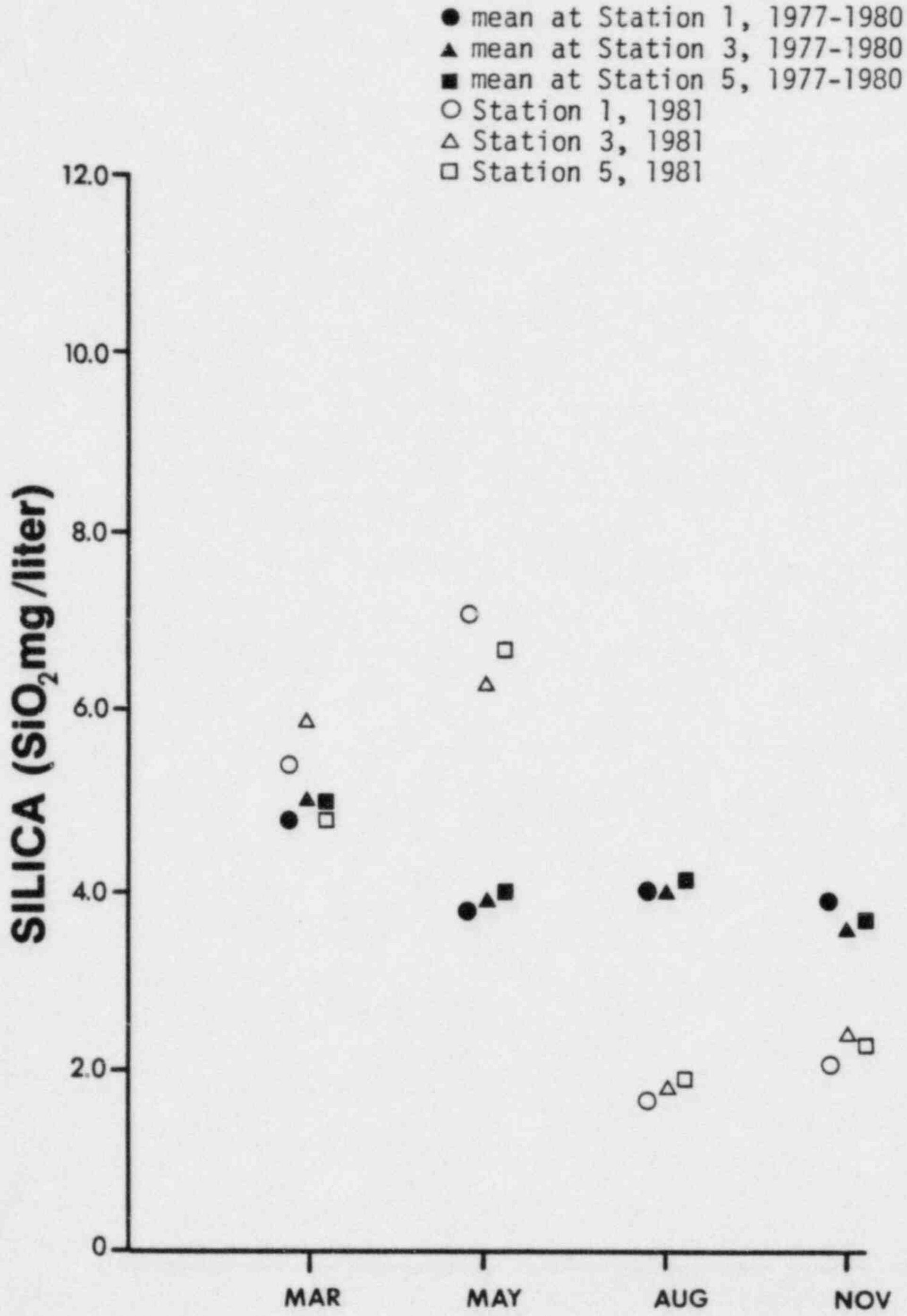

Figure A-15. Comparison of mean silica values from Stations 1, 3 and 5 (1977-1980) and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

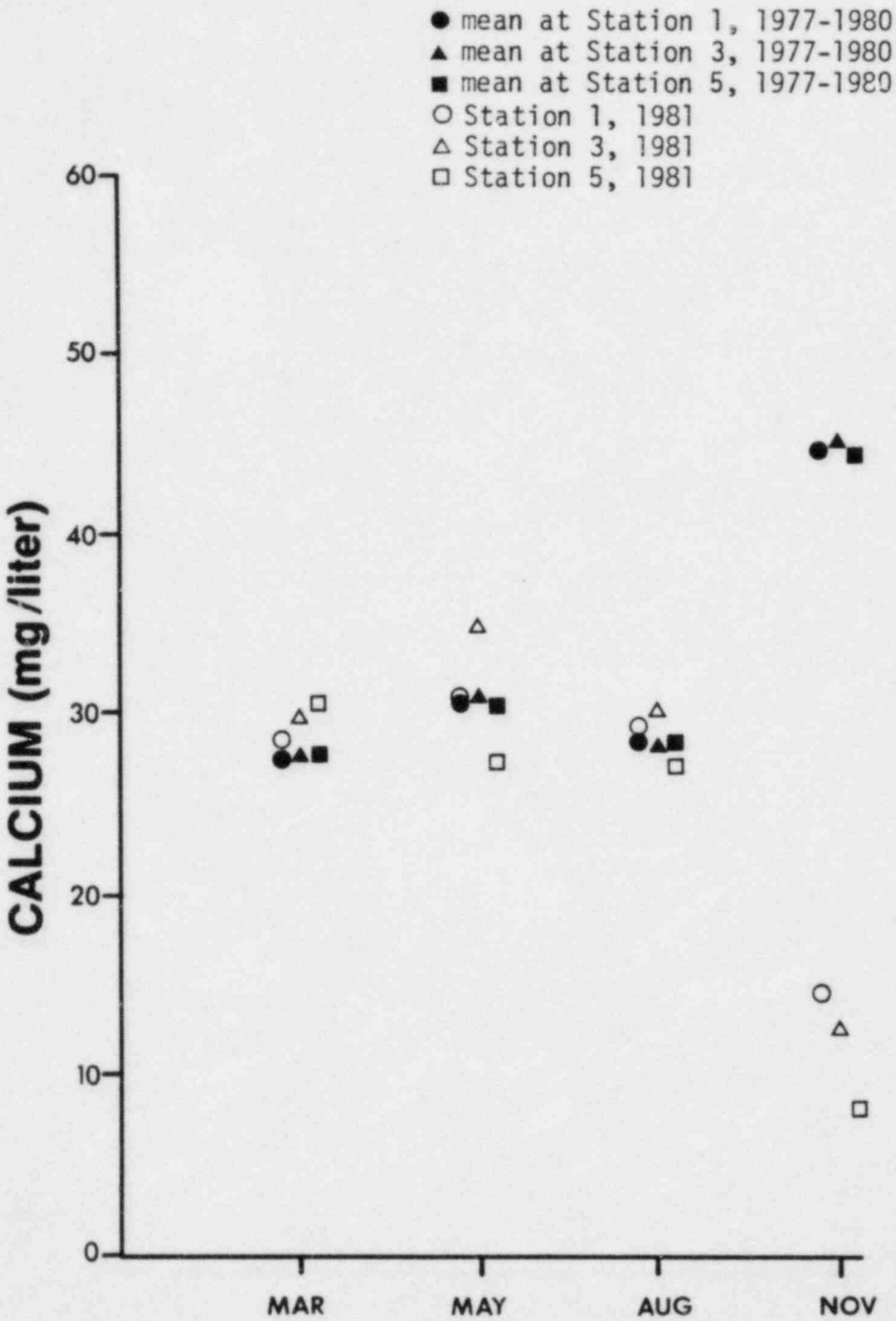

Figure A-16. Comparison of mean calcium values from Stations 1, 3 and 5 (1977-1980) and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

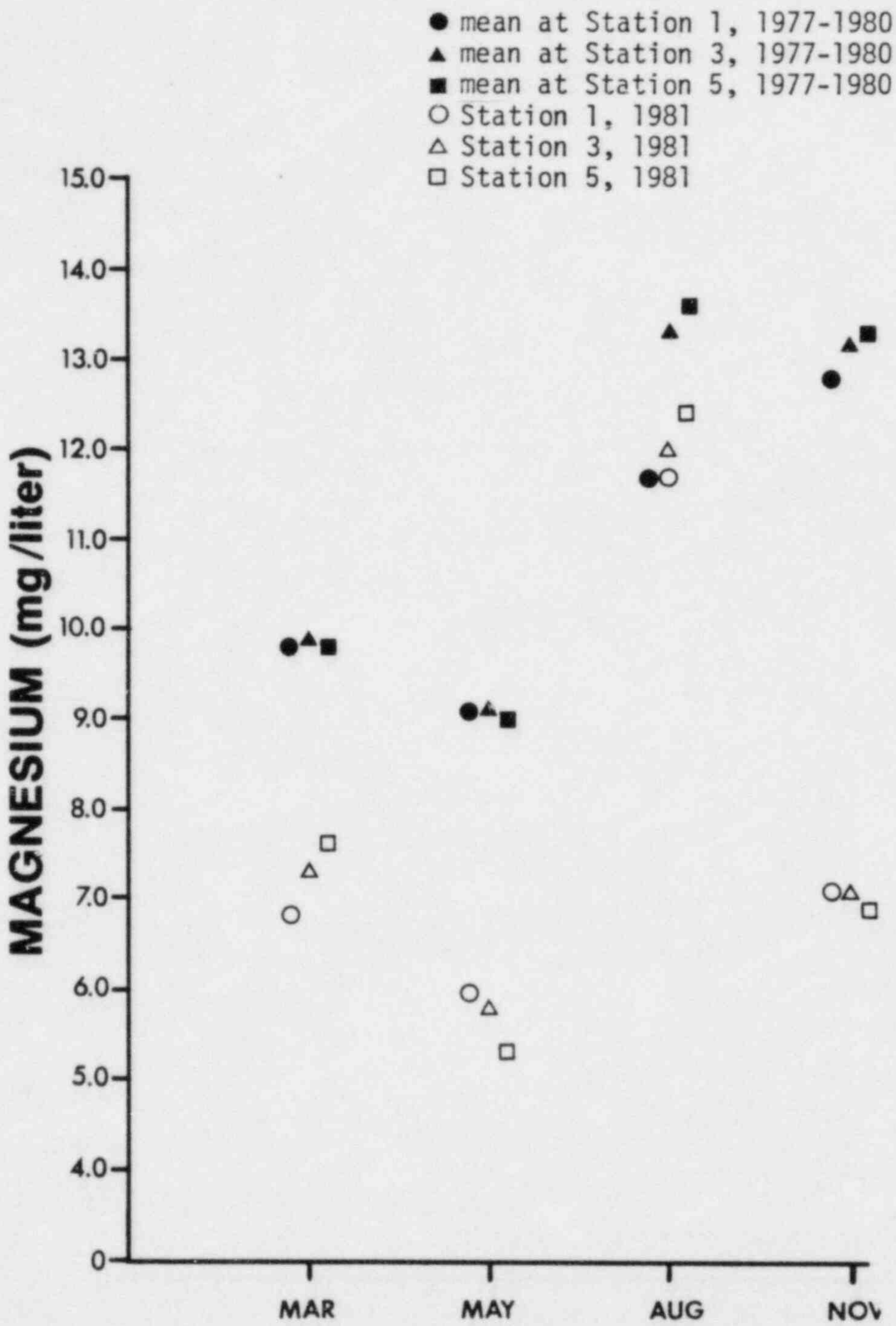

Figure A-17. Comparison of mean magnesium values from Stations 1, 3 and 5 (1977-1980) and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

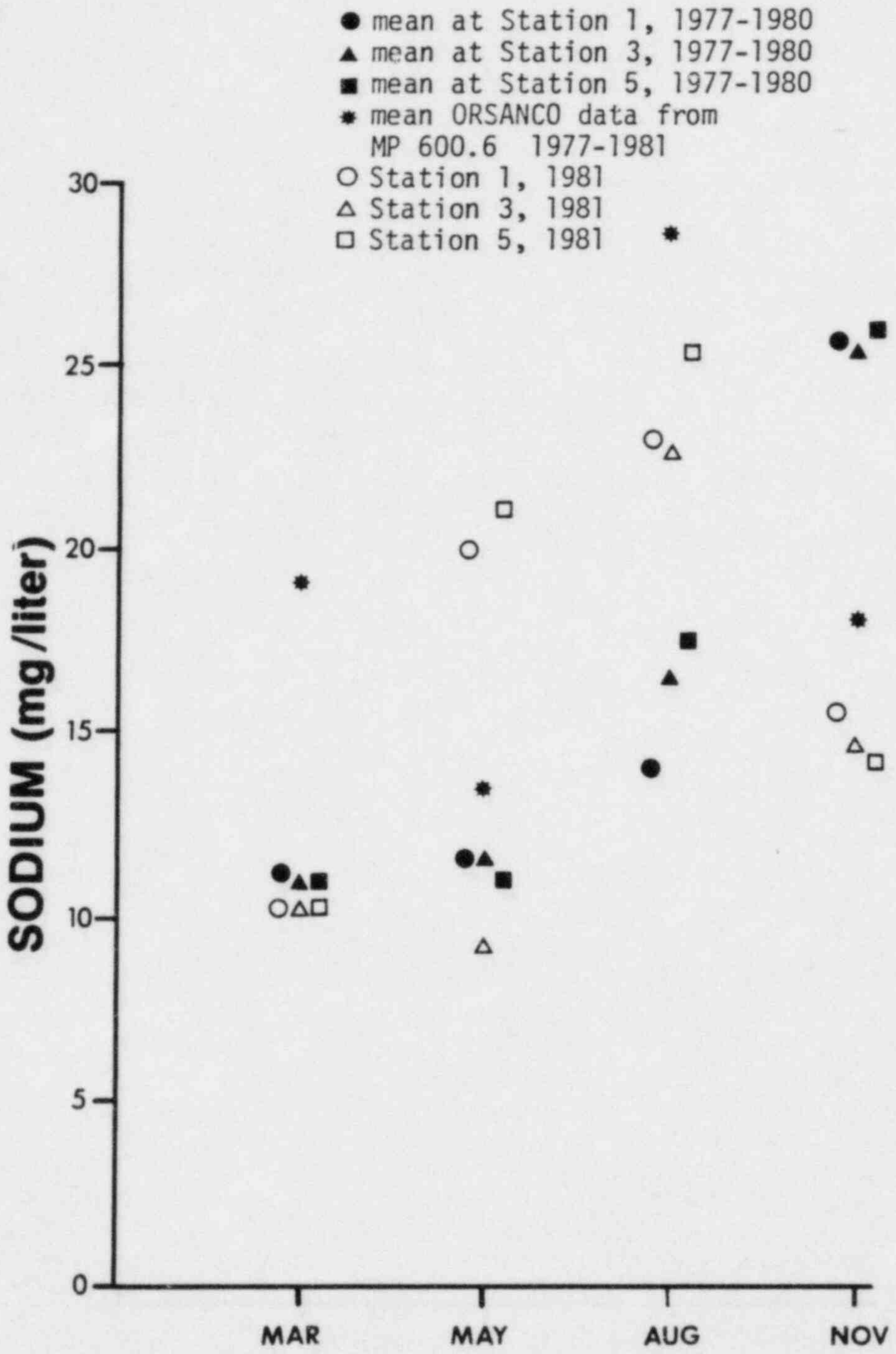

Figure A-18. Comparison of mean sodium values from Stations 1, 3 and 5 (1977-1980), ORSANCO data and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

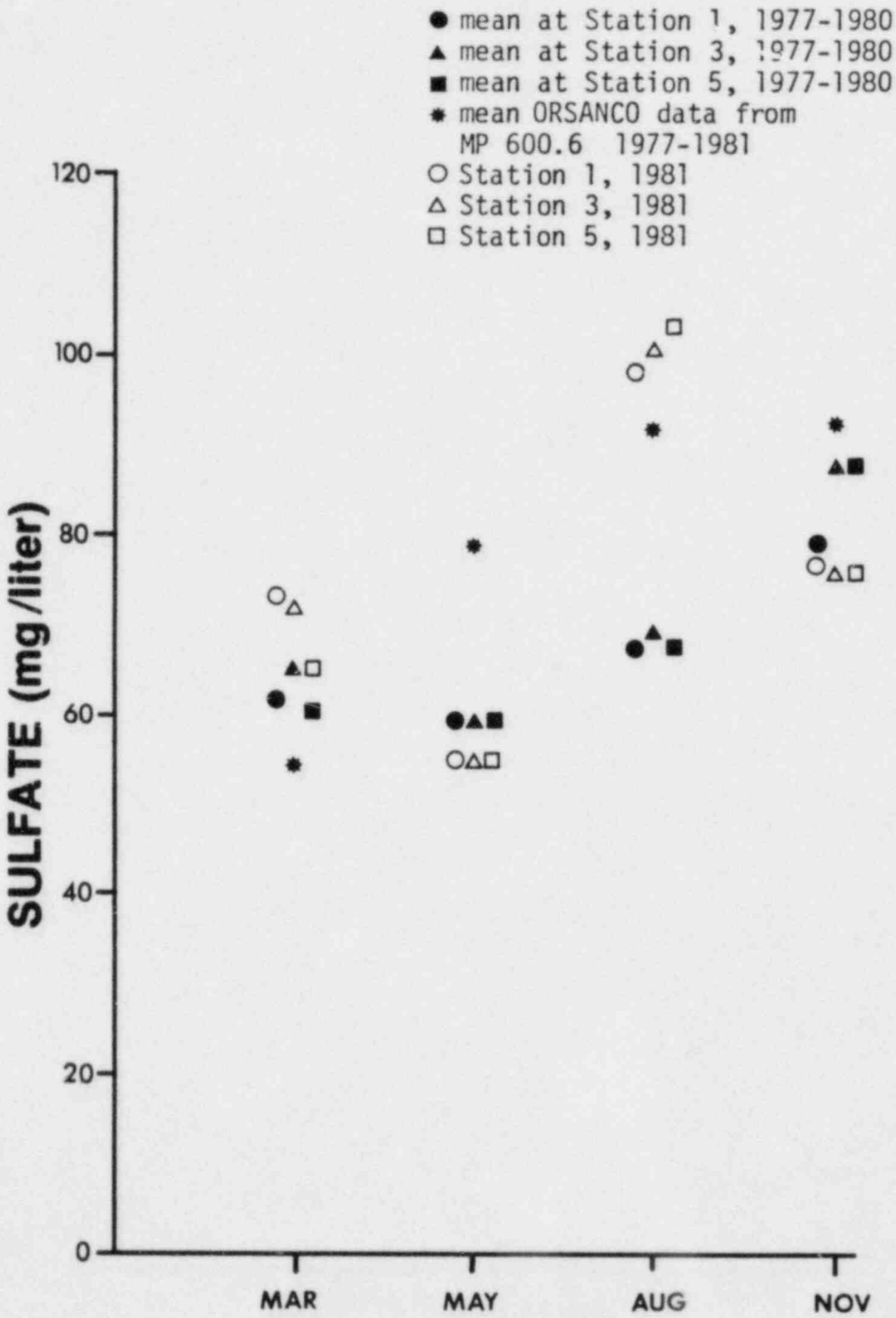

Figure A-19. Comparison of mean sulfate values from Stations 1, 3 and 5 (1977-1980), ORSANCO data and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

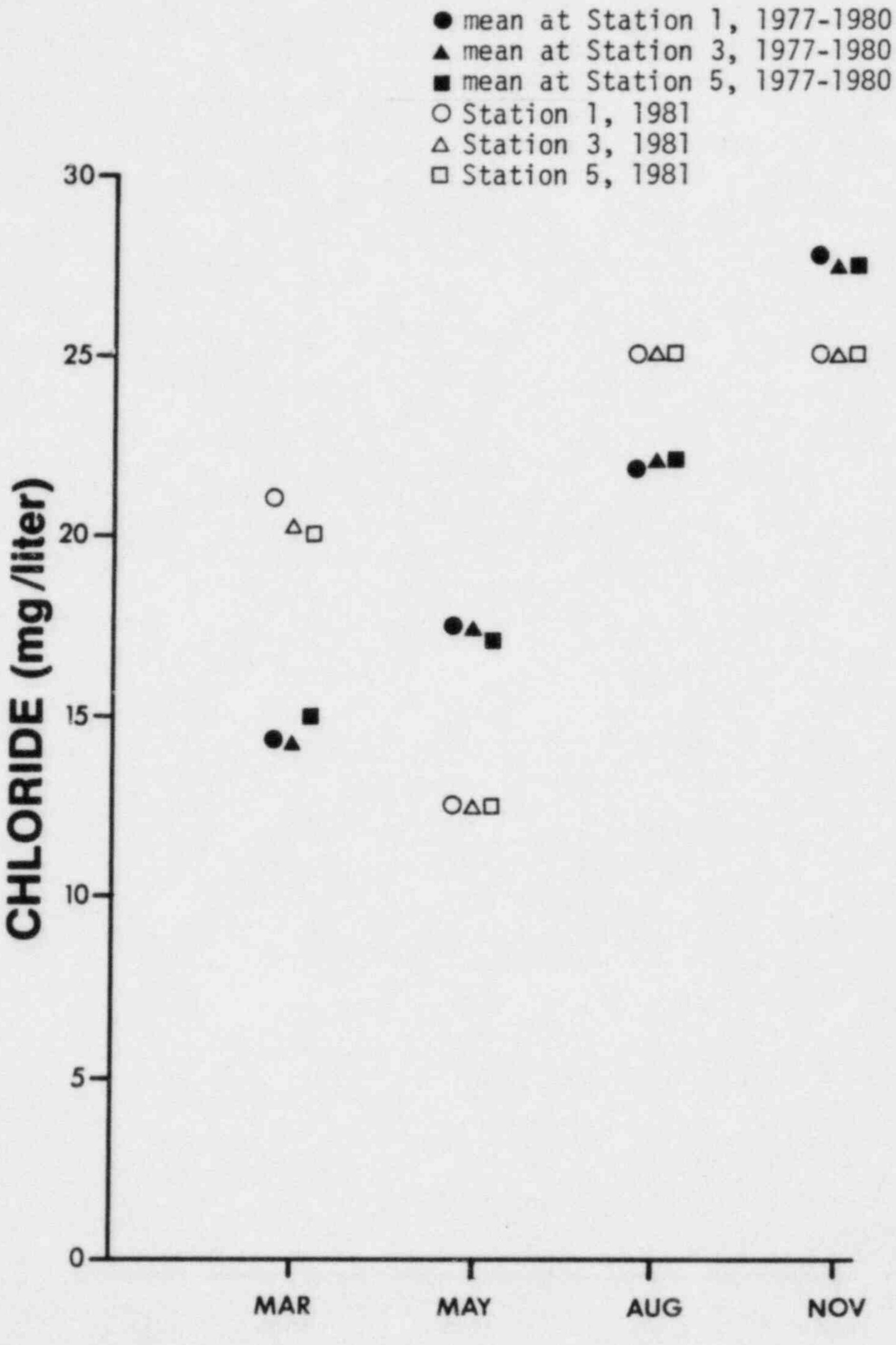

Figure A-20. Comparison of mean chloride values from Stations 1, 3 and 5 (1977-1980) and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

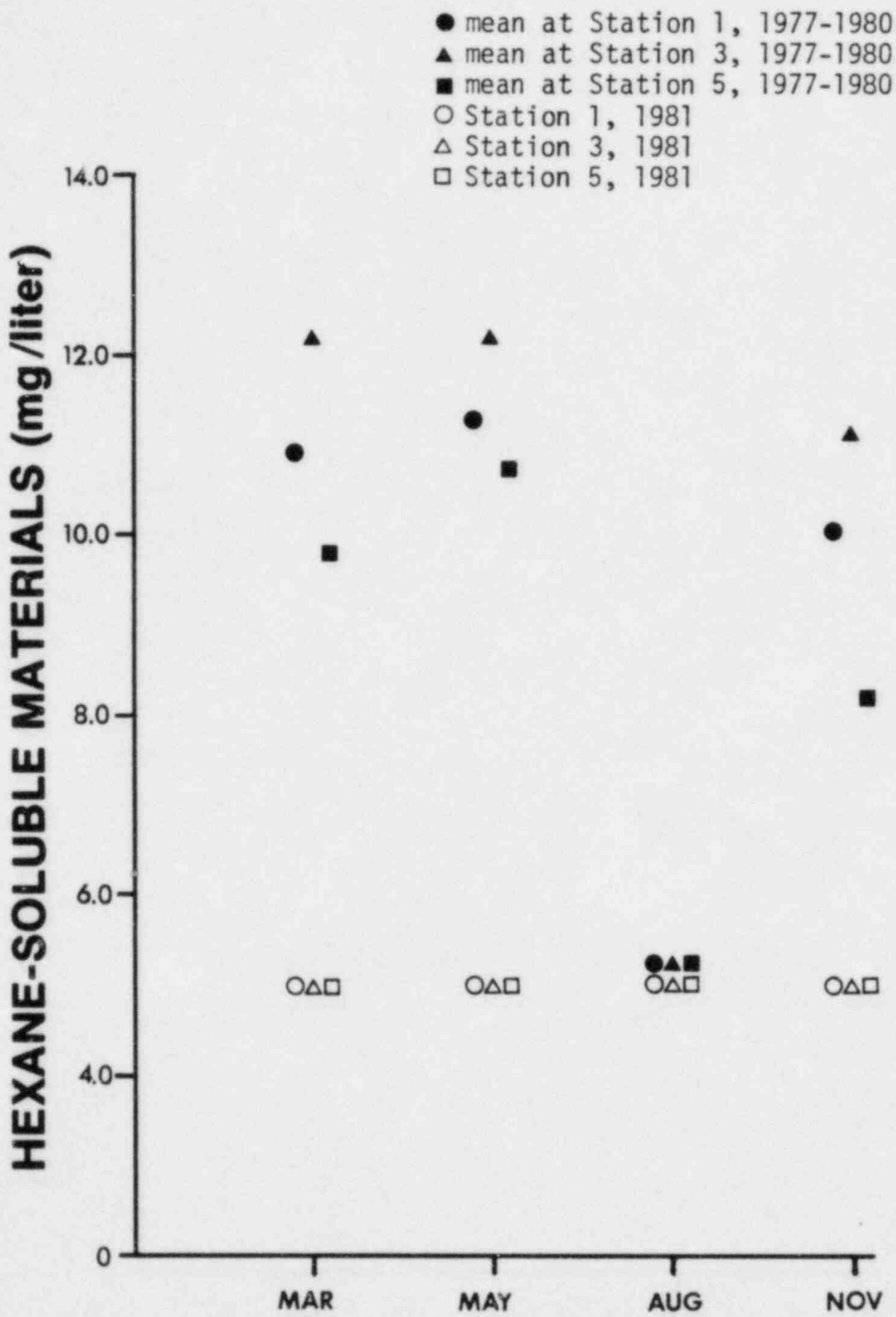

Figure A-21. Comparison of mean hexane-soluble materials values from Stations 1, 3 and 5 (1977-1980) and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

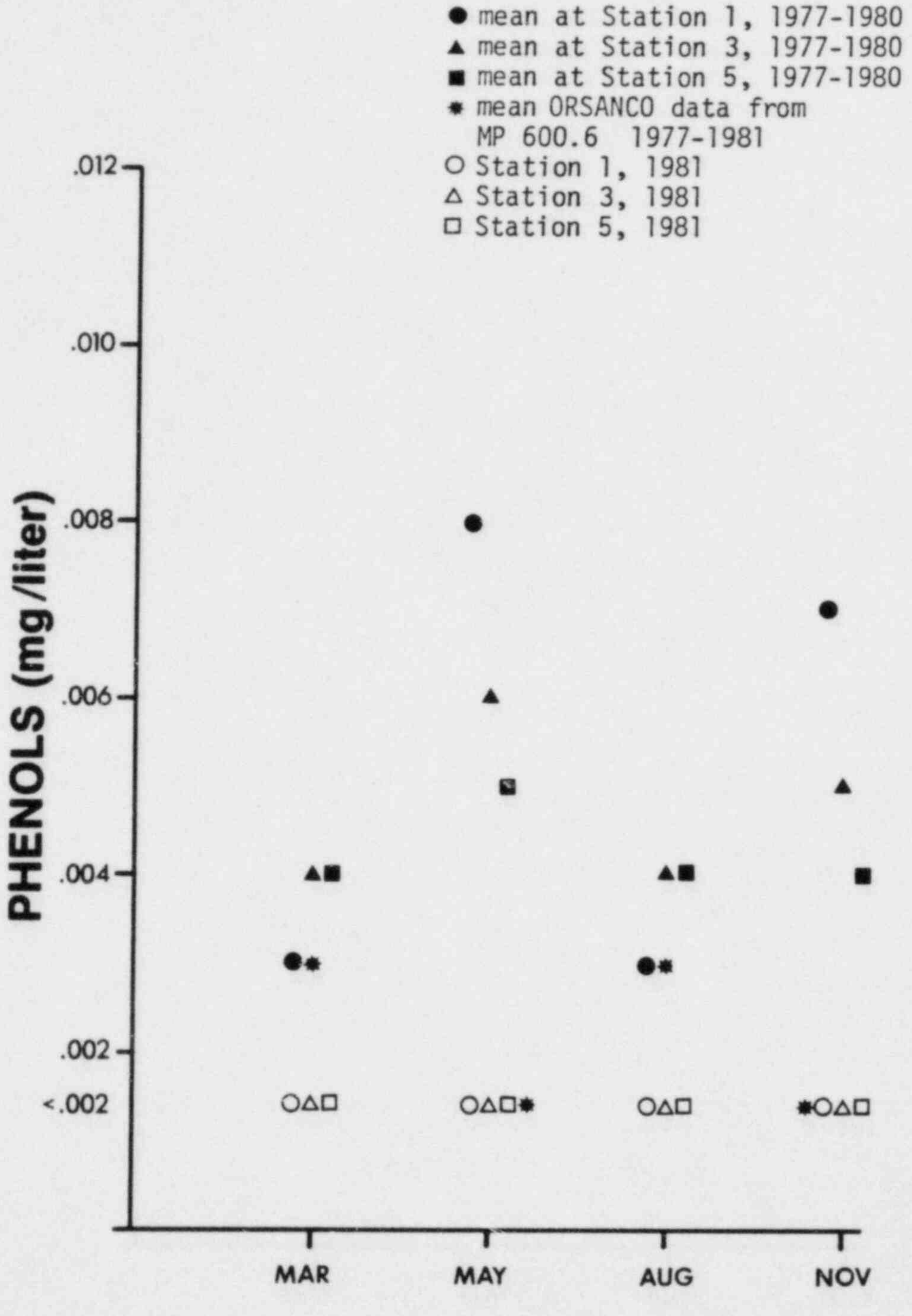

Figure A-22. Comparison of mean phenol values from Stations 1, 3 and 5 (1977-1980), ORSANCO data and 1981 values from Stations 1, 3 and 5, Marble Hill Plant site, 1981.

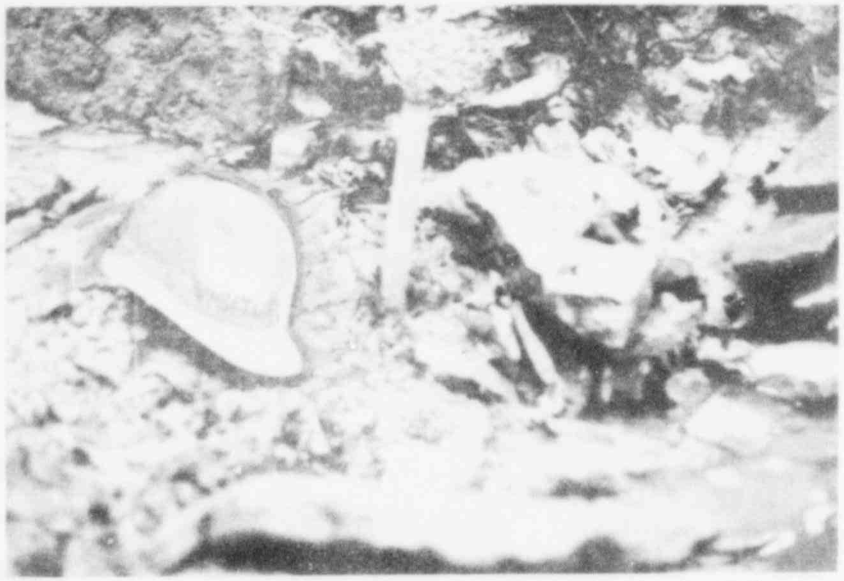

Figure A-23. Upstream sedimentation study rod at Station 8, 23 March 1981. Sediment accumulation of 7.5 cm since November 1980 was observed. Note recently eroded rocks and banks.

Figure A-24. Upstream sedimentation study rod at Station 8, 25 May 1981. Very little sediment accumulation since March.

Figure A-25. Upstream sedimentation study rod at Station 8, 10 August 1981. Major erosion of stream banks had occurred since May. Approximately 2 cm of additional sediment had accumulated. Rocks were removed from atop the study rod, and the rod was repositioned.

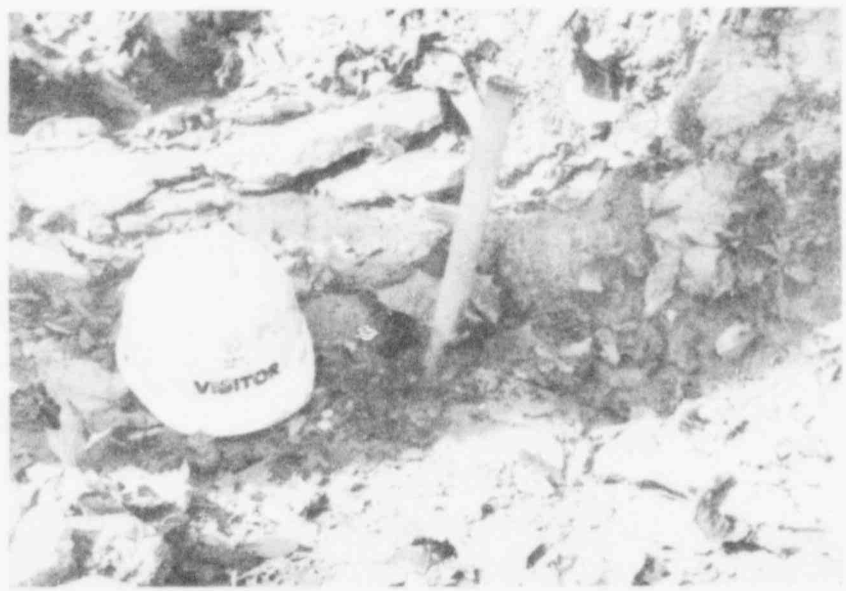

Figure A-26. Upstream sedimentation study rod at Station 8, 12 August 1981. Minor accumulations of sediment since August. Total accumulation for the year was 9.5 cm.

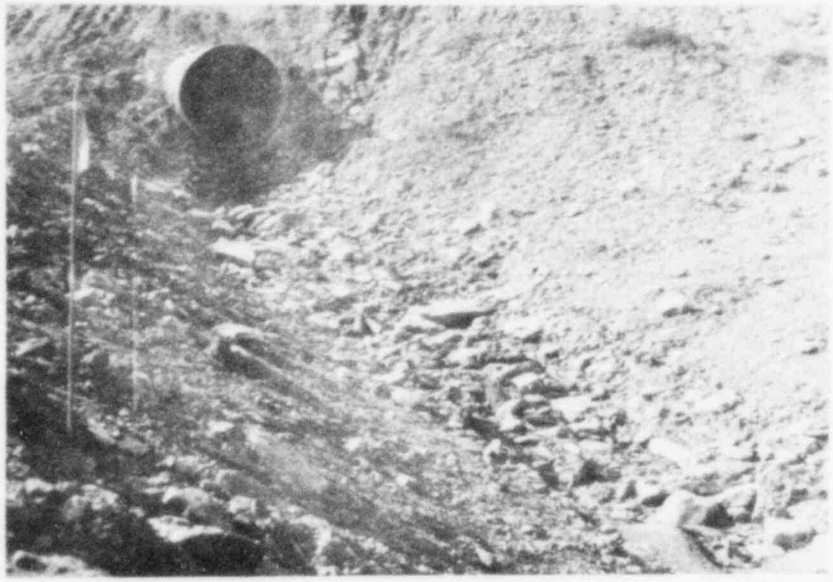

Figure A-27. Downstream sedimentation study site at Station 8, 23 March 1981. No noticeable sediment accumulation since November 1980.

Figure A-28. Downstream sedimentation study site at Station 8, 25 May 1981. No noticeable accumulations.

Figure A-29. Downstream sedimentation study rod at Station 8, 10 August 1981. No noticeable sediment accumulation since May, but ditch appeared deeper.

Figure A-30. Downstream sedimentation study rod at Station 8, 12 November 1981. No noticeable sediment accumulation.

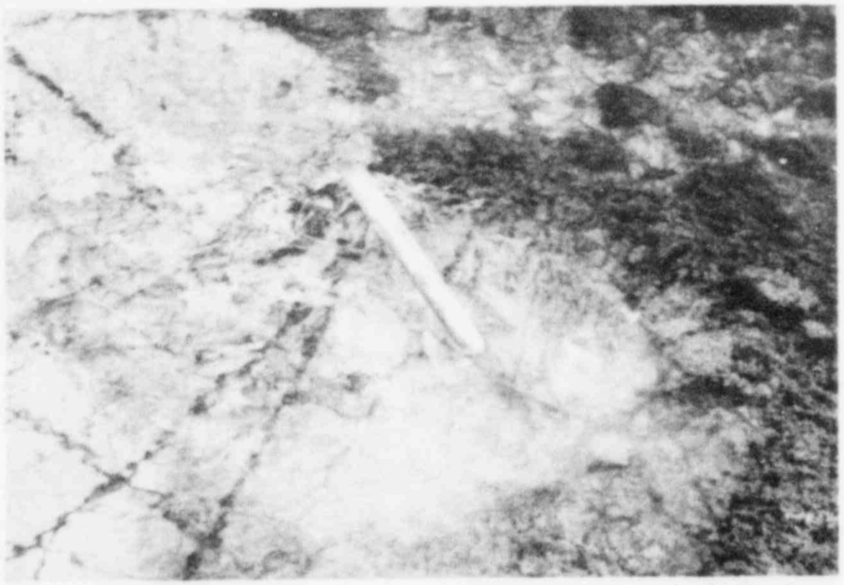

Figure A-31. Upstream sedimentation study rod at Station 6, 23 March 1981. No measureable sediment accumulation since November 1980. Note extensive algal growth on right.

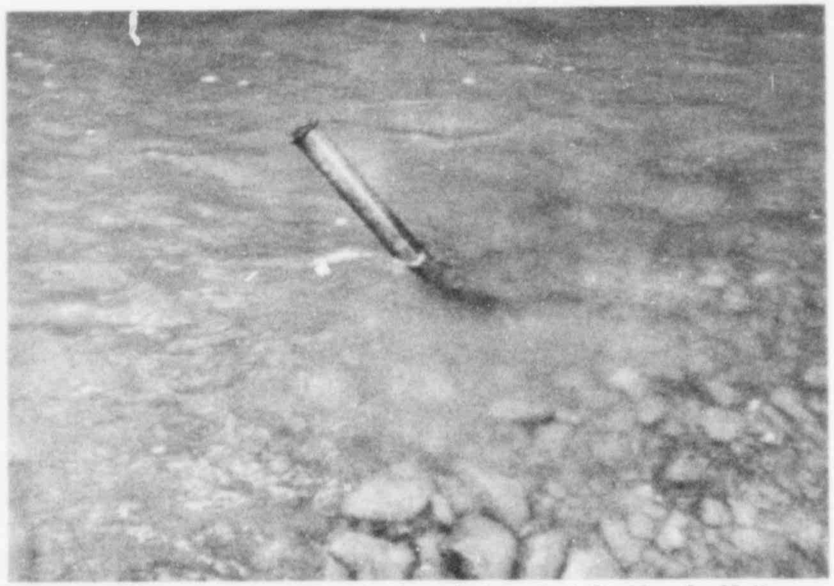

Figure A-32. Upstream sedimentation study rod at Station 6, 25 May 1981. No measureable sediment accumulation since March. Note scoured bottom and lack of algae.

Figure A-33. Upstream sedimentation study rod at Station [illegible], 10 August 1981. Approximately 1.5 cm sediment accumulation since May. Note spaces between rocks filled in with sediment.

Figure A-34. Upstream sedimentation study rod at Station 6, 12 November 1981. Most of previously accumulated sediment has been washed out. Note return of algal growth.

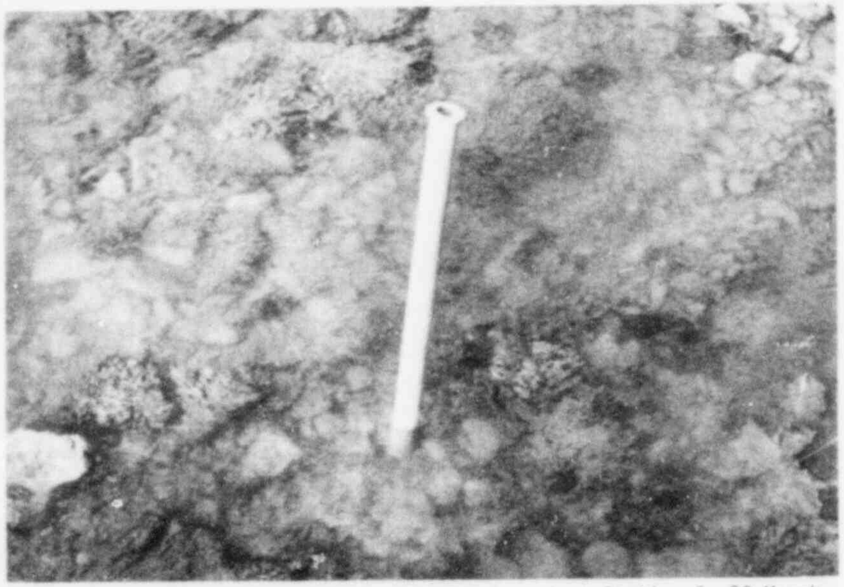

Figure A-35. Downstream sedimentation study rod at Station 6, 23 March 1981. No measureable sediment accumulation since November 1980. Note extensive algal growth.

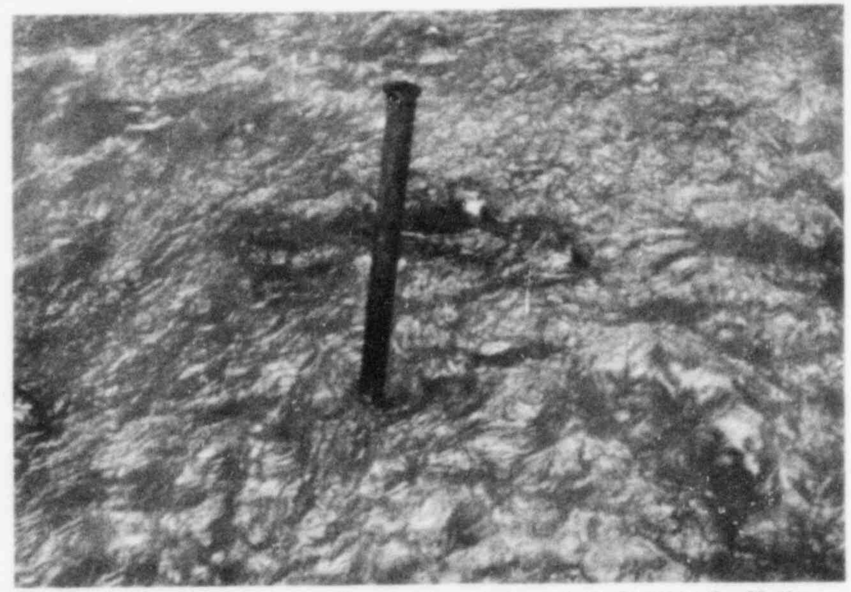

Figure A-36. Downstream sedimentation study rod at Station 6, 25 May 1981. No measureable sediment accumulation since March, but there was evidence along the banks that sediment had once been deposited. Rocks were scoured and algae had disappeared.

Figure A-37. Downstream sedimentation study rod at Station 6, 10 August 1981. Approximately 1 cm of sediment had accumulated since May. Note spaces between rocks filled in with sediment.

Figure A-38. Downstream sedimentation study rod at Station 6, 12 November 1981. Most of the accumulated sediment has been washed out. Note return of algal growth among the leaves.

TABLE A-1

COMPARISON OF 1981 WATER CHEMISTRY ANALYSIS RESULTS
WITH 1977-1980 RESULTS
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE

Chemical parameter	1977-1980 Range of values[a]	1981 Range of values[a]
Dissolved oxygen	7.4 - 16.0	7.1[b] - 14.6
pH (standard units)	6.6 - 8.2	7.2 - 8.0
Alkalinity	111.2 - 245.0	87.5[b] - 225.0
Specific conductance (μmho/cm)	218 - 790	550 - 750
Total dissolved solids	248 - 664	395 - 612
Total suspended solids	5 - 132	1[b] - 20
Biochemical oxygen demand	<1.0 - 4.2	1.1 - 5.7[b]
Chemical oxygen demand	2.6 - 32.2	5.0 - 24.5
Total organic carbon	1.5 - 13.4	2.3 - 3.3
Total phosphorus	<0.01 - 0.24	0.04 - 0.12
Orthophosphates	<0.01 - 0.09	<0.01 - 0.03
Nitrate nitrogen	0.25 - 1.97	0.18[b] - 2.15[b]
Ammonia nitrogen	<0.01 - 0.13	<0.01 - 0.02
Organic nitrogen	<0.03 - 1.00	0.35 - 0.65
Silica	1.64 - 9.14	2.82 - 8.01
Calcium	13.61 - 99.23	55.90 - 86.50
Magnesium	21.50 - 43.77	21.00[b] - 41.77
Sodium	1.42 - 42.62	14.80 - 28.98
Sulfate	33.0 - 121.0	88.1 - 193.0[b]
Chlorides	4.4 - 120.5	38.5 - 85.0
Free residual chlorine	<0.01	<0.01
Chloramines	<0.01	<0.01
Hexane soluble material	1.4 - 7.3	<5.0
Phenols	<0.002 - 0.009	<0.002

[a]All values are expressed as mg/liter unless otherwise specified.

[b]Indicates an upper or lower limit extension of the range of values from 1977 - 1980 studies.

B. BACTERIA

INTRODUCTION

This study was conducted to monitor the fecal coliform, total coliform and fecal streptococci of waters near the Marble Hill Plant site. Because certain coliform and streptococcal bacteria are normally found in the intestinal tract of man and other warm-blooded animals, these bacteria are good indicators of fecal contamination.

Coliforms are a diverse group of bacteria whose natural habitats include soil, water, vegetation, and human and animal feces. In general, the presence of fecal coliform organisms in water indicates recent and possibly dangerous pollution, and the presence of other coliform organisms suggests less recent pollution and contribution from non-fecal origins such as soil runoff water.

In addition to coliforms, fecal streptococci are a natural component of human and other warm-blooded animal intestinal tracts. The feces of man have been estimated to contain four times as many fecal coliforms as fecal streptococci, but fecal streptococci dominate in the excrement of other animals. A ratio of fecal coliforms to fecal streptococci has been used to indicate the source of fecal pollution in water systems (Geldreich, 1965). Ratios greater than 4:1 indicate contamination from human wastes, whereas ratios less than 0.6:1 indicate contamination from warm-blooded animals other than man.

The Indiana Stream Pollution Control Board, Indiana Water Quality Standards (SPC 1R-4, 1977) recommends a maximum permissible value of 400 counts per 100 ml for fecal coliforms from April through October. From November through March, fecal coliform bacteria counts are not to exceed 2000 per 100 ml. There are no specific recommendations for maximum permissible values of total coliform and fecal streptococci counts.

MATERIALS AND METHODS

Bacterial analyses were performed on duplicate samples from Stations 1, 3, 6 and 8 (Figure 1). Samples for bacterial examinations were collected in presterilized polyethylene containers, which were placed immediately in an iced cooler and shipped to the laboratory for analysis. The analyses were begun 6 to 8 hours after collection of the samples.

In the laboratory, the water samples were shaken vigorously to achieve homogeneity and were serially diluted with sterile, buffered water. The membrane filter technique (APHA, 1980) was used to analyze the appropriate dilutions for the number of total coliforms, fecal coliforms and fecal streptococci. APHA-recommended media, incubation conditions and colonial appearance criteria were utilized (Table B-1). Complete collection data are included in the appendix (Appendix Tables B-1 through B-4).

RESULTS AND DISCUSSION

Total Coliforms

Total coliform counts for Ohio River Stations 1 and 3 ranged from 220 to 5400 counts/100 ml (Figure B-1). This was the narrowest range of values yet observed at the Marble Hill site and continued the trend of reduced coliform levels that began in late 1980. The counts are generally an order of magnitude lower than the 1977-1980 means of coliform counts (ABI, 1978, 1979, 1980, 1981) and the counts reported during baseline studies (PSI, 1976). Past data have indicated an upstream source of the high total coliform counts reported in 1977-1980; therefore, it is assumed that this source, whatever it may be, has been eliminated. The slight differences in counts between Stations 1 and 3 indicate that activity at the plant site does not contribute to total coliform levels in the Ohio River. Counts were highest in May during the high runoff period and lowest in August. Total coliform counts in Little Saluda Creek Station 6 were also generally lower than in past years and were highest in August and lowest in November (Figure B-1).

Station 8, which is located in an intermittent stream near the plant site, was sampled only during March and May, the only months when water was available. Counts for total coliforms were very low in March but similar to the Ohio River counts during May. This may have resulted from the release of soil coliforms from the large eroded places at Station 8 that were reported during May (A. Chemical and Physical Parameters). Counts at Station 8 were generally lower than in past years (PSI, 1976; ABI, 1978, 1979, 1980, 1981).

Fecal Coliform

Fecal coliform counts for Ohio River Stations 1 and 3 ranged from 39 to 682 counts/100 ml (Figure B-2). As with the total coliform counts, this was the narrowest range of fecal coliform values yet observed in ecological monitoring at the Marble Hill site (PSI, 1976; ABI, 1978, 1979, 1980, 1981). Fecal coliform values were very similar to the 1977-1981 mean values taken by ORSANCO, but they were much lower than the mean values observed at the Marble Hill site from 1977-1980. Such large reductions were first reported in November 1980 and indicate the elimination of what must have been a relatively local source of coliform input upstream of the plant site. As in past years, there was no large or consistent difference between counts at Station 1 and counts at Station 3. Therefore, it appears that activity at the plant site does not contribute to the fecal coliform levels of the Ohio River. Counts were highest in May (during the high runoff period) when both river stations exceeded the recommended Indiana Water Quality Standards of 400 counts/100 ml.

At Little Saluda Creek Station 6, fecal coliform counts were generally very similar to those at Stations 1 and 3. They were also much lower than values reported for 1977-1980 or for baseline studies (PSI, 1976), but they were similar to ORSANCO mean counts for 1977-1981.

No water was available for sampling at Station 8 in August or November. Fecal coliform counts were highest there in May and were, in fact, higher than at any other sampling station.

Fecal Streptococcus

During the 1981 monitoring program, fecal streptococcus counts were quite similar at both Ohio River stations (Figure B-3). Counts for 1981 were usually lower than the 1977-1980 mean counts except in May, the high runoff period, when they were slightly higher.

Fecal streptococcus counts in Little Saluda Creek were higher than at the Ohio River stations in May, August and November. Counts were highest in May. This trend has generally been followed since monitoring began in 1977 and indicates fecal streptococcus input from domestic animals on the farms adjacent to the upper end of Little Saluda Creek. Fecal streptococcus counts were also highest in May at Station 8. No samples could be collected there during August and November.

Fecal coliform-to-fecal streptococcus (FC/FS) ratios exceeded 4:1 during March, August and November at Stations 1 and 3 and only in March at Stations 6 and 8 (Table B-2). Normally, these high ratios would suggest human fecal contamination, but the latest revision of Standard Methods (APHA, 1980) reports that FC/FS ratios lose their indicative validity when fecal streptococcus counts are below 100 counts/100 ml. Fecal streptococcus counts exceeded this level only in May when the highest FC/FS ratio was only 0.62 at Station 1. Considering this revision of FC/FS ratio validity, it appears that human fecal contamination was not indicated at any time during 1981.

CONCLUSIONS

Compared to the upstream Ohio River Station 1, Station 3 exhibited no increase in total coliform, fecal coliform or fecal streptococcus counts attributable to runoff from the Marble Hill Plant site. Total and fecal coliform counts were much lower during 1981 than during any previous monitoring (PSI, 1976; ABI, 1978, 1979, 1980, 1981), but 1981 fecal coliform counts were similar to ORSANCO mean data from 1977-1981. Counts for all three parameters were usually highest in May and appeared to coincide with high runoff periods in early and mid-May. The data indicate that coliform levels result from soil bacteria.

Little Saluda Creek bacterial levels were also lower than in past years and at no time indicated human fecal contamination. Results of sampling at Station 8 were generally similar to those at Station 6, but counts were usually somewhat higher probably as a result of the soil erosion noted at Station 8 during 1981.

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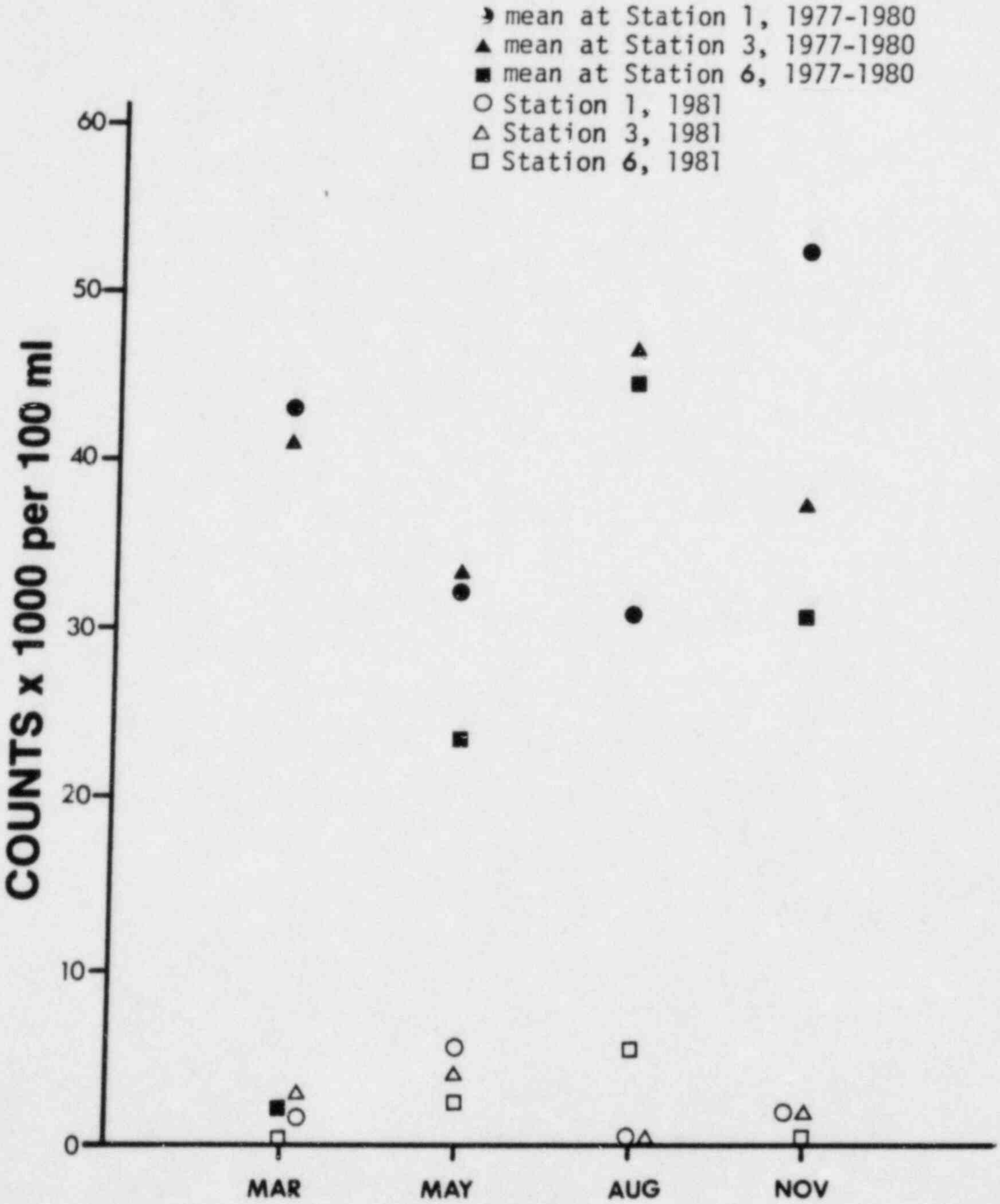

Figure B-1. Comparison of total coliform data collected from Stations 1, 3 and 6 in 1981 and mean data collected from 1977-1980, Marble Hill Plant site, 1981.

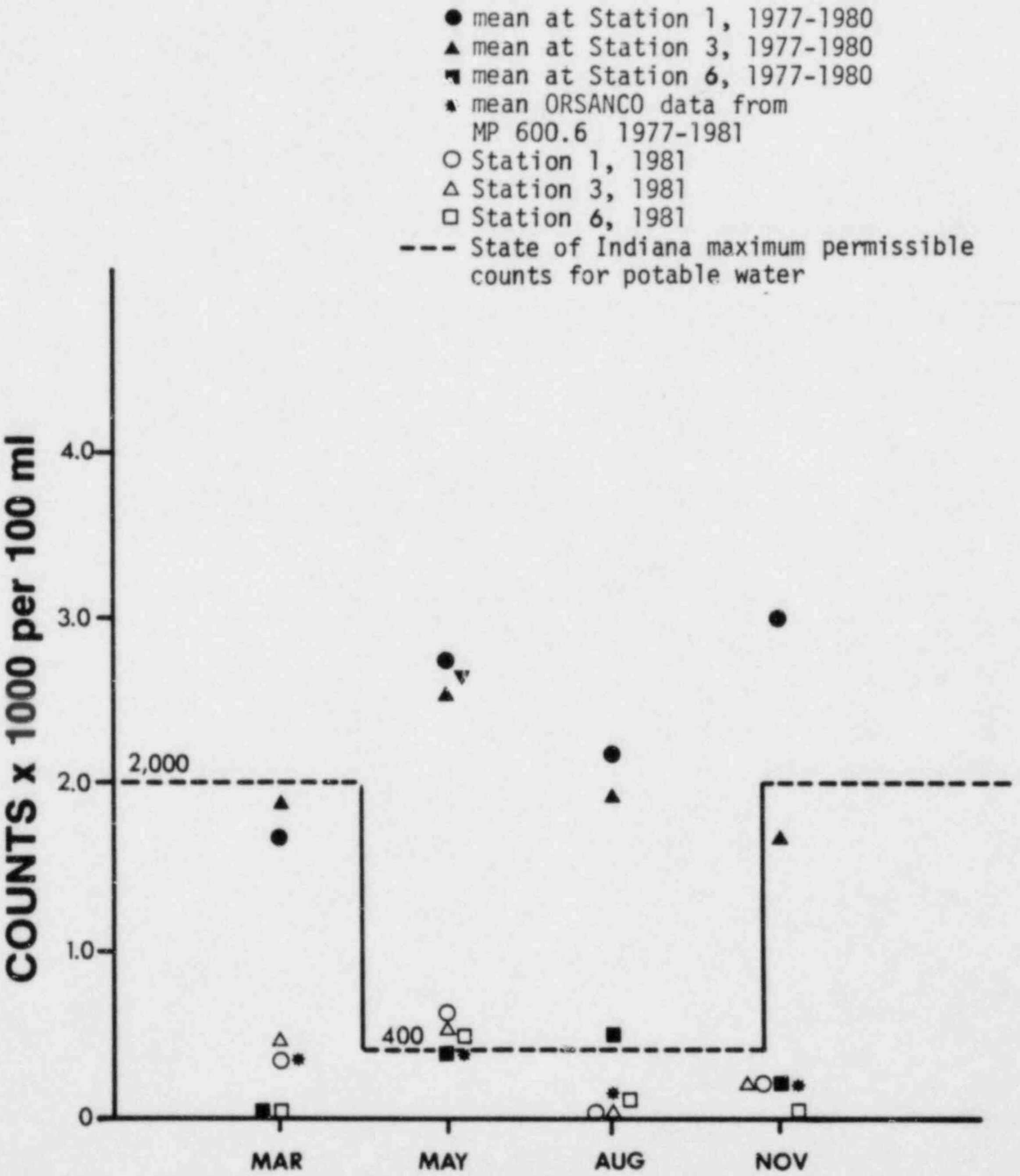

Figure B-2. Comparison of fecal coliform data collected from Stations 1, 3 and 6 in 1981, mean data collected from 1977-1980 and ORSANCO mean data from 1977-1981, Marble Hill Plant site, 1981.

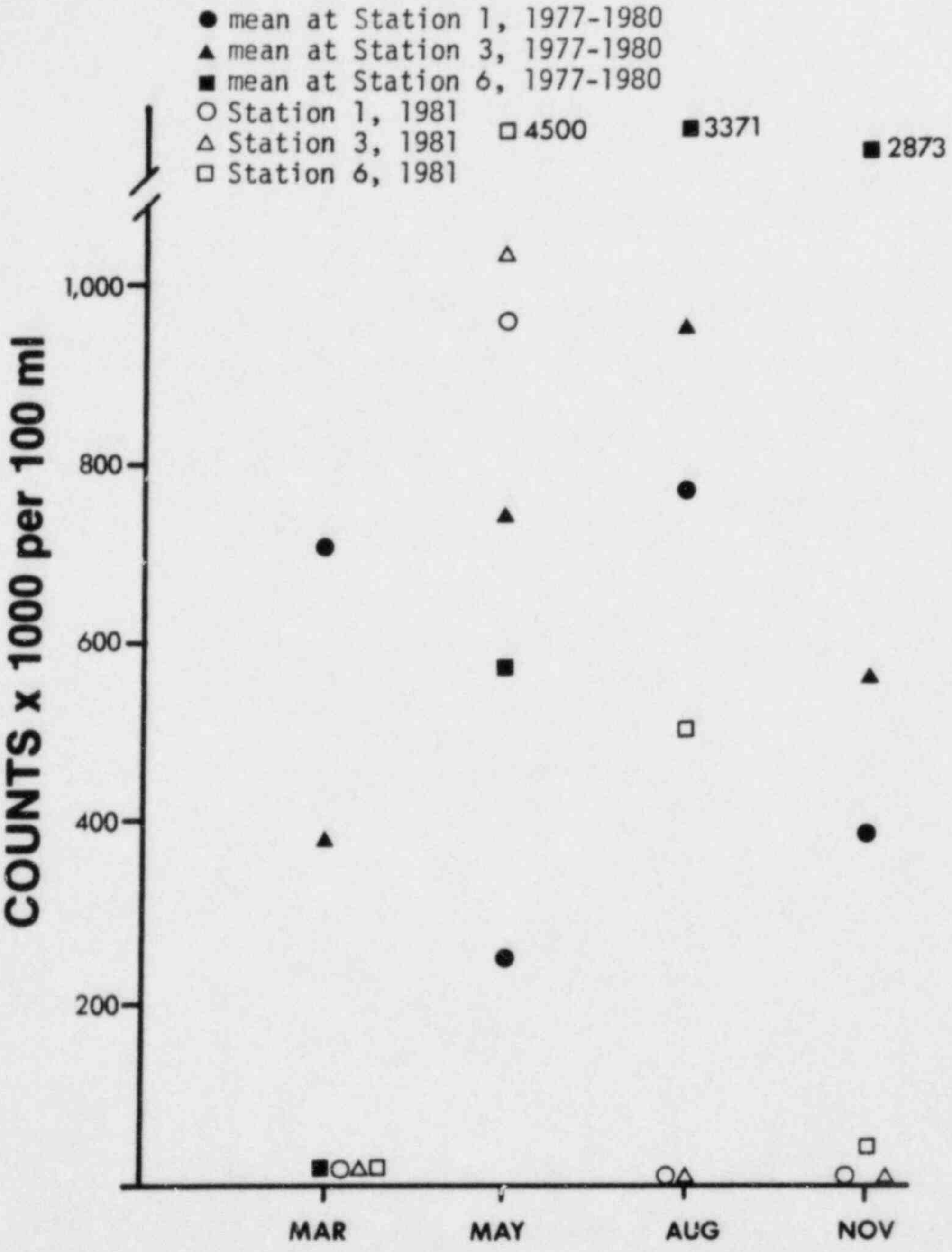

Figure B-3. Comparison of fecal streptococcus data collected from Stations 1, 3 and 6 in 1981 and mean data collected from 1977-1980, Marble Hill Plant site, 1981.

TABLE B-1

CONDITIONS USED IN ANALYSES FOR
DETERMINATION OF BACTERIAL POPULATIONS
MARBLE HILL PLANT SITE
1981

Bacterial type	Medium used	Incubation conditions	Colonial appearance
Total coliforms	M-Coliform Broth	35°C, 24 hr	Dark red with metallic surface sheen
Fecal coliforms	M-FC Broth	44.5°C, 24 hr	Blue
Fecal streptococci	KF Streptococcal Agar	35°C, 48 hr	Dark red to pink

TABLE B-2

MEAN FECAL COLIFORM TO FECAL STREPTOCOCCUS RATIOS
MARBLE HILL PLANT SITE
1981

Station	Sampling month			
	March	May	August	November
1	>18.25	0.62	<4.60	14.69
3	31.33	0.53	<6.10	20.00
6	>7.20	0.12	0.29	0.77
8	>11.4	0.20	-[a]	-[a]

[a]No water in stream

C. PLANKTON

C.1 PHYTOPLANKTON

INTRODUCTION

Phytoplankton are chlorophyll-bearing algae that passively drift or have limited means of locomotion and, therefore, are subject to waves and currents in aquatic environments. Through photosynthesis, phytoplankton convert solar energy and inorganic nutrients into protoplasm. This protoplasm, with organic debris, form the base of aquatic food chains. Consequently, phytoplankton abundance and composition determine, in part, the quantity and quality of larger organisms that depend directly or indirectly upon phytoplankters for their nutritional requirements.

True phytoplankters usually predominate in large rivers, and benthic algae washed off the stream bottom typify small streams. Diatoms are most often the dominant phytoplankton group (Hynes, 1970), but green and blue-green algae and flagellates are abundant seasonally. Replenishment from backwater areas and tributaries is needed to maintain phytoplankton densities.

The purpose of the phytoplankton study at the Marble Hill Plant site was to determine phytoplankton species composition, abundance and biovolume at stations in the Ohio River and in Little Saluda Creek during plant construction. Data collected during the 1981 monitoring program were compared to baseline data (PSI, 1976) and to previous construction-phase monitoring data (ABI, 1978, 1979, 1980, 1981) to evaluate plant construction effects on phytoplankton.

MATERIALS AND METHODS

Duplicate phytoplankton samples were collected quarterly at Stations 1, 3 and 5 in the Ohio River and at Station 6 in Little Saluda Creek. One-liter subsurface water samples were collected with a nonmetallic Kemmerer sampler and were preserved in the field with buffered, 4-percent formalin.

In the laboratory, each 1-liter replicate sample was allowed to settle and then concentrated to approximately 200 ml. Duplicate subsamples (0.15 to 5.0 ml) of each replicate sample concentrate were settled in Utermohl chambers (Utermohl, 1958). The amount of detritus and number of phytoplankters in the sample determined the degree of sample concentration and the volume of subsamples. Strip counts totaling approximately 200 phytoplankters per replicate Utermohl chamber (400 phytoplankters per replicate sample) were made at 560X magnification.

All phytoplankters were counted individually except for filamentous and colonial green and blue-green algae. Filamentous green and blue-green species were counted as 100-μ standard lengths (PSI, 1976) with each standard length representing one counting unit. Colonial forms, exclusive of diatoms, were counted with each colony representing one counting unit. Phytoplankton density (N) was calculated as number of cells per milliliter by:

$$N = \frac{\frac{V_c}{V_e} C}{V_s}$$

where: V_c = Volume of sample concentrate, in milliliters;

$$V_e = \frac{A_s}{A_u} S$$

where: A_s = Area of strips counted, in square millimeters;

A_u = Area of Utermohl chamber, in square millimeters;

S = Subsample volume, in milliliters.

C = Count;

V_s = Volume of sample, in milliliters.

Diatom species identifications to the lowest practicable taxon and proportional counts were made from permanent mounts at 1000X magnification. Total diatom counts were used with diatom species proportional counts to obtain density by species (APHA, 1980). Representative permanent diatom mounts and aliquots of all samples analyzed are retained for reference for the life of the plant.

Phytoplankton biovolume was estimated from optical measurements. The average volume for each predominant phytoplankter (5 percent or more of the total population at any station) was determined by measuring five individuals. For phytoplankters making up less than 5 percent of the total population at any station, at least one biovolume measurement was made. Average dimensions were converted to volume using formulae for solids approximating the shape of each species (Kutkuhn, 1958; Hargraves and Wood, 1967; EPA, 1973; APHA, 1980). Biovolume, expressed as cubic microns per milliliter, was calculated by the following equation:

$$\text{biovolume} = NV$$

where: N = Density of each species, in cells per milliliter;

V = Average volume of each species, in cubic microns.

Statistical procedures used in data analysis are described in Section H. Statistical Analysis Procedures.

RESULTS AND DISCUSSION

A total of 226 phytoplankton species were observed in the samples from the Ohio River and Little Saluda Creek (Table C.1-1). As in previous monitoring studies diatoms dominated the phytoplankton community in both number of species and density (PSI, 1976; ABI, 1978, 1979, 1980, 1981). Complete collection data are tabulated in Appendix Tables C.1-1 through C.1-8.

Ohio River Stations

Phytoplankton densities ranged from 1307 cells/ml to 8218 cells/ml (Tables C.1-2 through C.1-5). Annual mean density was similar to that in 1979 and 1980 and lower than that in 1977 and 1978. Maximum density occurred in August and minimum density occurred in November (Figure C.1-1). Seasonal variation in phytoplankton density did not directly correspond to that in any previous year. Moderate densities in March and May were also observed in 1980, and maximum density in August also occurred in 1977 and 1978. As in 1980, lower total phytoplankton density coincided with reduced zooplankton densities.

During 1981, no station consistently had the highest or lowest phytoplankton density. Station 1 had the highest density of the three river stations in March and the lowest in August. This suggested that interstation variation in phytoplankton densities was due to natural variation in riverine conditions.

This inconsistent pattern in density variation among stations was reflected in statistical results for 1981. Densities among stations were not significantly different. No single station was consistently higher or lower in density over the seasons (Table C.1-6). Significant seasonal differences were found, a result expected of quarterly Ohio River phytoplankton studies (Table C.1-6). Densities during all years of construction phase monitoring have been greater than those during baseline monitoring. However, annual mean density during baseline monitoring (1974-1975) was not significantly different from densities during 1979, 1980 and 1981 construction phase monitoring (Table C.1-6). Construction at the Marble Hill Plant site has not shown any adverse effect on Ohio River phytoplankton densities.

During 1981, estimated biovolume ranged from 4447×10^2 μ^3/ml in November to $50,399 \times 10^2$ μ^3/ml in August. (Tables C.1-2 through C.1-5). The August biovolume values were the highest reported during construction phase monitoring and were indicative of a predominance of large-celled phytoplankters during August. Generally, the biovolume pattern over the year followed the pattern seen for density (Figure C.1-2). A biovolume ranking of river stations showed no consistent pattern, an indication that variation in the phytoplankton community among stations was a result of natural environmental conditions rather than plant construction effects.

There were no significant differences in phytoplankton biovolume among river stations during 1981 (Table C.1-6). The wide range of biovolume estimates did show significant seasonal variation with August (summer) values significantly higher than other sampling months.

Biovolume was significantly lower in 1981 than during baseline monitoring (Table C.1-6). However, 1981 was the only year during construction phase monitoring to show significant variation from baseline values. Although annual biovolumes during 1979 and 1980 were also less than baseline values, the lack of significant variation suggests that causes other than plant construction effects are responsible for the lower biovolumes.

Phytoplankton biovolume exhibited significant positive correlations with water temperature at all three river stations (Table C.1-7). This, coupled with the significant positive correlations between density and water temperature (Table C.1-8), supports the finding that largest biovolume and densities in the Ohio River near the Marble Hill Plant site occur during the summer when water temperatures are highest.

Little Saluda Creek

Habitat differences between the Ohio River and Little Saluda Creek were again reflected in phytoplankton density and biovolume. Phytoplankton density and biovolume were lower in Little Saluda Creek than in the Ohio River. Density ranged from 184 cells/ml in November to 350 cells/ml in August, and biovolume ranged from 1689 x 10^2 μ^3/ml in August to 8200 x 10^2 μ^3/ml in November. The high biovolume relative to density in November was due to the presence of a very large euglenoid species that made up most of the density as well. The predominance of smaller cells in August was responsible for the reduced biovolume coinciding with the highest density during the year.

Biovolume was not significantly different over all monitoring years (Table C.1-9). Density during baseline monitoring (1974) was significantly lower than that in 1978 but was not significantly different from densities during any other year of construction phase monitoring (Table C.1-9). Biovolume and density variation in the phytoplankton community in Little Saluda Creek during 1981 did not suggest adverse impact from plant construction. Correlations between density and biovolume and measured physical and chemical parameters revealed no significant relationships.

Community Composition

As in previous monitoring programs, the phytoplankton communities in the Ohio River and Little Saluda Creek were dominated by diatoms (Figure C.1-3). Diatom relative abundance ranged from 66 to 80 percent in the

Ohio River and from 19 to 97 percent in Little Saluda Creek. Phytoplankton composition in the Ohio River was similar to that in earlier studies. The low relative abundance of diatoms in Little Saluda Creek during November was due to decreased diatom density and increased euglenoid density. It is unknown whether this increased euglenoid density has any major significance or whether it represented a response to short-term habitat variability.

For both the Ohio River and Little Saluda Creek, the dominant diatom species (contributing ≥ 5 percent of total phytoplankton at any single station on any sampling date) were:

Cyclotella glomerata*	Stephanodiscus astraea*
C. Meneghiniana*	Cymbella affinis
C. ocellata	Gomphonema angustatum
Cyclotella sp. 1*	G. olivaceum
Melosira distans*	Navicula graciloides
M. granulata*	Nitzschia acicularis v. closterioides
Achnanthes minutissima*	Synedra delicatissima
Amphora perpusilla	Rhoicosphenia curvata
Asterionella formosa*	centric sp. 1

(Species with an asterisk were also dominant in earlier construction phase monitoring.) Cyclotella Meneghiniana, Melosira distans, M. granulata, Asterionella formosa, and Gomphonema olivaceum were also dominant during the baseline study.

Species dominant in the Ohio River community were generally considered to be true phytoplankters and those dominant in Little Saluda Creek tended to be periphytic in habit (Lowe, 1974). Thus, it would seem that the Little Saluda Creek community is largely derived from the periphyton rather than from an indigenous phytoplankton population. The most common diatoms in the Ohio River in terms of density and occurrence were *Cyclotella glomerata*, *Melosira granulata*, and centric sp. 1. *Cyclotella glomerata* dominated during cooler seasons, and centric sp. 1 exhibited sizable densities in May and August.

The remaining phytoplankton groups were generally less important than diatoms in terms of relative abundance. The chlorophyta (green algae) was second to diatoms but never represented more than 20 percent of the total phytoplankton density, and the cyanophyta (blue-green algae) represented less than 10 percent. In Little Saluda Creek, euglenophytes were the most common phytoplankter in November.

Phytoplankton species richness (number of species) ranged from 61 to 85 species in the Ohio River and from 25 to 42 species in Little Saluda Creek. These ranges were similar to previous construction phase monitoring. Diatoms were most diverse in March and May, and green algae were most diverse in May and August. This pattern in species distribution reflected the typical ecological response of diatoms and green algae to changing water temperatures (Hynes, 1970). Diatoms, with lower temperature tolerance ranges (Patrick, 1973), may be expected to be more prevalent during cold-water periods with increased green species richness during and immediately following warmwater periods. Blue-green algae were most diverse in March but the number of species were nearly evenly distributed through the seasons.

CONCLUSIONS

As in previous studies, diatoms dominated the phytoplankton community. Phytoplankton composition, number of species, density and biovolume were generally similar to previous construction phase monitoring data in both the Ohio River and Little Saluda Creek.

There were no significant differences in density or biovolume among river stations during 1981. Seasonal and annual variations were noted, but, given the lack of interstation differences, this variation was most likely due to naturally occurring environmental conditions. Impact on the Little Saluda Creek phytoplankton community was not evident as annual phytoplankton density during baseline monitoring was significantly different from only 1978 construction phase monitoring and there were no significant biovolume differences among years.

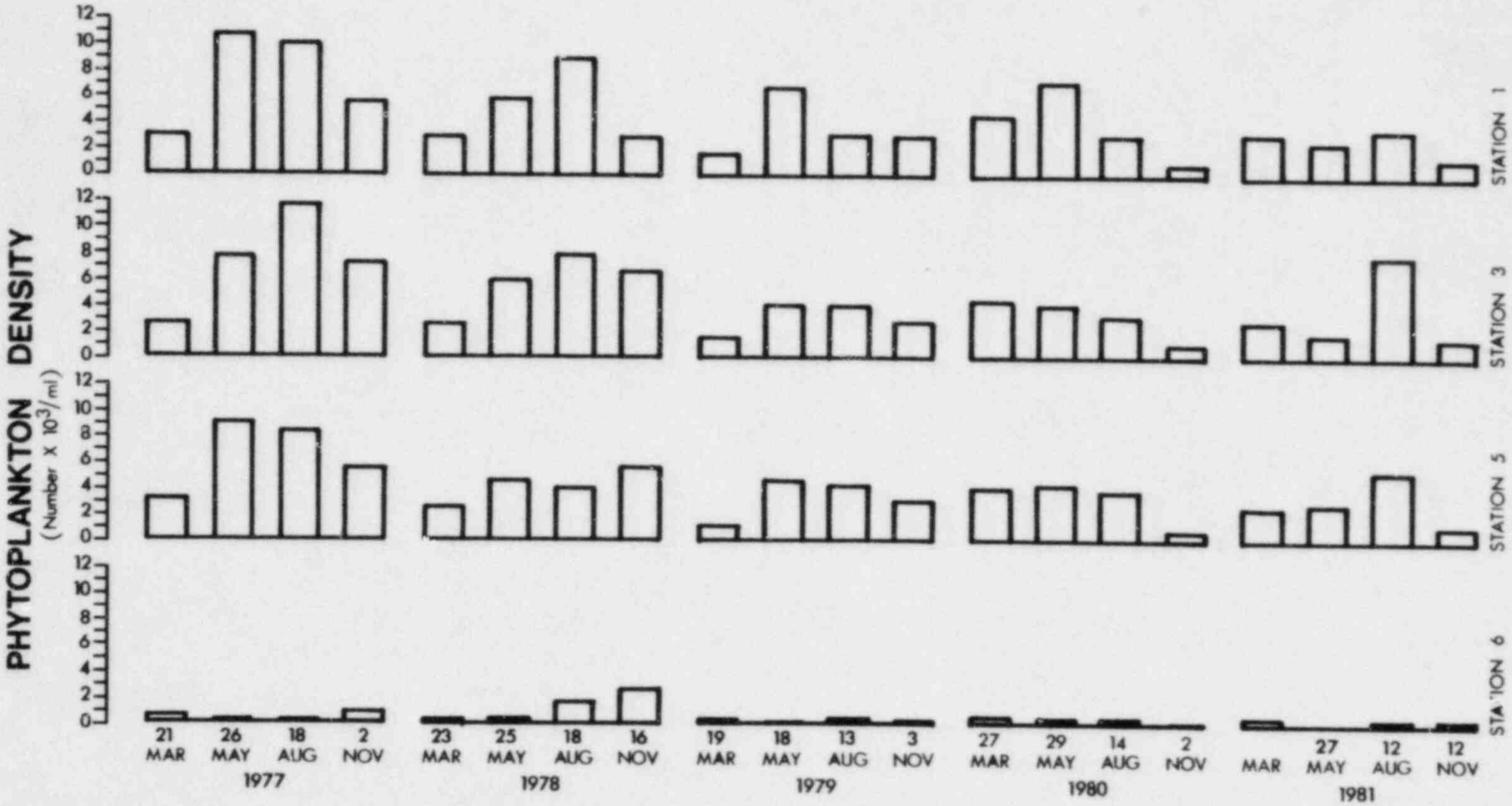

Figure C.1-1. Total phytoplankton density at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1981.

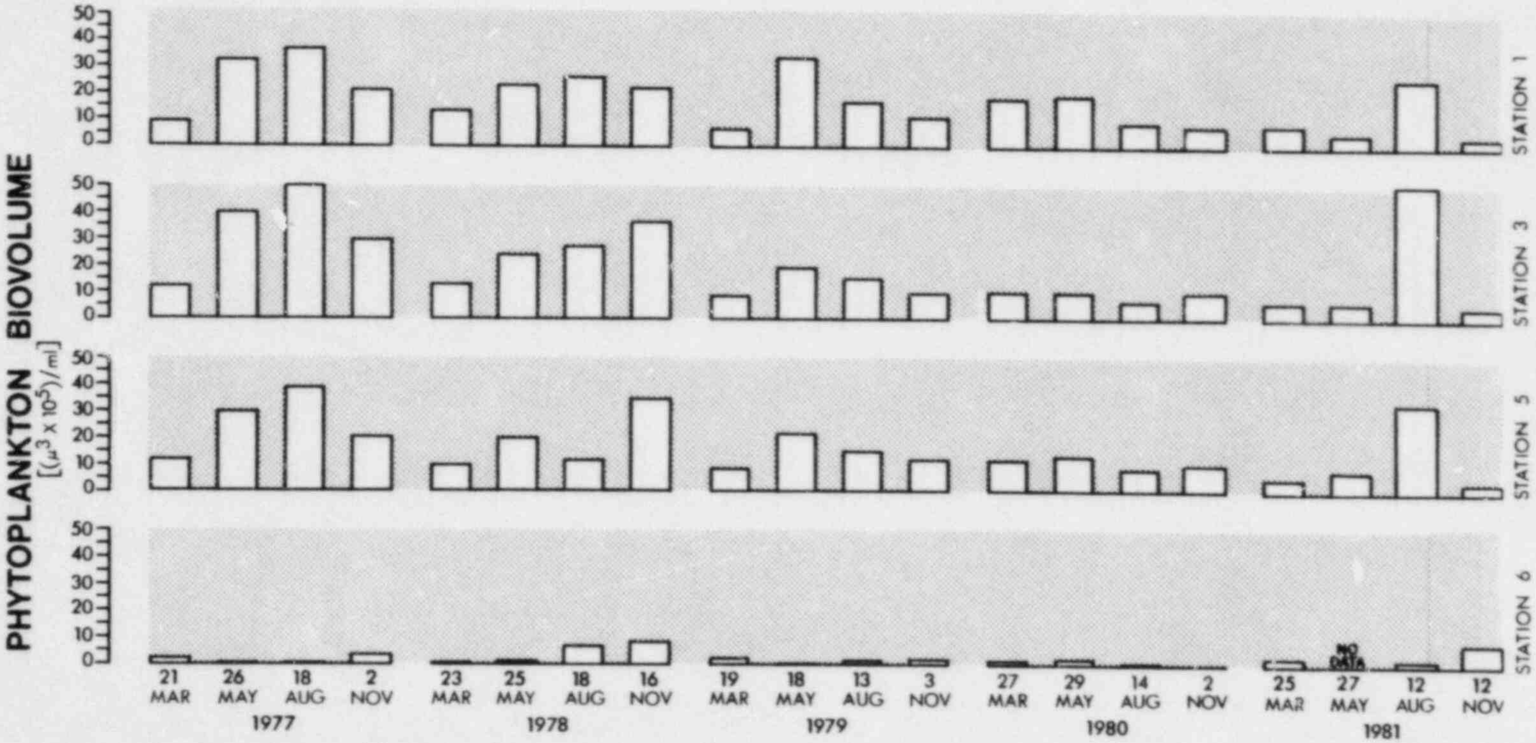

Figure C.1-2. Total phytoplankton biovolume at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1981.

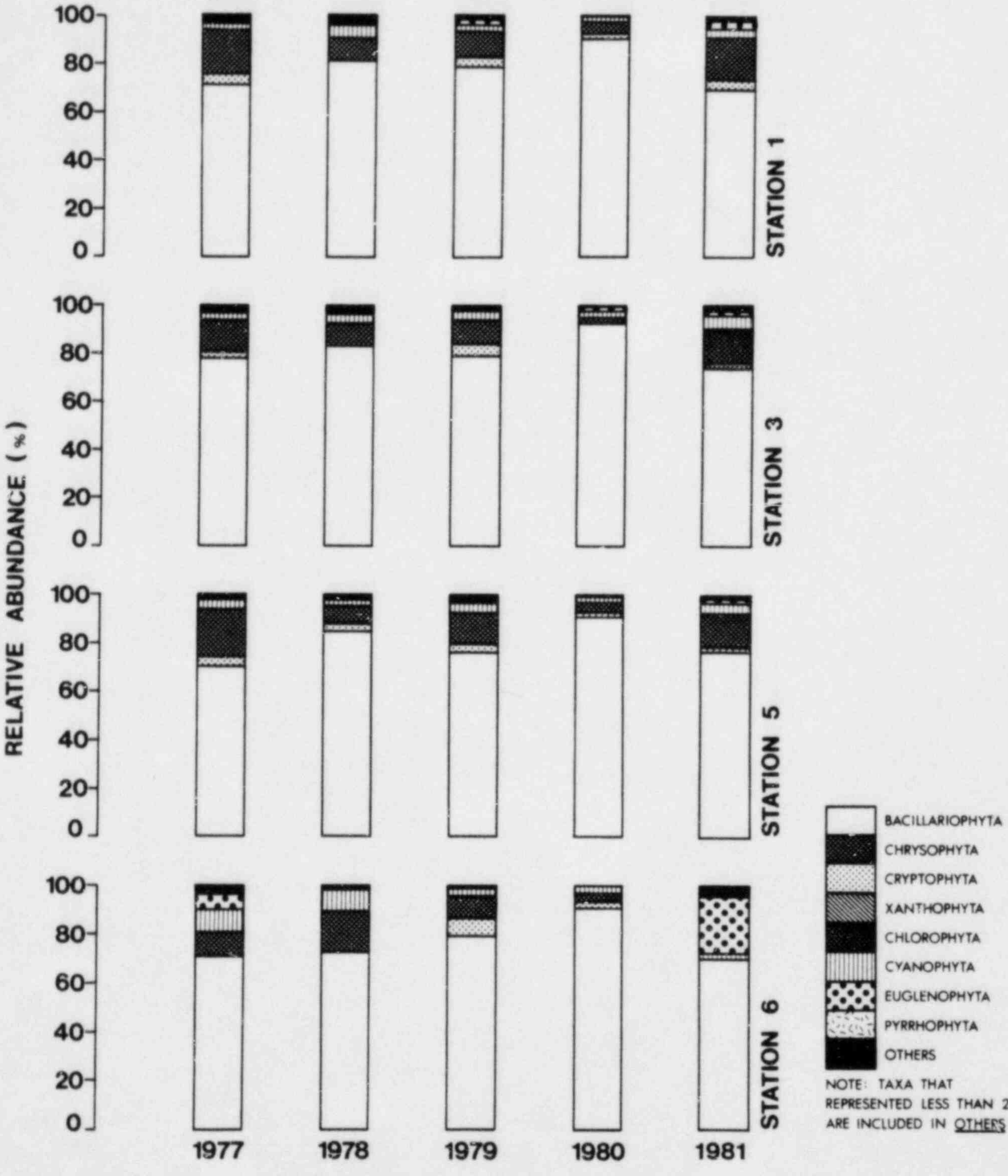

Figure C.1-3 Relative abundance of phytoplankton groups at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1981.

TABLE C.1-1

PHYTOPLANKTON SPECIES COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
1981

BACILLARIOPHYTA
Centrales
Coscinodiscus lacustris
Cyclotella glomerata
C. Meneghiniana
C. ocellata
C. pseudostelligera
C. stelligera
C. striata
Cyclotella sp. 1
Melosira ambigua
M. distans
M. granulata
M. granulata v. angustissima
M. italica
M. varians
Stephanodiscus astraea
S. astraea v. minutula
unidentified centric sp. 1
unidentified centric sp. 2
Pennales
Achnanthes affinis
A. deflexa
A. fragilarioides
A. hungarica
A. lanceolata
A. lanceolata v. dubia
A. linearis f. curta
A. microcephala
A. minutissima
A. nollii
Achnanthes sp. 1
Amphora perpusilla
A. submontana
Asterionella formosa
A. formosa v. gracillima
Cocconeis pediculus
C. placentula
C. placentula v. lineata
Cymbella affinis
C. minuta v. silesiaca
Diatoma tenue v. elongatum
D. vulgare
Eunotia curvata
Fragilaria capucina v. pumila
F. construens v. pumila
F. crotonensis
F. vaucheriae
Frustulia rhomboides v.
Gomphonema angustatum
G. olivaceum
G. parvulum
G. truncatum
Gyrosigma nodiferum
Hannaea arcus
Meridion circulare
Navicula bacillum
N. biconica
N. contenta
N. cryptocephala

BACILLARIOPHYTA (continued)
Pennales (continued)
Navicula cryptocephala v. veneta
N. graciloides
N. minusoula
N. mutica
N. mutica v. cohnii
N. rhyncocephala
N. seminulum
N. tripunctata
N. viridula
N. viridula v. rostellata
Navicula sp. 2
Navicula sp. 4
Nitzschia acicularis v. closterioides
N. amphibia
N. capitellata
N. communis v. abbreviata
N. dissipata
N. dubia
N. gandersheimiensis
N. Kutzingiana
N. palea
N. parvula
N. sigma
N. stagnorum
N. sublinearis
N. tryblionella v. victoriae
Pinnularia appendiculata
P. subcapitata v. paucistriata
Rhoicosphenia curvata
Stauroneis smithii
Surirella angustata
S. biseriata
S. ovalis
S. ovata
S. ovata v. pinnata
Synedra acus
Synedra delicatissima
S. delicatissima v. angustissima
S. fasciculata
S. filiformis v. exilis
S. radians
S. rumpens
S. rumpens v. familiaris
S. ulna
S. ulna v. contracta
S. ulna v. oxyrhynchus f. mediocontracta
Tabellaria fenestrata

CHRYSOPHYTA
Dinobryon sertularia
D. sociale
Mallomonas sp.

CRYPTOPHYTA
Cryptomonas ovata
cryptophyte sp. 1
cryptophyte sp. 2

TABLE C.1-1
(continued)
PHYTOPLANKTON SPECIES COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
1981

CHLOROPHYTA

Actinastrum hantzschii v. fluviatile
Ankistrodesmus Braunii
Ankistrodesmus convolutus
A. falcatus
A. falcatus v. acicularis
A. falcatus v. mirabilis
A. fractus
Carteria cordiformis
C. Klebsii
C. multifilis
Carteria sp.1
Characium ambiguum
Chlamydomonas globosa
Chlamydomonas sp. 1
Chlamydomonas sp. 3
Chlamydomonas sp. 5
Chlorella ? sp.
Coelastrum sphaericum
Cosmarium sp. 2
Cosmarium sp. 3
Crucigenia quadrata
C. rectangularis
C. tetrapedia
C. truncata
Desmatractum indutum
Dictyosphaerium Ehrenbergianum
D. pulchellum
Euastrum sp.
Francela droescheri
F. tuberculata
Gloeocystis gigas
G. planctonica
Golenkinia radiata
Kirchneriella contorta
K. lunaris
K. lunaris v. Dianae
K. lunaris v. irregularis
K. obesa
K. obesa v. major
Lagerheimia quadriseta
Micractinium pusillum
Nephrocytium limneticum
Oocystis Borgei
O. pusilla
O. morum
Pediastrum duplex v. clathratum
P. obtusum
Podyedriopsis quadrispina
Quadrigula Chodatii
Scenedesmus abundans
S. acuminatus
S. acutiformis
S. Bernardii
S. bijuga
S. denticulatus
S. dimorphus
S. quadricauda

CHLOROPHYTA (continued)

Scenedesmus sp. 2
Schroederia setigera
Selenastrum gracile
S. minutum
S. Westii
Sphaerocystis schroeteri
Tetraedron minimum
T. muticum
Tetrastrum elegans
T. glabrum
T. heteracanthum
T. punctatum
T. staurogeniaeforme
T. triacanthum
Wislouchiella planctonica
coccoid green 8
unidentified green 2

CYANOPHYTA

Anabaena sp. 1
Aphanothece sp.
Arthrospina gomontiana
Calothrix sp.
Chroococcus dispersus v. minor
C. limneticus
Dactylococcopsis fascicularis
D. raphioides
D. Smithii
Gomphosphaeria lacustris
G. lacustris v. compacta
Lyngbya contorta
L. limnetica
Lyngbya sp.
Marssoniella elegans
Merismopedia tenuissima
Microcystis incerta
Oscillatoria amphibia
O. limnetica
O. tenuis
Oscillatoria sp. (1,2)
Oscillatoria sp. 3
Phormidium minnesotense
Raphidiopsis curvata
Rhabdoderma lineare
Spirulina major
Synehocystis ? sp.
filamentous blue-green sp. 1

EUGLENOPHYTA

Euglena sp. 5
Phacus crenulata
P. Lemmermanii
Trachelomonas hispida
T. volvocina
Trachelomonas sp. 1
euglenoid sp. 1

TABLE C.1-1
(continued)
PHYTOPLANKTON SPECIES COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
1981

PYRRHOPHYTA
- *Glenodinium pulvisculus*
- *Peridinium inconspicuum*
- dinoflagellate sp. 1

XANTHOPHYTA
- xanthophyte sp. 1

OTHERS
- phytoflagellate sp. 3
- phytoflagellate sp. 6
- phytoflagellate sp. 8

TABLE C.1-2

SUMMARY OF PHYTOPLANKTON DENSITY, RELATIVE ABUNDANCE AND BIOVOLUME
MARBLE HILL PLANT SITE
25 MARCH 1981

Taxon	Station 1			Station 3			Station 5			Station 6		
	Density (no./ml)	Relative abundance (%)	Biovolume ($\mu^3 x 10^2$)/ml	Density (no./ml)	Relative abundance (%)	Biovolume ($\mu^3 x 10^2$)/ml	Density (no./ml)	Relative abundance (%)	Biovolume ($\mu^3 x 10^2$)/ml	Density (no./ml)	Relative abundance (%)	Biovolume ($\mu^3 x 10^2$)/ml
Bacillariophyta	2454.3	71.7	5872.42	2074.7	73.1	4878.62	1868.5	76.2	3733.21	315.8	96.6	2314.08
Chrysophyta	267.3	7.8	210.99	212.0	7.5	220.37	119.5	4.9	123.54	-	-	-
Cryptophyta	39.3	1.1	109.32	42.4	1.5	119.11	19.3	0.8	52.85	4.0	1.2	10.60
Chlorophyta	385.8	11.3	954.65	274.0	9.7	784.25	259.3	10.6	641.58	3.9	1.2	24.12
Cyanophyta	131.7	3.8	339.25	61.8	2.2	120.20	61.7	2.5	181.69	3.4	1.0	9.87
Euglenophyta	141.6	4.2	347.45	165.7	5.8	376.73	119.6	4.9	461.35	-	-	-
Pyrrhophyta	-	-	-	3.9	0.1	18.06	2.0	0.1	120.64	-	-	-
Others	4.0	0.1	42.38	3.9	0.1	41.32	-	-	-	-	-	-
TOTAL	3424.0		7876.46	2838.4		6558.66	2449.9		5314.86	327.1		2358.67

TABLE C.1-3

SUMMARY OF PHYTOPLANKTON DENSITY, RELATIVE ABUNDANCE AND BIOVOLUME
MARBLE HILL PLANT SITE
27 MAY 1981

	Station 1			Station 3			Station 5			Station 6		
Taxon	Density (no./ml)	Relative abundance(%)	Biovolume $(\mu^3 x10^2)$/ml	Density (no./ml)	Relative abundance(%)	Biovolume $(\mu^3 x10^2)$/ml	Density (no./ml)	Relative abundance(%)	Biovolume $(\mu^3 x10^2)$/ml	Density (no./ml)	Relative abundance(%)	Biovolume $(\mu^3 x10^2)$/ml
Bacillariophyta	1802.7	70.4	5375.07	1769.3	80.2	5815.98	2361.1	77.2	7617.88	Samples not adequately preserved		
Cryptophyta	75.9	3.0	135.91	32.3	1.5	62.82	64.7	2.1	73.04			
Chlorophyta	504.6	19.7	438.90	277.6	12.6	262.32	464.7	15.2	335.45			
Cyanophyta	113.1	4.4	86.90	89.0	4.0	218.32	91.5	3.0	7.53			
Euglenophyta	63.1	2.5	60.00	38.6	1.7	16.56	78.2	2.5	69.51			
TOTAL	2559.4		6096.78	2206.8		6396.00	3060.2		8103.41			

TABLE C.1-4

SUMMARY OF PHYTOPLANKTON DENSITY, RELATIVE ABUNDANCE AND BIOVOLUME
MARBLE HILL PLANT SITE
12 AUGUST 1981

	Station 1			Station 3			Station 5			Station 6		
Taxon	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml
Bacillariophyta	2398.4	66.6	15168.71	5861.1	71.3	42514.86	3983.1	72.1	27987.79	332.1	95.0	1668.31
Chrysophyta	-	-	-	25.3	0.3	72.33	6.3	0.1	18.01	-	-	-
Cryptophyta	227.8	6.3	1136.11	88.6	1.1	398.53	57.0	1.0	139.69	3.7	1.1	2.44
Chlorophyta	664.6	18.4	7332.50	1639.0	19.9	5789.28	1050.7	19.0	5052.55	1.8	0.5	3.97
Cyanophyta	150.4	4.2	260.46	541.1	6.6	881.80	410.2	7.5	500.48	7.1	2.0	14.39
Euglenophyta	142.5	4.0	1612.16	63.3	0.8	742.45	18.9	0.3	212.77	-	-	-
Xanthophyta	6.3	0.2	62.07	-	-	-	-	-	-	-	-	-
Pyrrhophyta	12.7	0.3	42.89	-	-	-	-	-	-	-	-	-
Others	-	-	-	-	-	-	-	-	-	4.9	1.4	0.46
TOTAL	3602.7		25614.90	8218.4		50399.25	5526.2		33911.29	349.6		1689.57

TABLE C.1-5

SUMMARY OF PHYTOPLANKTON DENSITY, RELATIVE ABUNDANCE AND BIOVOLUME
MARBLE HILL PLANT SITE
12 NOVEMBER 1981

Taxon	Station 1			Station 3			Station 5			Station 6		
	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml
Bacillariophyta	1047.2	75.3	2704.21	1257.7	71.4	3583.86	1052.5	80.5	4109.62	34.7	19.8	95.83
Chrysophyta	-	-	-	-	-	-	-	-	-	1.6	0.9	3.02
Cryptophyta	25.5	1.8	20.62	42.4	2.4	39.06	48.2	3.7	35.85	4.3	2.5	4.41
Chlorophyta	215.5	15.5	331.62	309.4	17.6	470.70	149.8	11.5	248.69	5.3	3.0	123.57
Cyanophyta	72.1	5.2	67.45	116.7	6.6	203.63	47.8	3.7	24.47	4.7	2.7	1.34
Euglenophyta	19.2	1.4	720.18	34.2	1.9	777.83	6.6	0.5	116.76	118.4	67.7	7961.03
Pyrrhophyta	-	-	-	-	-	-	-	-	-	1.9	1.1	9.95
Others	10.7	0.8	403.65				2.2	0.2	2.23	4.0	2.3	0.56
Total	1390.2		4447.73	1760.4		5075.08	1307.1		4537.62	174.9		8199.71

TABLE C.1-6

STATISTICAL ANALYSIS OF PHYTOPLANKTON SAMPLING DATA
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1974, 1977-1981

ANALYSIS OF VARIANCE

Parameter	Comparison	Calculated F value	Critical F value	
Density	by station	3.15	3.98	
(1981 only)	by season	68.35*	3.59	(see I. below)
Density	by station	0.26	3.08	
(1974, 1977-1981)	by year	9.00*	2.30	(see II. below)
Biovolume	by station	0.59	5.14	
(1981 only)	by season	48.73*	4.76	(see III. below)
Biovolume	by station	0.42	3.17	
(1974, 1977-1981)	by year	4.20*	2.39	(see IV. below)

*Significant at $P \leq 0.05$.

DUNCAN'S MULTIPLE RANGE TEST

I. DENSITY (1981 only)

Season	Mean density (no./ml)	Grouping[a]
August	5442.990	A
March	2844.663	B
May	2799.981	B
November	1440.290	C

II. DENSITY (1974, 1977-1981)

Year	Mean density (no./ml)	Grouping[a]
1977	6380.489	A
1978	4698.977	A
1980	3188.481	B
1979	3158.650	B
1981	2789.172	B
1974	2330.178	B

TABLE C.1-6
(continued)
STATISTICAL ANALYSIS OF PHYTOPLANKTON SAMPLING DATA
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1974, 1977-1981

DUNCAN'S MULTIPLE RANGE TEST

III. BIOVOLUME (1981 only)

Season	Mean biovolume ($\mu^3 x 10^2/ml$)	Grouping[a]
August	35,228.123	A
May	6,811.039	B
March	6,499.627	B
November	4,680.686	B

IV. BIOVOLUME (1974, 1971-1981)

Years	Mean biovolume ($\mu^3 x 10^2/ml$)	Grouping[a]		
1977	24,969.241	A		
1978	20,086.435	A		
1974	17,949.185	A	B	
1979	14,351.360	A	B	C
1980	11,432.323		B	C
1981	9,242.799			C

[a]Means with the same letter are not significantly different at P=0.05.

TABLE C.1-7

SIMPLE CORRELATION COEFFICIENTS (r) FOR PHYTOPLANKTON BIOVOLUME
AND SELECTED PHYSICAL AND CHEMICAL PARAMETERS
MARBLE HILL PLANT SITE
1977-1981

	Ohio River stations (N=20)			Little Saluda Creek (N=19)
Parameter	1	3	5	6
Temperature	0.4903*	0.4669*	0.4616*	-0.1642
Current speed	0.3610	0.1454	0.1172	-[a]
Secchi	-0.0072	0.2312	0.1194	-[a]
Nitrate nitrogen	-0.0357	0.1941	-0.1238	0.1759
Ammonia nitrogen	-0.2285	-0.1309	-0.1275	-0.3879
Orthophosphate	-0.0383	-0.2364	-0.1982	0.0458
Dissolved silica	-0.1756	-0.2976	-0.2357	-0.1249

*Significant at P=0.05; Critical r_{20} = 0.423; r_{19} = 0.433.

[a]Form of data did not permit calculation.

TABLE C.1-8

SIMPLE CORRELATION COEFFICIENTS (r) FOR PHYTOPLANKTON DENSITY WITH SELECTED PHYSICAL AND CHEMICAL PARAMETERS MARBLE HILL PLANT SITE 1977-1981

	Ohio River stations (N=40)			Little Saluda Creek (N=38)
Parameter	1	3	5	6
Temperature	0.4890*	0.5632*	0.5301*	-0.0455
Current speed	0.1992	0.1206	0.1837	-[a]
Secchi	-0.2166	0.0321	-0.0915	-[a]
Nitrate nitrogen	-0.1680	0.0128	-0.0431	0.3017
Ammonia nitrogen	-0.3476*	0.2110	-0.0892	-0.1570
Orthophosphate	0.0845	0.0294	0.0899	0.2824
Dissolved silica	0.1422	-0.0256	0.1344	0.0816

*Significant at P=0.05; Critical r_{40} = 0.304; r_{38} = 0.312.

[a]Form of data did not permit calculation.

TABLE C.1-9

STATISTICAL ANALYSIS OF PHYTOPLANKTON SAMPLING DATA
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1974, 1977-1981

ANALYSIS OF VARIANCE

Parameter	Comparison	Calculated F value	Critical F value
Density	by year	3.01*	2.50
Biovolume	by year	2.68	2.91

DUNCAN'S MULTIPLE RANGE TEST

DENSITY BY YEAR

Year	Mean density (no./ml)	Grouping[a]
1978	914.426	A
1977	418.175	A B
1980	398.218	A B
1981	274.349	B
1979	239.697	B
1974	141.500	B

[a]Means with the same letter are not significantly different at P=0.05.

*Significant at P=0.05.

C.2 ZOOPLANKTON

INTRODUCTION

Zooplankters are the aquatic invertebrate animal component of plankton. Although they may have limited mobility, they are still subject to water movements and therefore drift with water currents. Most river plankters originate in still or gently flowing waters. Lakes and impoundments along the course of a river can supply large amounts of zooplankton to its lower reaches. Generally, zooplankters are representative of the second trophic level in aquatic food chains. They are the major consumers of primary producers such as phytoplankton and, in turn, provide an important food source for larger macroinvertebrates and fishes.

Zooplankters are sensitive to disturbances within the ecosystem and reflect the influences of water velocity, temperature, silt loads and pollutants. Zooplankton populations of a river community are, therefore, likely to vary considerably along the river's length in both space and time (Hynes, 1970). Changes in zooplankton community composition and density may be used as a measure of changing environmental conditions.

The purpose of the 1981 zooplankton study was to examine species composition and relative abundance at three stations in the Ohio River and at one station in Little Saluda Creek (Figure 1). These findings were then compared to the baseline (1974) and previous construction phase monitoring data to evaluate the potential impact of construction at the Marble Hill Plant site.

MATERIALS AND METHODS

Duplicate zooplankton samples were taken quarterly at Stations 1, 3 and 5 in the Ohio River and at Station 6 in Little Saluda Creek. Samples were collected by pumping from subsurface, middle and near-bottom depths to accommodate potential variations in spatial distribution of zooplankton. At Stations 1, 3 and 5, 167 liters of water from each depth were filtered through an 80-μ mesh net. At each station, the concentrated samples from the three depths (500 liters total) were consolidated into a single polyethylene bottle. Because of low water levels in Little Saluda Creek, the entire 500-liter sample was taken from mid-depth only. Samples were preserved immediately after collection in a 5-percent formalin solution buffered with sodium borate to pH 7-8.

In the laboratory, samples were allowed to settle for a minimum of 48 hours. Settled samples were concentrated to a final volume determined by zooplankton density and the amount of detritus. Identifications and counts were made by placing a well-mixed 1-ml subsample into a Sedgwick-Rafter counting chamber. All organisms in the chamber were enumerated at 100X magnification. When densities were adequate, a minimum of 100 organisms per chamber were examined for each of four identically prepared subsamples. Organisms requiring dissection to achieve species identification were removed from the counting chamber and dissected. All zooplankters were identified to the lowest practicable taxon.

The number of zooplankters per liter (N) was calculated by:

$$N = \frac{\frac{V_s}{V_c} C}{V_i}$$

where: V_s = Volume of sample concentrate, in milliliters;

V_c = Volume of concentrate enumerated, in milliliters;

C = Count;

V_i = Initial volume of sample, in liters.

Entire zooplankton samples were retained as vouchers.

Statistical procedures used in data analysis are described in Section H. Statistical Analysis Procedures.

RESULTS AND DISCUSSION

As in previous years, the zooplankton species collected during the fifth year of construction phase ecological monitoring at the Marble Hill Plant site were typical of freshwater zooplankton communities. The community was dominated by rotifers, protozoans and crustaceans (Figure C.2-1). Species composition in 1981 did not differ greatly from the baseline or prior construction phase monitoring programs (PSI, 1976; ABI, 1978, 1979, 1980, 1981). A total of 74 taxa were observed from Stations 1, 3, 5 and 6 during 1981 (Table C.2-1), compared to 66 taxa that were identified during the 1980 program. Of the total number of taxa observed in 1981, rotifers represented 41 percent; cladocerans, 21 percent; protozoans, 14 percent; and copepods, 12 percent. The remainder accounted for 12 percent of the identified taxa.

Total zooplankton densities in the river ranged from approximately 4 organisms per liter at all stations in November to 43 zooplankters per liter at Station 5 in August (Tables C.2-2 through C.2-5). Zooplankton densities in Little Saluda Creek (Station 6) ranged from 3 organisms in November to 9 organisms per liter in August (Tables C.2-2 through C.2-5). Zooplankton composition, density and relative abundance by station and date for 1981 are presented in Appendix Tables C.2-1 through C.2-8.

Ohio River Stations

During the 1981 monitoring period, there was no significant difference in mean zooplankton density among Ohio River stations (Table C.2-6). Each station exhibited similar seasonal effects, having significantly higher densities in August and significantly lower densities in November (Table C.2-6). Significant seasonal variation is common to quarterly sampling programs because sampling periods are far apart and zooplankton life cycles are closely adapted to seasonally induced changes in the environment. The absence of significant interstation differences indicated that construction at the Marble Hill Plant site did not influence zooplankton densities among stations or seasons during 1981.

Species composition and density among the river stations for any given season were generally similar. In March, the unidentified protozoan Peritricha was very abundant. Normally this organism consists of several "head-like" projections attached to a stalk. The "head" was removed from the stalks by currents in all cases and each "head" was counted as one organism. This accounted for the large number of protozoans recorded. Differences in densities of particular zooplankters among stations were most likely because of temporal and spatial variations naturally found in the zooplankton communities of large rivers.

The seasonal pattern of zooplankton density varied from prior monitoring periods. Densities in March at all river stations were much lower that those seen in the previous year (Figure C.2-2). Densities were slightly higher in May, but they remained lower than those observed in May 1980. Lower densities in March and May 1981 were likely related to riverine conditions. The spring high water period with its associated high suspended sediment loads typically ends before May but extended into early June in 1981. These conditions probably hindered or delayed development of the spring zooplankton population. Overall, lower zooplankton densities and increased numbers of benthic dwelling protozoans suspended in the water column by scouring, accounted for the increased relative abundance of protozoans in the March and May collections.

Protozoans accounted for 60.2 percent of the total organisms at Station 1 in March. Rotifers and crustaceans accounted for approximately 37 percent of the organisms. The predominant protozoans at the river stations were unidentified Peritrichs (stalked protozoans). These organisms are common in large river habitats where they live on the bottom in shallow or slower moving waters. They are frequently observed in plankton samples because of the action of rapid stream flows and associated heavy silt loads scouring the organisms from the bottom.

The protozoan population declined in May and the density and relative abundance of rotifers at Stations 1 and 3 increased. At Station 5, protozoan abundance remained relatively constant (Tables C.2-3 and C.2-4). Increased rotifer densities have been observed at this time during previous monitoring years also. This may be because increased water temperature is conducive to the reproduction of rotifer populations, which typically show increased densities during summer months. The predominant rotifer species was Keratella cochlearis, followed by Brachionus urceolaris and Keratella quadrata.

In August, zooplankton densities in the Ohio River continued to show an increase from the previous months. Density in August was significantly greater than in any other month (Table C.2-6). Cladocerans replaced rotifers as the most abundant zooplankters with the cladoceran Eubosmina longispina becoming the predomiant species at all river stations. The density and relative abundance of protozoans was noticeably reduced in the river during August.

November zooplankton densities have been very inconsistent throughout the five years of construction phase monitoring, which may be because of the inconsistent environmental conditions during the fall. An early winter in some years and late winters during other years would affect zooplankton density levels in November. Zooplankton density was less than 10 organisms per liter at all river stations during November 1981, but densities in November 1980 were the highest observed during this month during the entire monitoring program. Rotifers comprised over 50 percent of the relatively few zooplankters present in November 1981.

Annual mean zooplankton density at Ohio River stations during 1981 was 21.2 organisms/liter. This density was less than that observed during previous years and likely reflected the influence of the extended spring flood period in 1981.

Zooplankton densities in 1981 were significantly lower than those during baseline (1974-1975) monitoring (Table C.2-6). However, baseline zooplankton densities were not significantly different from densities in any other year of construction phase monitoring. There were no significant differences in densities among river stations over the six years of monitoring (Table C.2-6). The lack of significant variation in densities among stations suggests that even though there are sizable differences in densities among seasons and among years, the differences likely result from natural variation in the flowing water environment, climate, and other environmental factors. As in previous years, the data indicated no apparent adverse plant construction impact on zooplankters in the Ohio River.

Little Saluda Creek

Consistent with previous years, low zooplankton densities in Little Saluda Creek reflect highly variable flow rates and turbulence that are not conducive to zooplankton growth and reproduction. Throughout the 1981 monitoring period, densities at Station 6 remained below 10 organisms per liter, with an average density of 5.4 organisms per liter. Very low densities observed throughout most of the six years of ecological monitoring indicate the overall unsuitable conditions for zooplankton growth in the riffle habitat of Little Saluda Creek.

Total zooplankton densities at Station 6 were compared among all previous monitoring programs and showed no significant difference among years (Table C.2-7). These results suggest that the variation in zooplankton density at Station 6 was not related to plant construction.

CONCLUSIONS

Zooplankton species collected in 1981 were similar to those collected during prior monitoring periods. During 1981, however, zooplankton mean densities in the river were the lowest observed since monitoring began. These low densities resulted from conditions associated with the extended spring flood period that hindered or delayed development of the spring zooplankton population. Densities remained low in May and increased in August. November densities were variable as in previous years and reflected the relatively variable late fall conditions as compared to other seasons. No significant differences were found among stations during 1981 or among stations over all monitoring periods. Significant differences were found among annual zooplankton densities during the monitoring period, but these differences were attributable to natural variations in the environment and did not indicate adverse impact from plant construction.

Zooplankton densities in Little Saluda Creek were very low during 1981 and were similar to those of previous monitoring periods. Turbulence and highly variable flow rates make riffle habitats of all small streams generally unfavorable for zooplankton growth and reproduction. Statistical comparison of all monitoring data for Station 6 showed no significant differences among the survey years and plant-related construction effects were not indicated.

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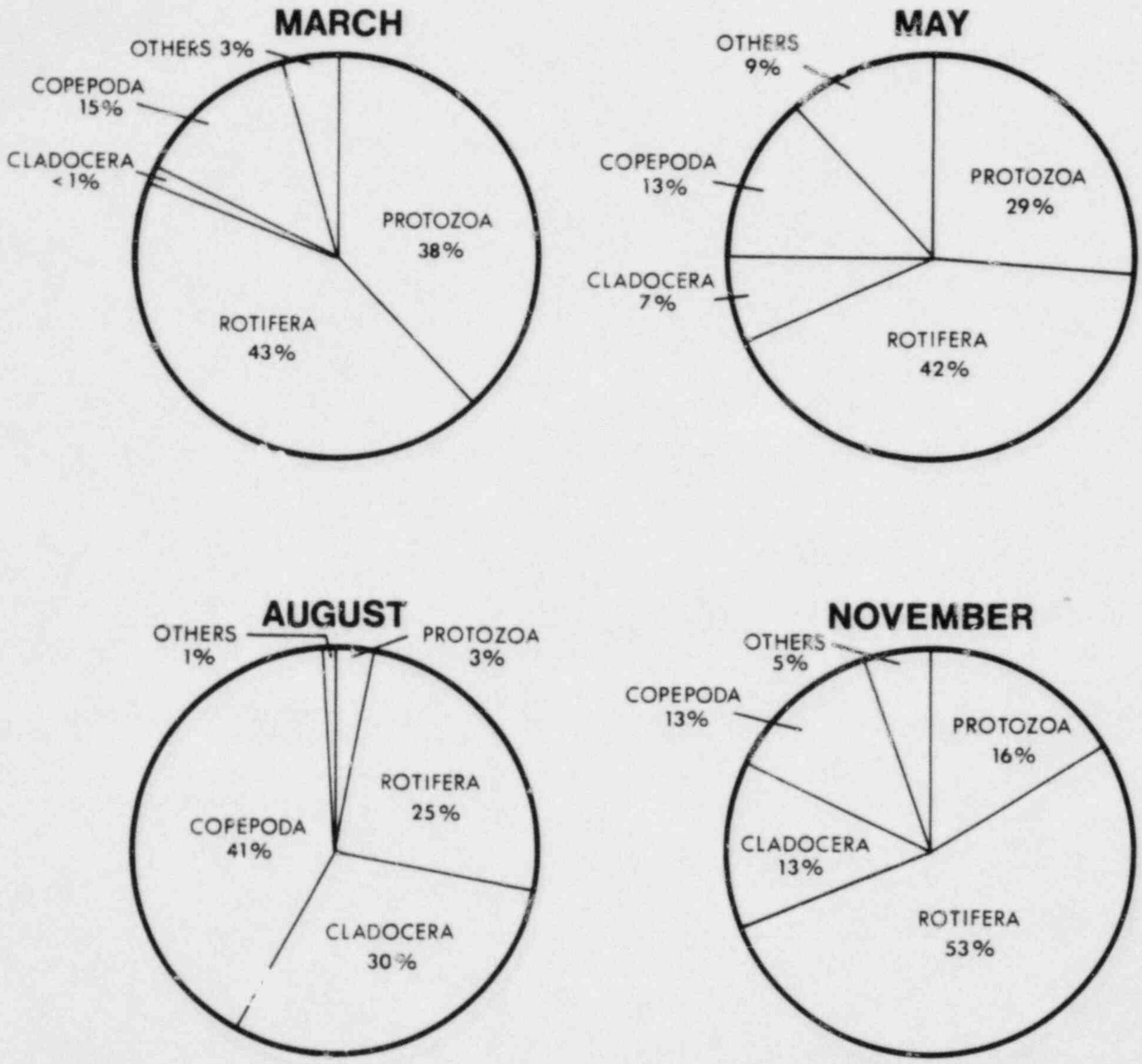

Figure C.2-1. Relative abundance of major zooplankton groups, Marble Hill Plant site, March-November 1981.

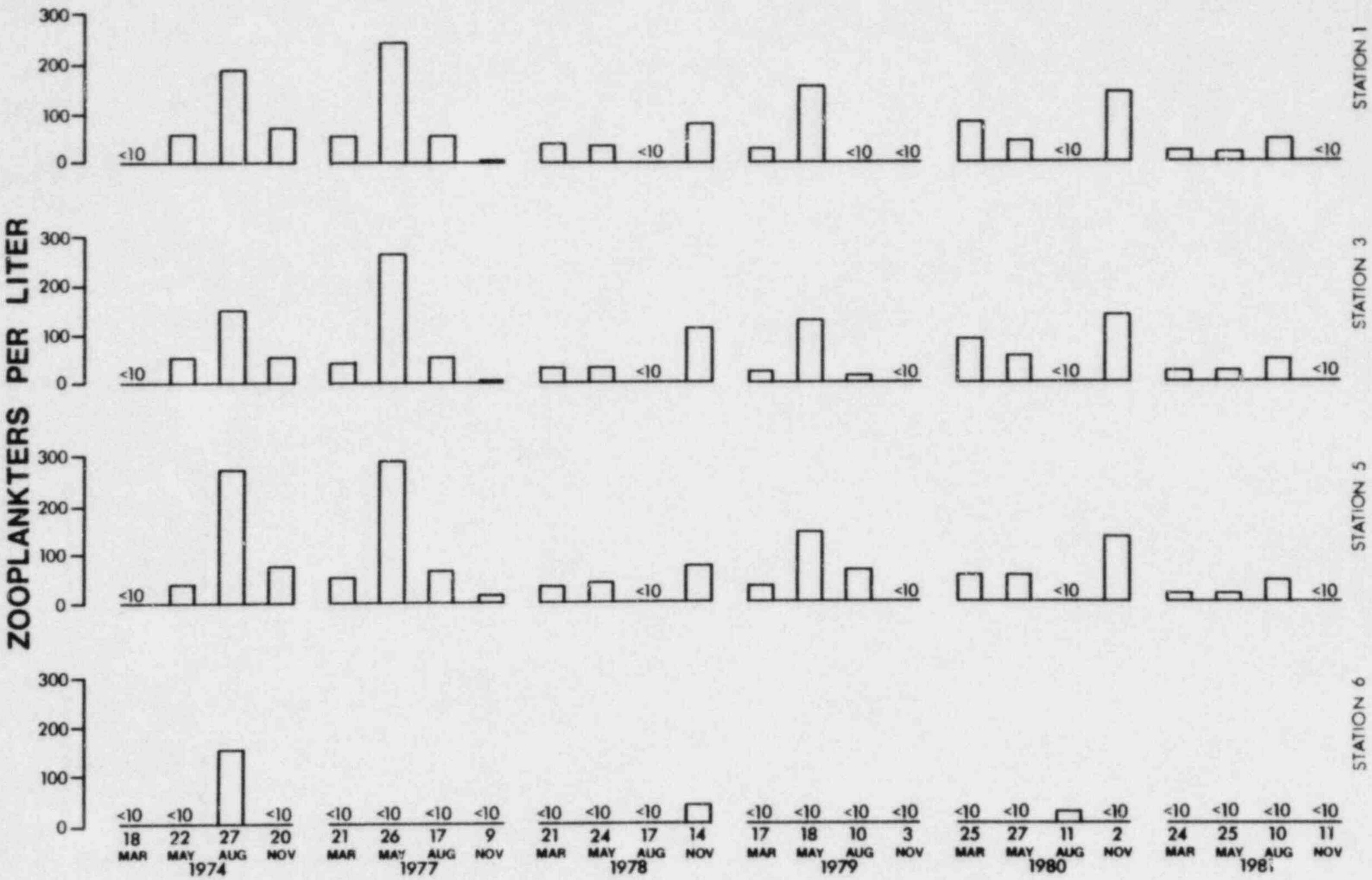

Figure C.2-2. Number of zooplankters per liter at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1974-1981.

TABLE C.2-1

ZOOPLANKTON SPECIES COLLECTED IN THE
OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
1981

PROTOZOA
- Acineta sp.
- Arcella sp.
- Carchesium sp.
- Centropyxis spp.
- Difflugia spp.
- Epistylis sp.
- Podophrya sp.
- Thecacineta sp.
- Tokophyra sp.
- Vorticella sp.
- unidentified Peritricha

ROTIFERA
- Ascomorpha sp.
- Asplanchna sp.
- Brachionus angularis
- B. bidentata
- B. calyciflorus
- B. caudatus
- B. havanaensis
- B. quadridentata
- B. rubens
- B. urceolaris
- Cephalodella sp.
- Euchlanis sp.
- Filinia longiseta
- Hexarthra sp.
- Kellicotia bostoniensis
- K. longispina
- Keratella cochlearis
- K. gracilenta
- K. quadrata
- K. valga
- Lecane sp.
- Monostyla lunaris
- Mytilina sp.
- Notholca sp.
- Platyias patulus
- P. quadricornis
- Polyarthra sp.
- Trichocerca sp.
- Trichotria sp.
- unidentified Bdelloidea
- unidentified Rotifera

CLADOCERA
- Alona guttata
- Alona sp.
- Bosmina longirostris
- Camptocercus rectirostris
- Ceriodaphnia quadrangu'a
- Chydorus sphaericus
- Daphnia ambigua
- D. parvula
- D. pulex
- D. retrocurva
- Daphnia sp.
- Diaphanosoma brachyurum
- Eubosmina coregoni
- E. longispina
- Moina micrura
- immature Cladocera

COPEPODA
- Calanoida
  - Diaptomus pallidus
  - D. siciloides
- Cyclopoida
  - Cyclops bicuspidatus thomasi
  - C. vernalis
  - Eucyclops agilis
  - E. speratus
  - Mesocyclops edax
  - Tropocyclops prasinus
- Harpacticoida
  - Attheyella illinoisensis
- Copepodites
  - Nauplii

OTHERS
- Diptera larvae
  - Chironomidae larvae
  - Ectoprocta statoblasts
  - Hydracarina
- Nematoda
  - Criconema sp.
- Oligochaeta
- Ostracoda
- Tardigrada

TABLE C.2-2

SUMMARY OF ZOOPLANKTON DENSITY AND RELATIVE ABUNDANCE
MARBLE HILL PLANT SITE
24 MARCH 1981

	Station 1		Station 3		Station 5		Station 6	
Taxon	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)
Protozoa	11.8	60.2	10.4	56.2	4.7	25.1	0.6	12.5
Rotifera	4.1	20.9	4.7	25.4	9.4	50.3	3.6	75.0
Cladocera	0.1	0.5	0.1	0.5	0.3	1.5	0.0	0.0
Copepoda	3.2	16.3	3.0	16.2	3.8	20.3	0.4	8.3
Others	0.4	2.0	0.3	1.6	0.5	2.6	0.2	4.2
Total	19.6		18.5		18.7		4.8	100.0

TABLE C.2-3

SUMMARY OF ZOOPLANKTON DENSITY AND RELATIVE ABUNDANCE
MARBLE HILL PLANT SITE
25 MAY 1981

	Station 1		Station 3		Station 5		Station 6	
Taxon	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)
Protozoa	6.8	37.6	7.5	35.9	6.5	30.0	0.7	15.9
Rotifera	6.7	37.0	8.3	39.7	10.1	46.5	1.6	36.3
Cladocera	1.2	6.6	1.4	6.7	1.5	6.9	0.4	9.1
Copepoda	1.8	10.0	2.3	11.0	2.3	10.6	0.9	20.5
Others	1.6	8.8	1.4	6.7	1.3	6.0	0.8	18.2
Total	18.1		20.9		21.7		4.4	

TABLE C.2-4

SUMMARY OF ZOOPLANKTON DENSITY AND RELATIVE ABUNDANCE
MARBLE HILL PLANT SITE
10 AUGUST 1981

Taxon	Station 1		Station 3		Station 5		Station 6	
	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)
Protozoa	0.1	0.2	0.1	0.3	0.2	0.4	1.0	11.2
Rotifera	9.9	23.5	8.5	22.3	13.5	31.2	2.0	22.5
Cladocera	16.6	39.5	14.4	37.7	14.3	33.1	1.0	11.2
Copepoda	15.2	36.2	14.8	38.6	14.9	34.6	4.7	52.9
Others	0.3	0.6	0.4	1.1	0.3	0.7	0.2	2.2
Total	42.1		38.2		43.2		8.9	

TABLE C.2-5

SUMMARY OF ZOOPLANKTON DENSITY AND RELATIVE ABUNDANCE
MARBLE HILL PLANT SITE
12 NOVEMBER 1981

	Station 1		Station 3		Station 5		Station 6	
Taxon	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)
Protozoa	0.4	9.1	0.4	9.6	0.4	12.0	1.5	42.9
Rotifera	3.0	68.1	2.5	59.4	2.4	57.0	0.8	22.9
Cladocera	0.5	11.4	0.8	19.0	0.8	19.0	0.1	2.9
Copepoda	0.4	9.1	0.3	7.2	0.4	9.6	0.8	22.9
Others	0.1	2.3	0.2	4.8	0.1	2.4	0.3	8.6
Total	4.4		4.2		4.2		3.5	

TABLE C.2-6

STATISTICAL ANALYSIS OF ZOOPLANKTON SAMPLING DATA
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1974, 1977 - 1981

ANALYSIS OF VARIANCE

Parameter	Comparison	Calculated F value	Critical F value
Density (1981 only)	by station	0.26	3.89
	by season	128.70*	3.49 (see I. below)
Density (1974, 1977-1981)	by station	0.21	3.06
	by year	3.32*	2.31 (see II. below)

*Significant at P=0.05.

I. DENSITY BY SEASON (1981 only) DUNCAN'S MULTIPLE RANGE TEST

Season	Mean density (no./l)	Grouping[a]
August	39.927	A
May	19.128	B
March	17.596	B
November	3.668	C

II. DENSITY BY YEAR (1974, 1977-1981)

Year	Mean density (no./l)	Grouping[a]
1977	51.112	A
1980	44.196	A B
1974	42.293	A B
1978	29.732	A B C
1979	21.815	B C
1981	15.379	C

[a]Means with the same letters are not significantly different at $P \leq 0.05$.

TABLE C.2-7

STATISTICAL ANALYSIS OF ZOOPLANKTON SAMPLING DATA
LITTLE SALUDA CREEK, STATION 6
MARBLE HILL PLANT SITE
1974, 1977 - 1981

Parameter	Comparison	Calculated F value	Critical F value
Density	by year	2.26	2.51

D. PERIPHYTON

INTRODUCTION

The term "periphyton" is used to describe organisms that attach to submerged substrates but do not penetrate into them (APHA, 1980). In current usage, periphyton includes all organisms that, in the past, have been called aufwuchs by various authors. Examples of periphyton organisms include bacteria, yeasts, molds, algae, protozoa, and larger colonial forms such as bryozoans. Periphyton also includes free-living organisms (i.e., rotifers, worms, larvae) that may inhabit the mat of attached forms. Because of the wide variety of plants and animals included in the periphyton community and their varied range of adaptations, virtually all submerged substrates (living and nonliving) may be colonized. Periphyton colonization is common in aquatic habitats such as those near the Marble Hill Plant site.

The periphyton community is widely accepted as a valuable indicator of water quality and related environmental conditions. Periphyton organisms have comparatively brief life cycles and compete intensely for substrate space. Therefore, any natural or man-induced change in habitat parameters can result in rapid qualitative and quantitative alterations in the periphyton community.

The purpose of the periphyton study at the Marble Hill Plant site was to evaluate interstation and seasonal variability in periphyton species composition, density, diversity, equitability and community biomass during power plant construction. Comparison of current data with baseline data (PSI, 1976) and previous construction phase monitoring data (ABI, 1978, 1979, 1980, 1981) was also used to assess possible construction-related effects on periphyton.

MATERIALS AND METHODS

Periphyton samples were collected quarterly from Ohio River Stations 1, 3 and 5 (Figure 1). Collections at these stations were made with floating diatometers that contained eight standard-sized (2.5 x 7.6 cm) microscope slides each. After a 3-week exposure period, three slides per station were preserved individually in jars containing approximately 100 ml of 5-percent buffered formalin solution and used for biomass determinations. Two slides per station were similarly preserved for species identifications and counts.

At Station 6 in Little Saluda Creek, periphyton was scraped from measured areas of natural substrate. For species identification, counts and biomass determinations, three replicate scrapings were washed separately into bottles of 5-percent buffered formalin solution. Natural substrate composition and habitat types were noted and included in the data.

In the laboratory, diatometer slides were scraped on both sides, and detached periphyton was washed back into the collection jars. Natural and artificial substrate samples were allowed to settle for at least 24 hours and then concentrated to approximately 30 ml. Sample suspensions used for species identification and counts were transferred to graduated test tubes, allowed to resettle for at least 24 hours, and then further concentrated to a known volume.

The inverted microscope technique (Utermohl, 1958) was used with 25-ml chambers for species identifications and counts. Periphyton species other than diatoms were identified to the lowest possible taxon; these species as well as total diatoms were enumerated by random strip counts at 400X magnification. A minimum of 400 individuals per replicate were routinely counted in two identically prepared chambers. Total live diatom counts were used with diatom species proportional counts (obtained from permanent slides examined at 1000X magnification) to obtain diatom density by species (APHA, 1980).

All algal species, excluding certain greens and blue-greens, were counted as individual cells. Filamentous green and blue-green species were measured in 100-μ lengths with each length representing one counting unit. Colonial forms, exclusive of diatoms, were counted as individuals unless otherwise noted. Nonalgal species were counted as individual organisms. Periphyton density per 10 square centimeters (N) was calculated by:

$$N = \frac{\frac{V_c}{V_e} C}{A_s}$$

where: V_c = Volume of sample concentrate, in milliliters;

V_e = Volume of sample concentrate examined, in milliliters;

C = Number of cells counted;

A_s = Area of substrate sampled, in square centimeter units.

Permanent diatom mounts and vouchers of all samples analyzed were retained after microscopic analysis.

Biomass was determined as ash-free dry weight for three replicate artificial substrate samples per station at Stations 1, 3 and 5 and for three rock substrate scrapings at Station 6 (APHA, 1980). Ash-free dry weight values were reported as milligrams per 10 square centimeters.

Species diversity was expressed in terms of the Shannon-Weaver mean diversity index ($\overline{d}$), which is recommended by the EPA (1973). The equitability component of diversity (Lloyd and Ghelardi, 1964) was also applied to the data. Statistical procedures used in data analysis are described in Section H. Statistical Analysis Procedures.

RESULTS AND DISCUSSION

Periphyton composition in the Ohio River and Little Saluda Creek was similar to that reported in baseline (PSI, 1976) and previous construction phase monitoring studies (ABI, 1978, 1979, 1980, 1981). Of the 157 taxa identified during 1981 monitoring, 100 were diatoms (Bacillariophyta, Table D-1). Green algae (Chlorophyta) and blue-green algae (Cyanophyta) accounted for 28 and 15 species, respectively. Relative abundance of these three groups totaled more than 93 percent of the total periphyton density in all samples.

Total Periphyton Density

During 1981, total periphyton densities at Ohio River Stations 1, 3 and 5 ranged from $4 \times 10^3/10\ cm^2$ to $11,746 \times 10^3/10\ cm^2$ (Table D-2). Minimum density occurred in March with greater densities seen as the year progressed. The seasonal pattern of abundance was most like that in 1980 although densities were lower in 1981 (Figure D-1). Seasonal trends among all sampling years have been inconsistent except for uniformly low values in March. This lack of a repetitive seasonal pattern is likely due to natural variation in river conditions from year to year.

Even though periphyton densities showed a wide variation over seasons, density levels among Ohio River stations were not significantly different from one another (Table D-3). In addition, no single station was consistently higher or lower in density over the seasons. This was especially true earlier in the year. Of the river stations, Station 1 had the highest density in March and the lowest density in May (Table D-2).

Comparisons of all monitoring data, both baseline and construction phase, revealed no significant differences in density among Ohio River stations (Table D-4). However, density levels did vary significantly from year to year with 1981 densities significantly lower than those in 1978 and 1980 (Table D-4). Mean periphyton densities for all construction phase monitoring were similar to baseline observations. The lack of a significant difference in periphyton densities between construction phase monitoring and baseline data indicated that variation over the years most likely resulted from natural variation rather than from advers› impact from plant construcion.

Total periphyton densities for Little Saluda Creek Station 6 ranged from 1980 x $10^3/10$ cm^2 in November to 36,431 x $10^3/10$ cm^2 in March (Table D-2). During 1981, March and August had the higher densities. These densities were greater than had been seen in previous monitoring years.

Statistical analysis of the difference in periphyton density in Little Saluda Creek among the years indicated that periphyton was not adversely affected by plant construction during 1981 (Table D-5).

Biomass

Periphyton biomass showed marked seasonal variation and generally reflected density trends (Figure D-2). In the Ohio River, biomass was lowest during March, increased through August, and decreased in November. Seasonal variation of periphyton biomass has not followed a consistent pattern over the years and, in general, reflects the influence of river level and current velocity variation that occurred during the time that samplers were being colonized.

Biomass values for 1981 and over all five years of construction monitoring exhibited no significant differences among Ohio River stations (Table D-3 and D-4). Significant variations were found among seasons and years (Table D-3 and D-4). These differences can be expected from a seasonally variable environment as well as from rapid changing riverine conditions and natural year to year variation. There was no apparent impact from plant construction on periphyton biomass in the Ohio River.

In Little Saluda Creek, biomass values ranged from 1.0 mg/10 cm^2 in November to 20.6 mg/10 cm^2 in March. This seasonal trend was unlike any previous monitoring year. In previous monitoring, March biomass estimates were low, followed by high biomass in May or August, and November biomass values were high (1977) or moderate (Figure D-2). There were no significant differences in biomass among years (Table D-5) indicating that periphyton growth in Little Saluda Creek has not been adversely affected by plant construction.

Periphyton Composition

Diatoms have dominated the periphyton community in both the Ohio River and Little Saluda Creek in every year of ecological monitoring (Figure D-3). The seasonal pattern of relative abundance in the river was similar to that observed in 1980. As in previous monitoring years, diatom relative abundance declined with warmer water temperatures. In

Little Saluda Creek, diatoms contributed more than 90 percent of the total density throughout the year. Diatom relative abundance was most like that observed in 1979.

Diatom species composition for Ohio River stations was similar to that observed in the baseline study and earlier construction phase monitoring. Melosira varians, Gomphonema olivaceum, G. parvulum, Navicula graciloides and Nitzschia palea were the more common Ohio River species in 1981. Melosira varians was the dominant species in March and August, and Gomphonema parvulum and G. olivaceum dominated the periphyton community in May and November. These diatoms have also occurred as major species during previous monitoring. Because diatoms are sensitive to small changes or shifts in habitat conditions (Patrick, 1977), the maintenance of major diatom species over the monitoring period suggests that plant construction has not produced long term changes in habitat conditions. As in previous studies, the major diatom species had environmental requirements that reflect conditions that are generally associated with the Ohio River environment (Table D-6). Wide-range temperature tolerance, preference for somewhat alkaline conditions, and the ability to grow in either standing or flowing water characterize most of these species.

The relative abundance of Chlorophyta and Cyanophyta was greatest during August when temperatures were highest. The higher summer abundance of these two groups has been observed to varying degrees during all monitoring years, especially 1977 and 1980. Characium ambiguum and Chamaesiphon incrustans were the major non-diatom species. Significant densities of these species developed only during August and primarily at Station 5. The total number of Chlorophyta and Cyanophyta species observed in 1981 remained similar to that in previous construction phase monitoring studies.

The most frequently observed diatoms in Little Saluda Creek were Achnanthes minutissima, A. linearis f. curta, Amphora perpusilla, Nitzschia communis v. abbreviata, Gomphonema angustatum and Rhoicosphenia curvata. Of these, Achnanthes linearis f. curta, A. minutissima and Amphora perpusilla dominated the periphyton during all the sampling periods. These three species also exhibited widespread seasonal occurrence during previous construction monitoring studies. Non-diatom species remained rare until the final sampling period when Lyngbya sp. 1 showed a significant density in one replicate. Periphyton density and the continued dominance of diatoms with an overall similarity of species composition suggest that periphyton growth and community composition in Little Saluda Creek have not been adversely affected by plant construction.

Community Similarity

Community similarity as indicated by Morisita's index (Horn, 1966) showed a wider variation at Ohio River stations in 1981 than during 1980 or any other prior sampling period. As in 1980, the index suggested that community composition at Station 5 differed from that at Stations 1 and 3 (Table D-7). Again, as in 1980, this difference was largely the result of a particularly heavy growth of Characium ambiguum and Chamaesiphon incrustans at Station 5. It is most likely that this qualitative difference in community composition at Station 5 resulted from differences in ambient environmental conditions. These differences were probably caused by summer water temperatures coupled with microhabitat current flow anomalies or greater habitat shading at Station 5 (Hynes, 1970). Impact from plant construction is unlikely.

Reduced similarity among Ohio River stations during March resulted from a heavier growth of Melosira varians at Station 1. Low densities of periphyton at this time probably resulted from adverse current or temperature conditions. However, once becoming established, M. varians grew rapidly.

High similarity in community composition among stations in May and November indicated that microhabitat or environmental differences were short term and more likely due to natural variability rather than plant construction. Community index comparisons were not made between Little Saluda Creek and Ohio River communities because habitat differences result in naturally different species composition.

Species Diversity

Species diversity ($\bar{d}$) and equitability (e) values were within the range observed in prior studies (Table D-8). Interstation differences in March were attributable to the relatively more abundant growth of Melosira varians at Station 1. Species diversity among stations was lowest in May. Lower diversity values resulted from a reduced number of species combined with dominance of Gomphonema species. Overall, in the Ohio River, interstation differences were smaller than variations among seasons. Species diversity and equitability values for Little Saluda Creek were also typical of those observed in prior studies and did not indicate adverse impact.

CONCLUSIONS

Periphyton composition in the Ohio River and in Little Saluda Creek was comparable to earlier monitoring data. Diatoms continued to dominate the periphyton community. Non-diatom taxa were most prevalent at Station 5 during August.

Morisita's community index revealed community dissimilarities among Ohio River stations during March and August. Low Morisita's index values in March were attributable to generally sparse periphyton growth with relatively high abundance of Melosira varians at Station 1. In August, the contrast between Station 5 and Stations 1 and 3 was most likely due to habitat variation among the stations. Habitat differences could include degree of shading and microhabitat current variation interacting with summer temperatures.

Interstation comparisons of densities and biomass revealed no differences among Ohio River stations over the five years of construction phase monitoring. Significant yearly differences in density and biomass in the Ohio River were attributable to natural variation rather than impact from plant construction. Density and biomass variation in Little Saluda Creek showed no differences among years. Variability in all periphyton community parameters measured in the Ohio River and Little Saluda Creek was most likely attributable to natural variation rather than adverse impact from plant construction.

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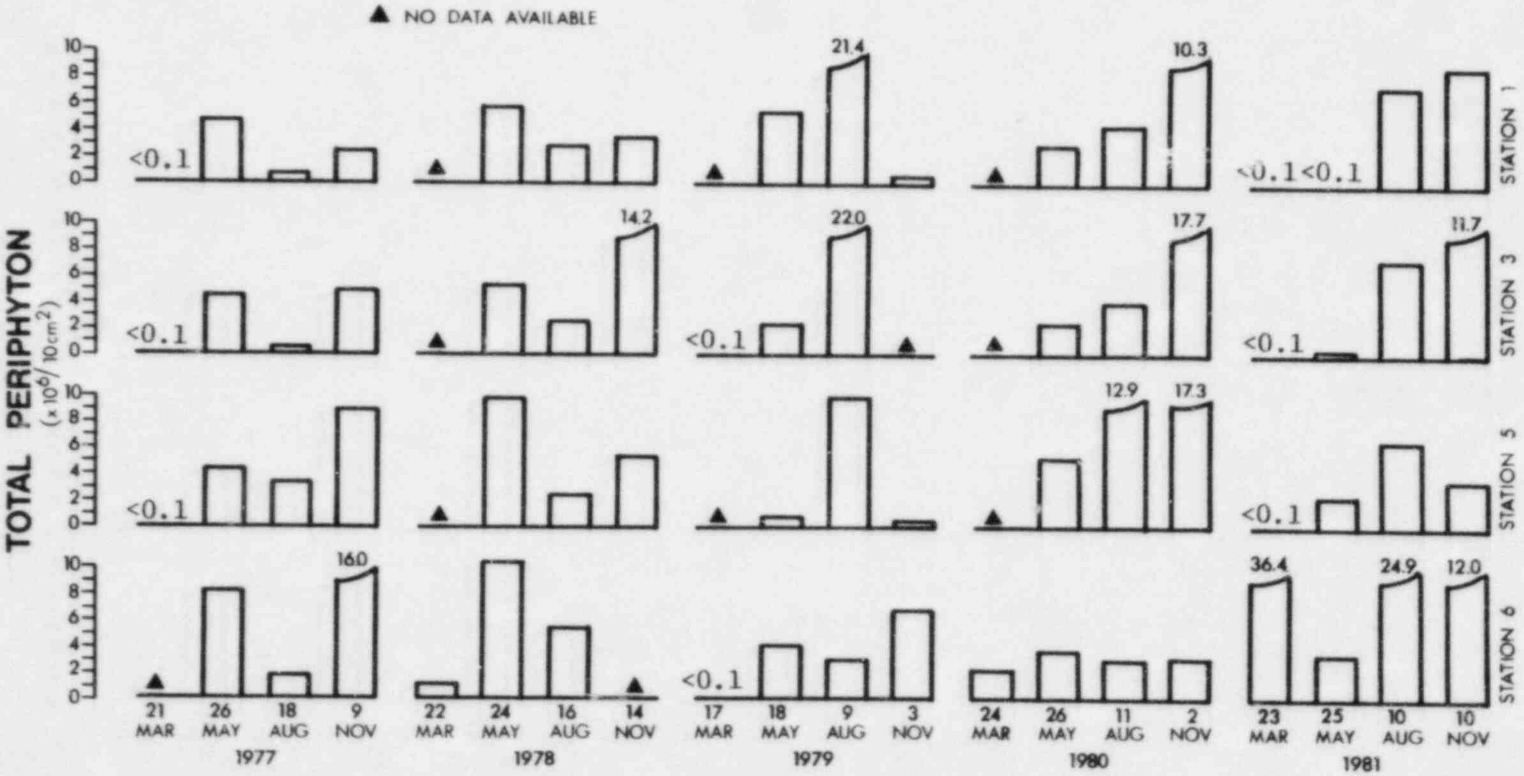

Figure D-1. Seasonal variation in total periphyton density at Ohio River Stations 1, 3 and 5 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1981.

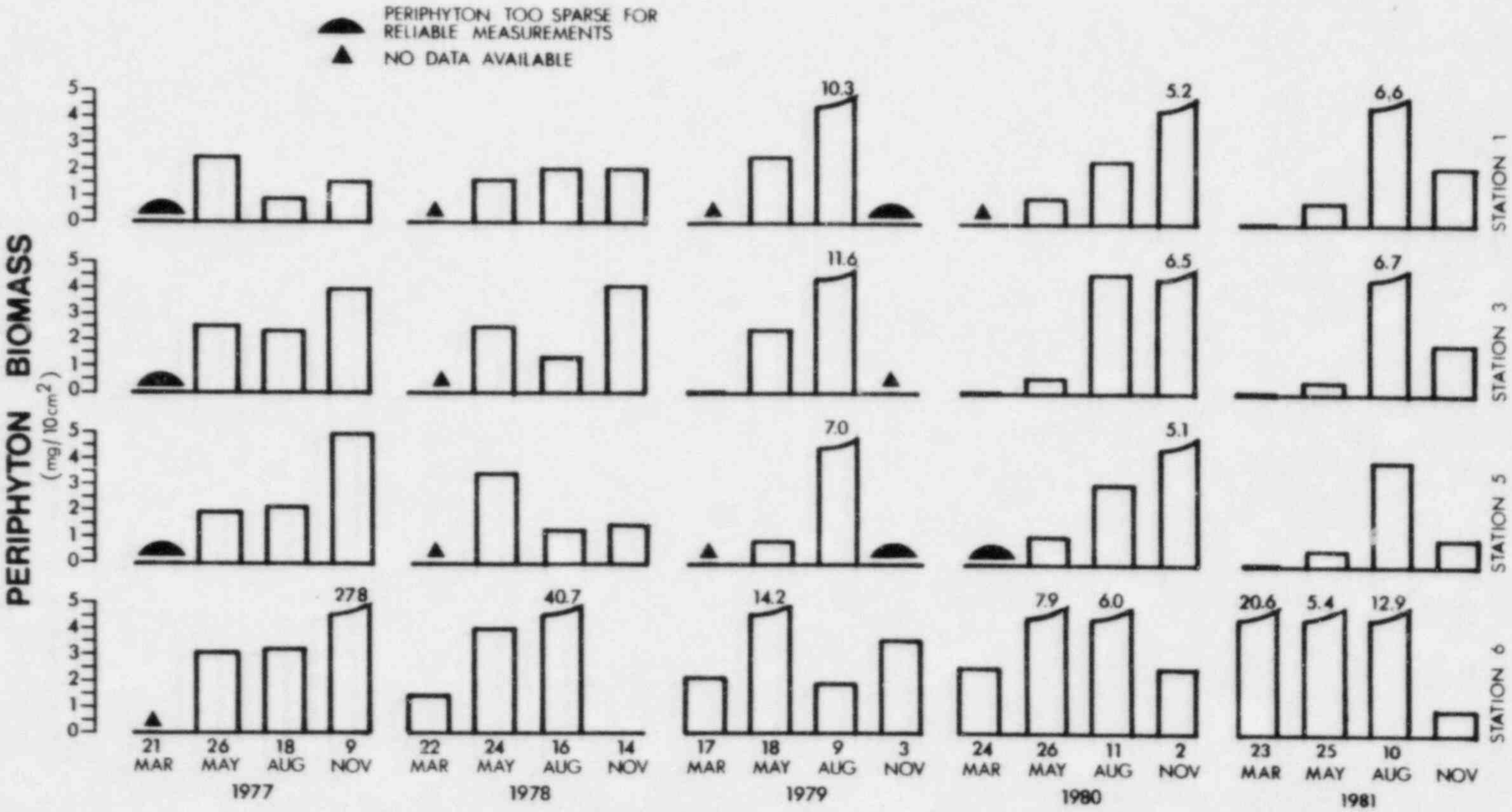

Figure D-2. Periphyton biomass at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1981.

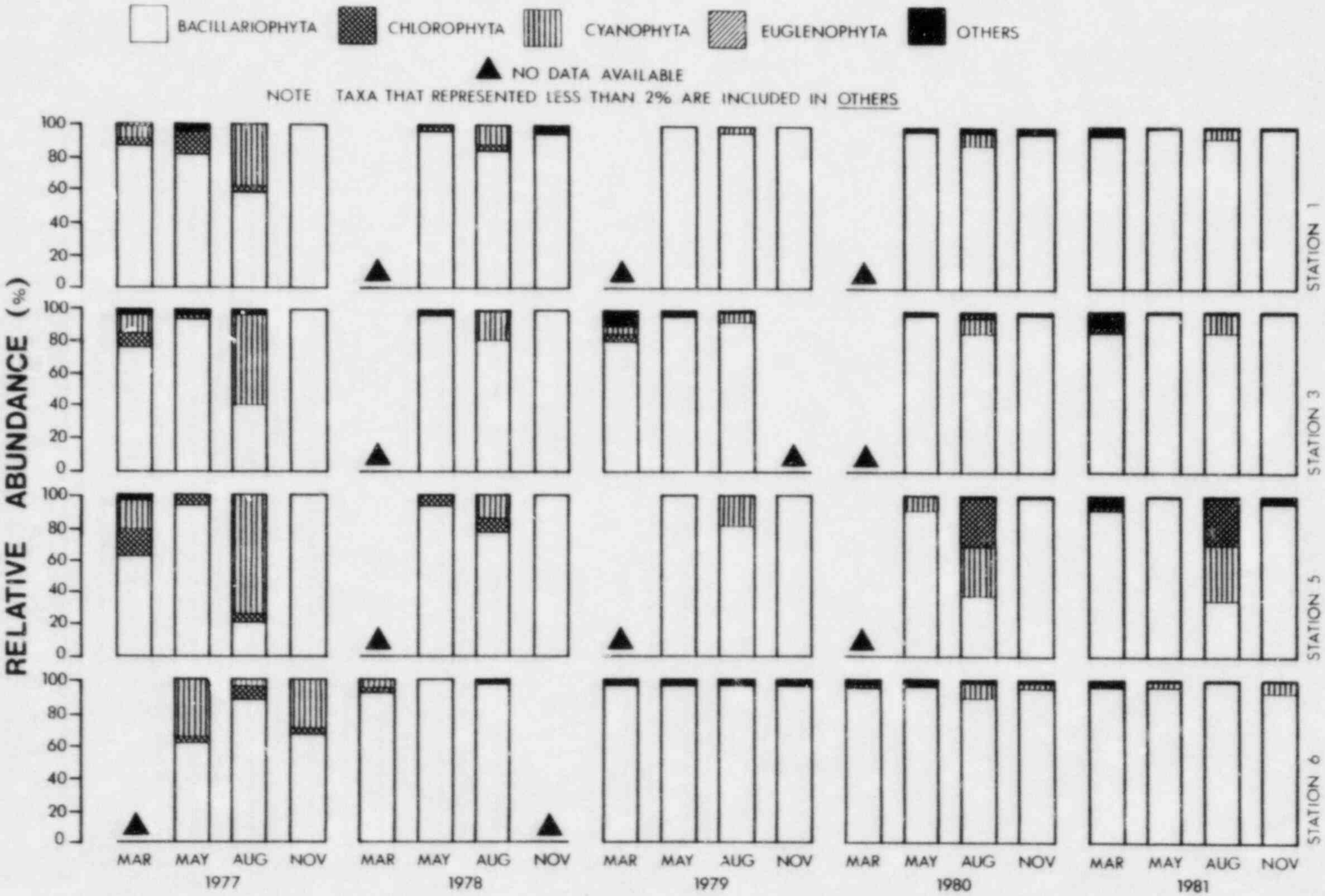

Figure D-3. Percentage composition of major phytoplankton groups in Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1981.

TABLE D-1

PERIPHYTON SPECIES COLLECTED IN THE OHIO RIVER AND LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
1981

BACILLARIOPHYTA
Centrales
Cyclotella glomerata
C. Kutzingiana
C. Meneghiniana
C. ocellata
C. pseudostelligera
C. stelligera
Cyclotella sp.
Melosira distans
M. granulata
M. varians
Stephanodiscus astraea
S. astraea v. minutula
Pennales
Achnanthes affinis
A. deflexa
A. exigua
A. lanceolata
A. lanceolata v. dubia
A. linearis
A. linearis f. curta
A. microcephala
A. minutissima
Amphipleura pellucida
Amphora perpusilla
A. submontana
Asterionella formosa
A. formosa v. gracillima
Cocconeis pediculus
C. placentula v. euglypta
Cymatoplema solea
Cymbella affinis
C. angustata
C. minuta v. silesiaca
C. sinuata f. antiqua
C. tumida
C. ventricosa
Diatoma tenue v. elongatum
D. vulgare
D. vulgare v. breve
Eunotia pectinalis
Eunotia sp.
Fragilaria capucina
F. gracillima

BACILLARIOPHYTA (continued)
F. vaucheriae
F. virescens
Frustulia rhomboides v. saxonica
Gomphonema angustatum
G. angustatum v. citera
G. dichotomum
G. divaceum
G. intricatum
G. olivaceum
G. parvulum
Gomphonema sp.
Hantzschia amphioxys
Meridion circulare
Navicula biconica
N. cryptocephala
N. cryptocephala v. veneta
N. graciloides
N. gysingensis
N. minima
N. rhyncocephala
N. rhyncocephala v. germainii
N. schroeteri v. escambia
N. tripunctata
N. tripunctata v. schizonemoides
N. viridula
N. viridula v. rostellata
Navicula sp. 2
Nitzschia acicularis
N. amphibia
N. communis
N. communis v. abbreviata
N. dissipata
N. filiformis
N. gandersheimiensis
N. hungarica
N. Kutzingiana
N. palea
N. paradoxa
N. parvula
N. sublinearis
N. tryblionella
Rhoicosphenia curvata
Surirella augustata
S. linearis
S. ovata

TABLE D-1
(continued)
PERIPHYTON SPECIES COLLECTED IN THE OHIO RIVER AND LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
1981

BACILLARIOPHYTA (continued)

- Synedra acus
- S. delicatissima
- S. delicatissima v. angustissima
- S. fasciculata v. truncata
- S. filiformis v. exilis
- S. pulchella
- S. rumpens
- S. rumpens v. meneghiniana
- S. ulna
- S. ulna v.oxyrhynchus
- S. ulna v. ramesi
- S. ulna v. spathulifera
- Synedra sp.

CHRYSOPHYTA

- Dinobryon sertularia
- D. sociale
- Mallomonas sp.

CRYPTOPHYTA

- cryptophyte sp. 1

CHLOROPHYTA

- Ankistrodesmus convolutus
- A. falcatus
- A. falctus v. mirabilis
- Characium ambiguum
- Characium sp.
- Chlamydomonas globosa
- Chlamydomonas sp.
- Cladophora sp.
- Closterium moniliferum
- Coelastrum sphaericum
- Cosmarium sp.
- Dictyosphaerium Ehrenbergianum
- Kirchneriella lunaris v. irregularis
- K. subsolitaria
- Lagerheima quadriseta
- Mougeotia sp.

CHLOROPHYTA (continued)

- Oocystis Borgei
- O. pusilla
- Oocystis sp.
- Scenedesmus acuminatus
- S. bijuga
- S. quadricauda
- Scenedesmus sp.
- Schraederia setigera
- Stigeoclonium sp.
- Ulothrix sp.
- Westella botryopides
- unidentified coccoid sp. (6-7µ dia.)

CYANOPHYTA

- Anabaena sp.
- Chamaesiphon incrustans
- Chroococcus sp.
- Lyngbya Diquetii
- L. major
- L. nordgaardii
- Lyngbya sp. 1
- Lyngbya sp.
- Marssoniella elegans
- Microcystis aeruginosa
- M. incerta
- Oscillartoria sp. 1
- Oscillatoria sp. 2
- Rhabdoderma lineare
- Spirulina major

EUGLENOPHYTA

- Euglena sp.
- Trachelomonas volvocina
- Trachelomanas sp.
- Unidentified euglenoid sp. 2

PHRRHOPHYTA

- Peridinium inconspicuum
- Peridinium sp.

TABLE D-1
(continued)
PERIPHYTON SPECIES COLLECTED IN THE OHIO RIVER AND LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
1981

PROTOZOA	OTHERS
Amoeba sp.	unidentified phytoflagellate sp. 2
unidentified ciliated protozoan	unidentified phytoflagellate sp. 3

TABLE D-2

PERIPHYTON DENSITY AND RELATIVE ABUNDANCE DATA SUMMARY
OHIO RIVER STATIONS 1, 3 AND 5 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
23 MARCH 1981

	Station 1		Station 3		Station 5		Station 6	
Taxon	Density (no.x10[3]/ 10 cm^2)	Relative abundance (%)	Density (no.x10[3]/ 10 cm^2)	Relative abundance (%)	Density (no.x10[3]/ 10 cm^2)	Relative abundance (%)	Density (no.x10[3]/ 10 cm^2	Relative abundance (%)
Bacillariophyta	32.66	97.70	3.53	86.73	8.04	92.73	35350.14	97.03
Chrysophyta	0.04	0.12	0.03	0.74	0.10	1.15		
Cryptophyta			0.01	0.25				
Chlorophyta	0.25	0.75	0.20	4.91	0.26	3.00	288.00	0.79
Cyanophyta	0.20	0.60	0.06	1.47	0.07	0.81	632.84	1.74
Euglenophyta	0.09	0.27	0.05	1.23	0.05	0.58	37.25	0.10
Pyrrhophyta	0.04	0.12			0.01	0.12		
Protozoa					0.01	0.12		
Others	0.15	0.45	0.19	4.67	0.13	1.50	122.63	0.34
Total	33.43		4.07		8.67		36430.86	

TABLE D-2
(continued)
PERIPHYTON DENSITY AND RELATIVE ABUNDANCE DATA SUMMARY
OHIO RIVER STATIONS 1, 3 AND 5 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
25 MAY 1981

	Station 1		Station 3		Station 5		Station 6	
Taxon	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2	Relative abundance (%)
Bacillariophyta	140.79	99.76	294.09	99.80	2414.31	99.59	3477.51	97.63
Chlorophyta	0.06	0.04	0.33	0.11	3.20	0.13	11.10	0.31
Cyanophyta	0.27	0.20	0.04	0.01	3.51	0.14	73.37	2.06
Euglenophyta			0.11	0.04	1.60	0.07		
Pyrrhophyta					1.60	0.07		
Others			0.11	0.04				
Total	141.12		294.68		2424.22		3561.98	

TABLE D-2
(continued)
PERIPHYTON DENSITY AND RELATIVE ABUNDANCE DATA SUMMARY
OHIO RIVER STATIONS 1, 3 AND 5 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
10 AUGUST 1981

	Station 1		Station 3		Station 5		Station 6	
Taxon	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2	Relative abundance (%)
Bacillariophyta	7037.24	92.98	6330.55	86.48	2387.16	36.81	24590.61	98.77
Chrysophyta					12.75	0.20		
Cryptophyta			12.75	0.17				
Chlorophyta	19.14	0.24	102.03	1.39	2327.67	35.89	34.38	0.14
Cyanophyta	519.48	6.85	881.08	12.04	1757.87	27.10	272.20	1.09
Euglenophyta			6.38	0.09				
Protozoa			6.38	0.09				
Others			6.38	0.09				
Total	7575.86		7345.55		6485.45		24897.19	

TABLE D-2
(continued)
PERIPHYTON DENSITY AND RELATIVE ABUNDANCE DATA SUMMARY
OHIO RIVER STATIONS 1, 3 AND 5 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
10 NOVEMBER 1981

Taxon	Station 1		Station 3		Station 5		Station 6	
	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2	Relative abundance (%)
Bacillariophyta	8831.88	98.76	11668.38	99.34	3504.18	97.27	1832.75	92.58
Chrysophyta	20.72	0.23						
Cryptophyta					31.08	0.86		
Chlorophyta	13.82	0.16	13.81	0.12	24.18	0.67	11.90	0.60
Cyanophyta	21.42	0.24	35.91	0.31	39.71	1.10	135.08	6.82
Euglenophyta	13.81	0.15	13.81	0.12				
Others	41.43	0.46	13.81	0.12	3.46	0.10	______	
Total	8943.08		11745.72		3602.61		1979.73	

TABLE D-3

STATISTICAL ANALYSIS OF PERIPHYTON SAMPLING DATA
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1981

ANALYSIS OF VARIANCE

Parameter	Comparison	Calculated F value	Critical F value
Density	by season	457.87*	3.49* (see I. below)
	by station	2.37	3.89
Biomass	by season	61.48*	3.01* (see II. below)
	by station	3.05	3.40

*Significant at $P \leq 0.05$.

DUNCAN'S MULTIPLE RANGE TEST

I. DENSITY BY SEASON	Mean density (no.x10^3/10 cm^2)	Grouping[a]
August	7079.080	A
November	7067.770	A
May	436.549	B
March	10.280	C

II. BIOMASS BY SEASON	Mean biomass (g/10cm^2)	Grouping[a]
August	323.048	A
November	5.597	B
May	1.577	C
March	1.195	C

[a]Means with the same letter are not significantly different at $P \leq 0.05$.

TABLE D-4

STATISTICAL ANALYSIS OF PERIPHYTON SAMPLING DATA
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1974, 1977 - 1981

ANALYSIS OF VARIANCE

Parameter	Comparison	Calculated F value	Critical F value
Density	by years	3.83*	2.33 (see I. below)
	by station	0.14	3.11
Biomass	by years	4.88*	2.44 (see II. below)
	by station	0.25	3.06

*Significant at $P \leq 0.05$.

DUNCAN'S MULTIPLE RANGE TEST

I. DENSITY BY YEAR	Mean density (no.x10^3/10cm^2)	Grouping[a]
1980	6396.460	A
1978	4863.920	A
1979	1849.184	A B
1974	1115.101	A B
1981	688.352	B
1977	412.815	B

II. BIOMASS BY YEAR	Mean biomass (g/10cm^2)	Grouping[a]
1979	144.923	A
1980	20.019	B
1977	12.228	B
1978	9.365	B
1981	7.639	B

[a]Means with the same letter are not significantly different at $P \leq 0.05$.

TABLE D-5

STATISTICAL ANALYSIS OF PERIPHYTON SAMPLING DATA
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1977 - 1981

ANALYSIS OF VARIANCE

Parameter	Comparison	Calculated F value	Critical F value
Density	by year	2.17	5.75
Biomass	by year	1.49	2.58

TABLE D-6

ENVIRONMENTAL REQUIREMENTS[a] OF MAJOR DIATOM SPECIES IDENTIFIED IN PERIPHYTON SAMPLES
MARBLE HILL PLANT SITE
1981

Species	Occurrence: Ohio River	Occurrence: Little Saluda Creek	Temperature	pH	Current	Nutrients
Melosira varians	x		eurythermal and oligothermal to mesothermal	6.4 - 9.0 8.5 optimum	indifferent	eutrophic
Achnanthes linearis f. *curta*		x	-	-	-	-
A. minutissima		x	eurythermal	indifferent 7.5 - 7.8 optimum	indifferent	-
Cocconeis placentula v. *euglypta*	x	x	eurythermal	6.2 - 9.0	indifferent	-
Fragilaria vaucheriae	x		oligothermal	5.0 - 9.0 6.5 - 9.0 optimum	indifferent to rheophilus	eutrophic
Gomphonema angustatum	x	x	eurythermal to metathermal, and oligothermal to mesothermal	6.0 - 9.0 7.5 to 7.7 optimum	indifferent	eutrophic
G. olivaceum	x	x	eurythermal, oligothermal to mesothermal	6.4 - 9.0	indifferent to rheophilus	eutrophic
G. parvulum	x	x	mesothermal to stenothermal	indifferent 4.2 - 9.0 7.8 - 8.2 optimum	rheophilus	nutrient enrichment, especially by sanitary or farm wastes
Navicula graciloides	x		-	-	-	-
Nitzschia dissipata	x	x	eurythermal, oligothermal to mesothermal	5.5 - 9.0 8.0 ca. optimum	rheophilus	eutrophic
N. palea	x	x	eurythermal 0° to 30°C	indifferent 4.2 - 9.0 8.4 ca. optimum	indifferent	eutrophic
Surirella ovata	x	x	oligothermal, eurythermal	6.4 - 8.2 7.5 - 8.0 optimum	rheophilus	-

[a]Adapted from Lowe (1974).

TABLE D-7

MORISITA'S COMMUNITY SIMILARITY INDEX VALUES[a] FOR PERIPHYTON SAMPLES
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1981

	Sampling date			
Comparison	23 March	25 May	10 August	10 November
Sta. 1 x Sta. 3	0.40	0.93	0.93	0.98
Sta. 1 x Sta. 5	0.29	0.99	0.22	0.89
Sta. 3 x Sta. 5	0.65	0.98	0.19	0.86

[a]Index values $\geq$ 0.50 indicate paired communities are similar.

TABLE D-8

PERIPHYTON SPECIES DIVERSITY INDEX AND EQUITABILITY VALUES[a]
MARBLE HILL PLANT SITE
1981

	23 March			26 May		
Station	S	$\overline{d}$	e	S	$\overline{d}$	e
1	42	2.682	0.21	32	1.441	0.11
3	64	5.129	0.82	11	1.161	0.25
5	53	4.601	0.68	21	1.326	0.15
6	29	2.599	0.29	28	2.907	0.37

	10 August			10 November		
Station	S	$\overline{d}$	e	S	$\overline{d}$	e
1	34	3.173	0.38	36	2.244	0.18
3	37	2.884	0.28	32	2.477	0.24
5	42	3.471	0.38	31	3.046	0.38
6	34	4.349	0.88	22	2.742	0.42

[a]S = number of species.

$\overline{d}$ = Shannon-Weaver species diversity index ($\log_2$).

e = equitability.

E. BENTHIC AND DRIFT MACROINVERTEBRATES

INTRODUCTION

Macroinvertebrates are animals large enough to be seen by the unaided eye and retained by a U.S. Standard No. 30 sieve (28 meshes per inch, 0.595-mm openings; EPA, 1973). They live at least part of their life cycles within or upon suitable substrata in a body of water.

A community of macroinvertebrates in an aquatic system responds to changes in environmental conditions such as temperature, salinity, depth, current, substratum, and the concentrations of chemical and organic pollutants. Because macroinvertebrates exhibit limited motility and relatively long life spans, the species composition of a macroinvertebrate community is a function of environmental conditions during the recent past. Thus, these communities are useful indicators of environmental perturbation (EPA, 1973).

The purpose of this construction phase monitoring program was to ascertain the character of the benthic and drift macroinvertebrate communities near the proposed Marble Hill Nuclear Generating Station. These data provide information for comparison with baseline data (PSI, 1976) and previous construction phase data (ABI, 1978, 1979, 1980, 1981) to determine the effects of plant construction.

MATERIALS AND METHODS

Benthos

Specimens from the benthic community were collected and analyzed in accordance with methods recommended by the EPA (1973), NESP (1975) and APHA (1980). Benthic sampling was done with a Ponar grab at Stations 1, 3 and 5 in the Ohio River in March, May, August and November 1981. The Ponar grab samples a surface area of 0.0523 m^2. Two replicate Ponar samples were taken at both inshore (3 m from shore) and offshore locations (30 m offshore) at each station. Samples were then washed through a U.S. Standard No. 30 mesh sieve to remove fine sediment and particulate detritus. All material retained on the sieve was preserved in a 1:1 mixture of Eosin B and Biebrich Scarlet stains in a 1:1000 concentration with 5-percent formalin (Williams, 1974). Preserved samples were placed in labeled containers and taken to the laboratory where they were hand-sorted, and the macroinvertebrates were identified to the lowest practicable taxon. Dry weight biomass was determined for each major taxonomic group (Annelida, Mollusca, Arthropoda and miscellaneous).

At Little Saluda Creek (Station 6), benthic sampling was conducted with a Surber square-foot sampler in both riffle and pool habitats. A Surber sampler samples 0.0929 m^2. Surber samples were preserved, identified and analyzed for biomass in the same manner as the Ponar samples.

Drift Macroinvertebrates

Drift sampling at Ohio River Stations 1, 3 and 5 was conducted in March, May, August and November 1981 using a pair of bongo nets towed from a boat. Nets were 200 cm long with 20-cm diameters and 505-μ mesh. Tows were made at each station for 10 minutes each at near-surface, middle, and near-bottom depths. The volume of flow through each net was measured with a General Oceanics Model 2030 flowmeter that was fixed in the mouth of the net. Samples were preserved and analyzed as previously outlined.

Macroinvertebrates

Long-term drift community analysis was conducted in March, May August and November using multiple-plate artificial substrate samplers (Hester and Dendy, 1962; Fullner, 1971). Each sampler has a surface area of 0.1626 m^2. At Stations 1, 3 and 5, samplers were suspended from floats approximately 1 m below the surface of the river. At Station 6, the samplers were hung just below the surface of Little Saluda Creek in areas where enough water was available to cover the samplers. All samplers were left in place for three weeks. Two replicate samplers were then retrieved from each station and scraped clean. The colonizing organisms were preserved, identified and analyzed for biomass using the methods previously outlined for benthic samples.

For both benthos and macroinvertebrate data, species diversity was expressed in terms of the Shannon-Weaver mean diversity index ($\bar{d}$), which is recommended by the EPA (1973). The equitability component of diversity (Lloyd and Ghelardi, 1964) was also applied to the data. Statistical procedures used in data analysis are described in Section H. Statistical Analysis Procedures.

RESULTS AND DISCUSSION

The benthic and macroinvertebrate faunas sampled during construction phase ecological monitoring near the Marble Hill Plant site were composed of oligochaete worms, molluscs, small crustaceans, immature insects, flatworms, hydrozoans and mites. No endangered or commercially valuable species were collected. A total of 9576 individuals of 98 benthic and macroinvertebrate species was collected (Table E-1). These were the highest numbers of individuals and species collected since construction phase monitoring began in 1977. Complete collection data are presented in Appendix Tables E-1 through E-28.

Ohio River Benthos

The benthic fauna of the Ohio River had a very patchy distribution. Density of individuals ranged from 48 to $2409/m^2$ in deep water and from 145 to $10,201/m^2$ in shallow water (Figure E-1). Because the substrate at the three Ohio River sampling stations was similar, it is presumed that the transitory presence of various microhabitats was responsible for the patchy distribution of benthic specimens. Mean densities recorded during 1981 were somewhat higher than those reported in previous studies at the Marble Hill site (Table E-2).

In 1981, the highest density (10,201 individuals/m^2) occurred in March at Station 5. While Station 5 usually has slightly higher densities than Stations 1 and 3, March is usually the month of lowest density (ABI, 1978, 1979, 1980, 1981). A mild winter and delay of spring flooding during 1981 was presumed to cause the density increase. During spring flooding (May), densities dropped significantly. Stations 1 and 3 also experienced higher than usual densities in March but not as great as Station 5. As in past years, density at offshore sampling stations was lower than that of inshore sampling stations (Figure E-1, Table E-2).

Biomass values in 1981 occurred in a very wide range and were generally higher than in previous years (Figure E-2, Table E-2). During 1981, 15 of the 24 samples collected at Stations 1, 3 and 5 had biomass values over 1 g/m^2. Previously, a maximum of only 7 of the 24 samples (from 1979) had biomasses of this magnitude. Increases were noted at every station and were attributed to a general increase in the density of Corbicula fluminea, the Asiatic clam. Higher biomass values are usually caused by the irregular occurrence of a large, heavy-bodied mollusc or the collection of several small molluscs. Insects, crustaceans and worms contribute a relatively small amount to total biomass because these animals are usually very small compared to molluscs. Biomass was higher in the second half of the year, a trend observed since 1977. As in the past, biomass was generally highest in November. Lowest biomass values occurred in May and, similar to the density data, was probably a result of the late spring flooding.

Diversity indices were generally low and ranged from 0.00 to 4.03 (Figure E-3). These values were similar to those encountered in previous monitoring (Table E-2). Diversity indices were usually highest in May and lowest in August.

With some exceptions, oligochaete worms dominated the benthic fauna at each of the river stations, particularly Station 5. The most numerous oligochaete worm species was Limnodrilus hoffmeisteri. Worms were more abundant at inshore locations where the bottom substrate was softer and more suitable for burrowing. The crustacean fauna was almost totally composed of the amphipod Gammarus pseudolimnaeus, while the most abundant mollusc was Corbicula fluminea. Both of these species were more abundant at offshore locations. The insect fauna was composed of immature individuals of flies, mayflies and caddisflies.

When compared to previous construction phase monitoring data, the most notable aspect of the benthic fauna collected in 1981 was the continued high number of Corbicula (Figure E-4). This trend was first noted in late 1980 with the appearance of numerous juvenile Corbicula. Most of the Corbicula encountered in 1981 were much larger individuals than those from 1980 and, consequently, contributed more to the higher total biomass observed during 1981.

The presence of Corbicula in the Ohio River at the Marble Hill site has been reported in each of the environmental studies conducted since 1974 (PSI, 1976; ABI, 1978, 1979, 1980, 1981). Throughout these studies, Corbicula has been most often collected at Station 3, which is located at the plant intake structure. The highest reported Corbicula density was 2005 individuals/m^2 at Station 2 in October 1974. (This station was sampled only during the 1974-75 baseline study.) Since that time, low density populations of Corbicula have been reported at Station 3 (and other sampling stations) usually in the latter half of the year. Between 1977 and 1980, however, the trend has been toward increasing Corbicula density (up to 727/m^2) with nearly year-round presence (Figure E-4). Data collected in 1981 indicated continued expansion of the size of the Corbicula community and, more importantly, in the size (and therefore, sexual maturity) of the individual clams.

The bottom of the Ohio River at Station 3 is composed of a hard mud and clay mixture with large amounts of eroding, unoccupied Corbicula shells estimated to have been over three years of age when death occurred. It is believed that these unoccupied shells are the remnants of a much larger Corbicula population than that which exists today. Horning and Keup (1964) reported that following several years of almost explosive population growth, a large decline in Corbicula populations occurred in the Ohio River. This phenomenon is not unusual among species imported from other locations. The initial exponential growth phase of population establishment is followed by a drastic drop in density which is, in turn, followed by several years in which population density oscillates above and below the optimum carrying capacity of the ecosystem. Data collected in recent years (ABI, 1981) indicate that the Corbicula population near the Marble Hill Plant's intake structure are again increasing in density apparently on one of the "overshoot" oscillations. Corbicula density of $564/m^2$ was reported at Station 3 in August 1981. Sickel (1979) observed similar population oscillations in the Altamaha River, Georgia, and estimated that the Corbicula population introduced there in 1971 would reach an equilibrium density sometime after 1984.

When 1981 benthos data were statistically analyzed, no significant differences were observed among seasons or stations for biomass or diversity (Table E-3). Station 1 had significantly lower density than either Stations 5 or 3 (Table E-3). While Station 1 has frequently had lower mean densities than Stations 5 or 3, the difference among means has rarely proven statistically significant. The unusually large number of worms collected at Station 5 in March 1981 undoubtedly contributed toward a greater than usual difference between the density means at Stations 1 and 5. Station 3 had lower density than Station 5, but not significantly so. Seasonal density differences were not observed (Table E-3).

Because no statistically significant station differences were observed among biomass or diversity means, there is no evidence to suggest impact upon these parameters of the Ohio River benthos by construction at the Marble Hill site during 1981. The sole statistical difference observed among station density means was attributed to the unusual lateness of spring flooding during 1981 and was in no way related to plant activities.

Ohio River Macroinvertebrates

Density of the macroinvertebrate fauna of the three Ohio River stations was lowest in May and highest in August (Figure E-5). Lowest densities usually occur in March but the usual pattern of density variation was apparently disrupted in 1981 by late spring floods. Other than the timing of the low density period, 1981 macroinvertebrate density in the Ohio River was similar to those of past years (Table E-4). The high density period has occurred in August every year since 1977 and was primarily a result of larval caddisfly populations, which are largest in late summer just after egg laying (Wiggins, 1977).

Biomass followed the same pattern of variation as density, being lowest in May and highest in August (Figure E-6). August biomass ranged from 0.947 to 1.728 g/m^2 and was much higher than the biomass found in other months (range of 0.012 to 0.129 g/m^2). Overall, biomass data were similar to that collected in previous studies (Table E-4).

Diversity of the macroinvertebrates was generally higher and much less variable than in the benthos samples (Figure E-7). Diversity values remained relatively high throughout the year and was not as seasonally variable as in past studies. They were also generally higher than in the past (Table E-4) and reflected the general increase in the number of species collected in 1981.

Immature insects, primarily caddisflies, comprised over 98 percent of the total macroinvertebrate specimens collected during 1981. Crustaceans, primarily the amphipod Gammarus pseudolimnaeus, were present only in August and November in small numbers. No molluscs were collected and only small numbers of worms were collected in March, August and November.

When the macroinvertebrate data were statistically analyzed, no significant differences in density, biomass or diversity were observed among stations (Table E-5). These analyses suggest that plant activities do not impact the downstream sampling stations in any way. Significant seasonal differences in density and biomass were observed (Table E-5). In both cases, the source of the significant difference among seasonal means was the high density and biomass noted in August. As related earlier, this high density and biomass season is a result of the increased caddisfly population. This increase is an annual, well-documented occurrence (Mason et al., 1971). It is in no way related to plant activities. No seasonal differences among diversity means were observed in 1981.

Little Saluda Creek Benthos

Density of the benthos in Little Saluda Creek was usually higher in riffle habitats (up to 2164 individuals/m^2) than in pool habitats (up to 974 individuals/m^2) and was highest in November for both habitats (Figure E-1). Biomass was also higher in riffle habitats and was lowest in August (0.097 g/m^2) and highest in March (3.864 g/m^2). Pool biomass followed a similar trend and ranged from 0.032 to 3.283 g/m^2 (Figure E-2). Major contributors to the high March biomass were some very large worms (Nais communis) and isopods (Lirceus fontinalis).

Diversity index values ranged from 0.35 to 2.26 in riffles and from 0.77 to 2.46 in pools. Diversity appeared to be generally similar to 1980 and lower than in 1979 primarily as a result of increased populations of the isopod Lirceus (Figure E-3). Lirceus dominated the fauna in all months of 1981 for the first time since baseline studies were conducted.

In past years, density and biomass were usually highest in August or November and lowest in March (ABI, 1977, 1978, 1979, 1980, 1981). Spring flooding of Little Saluda Creek had occurred in March of previous years, before most benthic species began to reproduce. In 1981, however, spring flooding occurred in May and washed the newly spawned, high density benthos community found in March back into the river. The high density community found in November was primarily composed of very small Lirceus as evidenced by the relatively low biomass for that month (Figures E-1 and E-2). These juvenile isopods were obviously the product of the late summer reproductive period.

Density and biomass in Little Saluda Creek generally declined from 1977 through 1979 while diversity simultaneously increased (Table E-6). These trends were a result of changes in the benthic fauna of Little Saluda Creek caused by increased sedimentation in the form of erosion runoff from the Marble Hill site (ABI, 1980). During the baseline study and through May 1978 construction phase monitoring, the isopod Lirceus was the dominant benthic species in Little Saluda Creek (Figure E-8). The degree of dominance by Lirceus declined steadily through 1979 due to eroded sediment from the plant site settling in the stream and rendering Little Saluda Creek substrates unsuitable for a large Lirceus population. During 1979, sedimentation was markedly reduced, and deposits were washed from the creek by high water flow during spring 1980. This allowed recolonization by Lirceus from upstream areas and resulted in Lirceus forming a much larger segment of the benthic fauna. The increase in Lirceus density caused a concomitant decrease in diversity. Recolonization by Lirceus suggests that the creek is recovering from 1978 and 1979 plant construction impacts. By November 1981, Little Saluda Creek had effectively regained the community structure observed before construction began at the Marble Hill site (Figure E-8).

Little Saluda Creek Macroinvertebrates

Macroinvertebrate density in Little Saluda Creek ranged from 181 to 950 individuals/m^2 in March and May, respectively (Figure E-5). Biomass varied in a similar manner with lowest values recorded in August (0.068 g/m^2) and highest values in March (0.873 g/m^2, Figure E-6). Macroinvertebrate diversity in the creek was lowest in March and highest in May (Figure E-7). Because of the differences in habitat, variation in the macroinvertebrate community of Little Saluda Creek bore little relationship to variation in the macroinvertebrate community of the Ohio River.

As with the benthic fauna of the creek, seasonal patterns of variation in macroinvertebrate density, biomass and diversity were somewhat different from those of past years because of the lateness of the spring floods. In addition, trends observed in the benthos such as increasing Lirceus populations, increasing density and biomass, and decreasing diversity, were also apparent in the macroinvertebrate community when data from past studies were compared (Table E-7).

Results of the 1981 macroinvertebrate monitoring program in Little Saluda Creek reinforce the hypothesis that the creek is essentially recovered from past plant construction impacts.

Ohio River Drift Macroinvertebrates

A total of 191 specimens representing 22 taxa were collected during drift macroinvertebrate sampling. The fauna was primarily composed of small crustaceans, but oligochaete worms, clams, insect larvae and hydroids were also present. Hydroids were particularly abundant in November when they comprised nearly 72 percent of the specimens collected. Generally, the drift fauna was dominated by organisms usually considered zooplanktonic.

When sampling began in late March, density was less than 0.2 individuals/m^3. Densities were higher in May and in August (0.0 to 0.7/m^3). Density was also generally low in November but the range was greater than in August (0.1 to 1.4/m^3). This pattern of seasonal density variation was very similar to that of 1980 (ABI, 1981). Overall density, the total number of specimens and total number of species was much lower, however. As in previous years, samples taken near the bottom of the river usually had greater densities than either surface or mid-depth samples.

Statistical analysis of the drift macroinvertebrate data from 1981 revealed no significant statistical differences among sampling stations at any depth or when all sampling depths were combined (Table E-8). Because no statistical differences were found, the data indicate that construction activity at the Marble Hill plant site does not affect drift macroinvertebrate density in the Ohio River.

CONCLUSIONS

The benthic and macroinvertebrate fauna of the Ohio River were of highly variable density, biomass and diversity. Data collected during the 1981 construction phase ecological monitoring program showed a somewhat higher density and biomass but lower diversity than was found at the Marble Hill Plant site during previous monitoring programs. Changes in the benthic and macroinvertebrate fauna of the Ohio River observed during 1981 were a result of annual or seasonal changes in the environment rather than construction activity at the Marble Hill Plant site.

From 1977 to 1980, density and biomass decreased in Little Saluda Creek and diversity increased. These trends probably resulted from excessive sedimentation in the creek caused by erosion at the Marble Hill site. Procedures to stop sedimentation in the creek were apparently successful, and these trends were reversed in 1980. They remained so in 1981. This suggests that the benthic and macroinvertebrate communities of the creek are recovering their preconstruction structures.

Drift macroinvertebrate collections in the river had lower densities in 1981 than in 1980. No statistically significant differences related to plant construction were found among station densities. The drift community was sparsely populated by benthic invertebrates and was numerically dominated by zooplanktonic forms. Construction at the Marble Hill Plant site does not appear to have influenced or inhibited the drift macroinvertebrate community.

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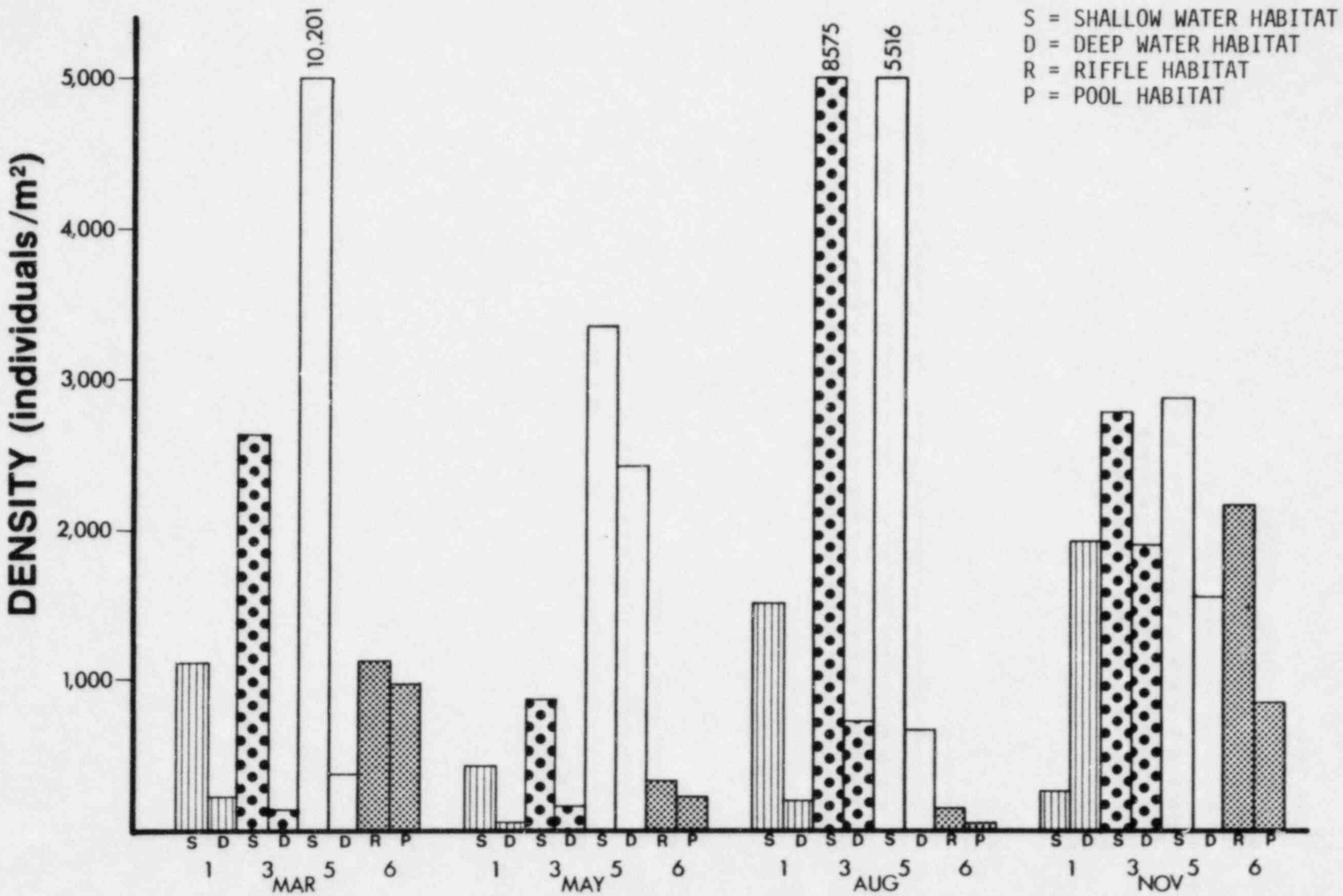

Figure E-1. Density of the benthos at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1981.

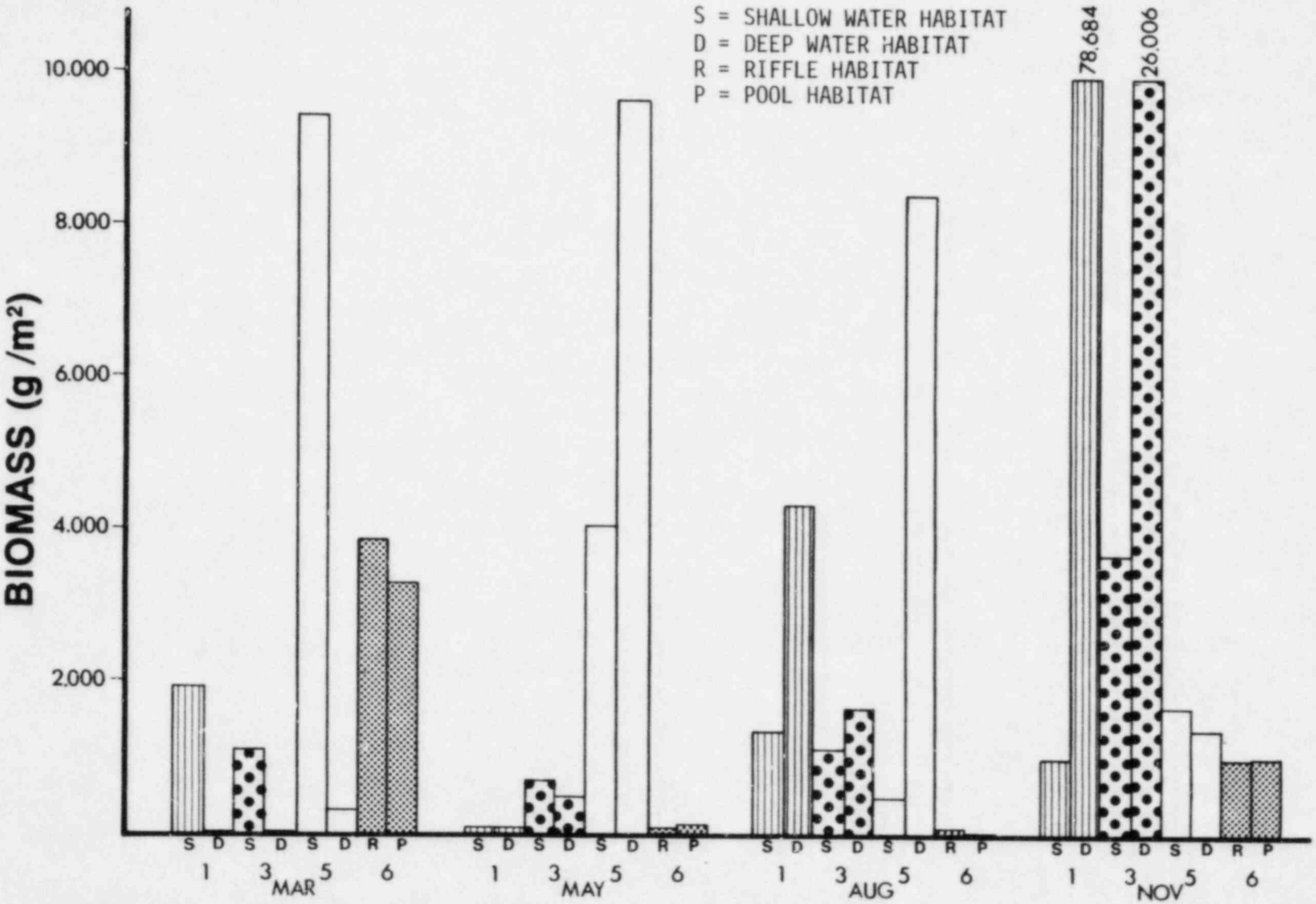

Figure E-2. Biomass of the benthos at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1981.

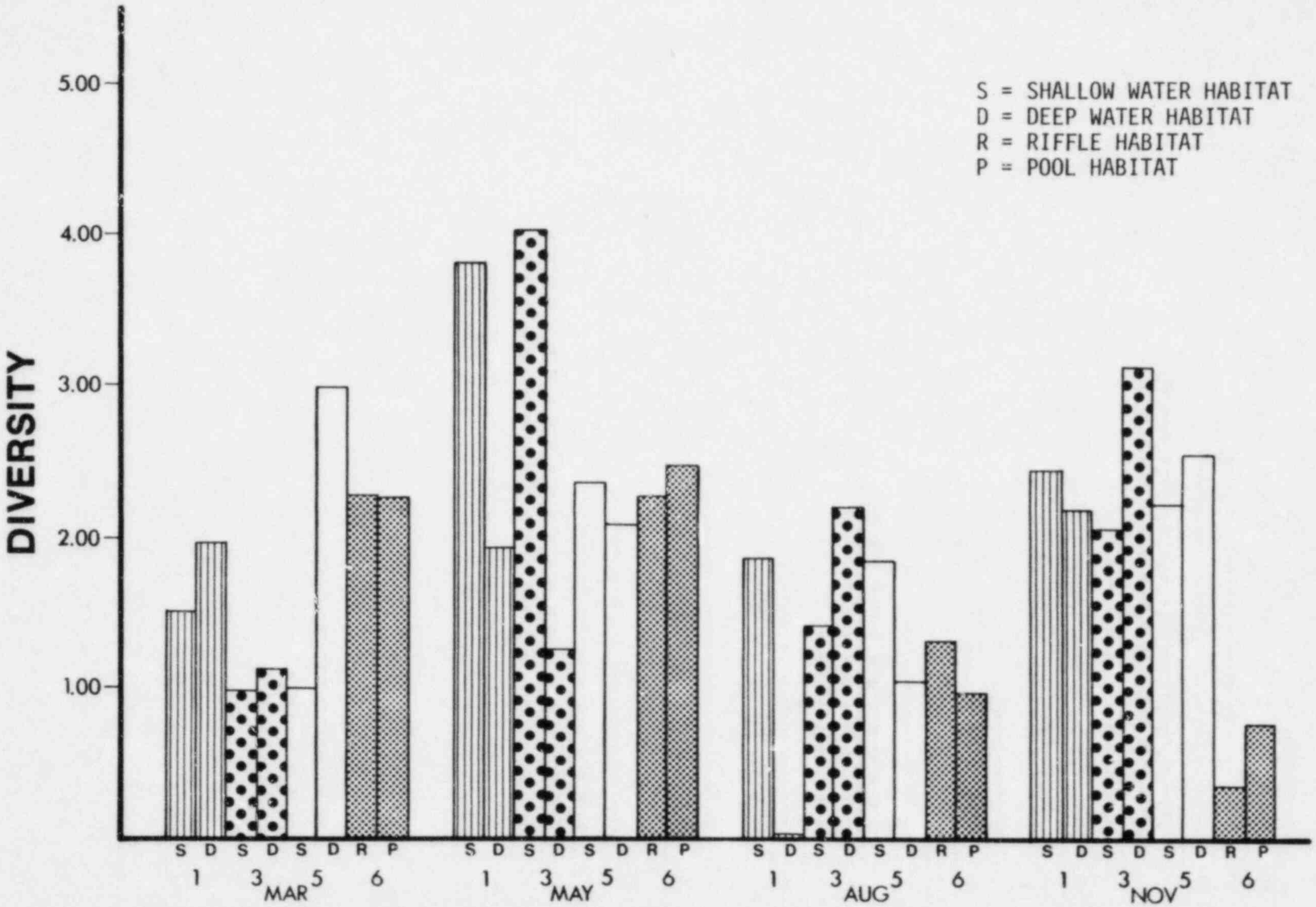

Figure E-3. Diversity of the benthos at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1981.

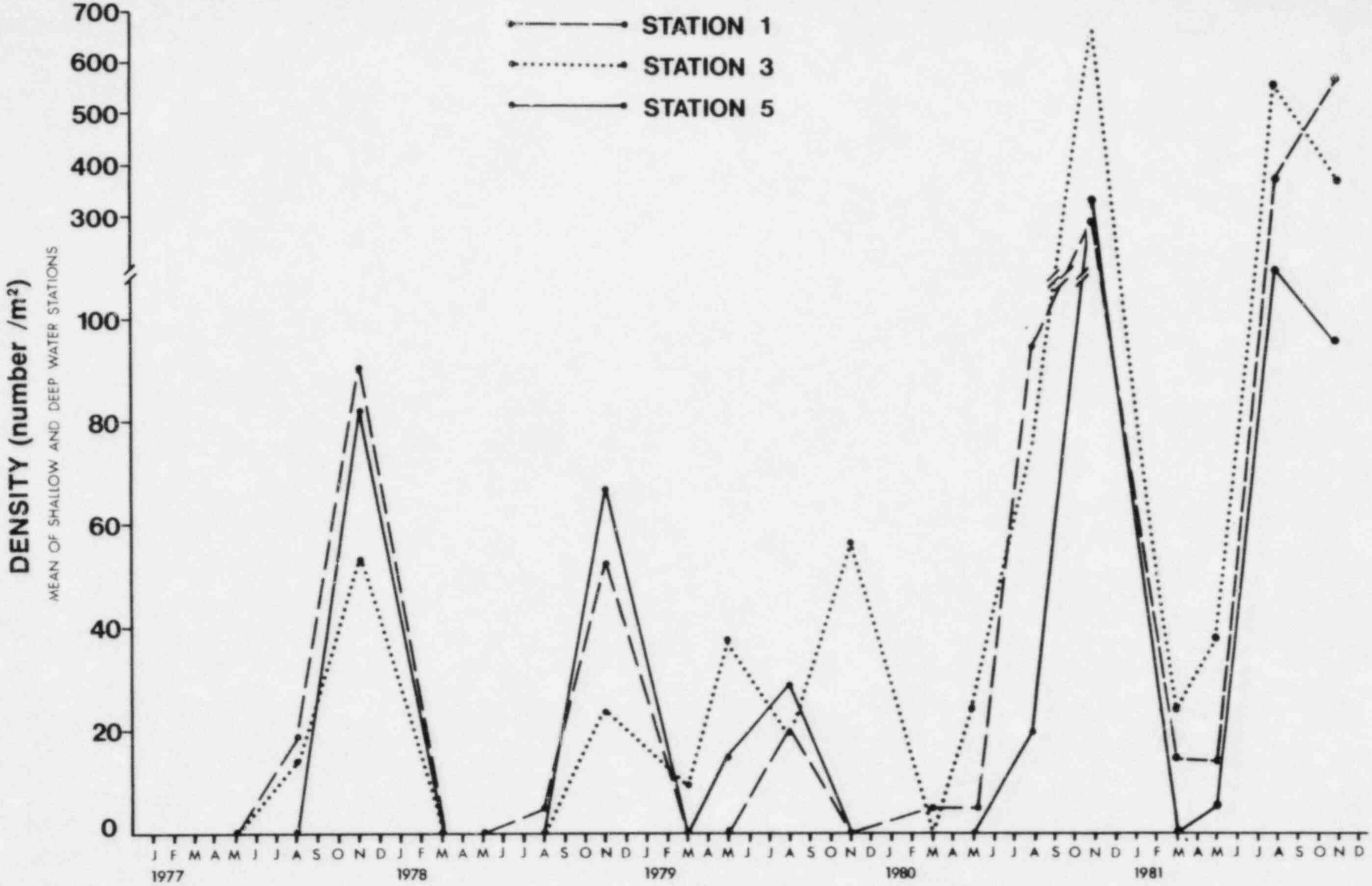

Figure E-4. Density of Corbicula fluminea in the Ohio River at the Marble Hill Plant site, 1977-1981.

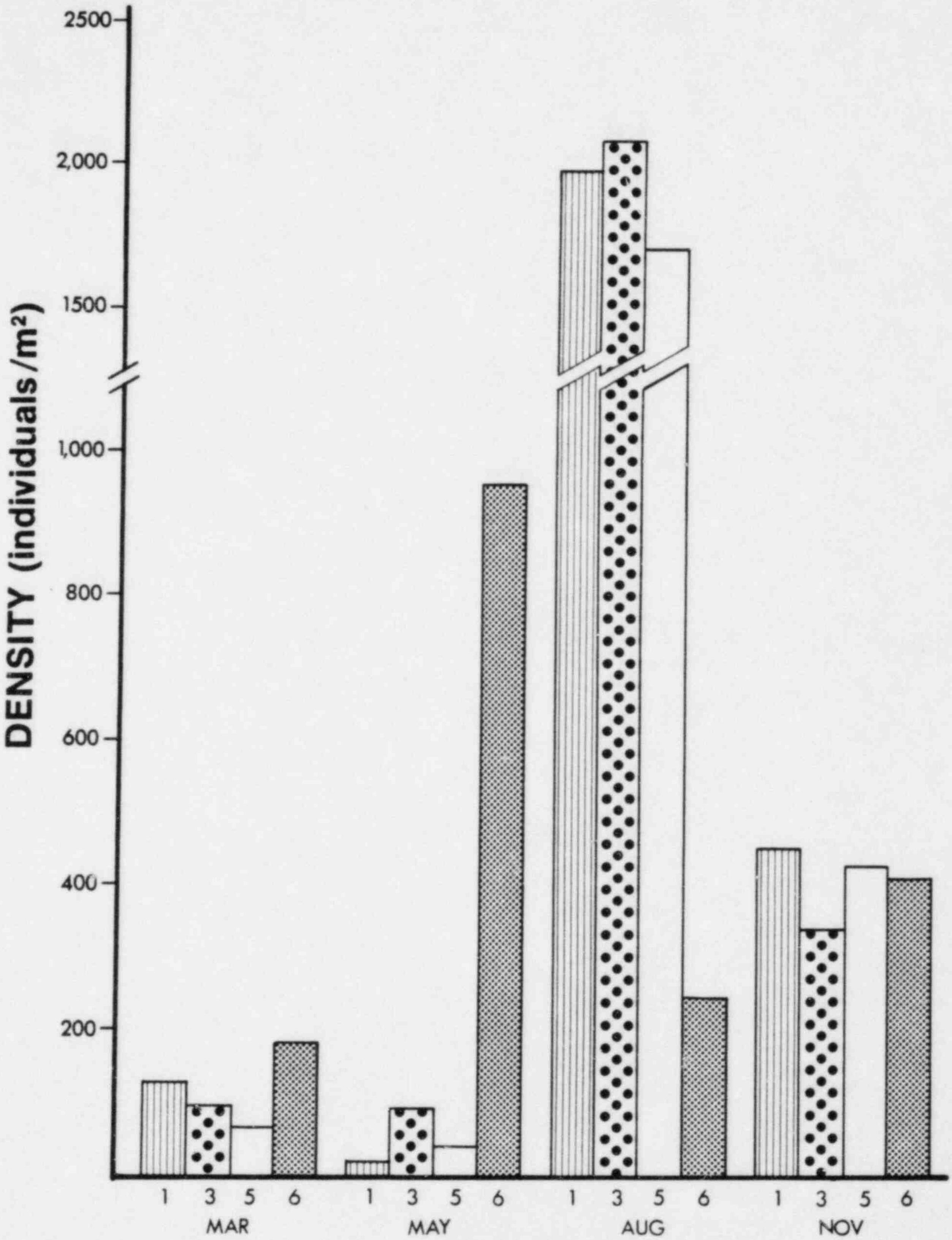

Figure E-5. Macroinvertebrate density at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1981.

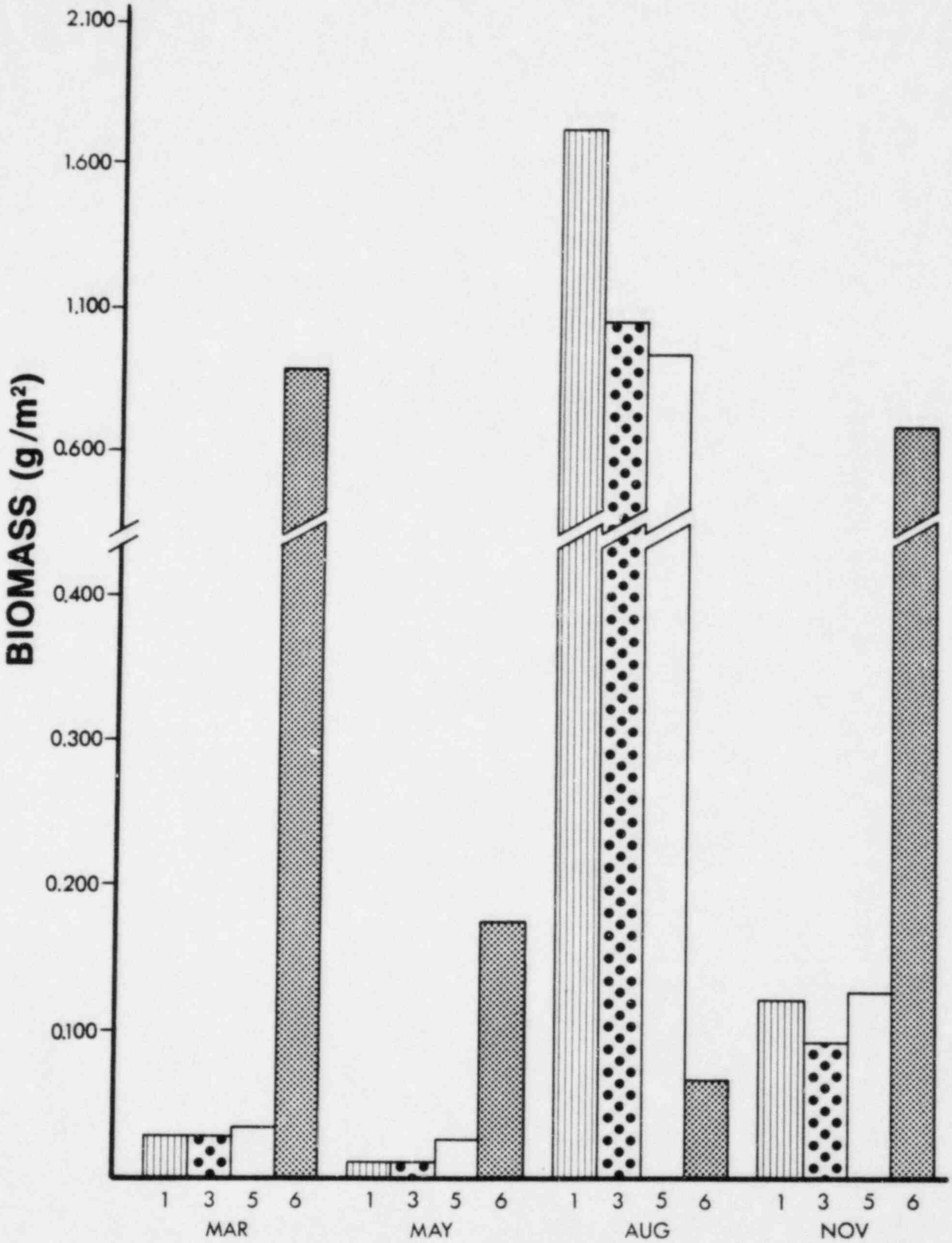

Figure E-6. Macroinvertebrate biomass at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1981.

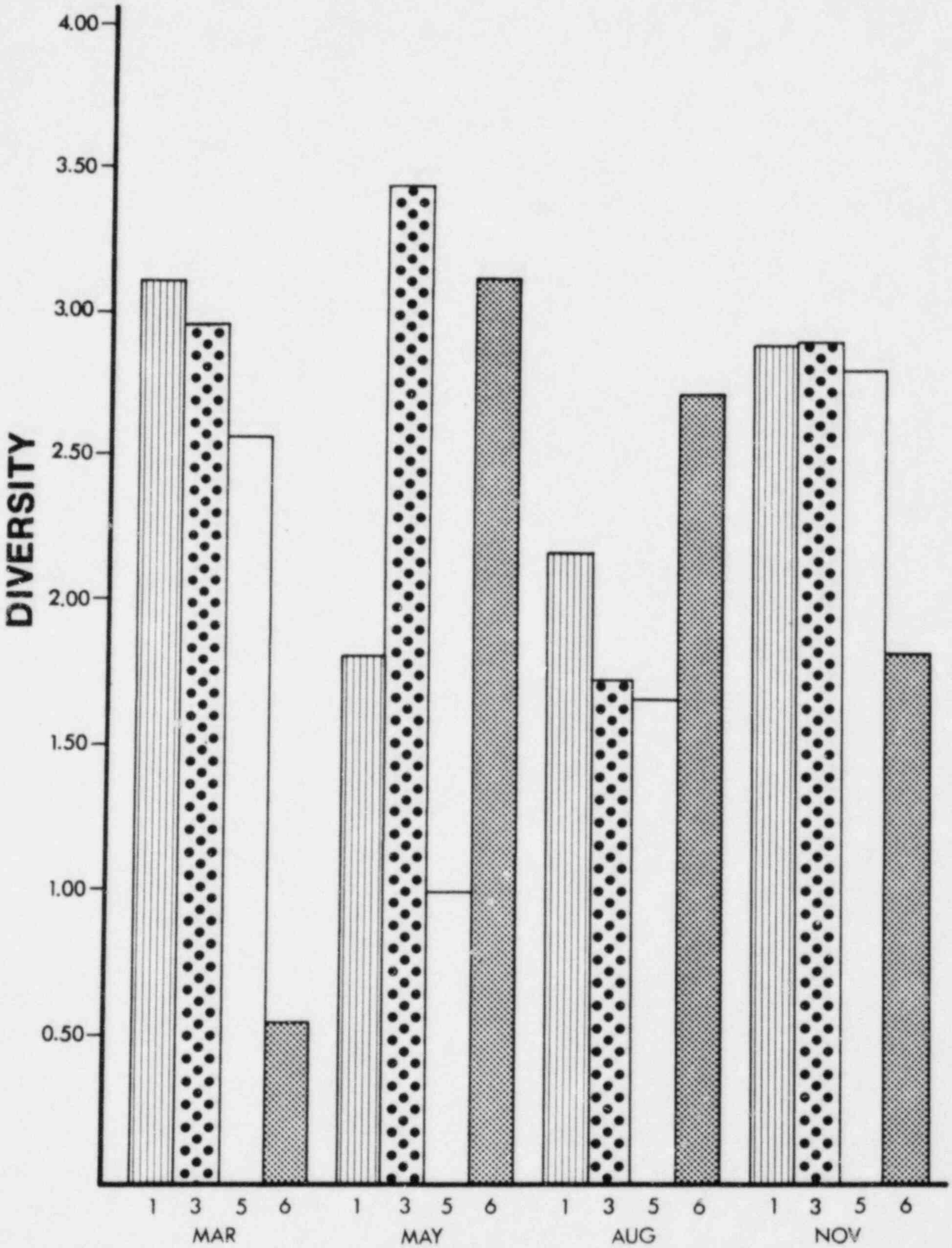

Figure E-7. Macroinvertebrate diversity at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6 Marb'e Hill Plant site, 1981.

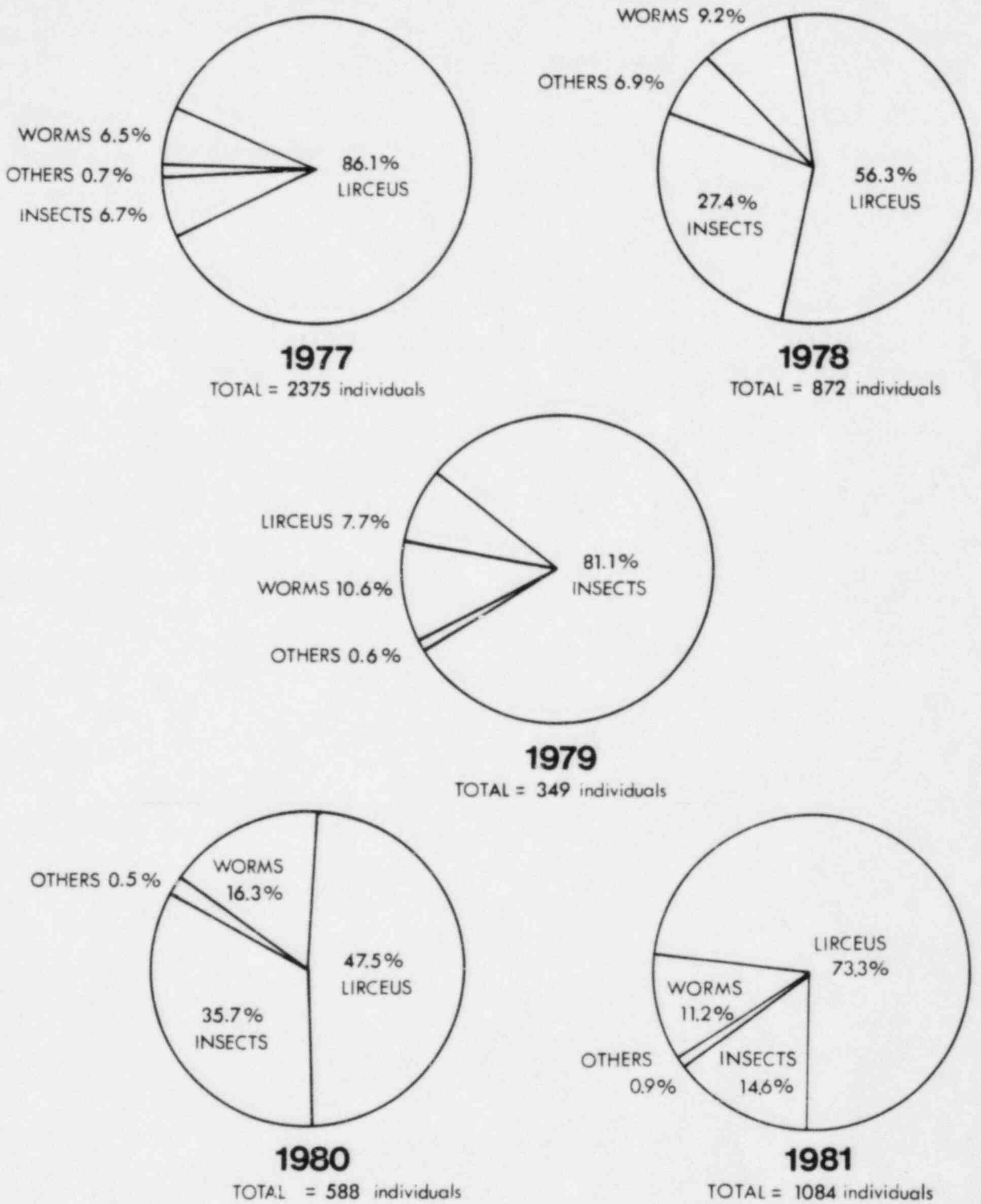

Figure E-8. Percentage composition of the benthic fauna in Little Saluda Creek, Marble Hill Plant site, 1977-1981.

TABLE E-1

OCCURRENCE OF BENTHIC AND MACROINVERTEBRATE SPECIES
MARBLE HILL PLANT SITE
1981

Species	Station 1	3	5	6
Class Hydrozoa				
Hydra sp.	X	X	X	
Class Turbellaria				
Phagocata velata		X	X	X
Class Oligochaeta				
Branchiura sowerbyi		X	X	X
Chaetogaster sp.		X		
Enchytraeidae	X			
Limnodrilus hoffmeisteri	X	X	X	
L. maumeensis		X		X
L. undekemianus			X	
Lumbriculus variegatus		X	X	
Lumbriculidae			X	X
Nais communis		X		X
N. elinguis	X	X		X
Peloscolex sp.		X	X	
immature Tubificidae	X	X	X	X
Waspa mobilis		X		
Class Arachnida				
Arrenurus sp.	X	X		
Class Crustacea				
Argulus stizostethi	X	X	X	
Gammarus pseudolimnaeus	X	X	X	
Lirceus fontinalis				X
Synurella dentata				X
Class Insecta				
Order Diptera				
Ablabesmyia mallochi	X			X
Chaoborus punctipennis	X	X	X	
Chironomus plumosus	X	X	X	X
Coelotanypus concinnus	X	X	X	
C. scapularis			X	
C. tricolor				X
Corynoneura sp.		X		X
Cricotopus sp.	X		X	
C. bicinctus	X	X	X	X
C. trifasciata	X	X	X	
C. tremulus		X		
Cryptochironomus blarina	X	X	X	

TABLE E-1
(continued)
OCCURRENCE OF BENTHIC AND MACROINVERTEBRATE SPECIES
MARBLE HILL PLANT SITE
1981

Species	Station 1	3	5	6
Class Insecta (continued)				
Order Diptera (continued)				
Cryptochironomus digitatus				X
C. fulvus	X	X	X	X
Eukiefferiella sp.	X	X	X	
Glyptotendipes (*lobiferus* ?)			X	
Hemerodromia sp.	X	X		X
Labrundinia pilosella	X	X		
Limnochironomus neomodestus	X	X	X	
L. nervosus		X		X
Nanocladius distinctus	X	X	X	
Orthocladius sp.	X	X	X	X
Palpomyia sp.			X	
Parachironomus abortivus ?		X	X	X
Phaenopsectra dyari				X
Polypedilum convictum	X	X	X	
P. halterale	X		X	X
P. illinoense	X	X	X	X
P. scalaenum	X	X	X	
Procladius sp.	X		X	X
Rheotanytarsus sp.	X	X	X	X
Simulium rugglesi	X		X	
S. vittatum	X	X		
Stictochironomus sp.	X	X		X
Tanypus sp.		X		X
Tanytarsus sp.	X	X		X
Thienemanniella sp.	X	X		X
T. xena	X	X	X	
Xenochironomus sp.	X	X		
Order Trichoptera				
Ceraclea sp.			X	
Cheumatopsyche sp.				X
Cyrnellus fraternus	X	X		
Diplectrona modesta				X
Hydropsyche orris	X	X	X	X
H. simulans			X	X
Macronema transversum				X
Neureclipsis crepuscularis	X	X	X	
Ochrotrichia (*viesi* ?)	X	X	X	
Oecetis sp.	X			
Potamyia flava	X	X	X	X
Order Plecoptera				
Isoperla ? sp.				X
Isoperla clio	X	X		

TABLE E-1
(continued)
OCCURRENCE OF BENTHIC AND MACROINVERTEBRATE SPECIES
MARBLE HILL PLANT SITE
1981

Species		Station 1	3	5	6
Order Ephemeroptera					
Anepeorus sp.			X		
Baetis cingulatus		X	X	X	
B. intercalaris					X
Caenis sp.		X		X	
Hexagenia limbata			X	X	
Stenonema sp.		X			
Stenonema exiguum		X	X	X	X
S. integrum		X	X		
S. pulchellum		X	X		
S. tripunctatum		X	X	X	X
Stenacron interpunctatum		X	X	X	X
Order Odonata					
Coenagrion sp.			X		
Didymops sp.			X	X	
Gomphus quadricolor		X		X	
Taeniopteryx nivalis		X			
Order Coleoptera					
Donacia sp.				X	
Psephenus herricki					X
Class Pelecypoda					
Corbicula fluminea		X	X	X	
Lampsilis sp.				X	
Sphaerium sp.			X	X	
S. striatinum			X		
Class Gastropoda					
Amnicola sp.					X
Ferrissia parallela					X
Physa sp.		X			
Physa elliptica					X
Somatogyrus sp.		X		X	
Taxa per station		55	61	54	45
Total taxa	98				
Individuals per station		1475	2682	3754	1665
Total individuals	9576				

TABLE E-2

COMPARISON OF BENTHIC DATA COLLECTED AT OHIO RIVER
STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1977 - 1981

Year	Density range (no./m^2)		Biomass range (g/m^2)		Diversity range	
	Shallow water	Deep water	Shallow water	Deep water	Shallow water	Deep water
1981	145-10,201	48-2409	0.097-9.446	0.019-78.684	0.35-4.03	0.00-3.83
1980	0-6052	10-2218	0.000-3.346	0.038-6.711	0.00-2.53	0.00-2.58
1979	38-2719	19-977	0.019-2.620	0.019-2.084	0.16-2.65	0.00-4.02
1978	38-3499	153-1644	0.038-0.859	0.019-1.948	0.93-2.63	0.74-3.20
1977	182-2782	10-1635	0.172-3.098	0.004-3.614	1.23-2.83	0.00-2.63

TABLE E-3

STATISTICAL ANALYSIS OF BENTHIC SAMPLING DATA
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1981

ANALYSIS OF VARIANCE

Parameter	Comparison	Calculated F value	Critical F value
Density	by season	2.84	4.76
	by station	9.88*	5.14 (see below)
Biomass	by season	0.10	4.76
	by station	1.41	5.14
Diversity	by season	3.47	4.76
	by station	0.21	5.14

*Significant difference at $P \leq 0.05$.

DUNCAN'S MULTIPLE RANGE TEST

DENSITY BY STATION	Mean density (no./m^2)	Grouping[a]
5	3358	A
3	1604	A
1	624	B

[a]Means with the same group letter are not significantly different at $P \leq 0.05$.

TABLE E-4

COMPARISON OF MACROINVERTEBRATE DATA COLLECTED AT OHIO RIVER
STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1977 - 1981

Year	Density range (no./m^2)	Biomass range (g/m^2)	Diversity range
1981	18-2070	0.012-1.728	0.99-3.43
1980	0-3958	0.006-1.851	0.00-3.30
1979	9-2260	0.006-1.328	1.45-2.95
1978	114-1233	0.031-1.525	2.01-3.04
1977	12-1584	0.001-2.116	0.81-2.80

TABLE E-5

STATISTICAL ANALYSIS OF MACROINVERTEBRATE SAMPLING DATA
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1981

ANALYSIS OF VARIANCE

Parameter	Comparison	Calculated F value	Critical F value
Density	by season	38.65*	4.76 (see I. below)
	by station	0.46	5.14
Biomass	by season	51.23*	4.76 (see II. below)
	by station	1.10	5.14
Diversity	by season	1.20	4.76
	by station	1.51	5.14

*Significant difference at $P \leq 0.05$.

DUNCAN'S MULTIPLE RANGE TEST

I. DENSITY BY SEASON	Mean density (no./m^2)	Grouping[a]
August	1909	A[a]
November	404	B
March	91	C
May	40	C

II. BIOMASS BY SEASON	Mean biomass (g/m^2)	Grouping[a]
August	1.217	A[a]
November	0.120	B
March	0.033	B
May	0.016	B

[a]Means with the same group letter are not significantly different at $P \leq 0.05$.

TABLE E-6

COMPARISON OF BENTHIC DATA COLLECTED AT
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1977 - 1981

	Density range (no./m^2)		Biomass range (g/m^2)		Diversity range	
Year	riffle	pool	riffle	pool	riffle	pool
1981	145-2164	48-974	0.097-3.864	0.032-3.283	0.35-2.26	0.77-2.46
1980	172-2198	43-1023	0.258-4.034	0.012-2.180	0.88-2.19	1.16-2.44
1979	5-942	11-398	0.005-0.544	0.005-0.070	0.00-3.26	0.00-2.52
1978	107-1674	65-1588	0.054-0.732	0.048-1.572	1.27-3.23	0.89-2.69
1977	1647-3498	145-603	1.781-6.206	0.172-0.511	0.40-1.66	0.53-1.65

TABLE E-7

COMPARISON OF MACROINVERTEBRATE DATA COLLECTED AT
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1977 - 1981

Year	Density range (no./m^2)	Biomass range (g/m^2)	Diversity range
1981	181-950	0.068-0.873	0.55-3.11
1980	188-480	0.062-1.562	1.90-2.29
1979	40-387	0.025-0.185	2.07-3.00
1978	18-311	0.080-0.664	0.24-2.29
1977	9-1602	0.018-2.503	0.60-2.39

TABLE E-8

STATISTICAL ANALYSIS OF DRIFT MACROINVERTEBRATE DATA
MARBLE HILL PLANT SITE
1981

T-TESTS

Depth	Comparison	Calculated t(P=0.05)	Critical t(P=0.05)	Result
Surface	Station 1 - Station 3	0.489	2.145	n.s.[a]
	Station 1 - Station 5	-0.357	2.145	n.s.
	Station 3 - Station 5	-0.878	2.145	n.s.
Mid-depth	Station 1 - Station 3	-1.057	2.145	n.s.
	Station 1 - Station 5	0.475	2.145	n.s.
	Station 3 - Station 5	1.570	2.145	n.s.
Bottom	Station 1 - Station 3	0.810	2.145	n.s.
	Station 1 - Station 5	1.305	2.145	n.s.
	Station 3 - Station 5	1.729	2.145	n.s.
All depths combined	Station 1 - Station 3	0.387	2.015	n.s.
	Station 1 - Station 5	1.354	2.015	n.s.
	Station 3 - Station 5	1.231	2.015	n.s.

[a]n.s. = No significant difference.

F. FISH

INTRODUCTION

Riverine habitats are often characterized by rapidly fluctuating environmental conditions. Chemical composition, current velocities, water levels and stream widths vary, and waters are often turbulent and muddy. While the fish communities found in these habitats are adapted to a fluctuating environment, the effects of industrial development could alter fish populations or community composition by causing additional stresses.

The purpose of this study was to determine the species composition and abundance of fish near the Marble Hill Plant site during plant construction. Results of this study were compared with those obtained during the 1974-1975 baseline study (PSI, 1976) to determine if changes in fish community composition have occurred as a result of plant construction activity. Comparisons were also made with the 1977 through 1980 construction phase ecological monitoring programs (ABI, 1978, 1979, 1980, 1981).

MATERIALS AND METHODS

Gill Netting

Collections were made during each quarterly sampling period at Ohio River Stations 1, 3 and 5 with gill nets measuring 30.5 m long by 1.8 m deep. The nets were constructed of three 10.2-m panels sewn end-to-end with mesh sizes of 25.4-, 38.1- and 50.8-mm^2. The nets were set on the bottom and held perpendicular to the shore from nearshore shallows to depths of about 4 m. The nets were fished for two consecutive 24-hour periods; fishes were removed from the nets and analyzed after each period. Two nets were fished about 30 m apart at each station. Results were expressed as number of fish per net-hour.

Electrofishing

Electrofishing collections were made during daylight hours during each quarterly sampling period at Ohio River Stations 1, 3 and 5 and at Little Saluda Creek Station 6. River stations were sampled with a direct-current (DC) shocking assembly (Smith-Root Model VI-A) powered by a Honda 3500-watt, 115-volt, single-phase generator connected to two electrodes suspended approximately 2 m in front of the boat. Current was automatically pulsed at 60 or 120 pulses per second (pps) depending on water quality and fish response. A shocking run was completed by running the boat upstream as close to the shore as the boat's draft would allow. The Little Saluda Creek station was electrofished with a battery-powered Smith-Root Model VII backpack shocker that produced a 500-volt DC charge automatically pulsed at 40 to 80 pps between hand-held electrodes. In both cases, fishes stunned by the electric current were removed from the water by operators using wooden-handled dip nets.

Electrofishing effort was measured at each station by distance fished, which was 150 m at Ohio River stations and 50 m in Little Saluda Creek. Two replicate samples were taken over these distances at each station. Results were expressed as number of fish per meter of shoreline electrofished.

Seining

Collections were made by seining during each quarterly sampling period at Little Saluda Creek Station 6. The seine was 9.1 m long by 1.2 m deep and of 3-mm^2 mesh. Two replicate seine hauls were made over a distance of 50 m during each sampling period. Results were expressed as number of fish per meter of shoreline seined.

Analytical Methods

Fish were identified to the lowest practicable taxon, counted, measured, weighed and examined for ectoparasitic infestations. Taxonomic nomenclature is in accordance with Bailey et al. (1970). The total length (TL) of each fish was measured to the nearest millimeter and weight was measured to the nearest gram. Fish were individually analyzed, with the exception of small (TL <50 mm) species such as shiners. The range of total lengths and the combined weights were recorded for individuals of each of these small species. Live fish were released after sampling unless needed for taxonomic verification.

The coefficient of condition (K) is an expression of the condition, plumpness or well-being of a fish (Carlander, 1969). The coefficient of condition was calculated as follows for each individual weighed and measured:

$$K = \frac{W10^5}{L^3}$$

where: W = Weight, in grams;

10^5 = Factor to bring the value of K near unity;

L = Length, in millimeters.

Statistical procedures used in data analysis are described in Section H. Statistical Analysis Procedures.

RESULTS AND DISCUSSION

A total of 39 fish taxa representing 10 families were collected during the 1981 monitoring program (Table F-1). A complete list of fishes collected with length, weight and condition factor by date, station and collection method is presented in Appendix Tables F-1 through F-16. Because the Ohio River and Little Saluda Creek represent two entirely different habitats having separate indigenous fish communities, they will be discussed separately.

Ohio River

A total of 615 fish representing 26 species were collected by gill netting and electrofishing at Ohio River Stations 1, 3 and 5 (Table F-2). Of these fish, 12 species are of sport or commercial value. Sport fishes include white bass, rock bass, smallmouth and largemouth bass, longear sunfish, green sunfish, bluegill, black crappie and sauger, and the commercial fishes include smallmouth buffalo, channel catfish and freshwater drum (Preston and White, 1978). No rare, threatened or endangered species were found.

Gill netting yielded the majority of the fish collected in the Ohio River, and most of these were collected during the August sampling period (Figure F-1, Table F-3). The 1981 gill netting catch per unit of effort (CPUE) ranged from 0.052 at Station 3 during November to 0.375 fish per net-hour at Station 1 during August (Table F-3). The annual CPUE was 0.224 fish per net-hour at Station 1, 0.133 at Station 3, and 0.227 at Station 5. The differences in CPUE among stations were not significantly different (Table F-4). Although some annual variation was observed in gill netting CPUE, no significant differences in CPUE were found among years (Figure F-2; Table F-5).

The 1981 electrofishing CPUE ranged from 0.007 to 0.480 fish per meter of shoreline. Overall, the CPUE was 0.072 fish per meter of shoreline at Station 1, 0.122 at Station 3 and 0.134 at Station 5 (Table F-3). No significant difference in CPUE was found among stations electrofished (Table F-4).

The electrofishing CPUE during the present study was appreciably higher than during the 1980 study (Figure F-2). Statistically, the electrofishing CPUE during 1981 was significantly higher than the CPUE observed during 1977, 1978 or 1980 (Table F-5). Because no consistent upward or downward trends were observed in CPUE among studies, the higher CPUE found during 1981 was probably due to natural yearly variations in fish populations.

Gizzard shad was the most abundant species of fish collected in the Ohio River and accounted for 40.1 percent of the total number of fish (Table F-2). The majority (72.5 percent) of the gizzard shad were collected during the November sampling period. Gizzard shad are schooling fish that feed primarily on plankton. They have no sport or commercial value, but juveniles are important as forage for larger fish (Scott and Crossman, 1973; Preston and White, 1978). Condition factors for gizzard shad ranged from 0.39 to 1.76 with an overall mean of 0.92 during the 1981 study.

Emerald shiner was the second most abundant species collected and accounted for 27.1 percent of the number of fish (Table F-2). The majority (82.6 percent) of emerald shiners were collected during the November sampling period. This fish is probably the most abundant species in the Ohio River and the lower portions of its larger tributaries (Clay, 1975). It is a schooling species with populations that fluctuate widely in abundance from year to year (Scott and Crossman, 1973). Emerald shiners are an important forage species and are often used as bait in sportfishing.

Longnose gar made up 6.0 percent of the total number of fish collected and ranked third in abundance (Table F-2). This species was collected during every sampling period except November. Longnose gar are large carnivores common in the middle Ohio River. They have no sport, commercial or forage value (Preston and White, 1978). Condition factors for longnose gar ranged from 0.18 to 0.92 with an overall mean of 0.26.

Channel catfish was the fourth most abundant fish collected and accounted for 5.5 percent of the total number of fish (Table F-2). This omnivorous species was found during every sampling period and has both sport and commercial importance in the Ohio River. Condition factors for channel catfish ranged from 0.76 to 1.14 with an overall mean of 0.93.

All other species individually accounted for 4.2 percent or less of the total number of fish collected. These were skipjack herring, goldeye, mooneye, carp, silver chub, six species of suckers, flathead catfish, white bass, rock bass, green sunfish, bluegill, longear sunfish, smallmouth and largemouth bass, black crappie, sauger and freshwater drum (Table F-2).

Interstation comparisons indicated that all stations were basically similar with regard to the fish communities present. Overall observations indicate that the fish communities at these stations are typical of those found in the Ohio River.

Depending upon the study year, the most abundant species collected during all five monitoring programs was either the gizzard shad (Clupeidae) or emerald shiner (Cyprinidae; Figure F-3). The relative abundance of both these species has varied widely among years. Because both are schooling species, annual changes in relative abundance may be attributed to their chance occurrence during the quarterly sampling periods. Annual variations may also be caused by natural yearly cycles in fish populations. For example, emerald shiner populations are known to fluctuate widely in abundance from year to year (Scott and Crossman, 1973). The relative abundance of other taxa was generally similar among studies (Figure F-3). All of the species collected during 1981, except for silver chub, were reported in one or more of the previous monitoring programs (Table F-6). At present, the Ohio River fish community in the study area is similar to that observed during the baseline study.

When condition factors from 1981 were compared with those of past studies, variation was observed in all the species analyzed over the years. The variation found is not unusual in the Ohio River and can be attributed to natural causes. Rounsefell and Everhart (1953) stated that condition factors vary with season, sex, sexual maturity, age and various other factors, thereby limiting the usefulness of condition factors as an indicator of environmental stress.

Little Saluda Creek

A total of 238 fish representing 17 taxa were collected by electrofishing and seining at Little Saluda Creek Station 6 (Table F-7). No rare, threatened or endangered species were found.

The electrofishing CPUE ranged from 0.080 fish per meter of shoreline distance in August to 0.760 in May with an annual mean of 0.302 (Table F-3). Although some variation was observed in CPUE among years, no significant differences were found (Figure F-2; Table F-8).

The seining CPUE ranged from 0.090 fish per meter of stream distance in May to 0.570 in November (Table F-3). The annual mean CPUE in Little Saluda Creek was 0.292 fish per meter of stream sampled. Considerable variation was observed in seining CPUE among years (Figure F-2). The seining CPUE during 1979 was significantly higher than during all other years (Table F-8). Differences in CPUE among years were most likely a result of the wide fluctuations commonly observed in emerald shiner populations.

The vast majority (89.5 percent) of the fishes collected in Little Saluda Creek were members of the minnow family. The creek chub was the most abundant species collected and accounted for 47.9 percent of the total number collected (Table F-7). Second in abundance was the blacknose dace, which accounted for 14.3 percent of the total number of fish.

The relative abundance of fishes has changed over the years studied. During 1974, blacknose dace was the most abundant species, whereas from 1977 through 1979, emerald shiner was the dominant species (Figure F-4). The changes observed in relative abundance are attributed to natural yearly variations in fish populations. For example, emerald shiners were extremely abundant during 1977 through 1979, however, during 1974, 1980 and 1981 their numbers were drastically reduced. These wide year-to-year changes in population occur commonly in nature. Scott and Crossman (1973) reported that periods of scarcity followed by great abundance have been characteristic of emerald shiner populations for over 50 years.

Year-to-year changes are especially common in small streams of intermittent flow and shallow depth such as Little Saluda Creek. All of the species collected during 1981, except for spotted sunfish, largemouth bass and orangethroat darter, were reported in one or more of the previous monitoring programs (Table F-9). At present the Little Saluda Creek fish community is similar to that observed during the baseline study. Apparently plant construction activities have not altered the composition of the fish community in Little Saluda Creek.

CONCLUSIONS

In the Ohio River, the gill netting CPUE did not differ significantly among stations or years studied. Although electrofishing CPUE did not differ significantly among stations, annual CPUE during 1981 was significantly higher than the CPUE observed during 1977, 1978 or 1980. Of the 26 species of fish collected, gizzard shad was the most abundant. The relative abundance of most fishes was similar among the years studied. However, emerald shiner and gizzard shad populations varied considerably. Wide natural year-to-year variations in emerald shiner and gizzard shad populations occur naturally and have been documented by other investigators. Condition factors for certain fish varied from one study to another. Minor differences in species occurrence, abundance and condition of Ohio River fishes among stations and years were not considered unusual and were attributed to natural causes.

During studies in Little Saluda Creek, members of the minnow family were the dominant taxa, however, the most abundant minnow species has changed between years. Differences in the occurrence, abundance and CPUE of fishes in Little Saluda Creek were attributed to natural yearly variations in fish populations. No apparent adverse impact upon the fish community was attributed to construction activities at the Marble Hill Plant site.

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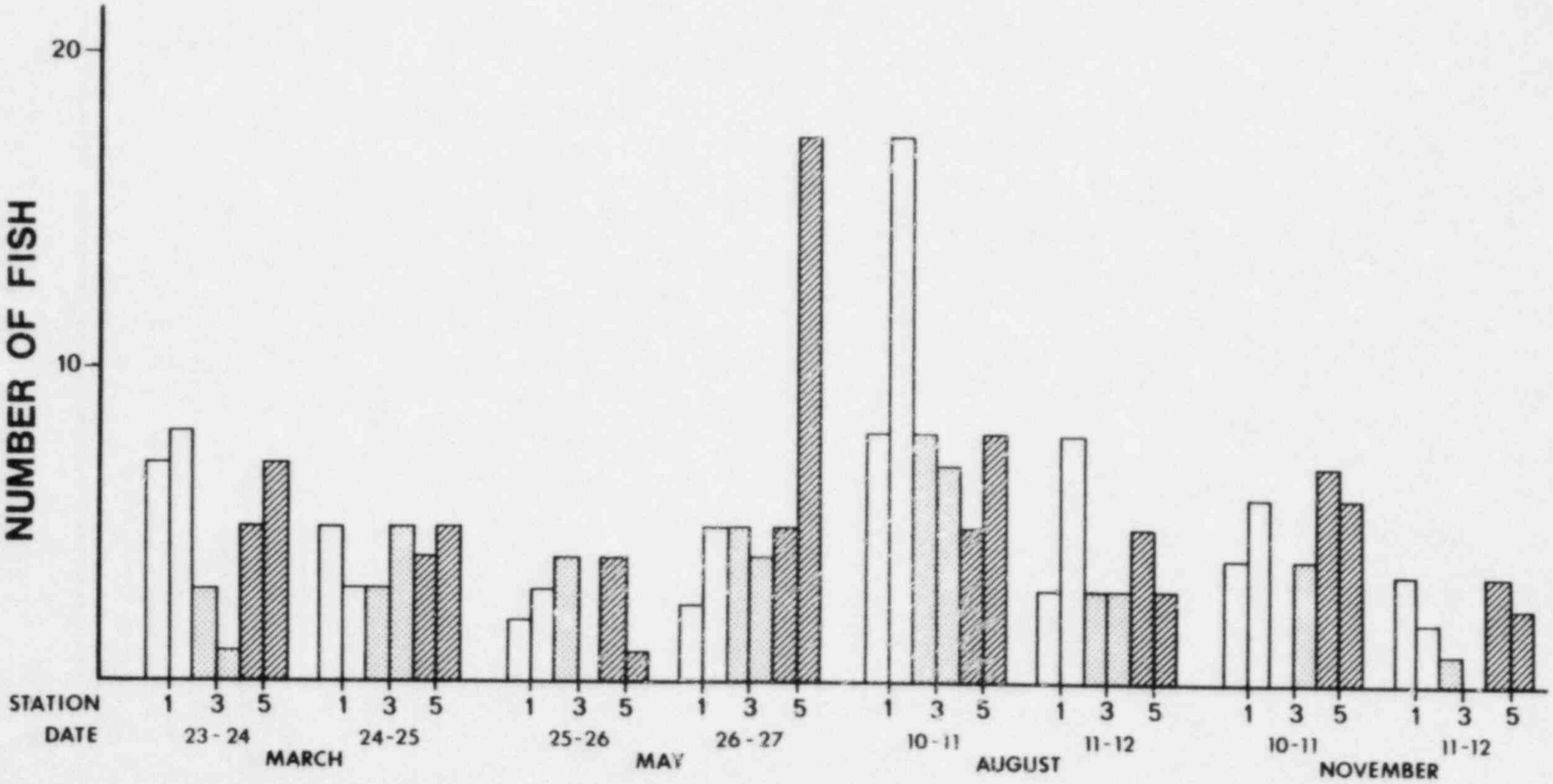

Figure F-1. Number of fish collected per gill net per 24 hours in each of two replicates per station, Marble Hill Plant site, 1981.

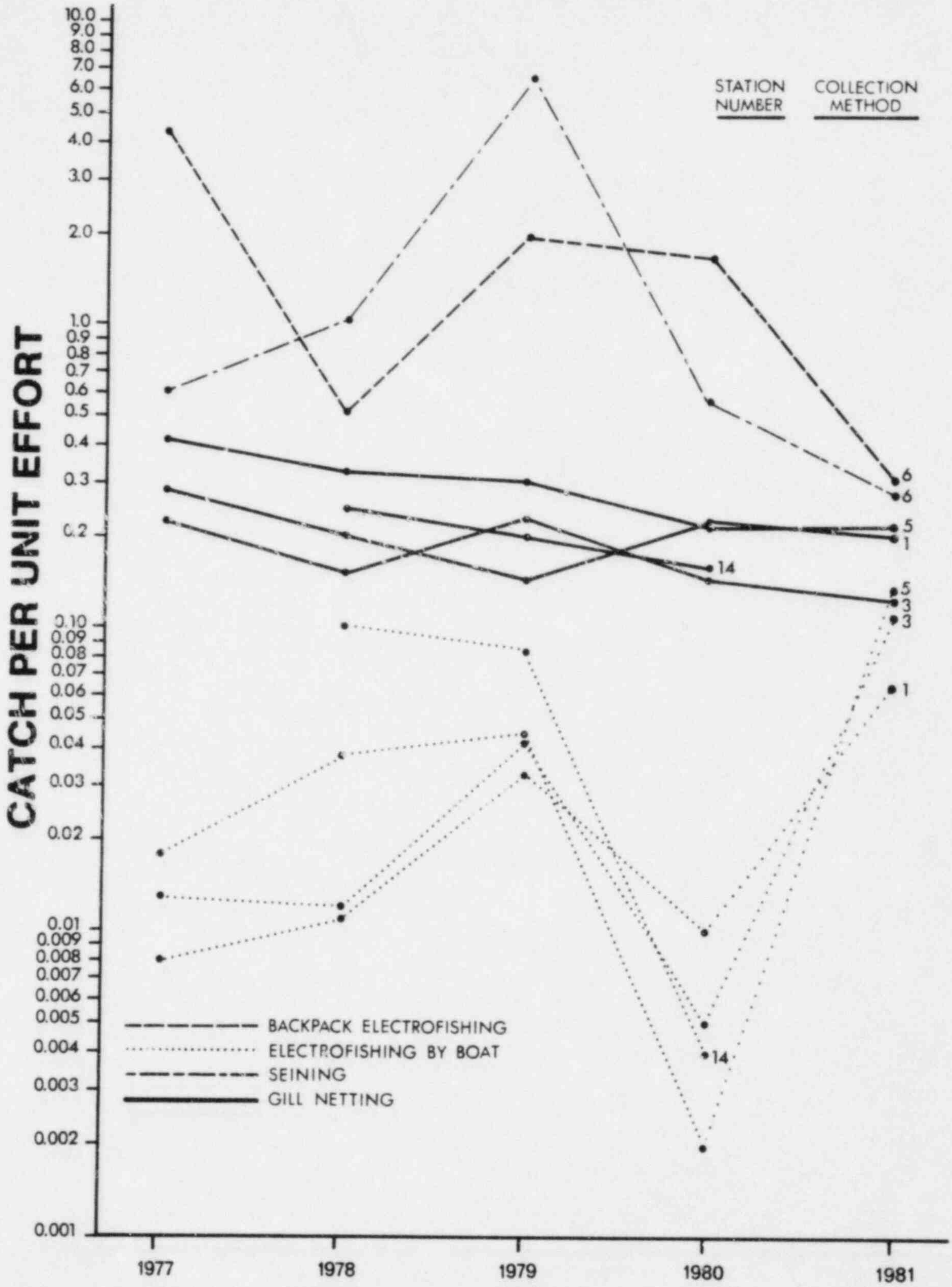

Figure F-2. Annual catch per unit effort by station for fishes collected in the vicinity of the Marble Hill Plant site, 1977-1981.

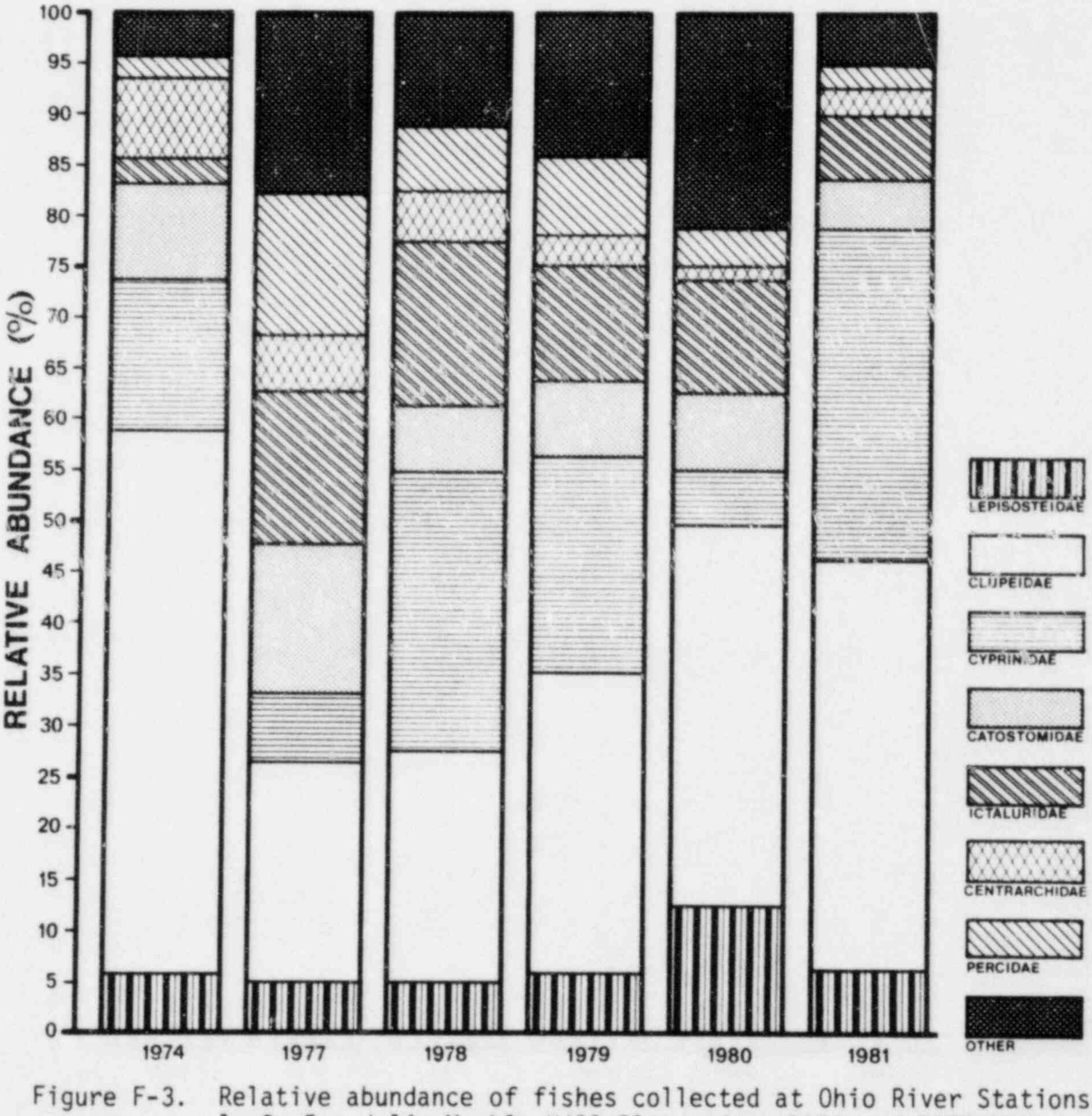

Figure F-3. Relative abundance of fishes collected at Ohio River Stations 1, 3, 5 and 14, Marble Hill Plant site, 1974 and 1977-1981.

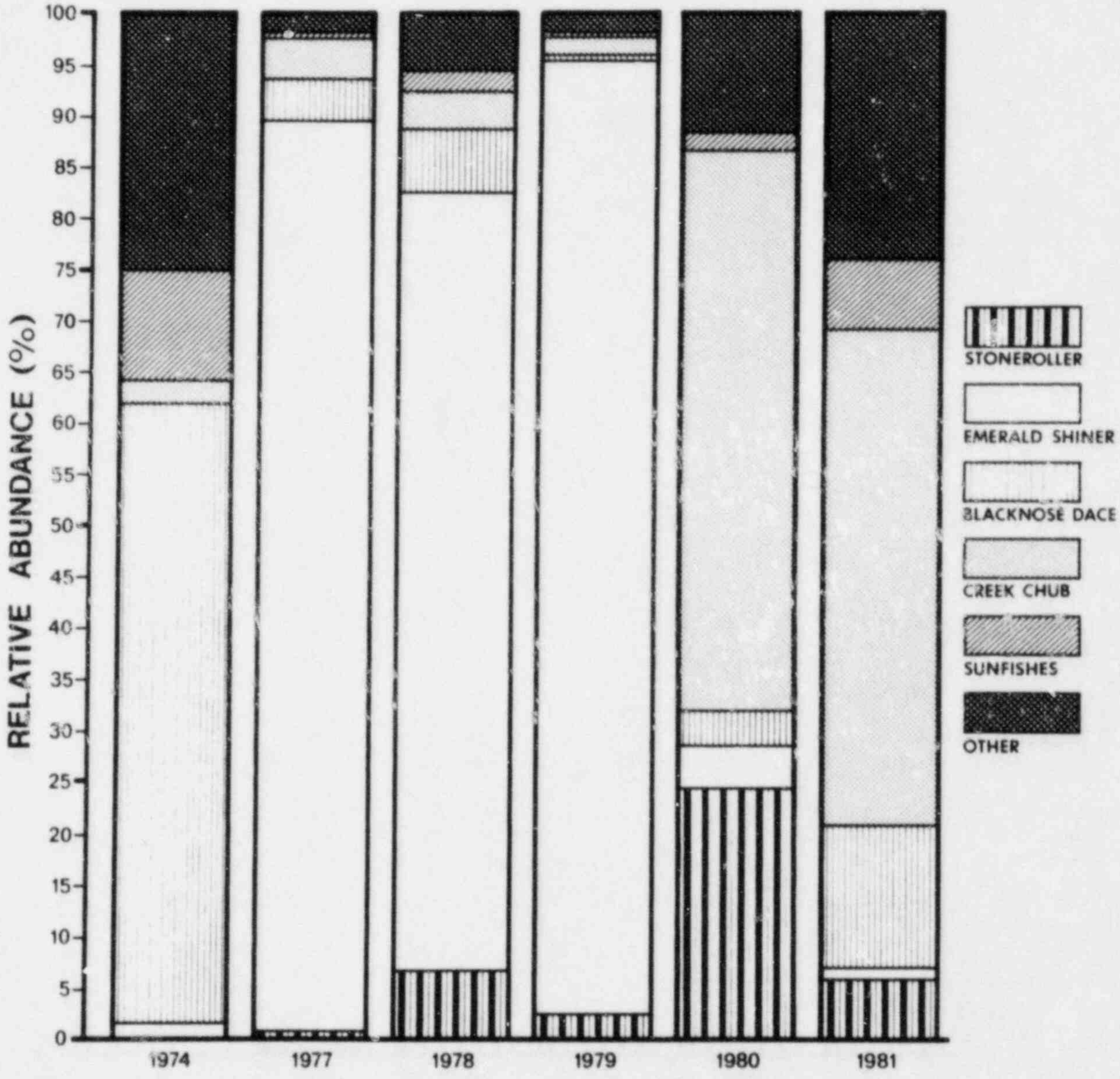

Figure F-4. Relative abundance of fishes collected at Little Saluda Creek Station 6, Marble Hill Plant site, 1974 and 1977-1981.

TABLE F-1

SCIENTIFIC AND COMMON NAMES OF FISHES
COLLECTED BY ALL METHODS
MARBLE HILL PLANT SITE
1981

Lepisosteidae-gars	
Lepisosteus osseus	longnose gar
Clupeidae-herrings	
Alosa chrysochloris	skipjack herring
Dorosoma cepedianum	gizzard shad
Hiodontidae-mooneyes	
Hiodon alosoides	goldeye
H. tergisus	mooneye
Cyprinidae-minnows and carps	
Campostoma anomalum	stoneroller
Cyprinus carpio	carp
Hybopsis storeriana	silver chub
Notemigonus crysoleucas	golden shiner
Notropis sp.	shiner
N. atherinoides	emerald shiner
N. chrysocephalus	striped shiner
N. cornutus	common shiner
N. rubellus	rosyface shiner
Pimephales notatus	bluntnose minnow
Rhinichthys atratulus	blacknose dace
Semotilus atromaculatus	creek chub
Catostomidae-suckers	
Carpiodes carpio	river carpsucker
C. velifer	highfin carpsucker
Catostomus commersoni	white sucker
Ictiobus bubalus	smallmouth buffalo
Minytrema melanops	spotted sucker
Moxostoma carinatum	river redhorse
M. erythrurum	golden redhorse
Ictaluridae-freshwater catfishes	
Ictalurus punctatus	channel catfish
Pylodictis olivaris	flathead catfish

TABLE F-1
(continued)
SCIENTIFIC AND COMMON NAMES OF FISHES
COLLECTED BY ALL METHODS
MARBLE HILL PLANT SITE
1981

Percichthyidae-temperate basses	
Morone chrysops	white bass
Centrarchidae-sunfishes	
Ambloplites rupestris	rock bass
Lepomis sp.	sunfish
L. cyanellus	green sunfish
L. macrochirus	bluegill
L. megalotis	longear sunfish
L. punctatus	spotted sunfish
Micropterus dolomieui	smallmouth bass
M. salmoides	largemouth bass
Pomoxis nigromaculatus	black crappie
Percidae-perches	
Etheostoma spectabile	orangethroat darter
Stizostedion canadense	sauger
Sciaenidae-drums	
Aplodinotus grunniens	freshwater drum

TABLE F-2

TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES
COLLECTED BY GILL NETTING AND ELECTROFISHING
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1981

Taxon	Station 1	Station 3	Station 5	Total	Relative abundance(%)
longnose gar	7	12	18	37	6.0
skipjack herring	-	1	2	3	0.5
gizzard shad	51	49	147	247	40.1
goldeye	-	1	-	1	0.2
mooneye	2	1	7	10	1.6
carp	-	-	1	1	0.2
silver chub	9	17	-	26	4.2
emerald shiner	46	95	26	167	27.1
river carpsucker	3	-	-	3	0.5
highfin carpsucker	1	1	-	2	0.3
smallmouth buffalo	4	2	5	11	1.8
spotted sucker	1	-	-	1	0.2
river redhorse	5	1	-	6	1.0
golden redhorse	5	2	3	10	1.6
channel catfish	15	5	14	34	5.5
flathead catfish	3	1	1	5	0.8
white bass	3	1	2	6	1.0
rock bass	1	-	-	1	0.2
green sunfish	-	1	-	1	0.2
bluegill	1	1	1	3	0.5
longear sunfish	-	-	1	1	0.2
smallmouth bass	2	-	1	3	0.5
largemouth bass	2	-	-	2	0.3
black crappie	1	-	1	2	0.3
sauger	3	1	8	12	2.0
freshwater drum	6	6	8	20	3.2
Total	171	198	246	615	100.0

TABLE F-3

CATCH PER UNIT EFFORT OF FISH COLLECTED BY GILL NETTING,
ELECTROFISHING AND SEINING
OHIO RIVER STATIONS 1, 3 AND 5 AND
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1981

Sampling method	Station	March	May	August	November	Overall
Gill netting	1	0.240	0.125	0.375	0.156	0.224
(no. fish/net-hr)	3	0.125	0.135	0.219	0.052	0.133
	5	0.219	0.281	0.219	0.188	0.227
Electrofishing	1	0.030	0.017	0.037	0.203	0.072
(no. fish/m)[a]	3	0.007	0.033	0.013	0.433	0.122
	5	0.010	0.013	0.033	0.480	0.134
	6	0.150	0.760	0.080	0.220	0.302
Seining	6	0.360	0.090	0.150	0.570	0.292
(no. fish/m)[a]						

[a]Meter of shoreline or stream distance that was electrofished or seined.

TABLE F-4

STATISTICAL ANALYSIS OF GILL NETTING AND ELECTROFISHING COLLECTION DATA FROM OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1981

ANALYSIS OF VARIANCE

Parameter	Comparison	Calculated F value	Critical F value
gill netting CPUE	by station	1.95	4.26
electrofishing CPUE	by station	1.10	4.26

TABLE F-5

STATISTICAL ANALYSIS OF GILL NETTING AND ELECTROFISHING COLLECTION DATA FROM OHIO RIVER STATIONS 1, 3, 5 AND 14
MARBLE HILL PLANT SITE
1977 - 1981

ANALYSIS OF VARIANCE

Parameter	Comparison	Calculated F value	Critical F value
gill netting CPUE	by year	0.81	3.02
electrofishing CPUE	by year	3.56*	3.02 (see below)

*Significant at $P \leq 0.05$.

DUNCAN'S MULTIPLE RANGE TEST

Electrofishing by year	Mean CPUE	Grouping[a]
1981	0.106	A
1979	0.050	A B
1978	0.037	B
1977	0.012	B
1980	0.005	B

[a]Means with the same group letter are not significantly different at $P \leq 0.05$.

TABLE F-6

FISH SPECIES COLLECTED FROM THE OHIO RIVER
MARBLE HILL PLANT SITE
1974, 1977-1981

	Baseline	Construction Phase				
Taxon	1974	1977	1978	1979	1980	1981
longnose gar	x	x	x	x	x	x
skipjack herring	x	x		x	x	x
gizzard shad	x	x	x	x	x	x
goldeye	x	x	x	x	x	x
mooneye	x		x	x	x	x
goldfish	x			x	x	
carp	x	x	x	x	x	x
silver chub						x
emerald shiner	x	x	x	x	x	x
river carpsucker	x	x	x	x		x
quillback			x	x	x	
highfin carpsucker		x	x		x	x
white sucker	x			x		
smallmouth buffalo	x	x		x	x	x
bigmouth buffalo	x					
black buffalo		x		x	x	
spotted sucker	x	x		x	x	x
silver redhorse		x			x	
river redhorse		x		x		x
golden redhorse		x	x	x	x	x
shorthead redhorse		x				
blue catfish	x					
yellow bullhead			x			
channel catfish	x	x	x	x	x	x
flathead catfish		x	x	x	x	x
white bass	x	x	x	x	x	x
rock bass	x		x			x
green sunfish	x		x			x
pumpkinseed	x	x				
warmouth		x		x		
bluegill	x	x	x	x		x
longear sunfish	x	x		x	x	x
spotted sunfish						
smallmouth bass	x	x	x			x
spotted bass	x	x				
largemouth bass	x	x	x	x	x	x

TABLE F-6
(continued)
FISH SPECIES COLLECTED FROM THE OHIO RIVER
MARBLE HILL PLANT SITE
1974, 1977-1981

	Baseline	Construction Phase				
Taxon	1974	1977	1978	1979	1980	1981
white crappie	x		x			
black crappie	x		x	x		x
yellow perch	x	x				
sauger	x	x	x	x	x	x
walleye	x					
freshwater drum	x	x	x	x	x	x
Total species	30	28	23	26	22	26

TABLE F-7

TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES COLLECTED BY ELECTROFISHING AND SEINING LITTLE SALUDA CREEK STATION 6 MARBLE HILL PLANT SITE 1981

Taxon	ELECTROFISHING		SEINING		Total	Overall
	Number of fishes	Relative abundance (%)	Number of fishes	Relative abundance (%)	Number of fishes	Relative abundance (%)
stoneroller	6	5.0	8	6.8	14	5.9
golden shiner	-	-	3	2.6	3	1.3
emerald shiner	-	-	2	1.7	2	0.8
striped shiner	-	-	12	10.3	12	5.0
common shiner	-	-	4	3.4	4	1.7
rosyface shiner	-	-	3	2.6	3	1.3
shiner (<u>Notropis</u> sp.)	5	4.1	-	-	5	2.1
bluntnose minnow	6	5.0	16	13.7	22	9.2
blacknose dace	33	27.3	1	0.8	34	14.3
creek chub	63	52.1	51	43.6	114	47.9
white sucker	-	-	1	0.8	1	0.4
green sunfish	-	-	1	0.8	1	0.4
bluegill	1	0.8	1	0.8	2	0.8
spotted sunfish	-	-	1	0.8	1	0.4
sunfish (<u>Lepomis</u> sp.)	-	-	12	10.3	12	5.0
largemouth bass	-	-	1	0.8	1	0.4
orangethroat darter	7	5.7	-	-	7	2.9
Total	121	100.0	117	99.8	238	99.8

TABLE F-8

STATISTICAL ANALYSIS OF ELECTROFISHING AND SEINING
COLLECTION DATA FROM
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1977 - 1981

ANALYSIS OF VARIANCE

Parameter	Comparison	Calculated F value	Critical F value
Electrofishing CPUE	by year	0.78	3.11
Seining CPUE	by year	4.83*	3.06

*Significant at $P \leq 0.05$.

DUNCAN'S MULTIPLE RANGE TEST

Seining CPUE by year	Mean CPUE	Grouping[a]
1979	4.752	A
1978	0.589	B
1977	0.509	B
1980	0.431	B
1981	0.279	B

[a]Means with the same group letter are not significantly different at $P \leq 0.05$.

TABLE F-9

FISH SPECIES COLLECTED FROM LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
1974, 1977-1981

	Baseline	Construction Phase				
Taxon	1974	1977	1978	1979	1980	1981
stoneroller		x	x	x	x	x
golden shiner				x		x
emerald shiner	x	x	x	x	x	x
river shiner				x		
striped shiner		x	x			x
common shiner	x					x
pugnose shiner		x				
rosyface shiner			x			x
sand shiner	x			x		
mimic shiner		x	x	x	x	
suckermouth minnow				x		
bluntnose minnow	x	x		x	x	x
fathead minnow				x		
bullhead minnow	x					
blacknose dace	x	x	x	x	x	x
creek chub	x	x	x	x	x	x
white sucker			x	x	x	x
smallmouth buffalo		x				
golden redhorse					x	
black bullhead		x	x		x	
mosquito fish	x					
green sunfish	x		x			x
bluegill	x	x	x	x	x	x
spotted sunfish						x
smallmouth bass		x				
largemouth bass						x
rainbow darter	x			x		
fantail darter			x		x	
orangethroat darter						x
Total	11	12	12	14	11	15

G. FISH EGGS AND LARVAE

INTRODUCTION

Fish eggs and larvae are temporary members of the plankton community and serve an important role in the food chain of the Ohio River and its tributaries. The eggs and larvae of certain fish species also represent an important future contribution to recreational and commercial fisheries.

Changes in the physical and chemical composition of a water body can influence both the spawning success of adult fish and the subsequent survival of their eggs and larvae. The extent of larval survival will determine juvenile recruitment into the population, which will influence future spawning potential.

The purpose of this study was to determine the composition and abundance of fish eggs and larvae near the Marble Hill Plant site during plant construction. Results of this study were compared with those obtained during the 1974-1975 baseline study (PSI, 1976) and the 1977 through 1980 construction phase ecological monitoring programs (ABI, 1978, 1979, 1980, 1981). Because construction had not started prior to the completion of the 1977 ichthyoplankton sampling program, both the 1974 and 1977 studies were considered baseline. The comparisons among study years enabled characterization of annual ichthyoplankton fluctuations and determination of possible plant construction effects on ichthyoplankton densities.

MATERIALS AND METHODS

Fish egg and larvae collections were made on 12 occasions between 10 April and 9 July 1981 at Ohio River Stations 1, 3, and 5 (Figure 1). Collections were made with 20 -cm long bongo nets of 505-micron mesh and 20-cm mouth diameter. During each sampling period, duplicate 10-minute tows were made at near-surface, middle and near-bottom depths. Tows were made approximately 30 m offshore; this distance is the length of the offshore discharge pipe and intake structure proposed for the Marble Hill Plant.

Nets were towed upstream at approximately 150 cm/sec. A General Oceanics Model 2030 flowmeter was fixed in the mouth of each net to enable the calculation of the volume of water passing through each net. Ichthyoplankton samples were preserved in the field immediately after collection in 5-percent buffered formalin.

In the laboratory, fish eggs and larvae were separated from each sample using a stereo microscope. Fish eggs were counted and examined for viability. A clear egg was considered viable and an opaque egg non-viable (Bagenal and Braum, 1971). Larval fishes were enumerated and identified to the lowest practicable taxon. The current status of taxonomy of larval fishes is not sufficiently developed for species identification except among the more common species. Consequently, the "lowest practicable taxon" may be only to the family level in many cases. Taxonomic nomenclature was in accordance with Bailey et al. (1970). Representative specimens were retained in 3-percent buffered formalin as reference material.

Statistical procedures used in data analysis are described in Section H. Statistical Analysis Procedures.

RESULTS AND DISCUSSION

Fish Eggs

Fish eggs were found on 26 May and from 17 June through 9 July 1981 (Appendix Tables G-1 through G-12). Mean egg densities for all stations combined ranged from 0.00/m^3 in early April through late-May to 0.28/m^3 during late June. The highest density of fish eggs per station (0.33/m^3) was found at Station 5 during the 25 June sample collection (Figure G-1). Of all eggs collected, 91.8 percent were considered viable.

The mean densities of eggs were not significantly different among stations or depths (Table G-1). Mean egg densities were 0.04/m^3 at Stations 1 and 5 and 0.03/m^3 at Station 3 (Figure G-2). By depth, mean egg densities were 0.04/m^3 at the bottom and mid-depth and 0.03/m^3 at the surface (Figure G-2).

Temporal differences in fish egg occurrence and abundance were apparent among the years studied. Fish eggs were first collected in 1974 on 7 May, in 1977 on 30 April, in 1978 on 5 May, in 1979 on 3 May, in 1980 on 26 May, and in 1981 on 26 May. The maximum abundance of fish eggs was observed during July in 1974, May in 1977, and June in 1978 through 1981 (Figure G-3 and G-4).

Peak egg densities were considerably lower during 1979 and 1980 than during 1977, 1978 and 1981 (Figure G-4). Natural physical variations such as the amount of river flow among years or differences in water temperature resulting from the length of the preceding winter are factors that affect the initiation and duration of spawning in fishes (Lagler et al., 1962). Accordingly, certain species may spawn earlier or later depending on the river conditions during any particular year. In addition, some species produce large quantities of eggs during relatively short periods of time and their peak spawning may have occurred between scheduled sampling periods. Therefore, differences in the occurrence and abundance of fish eggs were not attributed to plant construction activities.

Fish Larvae

Fish larvae were found from 25 April through 9 July 1981 when sampling was stopped (Appendix Tables G-1 through G-12). Larval densities fluctuated widely throughout the spawning season; mean densities for all stations combined ranged from $0.00/m^3$ on 10 April to $1.29/m^3$ on 3 June (Figure G-5). The highest density of fish larvae per station ($1.79/m^3$) was found at Station 3 during the 9 July sampling period (Figure G-6).

No statistically significant differences in larval fish densities were found between stations (Table G-1). Annual mean larval density was $0.46/m^3$ at Station 1, $0.44/m^3$ at Station 3 and $0.50/m^3$ at Station 5 (Figure G-2).

Larval densities were significantly higher near the surface than at the bottom (Table G-1). No significant differences in larval densities were found between the surface and mid-depth, or between mid-depth and the bottom. Annual mean larval densities were 0.59/m^3 near the surface, 0.45/m^3 at mid-depth and 0.36/m^3 at the bottom (Figure G-2). Herrings and freshwater drum larvae are known to orient themselves to the surface (Nelson and Cole, 1975; Tuberville, 1979). These species account for the bulk of the higher larval densities observed at the surface.

During all the study years, fish larvae were first observed between 20 and 30 April. Definite peaks in larval fish abundance were observed during each year (Figure G-7); the first peak usually occurred in mid-to-late May and a second between mid-June and early July. During 1977, however, the highest density was recorded on 30 April, the first sampling date. Maximum densities varied among years but, in general, higher peak densities were observed during the last three years of plant construction than during previous years (Figure G-7).

Lagler et al. (1962) reported that environmental factors including temperature, current and photoperiod have an effect on the reproduction of fishes. The observed differences in the occurrence and abundance of fish larvae are caused by natural variations in the Ohio River and in the spawning success of resident fishes and are not related to construction activity at the Marble Hill Plant site.

Taxonomic Composition of Fish Larvae

During 1981, members of only four taxonomic families of fish comprised 97.3 percent of the fish larvae collected (Table G-2). These families were the Catostomidae (suckers), Sciaenidae (drums), Cyprinidae (minnows and carp), and Clupeidae (herrings). Each of these families was individually examined statistically to determine whether or not construction at the Marble Hill Plant may have exerted a selective effect on fish larvae of certain families.

Suckers

Of the larval fishes collected from the Ohio River during 1981, the sucker family was the dominant group and accounted for 29.1 percent of the larval fishes found (Table G-2). No significant differences were found in sucker densities among stations or depths (Table G-3).

As in all of the major taxonomic groups, the percentage abundance of suckers has fluctuated greatly among study years. Suckers were the most abundant taxa collected during 1977 and 1978, accounting for 70.0 and 40.1 percent of the total larvae collected, respectively (Table G-4). During 1974 and 1979, they comprised only 2.0 and 16.0 percent of the total, respectively. These annual variations in percentage abundance of suckers are believed to be natural and unrelated to construction activities at the Marble Hill Plant site.

Drums

The freshwater drum is the only member of the drum family (Sciaenidae) that is indigenous to fresh water. This species accounted for 28.7 percent of the total larval fishes collected in 1981, second in overall abundance (Table G-2). Densities of freshwater drum were not significantly different between stations (Table G-3). However, densities were significantly greater at the surface and at mid-depth than at bottom (Table G-3) because of the buoyancy of early drum larvae (Nelson and Cole, 1975). Freshwater drum spawn between May and August with peaks in June or July (Scott and Crossman, 1973; Pflieger, 1975; Smith, 1979). Freshwater drum larvae were first found on 3 June in 1981 and continued to appear throughout the remainder of the study.

The freshwater drum was the most abundant taxa collected during 1974 and accounted for 82.5 percent of the total larvae collected. During subsequent years, the percentage abundance of freshwater drum was considerably lower, ranging between 3.8 percent in 1977 to 28.7 percent in 1981 (Table G-4).

Minnows and Carp

The minnows and carp family (Cyprinidae) was the third most abundant family of larval fishes collected in 1981. This group was primarily composed of carp, which accounted for 23.7 percent of the total larval fishes collected (Table G-2). No significant differences in larval carp densities were found among stations or depths (Table G-5). Carp spawn in shallow areas and have an extended spawning season starting in the spring, possibly continuing to early fall (Scott and Crossman, 1973; Clay, 1975; Pflieger, 1975). During 1981, carp were found from 25 April through the remainder of the study. The percentage abundance of carp has gradually increased from a low of 2.8 percent during 1974 to a high of 23.7 percent during the present study year (Table G-4). Other minnow larvae, such as emerald shiner larvae, were occasionally collected. Adult emerald shiners are the most abundant species in the Ohio River by number (Preston and White, 1978). The collection of a low number of emerald shiner larvae is probably due to the species' unequal distribution within the river. They are known to occur along the immediate shoreline rather than more open waters, a fact confirmed in the electrofishing collection of adults (Section F. Fish).

Herrings

Larval herrings accounted for 15.3 percent of the larval fishes found in 1981 (Table G-2). Larval herrings were the most abundant group collected during 1979 and 1980. Prior to 1979, however, the percentage of herrings was considerably lower (Table G-4). Because the vast majority of the adult herrings collected were gizzard shad (Section F. Fish), it is reasonable to assume that the majority of the larvae identified as herrings (Clupeidae) were undoubtedly gizzard shad also. Additionally, Preston and White (1978) reported that gizzard shad was the most abundant species in the Ohio River by weight, and only the emerald shiner was more abundant in number. No statistically significant differences were found in the density of herrings between stations (Table G-5). Significantly more herrings were collected at the surface

($0.15/m^3$) than at mid-depth ($0.03/m^3$) or the bottom ($0.02/m^3$; Table G-5). As previously mentioned, this is probably due to the tendency of larval herring to orient to the surface, especially during the daytime (Tuberville, 1979).

Other Taxa

All other taxa combined made up 2.7 percent of the total larval fishes collected during 1981. These larvae were longnose gar, goldeye, mooneye, temperate bass, sunfish, yellow perch, logperch, sauger, (*Stizostedion* spp.), perch (including all prolarval and some postlarval sauger and walleye), and unidentifiable (damaged) larvae (Tables G-2 and G-4).

Differences in species composition may have resulted from variations in the spawning success of different species and, in some cases, may have been related to sampling frequencies and the chance occurrence of larvae. For example, during 1974, 83 percent of the larvae (primarily freshwater drum) were taken on one date, and during 1977, 68 percent of the larvae were collected on one date.

Interstation comparisons indicated that all stations were generally similar with regard to the fish eggs and larvae present. Differences were observed in the relative abundance between stations of certain taxa during one year or another, however, no consistent dissimilarities were observed among the years studied.

CONCLUSIONS

Fish egg and larvae collections were made on 12 occasions on the Ohio River from 10 April through 9 July 1981. Fish eggs were first found on 26 May and the highest density was observed on 25 June. No significant differences were found in mean egg densities between stations or depths.

Fish larvae first appeared on 25 April and the highest density for an individual station was recorded on 9 July. No significant differences were found among stations. Significantly more larvae were collected at the surface than at the bottom. This was attributed to the surface orientation characteristic of the larvae of many of the abundant taxa.

Nine families of larval fishes were collected during 1981. Members of the sucker family were the most abundant taxa, followed in abundance by freshwater drum, carp and minnows, and herring.

Fish egg and larval occurrence, abundance and species composition differed among study years. These differences were most likely because of natural physical variations in the Ohio River among years, the chance occurrence of large numbers of eggs or larvae on particular occasions, variations in sampling frequencies, and annual variations in spawning success of different species. Construction at the Marble Hill Plant is not believed to be the cause of any of the observed differences in ichthyoplankton abundance or species composition.

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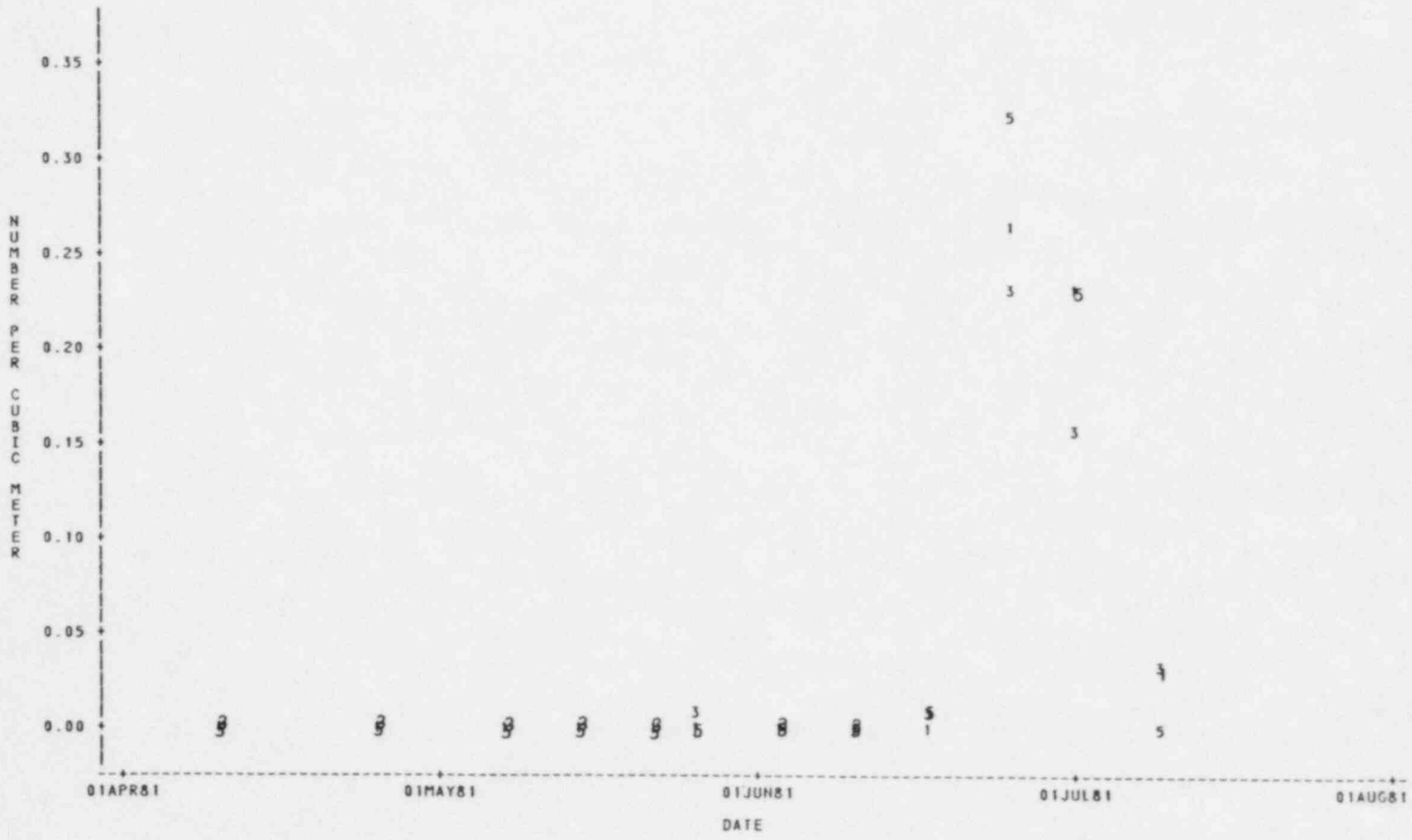

Figure G-1. Mean densities of fish eggs collected by station, Marble Hill Plant site, 1981.

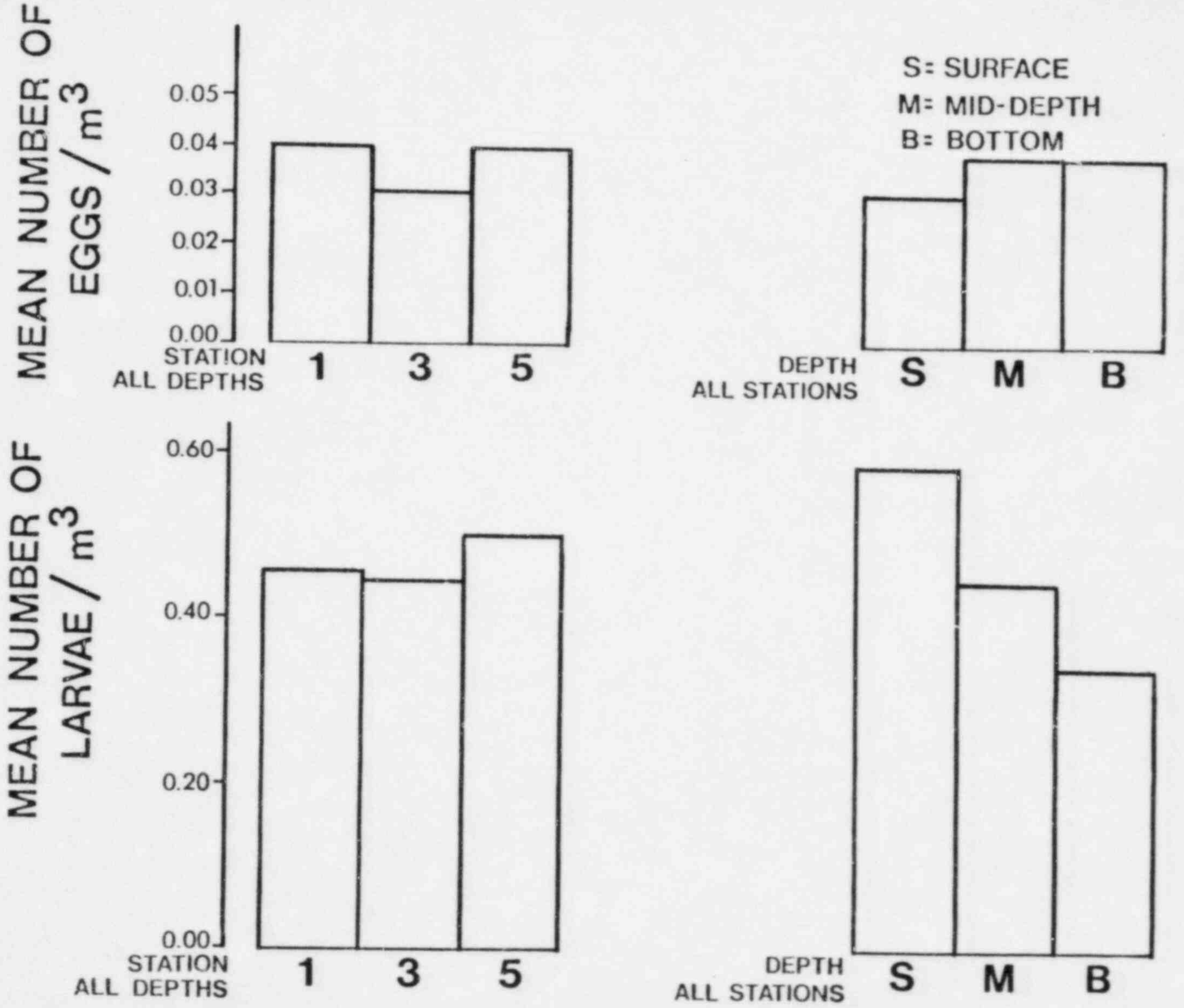

Figure G-2. Mean densities of fish eggs and larvae collected by station and depth from the Ohio River, Marble Hill Plant site, 1981.

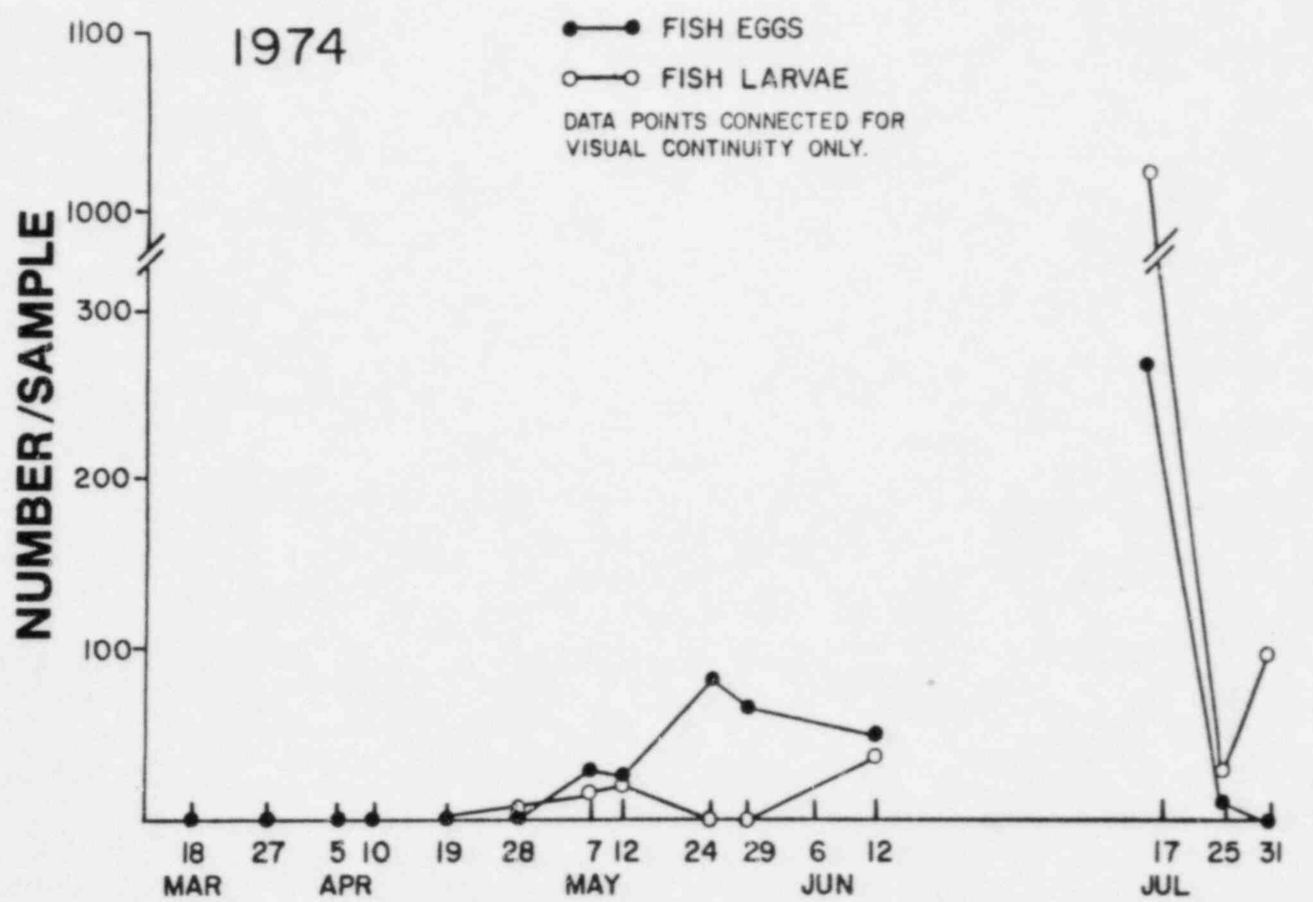

Figure G-3. Fish eggs and larvae collected by 15-minute drift net sets for baseline study (PSI, 1976), Marble Hill Plant site, 18 March - 13 July 1974.

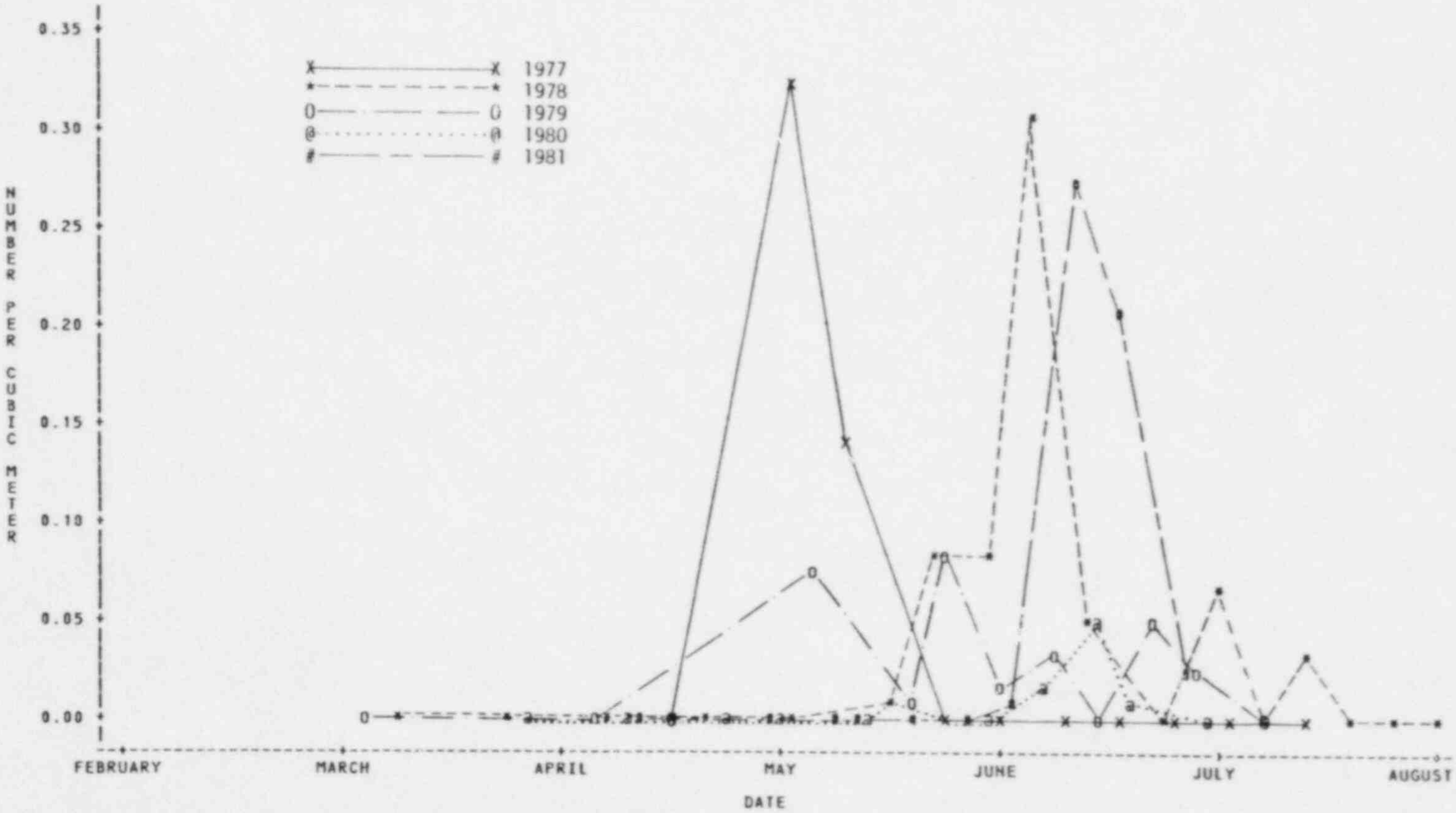

Figure G-4. Mean densities of fish eggs collected by 10-minute bongo-net tows, Marble Hill Plant site, 1977-1981.

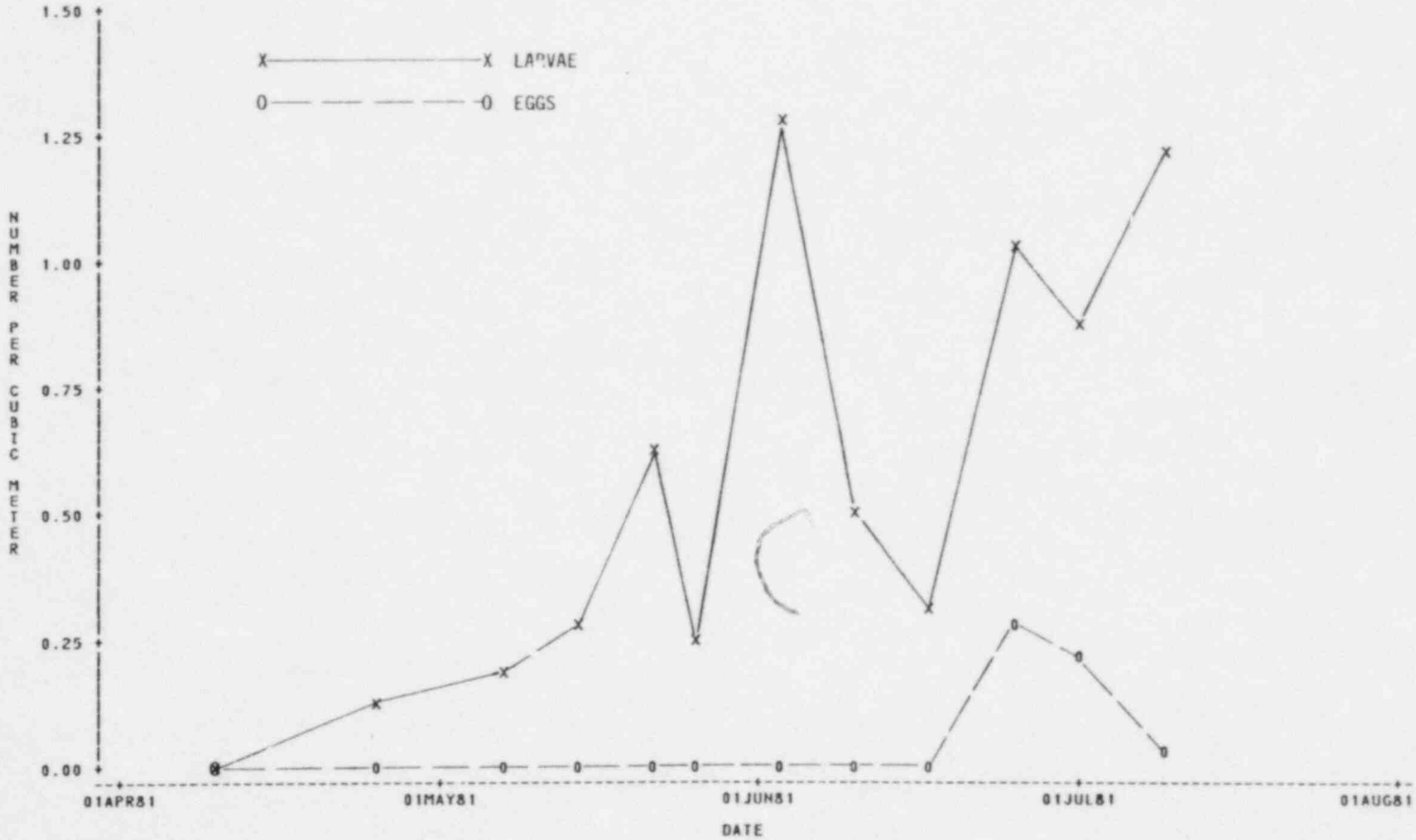

Figure G-5. Mean densities of fish eggs and larvae by date, Marble Hill Plant site, 1981.

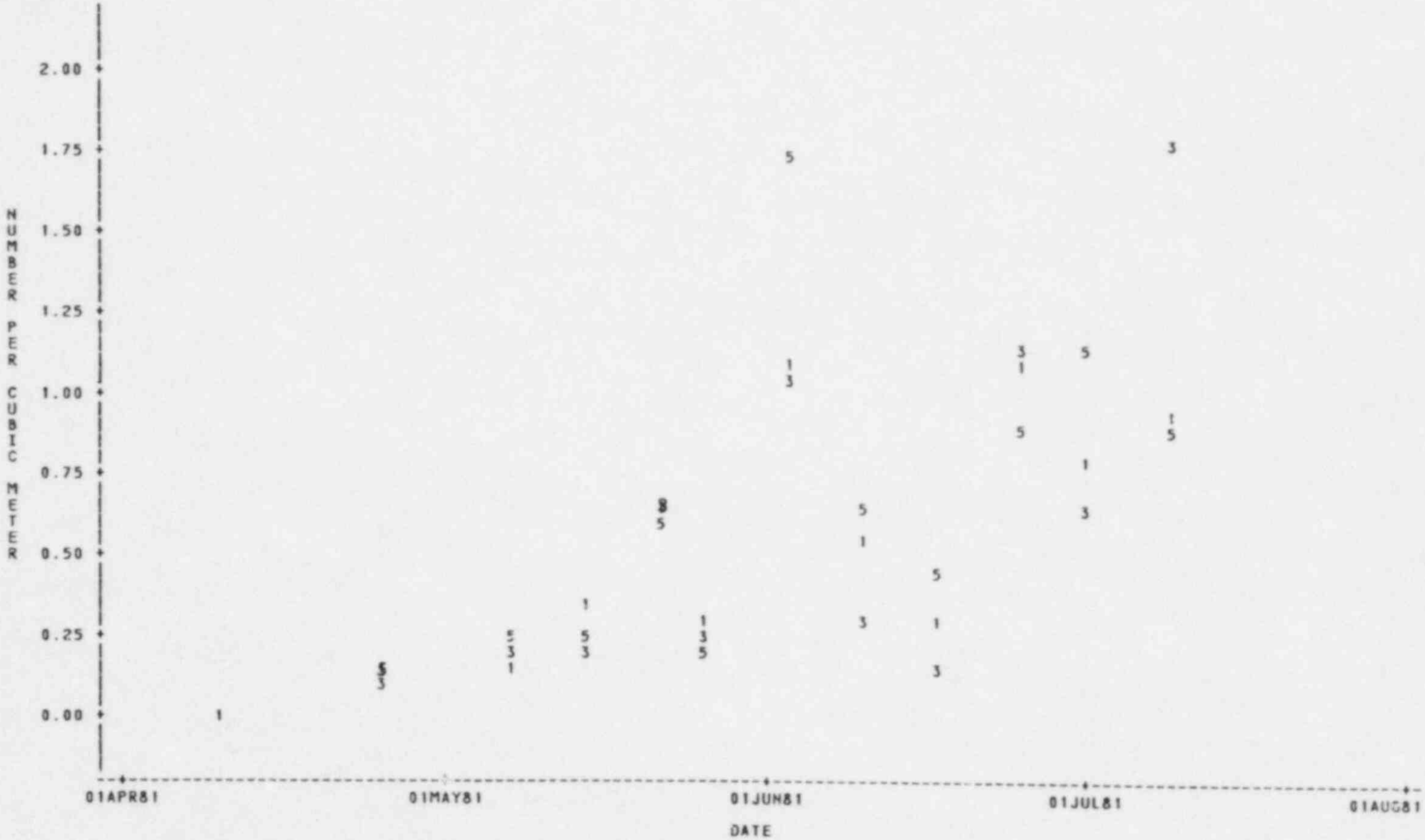

Figure G-6. Mean densities of fish larvae by station, Marble Hill Plant site, 1981.

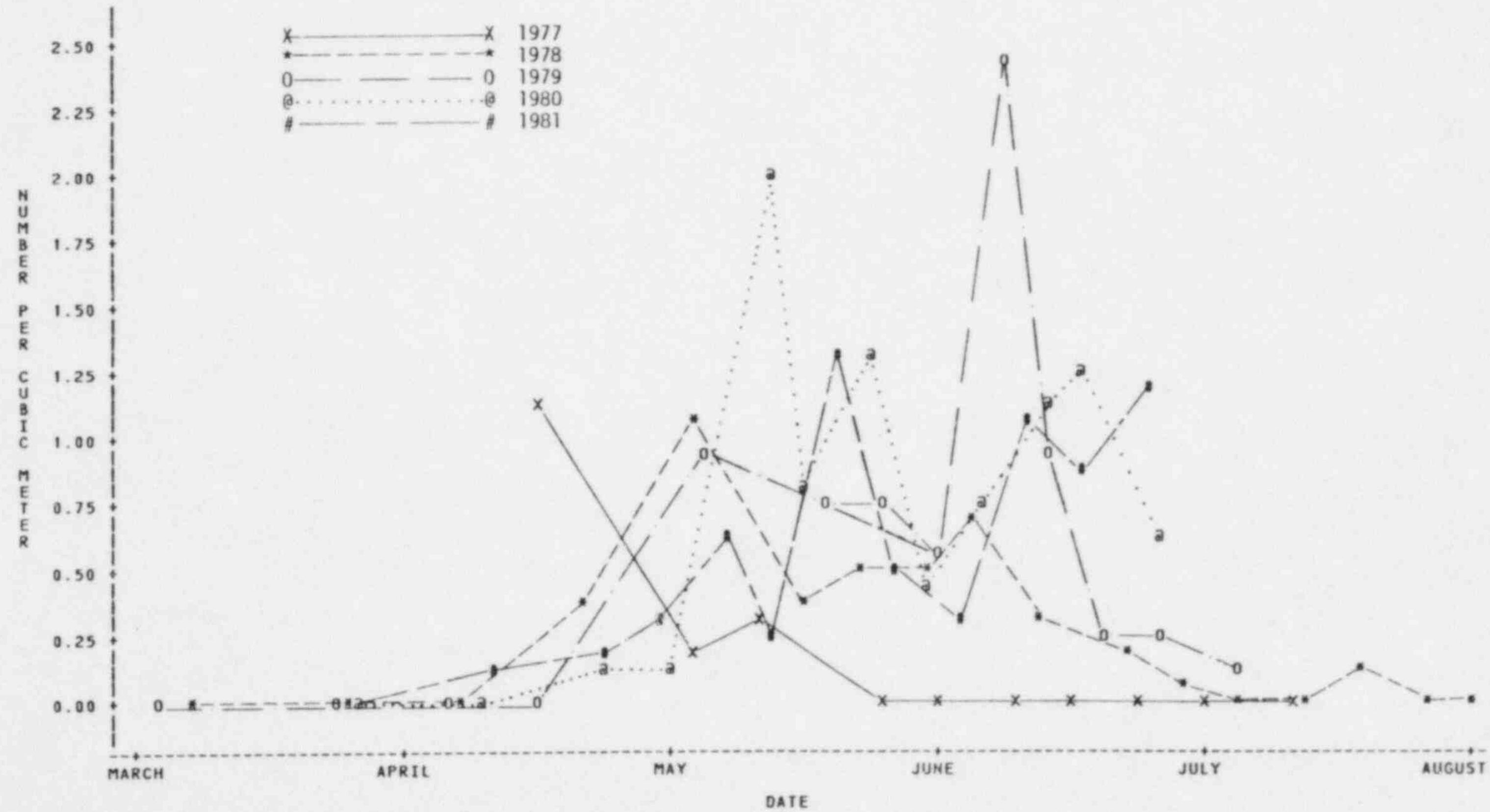

Figure G-7. Mean densities of fish larvae collected by 10-minute bongo-net tows, Marble Hill Plant site, 1977-1981.

TABLE G-1

STATISTICAL ANALYSIS OF FISH EGGS AND LARVE
SAMPLING DATA
MARBLE HILL PLANT SITE
1981

ANALYSIS OF VARIANCE

Parameter	Comparison	Calculated F value	Critical F value
Egg density ($no./m^3$)	by station	0.20	1.94
	by depth	0.44	1.94
Larvae density ($no./m^3$)	by station	0.31	1.94
	by depth	4.15*	1.94 (see below)

*Significant at $P \leq 0.05$.

DUNCAN'S MULTIPLE RANGE TEST

LARVAL DENSITY by depth	Mean density ($no./m^2$)	Grouping[a]	
Surface	0.59	A	
Middle	0.45	A	B
Bottom	0.36		B

[a]Means with the same group letter are not significantly different at $P \leq 0.05$.

TABLE G-2

COMMON NAME, SCIENTIFIC NAME AND PERCENTAGE COMPOSITION OF LARVAL FISH TAXA
OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT SITE
1981

Common name	Scientific name	Percentage composition by station 1	3	5	Overall percentage composition
longnose gar	*Lepisosteus osseus*	0.0	0.0	0.1	<0.1
herring	Clupeidae spp.	12.6	17.7	15.5	15.3
goldeye	*Hiodon alosoides*	0.1	0.0	0.0	<0.1
mooneye	*Hiodon tergisus*	0.4	0.1	0.2	0.2
carp	*Cyprinus carpio*	23.2	20.9	27.0	23.7
other minnows	Cyprinidae spp.	0.2	0.9	0.4	0.5
sucker	Catostomidae spp.	30.0	26.4	30.6	29.1
temperate bass	*Morone* spp.	0.1	0.3	0.0	0.1
sunfish	Centrarchidae spp.	1.1	0.0	0.1	0.4
perch	Percidae spp.	0.2	0.0	0.0	<0.1
yellow perch	*Perca flavescens*	0.0	0.0	0.1	<0.1
logperch	*Percina caprodes*	0.2	0.1	0.0	0.1
sauger/walleye	*Stizostedion* spp.	1.7	0.6	2.1	1.5
freshwater drum	*Aplodinotus grunniens*	30.0	32.4	23.9	28.7
unidentifiable (damaged) larvae		0.2	0.4	0.1	0.2

TABLE G-3

STATISTICAL ANALYSIS OF SUCKER AND DRUM
LARVAL DENSITY DATA
MARBLE HILL PLANT SITE
1981

ANALYSIS OF VARIANCE

Parameter	Comparison	Calculated F value	Critical F value
Sucker density ($no./m^3$)	by station	0.37	2.37
	by depth	1.12	2.37
Drum density ($no./m^3$)	by station	0.08	2.37
	by depth	5.84*	2.37

*Significant at $P \leq 0.05$.

DUNCAN'S MULTIPLE RANGE TEST

DRUM DENSITY by depth	Mean density ($no./m^2$)	Grouping[a]
Surface	0.18	A
Middle	0.12	A
Bottom	0.04	B

[a]Means with the same group letter are not significantly different at $P \leq 0.05$.

TABLE G-4

RELATIVE PERCENTAGE ABUNDANCE OF LARVAL FISH
MARBLE HILL PLANT SITE
1974, 1977-1981

Taxon	1974	1977	1978	1979	1980	1981
herrings	6.5	7.7	15.0	39.6	37.8	15.3
carp	2.8	13.6	10.8	20.2	22.0	23.7
minnows other than carp	5.0	0.0	9.5	6.0	1.9	0.5
suckers	2.0	70.0	40.1	16.0	30.4	29.1
freshwater drum	82.5	3.8	12.3	14.5	5.1	28.7
all others	1.2	4.9	12.3	3.7	2.8	2.7

TABLE G-5

STATISTICAL ANALYSIS OF CARP AND HERRING
LARVAL DENSITY DATA
MARBLE HILL PLANT SITE
1981

ANALYSIS OF VARIANCE

Parameter	Comparison	Calculated F value	Critical F value
Carp density ($no./m^3$)	by station	1.14	2.37
	by depth	0.27	2.37
Herring density ($no./m^3$)	by station	0.06	2.37
	by depth	12.80*	2.37

*Significant at $P \leq 0.05$.

DUNCAN'S MULTIPLE RANGE TEST

HERRING DENSITY by depth	Mean density ($no./m^2$)	Grouping[a]
Surface	0.15	A
Middle	0.03	B
Bottom	0.02	B

[a]Means with the same group letter are not significantly different at $P \leq 0.05$.

H. STATISTICAL ANALYSIS PROCEDURES

Statistical analyses used in this report were performed on an IBM 370 computer utilizing procedures of the Statistical Analysis System (SAS). SAS is a computer system using prepackaged basic statistical analysis routines in conjunction with chemical/biological data collected by Applied Biology, Inc., and entered on computer cards. The computer merges the data with a selected method of data analysis.

Since biological data may not meet the assumptions inherent in a normal or bell-shaped distribution about a mean, the data were log-transformed prior to analysis. The log-transformation allows the data to better fit a normal distribution curve and therefore renders it analyzable with standard parametric statistical methods. Transformation is performed by the following algorithm:

$$Y_1 = \log_e (Y+1)$$

where $\log_e$ = natural logarithm;

Y = dependent variable;

Y_1 = log-transformed dependent variable.

One is added to the dependent variable so that logarithms for numbers less than 1 (0.012, for example) can be calculated. Means calculated from Y values are decoded prior to interpretation by subtracting 1 from the antilog of Y . All hypotheses were tested at the critical probability (P) level of $P \leq 0.05$ unless otherwise stated. This means that there is a probability of 1 chance in 20 that you are incorrect in accepting the null hypothesis (H_0) that there are no statistically significant differences in Y values.

The following statistical tests were used in the analysis of data from the Marble Hill Plant site.

ANALYSIS OF VARIANCE (ANOVA)

Analysis of variance may be considered as a test of whether two or more sample means could have been obtained from the same population. Two or more sample means may be tested simultaneously using ANOVA. The SAS program provides a regression approach to ANOVA and allows analysis of blocks of data of unequal size. The ANOVA program provides a calculated F-value that is then compared to a critical F value for the appropriate probability level ($P \leq 0.05$) and number of degrees of freedom. If the calculated F value equals or exceeds the critical F value, it may be concluded that the means being compared came from at least two different populations and are statistically significantly different. If the calculated F is lower than the critical F, the means are concluded to have come from the same or very similar populations and are not significantly different.

DUNCAN'S MULTIPLE RANGE TEST

The Duncan's Test is utilized only when significant differences are revealed by an ANOVA. While ANOVA reveals the presence of means from different populations, the Duncan's locates the specific mean that is significantly different. The test compares each factor mean (density, biomass, etc.) with every other factor mean to delineate significant differences.

SIMPLE CORRELATION (r)

The simple correlation procedure provides a measure of the degree of association between two independent variables (density and temperature, for example) and the statistical significance probability of their correlation. The correlation coefficient (r) has no unit of measurement; its absolute value can range from 0.0 to 1.0, 0.0 indicating no correlation and 1.0 indicating perfect correlation. Statistical significance of the r value is determined by looking up the critical r value for the appropriate number of independent variables probability level ($P \leq 0.05$), and degrees of freedom. If the r value calculated by the simple correlation test equals or exceeds the critical value in the table, then the calculated r value indicates a statistically significant correlation. No statistical significance is associated with calculated r values less than the critical r.

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CONSTRUCTION PHASE ECOLOGICAL MONITORING PROGRAM

MARBLE HILL NUCLEAR GENERATING STATION UNITS 1 and 2

FINAL REPORT

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APPENDIX: VOLUME II

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