AB-96

CONSTRUCTION PHASE ECOLOGICAL MONITORING PROGRAM

MARBLE HILL NUCLEAR GENERATING STATION UNITS 1 AND 2

FINAL REPORT FEBRUARY–NOVEMBER 1977

Volume 1

JANUARY 1978

APPLIED BIOLOGY, INC.
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ATLANTA, GEORGIA 30340

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FINAL REPORT

CONSTRUCTION PHASE ECOLOGICAL MONITORING PROGRAM

MARBLE HILL NUCLEAR GENERATING STATION-UNITS 1 AND 2

Prepared for

PUBLIC SERVICE COMPANY OF INDIANA, INC.

By

Applied Biology, Inc.
Atlanta, Georgia
January 1978

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Project Manager

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TABLE OF CONTENTS

INTRODUCTION

Applied Biology, Inc., was contracted by Public Service Company of Indiana, Inc. (PSI), to conduct a construction phase ecological monitoring program at the proposed Marble Hill Nuclear Generating Station - Units 1 and 2, located near Madison, Indiana. This report presents the results of that monitoring program and analyses of all ecological data collected in 1977.

The objectives of this program were to: (a) "ascertain and document the existing ecological conditions in the immediate vicinity of the Marble Hill Nuclear Generating Station," and (b) "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 April 15, 1976. During 1977, the mammal, plankton, periphyton, macroinvertebrate, fish and larval fish communities, as well as chemical and physical parameters, were sampled at six aquatic and terrestrial sampling stations. These stations were established at locations previously sampled in a baseline study conducted during 1974-75. Station numbers of the present study were consistent with those used in the baseline study.

AQUATIC MONITORING PROGRAM

The five aquatic sampling stations (Stations 1, 3, 5, 6 and 8; Figure 1) were sampled in March, May, August and November 1977. Originally, sampling was to have begun in February but was delayed until March by the total freeze-over of the Ohio River. Station 1 was the upstream reference station against which potential environmental impact would be measured. Station 3 was located in the area of the proposed intake and discharge, where construction impact would most likely take place, and Station 5 was the downstream control station outside the predicted impact area. Data from Station 5 would also be reflective of a recovery from construction effects. Stations 6 and 8 were located in creeks which drain the northern and eastern margins, respectively, of the plant site.

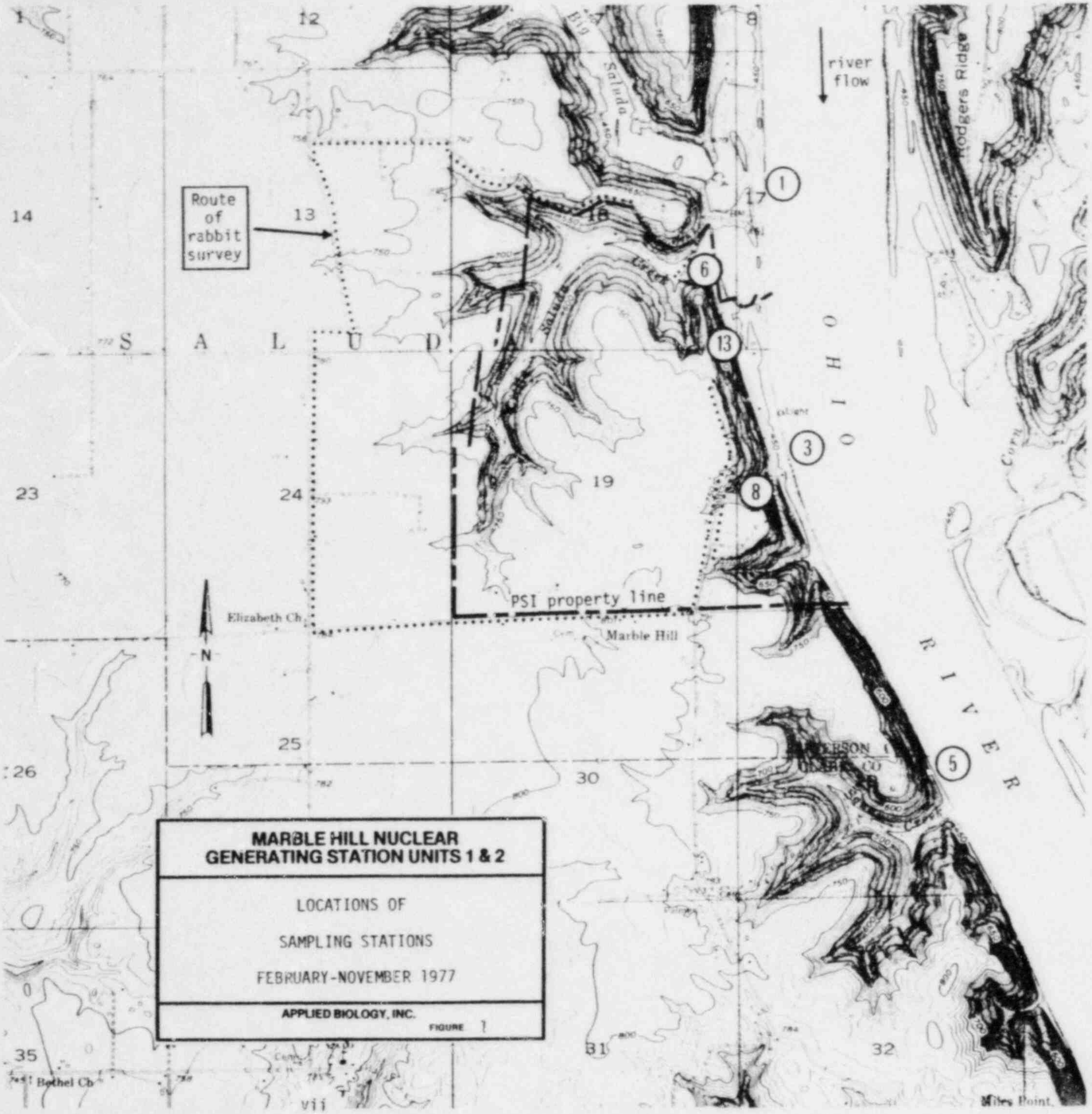
TERRESTRIAL MONITORING PROGRAM

One terrestrial sampling station (Station 13; Figure 1) was located in the wooded area on the east-facing slope. This station, actually five observation posts rather than one specific location, was surveyed for the abundance of squirrels. Observations were made in February and November 1977. In addition, rabbit counts were conducted on the roads which approximate the site boundaries. Counts were made in May 1977.

1977 ECOLOGICAL MONITORING

Sampling at the aquatic and terrestrial sampling stations was undertaken 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.

Construction at the Marble Hill site did not begin until late August 1977, after three of the quarterly samples and all ten of the fish egg and larvae samples had been taken. As a consequence, very little opportunity was afforded for observation of potential construction impact on the ecosystem. The relatively small number of samples collected while construction was underway was insufficient to determine construction impact.



MARBLE HILL NUCLEAR GENERATING STATION UNITS 1 & 2

LOCATIONS OF SAMPLING STATIONS

FEBRUARY-NOVEMBER 1977

APPLIED BIOLOGY, INC.

FIGURE 1

TABLE 1

FIELD WORK AT MARBLE HILL PLANT
FEBRUARY-NOVEMBER 1977

Date	Purpose of Field Trip	ABI Personnel
March 4	Survey Area Placing of periphyton and macroinvertebrate samplers	W. Rhodes G. Hater
March 21-24	1st quarterly sampling	W. Rhodes W. Howard D. Herrema H. Kania J. O'Hara
April 29-30	Ichthyoplankton collection Placing of periphyton and macroinvertebrate samplers	W. Rhodes S. Dupont B. Averill
May 17	Fish egg and larvae collection	W. Rhodes D. Herrema
May 24-26	2nd quarterly sampling Fish egg and larvae collection	W. Rhodes D. Kania H. Kania J. O'Hara
June 8-9	Fish egg and larvae collection	W. Rhodes B. Averill
June 15	Fish egg and larvae collection	R. Goldstein B. Averill
June 24	Fish egg and larvae collection	D. Yeakel B. Averill
June 30	Fish egg and larvae collection	D. Herrema B. Averill
July 8	Fish egg and larvae collection	B. Averill D. Yeakel
July 15	Fish egg and larvae collection	B. Averill J. Dineen

TABLE 1
(continued)
FIELD WORK AT MARBLE HILL PLANT
FEBRUARY-NOVEMBER 1977

Date	Purpose of Field Trip	ABI Personnel
July 26	Fish egg and larvae collection Placing of periphyton and macroinvertebrate samplers	W. Howard B. Averill
August 16-18	3rd quarterly sampling	W. Rhodes W. Howard S. Dupont H. Kania
October 17	Placing of periphyton and macroinvertebrate samplers	B. Averill D. Yeakel
November 8-10	4th quarterly sampling	W. Rhodes D. Herrema R. Comegys J. O'Hara H. Kania

A. CHEMICAL AND PHYSICAL PARAMETERS

INTRODUCTION

This study was designed to monitor the physical and chemical parameters of the aquatic habitat at locations near the Marble Hill Plant site. Chemical and physical parameters are especially important to the biological community in aquatic environments because of possible effects on the entire food chain. The more chemical and physical data that are available, the more likely the effects of such parameters on any particular member of the community will be understood.

MATERIALS AND METHODS

Duplicate subsurface water samples were collected at Stations 1, 3, 5, and 6 with a non-metallic Kemmerer sampler. Water samples were preserved as prescribed by the EPA (1974) and analyzed according to Standard Methods (APHA, 1976). A list of the chemical parameters analyzed, preservation techniques, detection limits, and methodologies is shown in Appendix Table A-1.

Current velocity, water temperature, Secchi depth, water depth, and turbidity (Station 8 only) were determined on each sampling trip. In addition, quarterly sedimentation studies were conducted at Station 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 determined with a Heathkit Model 1031 depth meter. Oxygen determinations were made using a YSI Model 54 oxygen meter. Conductivity was determined with a YSI Model 33 salinity-conductivity-temperature (SCT) meter. Temperature was measured electronically with the oxygen and conductivity meters. Turbidity was determined in the laboratory with a Hach Model 2100A nephelometric turbidimeter.

RESULTS OF WATER CHEMISTRY ANALYSIS

The results from the chemical analysis of water samples collected quarterly at Stations 1, 3, 5, and 6 during 1977 are tabulated in Appendix Tables A-2 through A-5. Both replicate values and their average are shown in these tables.

The results obtained from the Ohio River Stations (1, 3, and 5) are graphically compared for each chemical parameter in Figures A-1 through A-22 with baseline data from the Environmental Report (PSI, 1976) and, where available, with Ohio River Valley Water Sanitation Commission (ORSANCO) data. Average monthly values from the closest ORSANCO sampling stations upstream (Mile Post 528.1 at Neville, Ohio) and downstream (Mile Post 600.6 at Louisville) of the Marble Hill Plant site (Mile Post 570) were used for these comparisons.

In general, the quarterly data collected in 1977 showed very small variations between Ohio River stations but sometimes varied appreciably between seasons. The absolute values for chemical parameters measured in 1977 compared favorably with those from the baseline study and with ORSANCO values.

The results of water chemistries obtained for Little Saluda Creek (Station 6) by Applied Biology, Inc., in 1977 are compared to baseline results from the Environmental Report (PSI, 1976) in Table A-1. Minimum and maximum values of each chemical parameter for the respective study period are presented for comparison.

Dissolved Oxygen

Dissolved oxygen (D.O.) values showed little variability among Ohio River stations but did exhibit seasonal variations, being highest in the fall and lowest in the summer. Values for D.O. ranged from 6.0 to 10.8 mg/liter. D.O. values in Little Saluda Creek were similar to those in the Ohio River except in August when creek values were appreciably higher, remaining at 102% saturation while the Ohio River station values dropped to 75% saturation. Regardless of the season, D.O. values for all stations remained above 5.0 mg/liter, which is the minimum value recommended by the National Technical Advisory Committee (1968) for the general well-being of diversified warm-water biota.

pH and Alkalinity

The pH values at the Marble Hill Plant site during 1977 quarterly samplings ranged from 6.8 to 7.6 in the Ohio River and from 7.5 to 8.0 in Little Saluda Creek. These are well within ORSANCO's criteria for the mainstream of the Ohio River.

Alkalinity, which is a measure of the carbonate and bicarbonate buffering capacity of water, ranged from 43.3 to 66.8 mg/liter in the Ohio River. The National Technical Advisory Committee (1968) states that to protect the carbonate system, acid should not be added to lower the total alkalinity to less than 20 mg/liter. Little Saluda Creek, which had alkalinity values between 192 and 245 mg/liter, was also well above this minimum acceptance value. The higher alkalinity of the creek is a result of water leaching through the surrounding limestone cliffs.

Conductivity, Total Dissolved Solids, and Suspended Solids

Conductivity is a measure of the dissociated ions in water while total dissolved solids (TDS) is a measure of dissociated ions plus all other dissolved solids. Conductivity values varied between 169 and 345 μmhos for the Ohio River and between 218 and 445 for Little Saluda Creek. The TDS values varied between 163 and 263 mg/liter for the Ohio River and between 248 and 359 for Little Saluda Creek.

Suspended solids are insoluble particles suspended in the water column which cause the water to be turbid and thus can cause problems with light penetration and animal sensory functions. Suspended solids values varied between 9 and 196 mg/liter for the Ohio River, with the highest values recorded in March when runoff was high. The values for Little Saluda Creek remained relatively constant and low, ranging between 5 and 39 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 in terms of oxygen consumption while chemical oxygen demand (COD) is a measure of the amount of material which can be oxidized by a chemically defined dichromate solution. Both these tests, as well as total organic carbon (TOC) values, indicate the concentration of organic waste material present in water. Ohio River station values for BOD, COD, and TOC were in the ranges of 1.8 to 4.2, 6.2 to 16.1, and 3.98 to 8.47 mg/liter, respectively, while Little Saluda Creek values were in the ranges of 1.0 to 2.9, 2.6 to 5.3, and 1.71 to 5.33. As would be expected of a relatively non-polluted tributary, the values from Little Saluda Creek were consistently lower for each parameter than those from the Ohio River.

Nitrogen and Phosphorous

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

To prevent biological nuisances such as plankton blooms, it has been suggested that total phosphorous concentrations should not exceed 0.10 mg/liter at any point within a flowing stream (MacKenthun, 1969). This maximum value for total phosphorous was repeatedly exceeded at Stations 1, 3, and 5 in the Ohio River during 1977, while concentrations of total phosphorous in Little Saluda Creek always remained below 0.10 mg/liter. Total phosphorous and orthophosphate levels varied from 0.09 to 0.25 and 0.03 to 0.04 mg/liter, respectively, for the Ohio River stations and from 0.02 to 0.09 and <0.01 to 0.02, respectively, in Little Saluda Creek. Nitrate-nitrogen values for stations in the Ohio River and Little Saluda Creek were relatively constant during the year, and both exceeded the minimum concentration necessary to limit growth of algae and plants (MacKenthun, 1969). Nitrate values for all stations were, however, much less than ORSANCO's maximum recommended level of 10.0 mg/liter. Ammonia nitrogen values were higher in the Ohio River stations than in Little Saluda Creek, with respective ranges of 0.06 to 0.18 and <0.02 to 0.08 mg/liter.

Other Chemical Parameters

Quarterly values for silica, chloride, sulfate, calcium, magnesium, and sodium were similar along the three Ohio River stations but differed significantly between the Ohio River and Little Saluda Creek. The Ohio River had a higher concentration of sulfate, sodium, and chlorides than Little Saluda Creek, while the reverse was true with silica, calcium, and magnesium. High concentrations of calcium, magnesium, and silica probably are due to minerals dissolving along the flow of Little Saluda Creek. High levels of sodium, sulfate, and chloride in the Ohio River are probably due to municipal wastes. The highest values of sulfate and chloride measured during 1977 (90 and 23 mg/l) were well below ORSANCO's recommended maximum of 250 mg/l.

Residual free chlorine and chloramines, which result from chlorine reactions with nitrogen compounds, were both measured to be less than 0.01 mg/liter during each quarter of 1977 in the Ohio River and in Little Saluda Creek.

Hexane-soluble materials and phenolic compounds were relatively constant during 1977. Hexane-soluble materials decreased to <1.0 mg/liter in the Ohio River stations and 2.1 mg/liter in Little Saluda Creek in August while ranging between 11.4 and 27.2 mg/liter during the rest of the year. Phenols varied between <0.003 and 0.010 mg/liter at both the Ohio River and Little Saluda Creek stations. These phenol values were equal to or below ORSANCO's maximum recommended criteria for the mainstream of the Ohio River of 0.010 mg/liter.

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.

SEDIMENTATION

Sedimentation studies were undertaken at Station 8, located in an intermittent stream which drains the plant site. This study consisted of erosion estimates as determined by sediment level on measured rods placed in the stream bed. Photographs (Figures A-23 through A-35) were taken at two selected locations to visually evaluate changes in stream bed appearance over time. The upstream location was approximately midway up the east-facing slope adjacent to the plant site. The downstream location was just below the road on the narrow flood plain lining the banks of the Ohio River.

No construction was undertaken on the Marble Hill site until after the August sampling, and no measurable change in the height of the sedimentation study rods above the surface of the stream bed was noticed. Observations in November revealed that sedimentation had taken place between August and November as a result of erosion from clearing and grading on top of the Marble Hill site and from clearing of the area where the proposed make-up water intake line will be located, just to the right of the stream bed. Sedimentation in November was observed to measured depths of 14.9 cm at the upstream sedimentation study rod, and 2.6 cm at the downstream sedimentation study rod. At points just below the intersection of the stream bed and the intake line, sediment accumulation was observed to be more than 30 cm deep.

To reduce future sedimentation, a settling pond was constructed where the intermittent stream (Station 8) intersected the top of the east-facing slope. This pond should reduce the sediment flow down the stream bed. Additional observations will be made to assess the effectiveness of this measure.

CONCLUSIONS

During the quarterly sampling program in 1977, values for chemical and physical parameters exhibited little variability between Ohio River stations; Station 3 showed no deviations from control Stations 1 and 5. The Marble Hill Plant site thus seems to have a negligible effect at this time upon the chemical and physical parameters measured in this study.

The chemical parameters measured 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 which indicate a decreased water quality are higher in the Ohio River than in Little Saluda Creek. This decreased water quality is almost certainly due to municipal discharges upstream from the Marble Hill Plant.

In November, sediment accumulations were observed in the intermittent stream on the east-facing slope. Corrective measures in the form of a settling pond have been taken.

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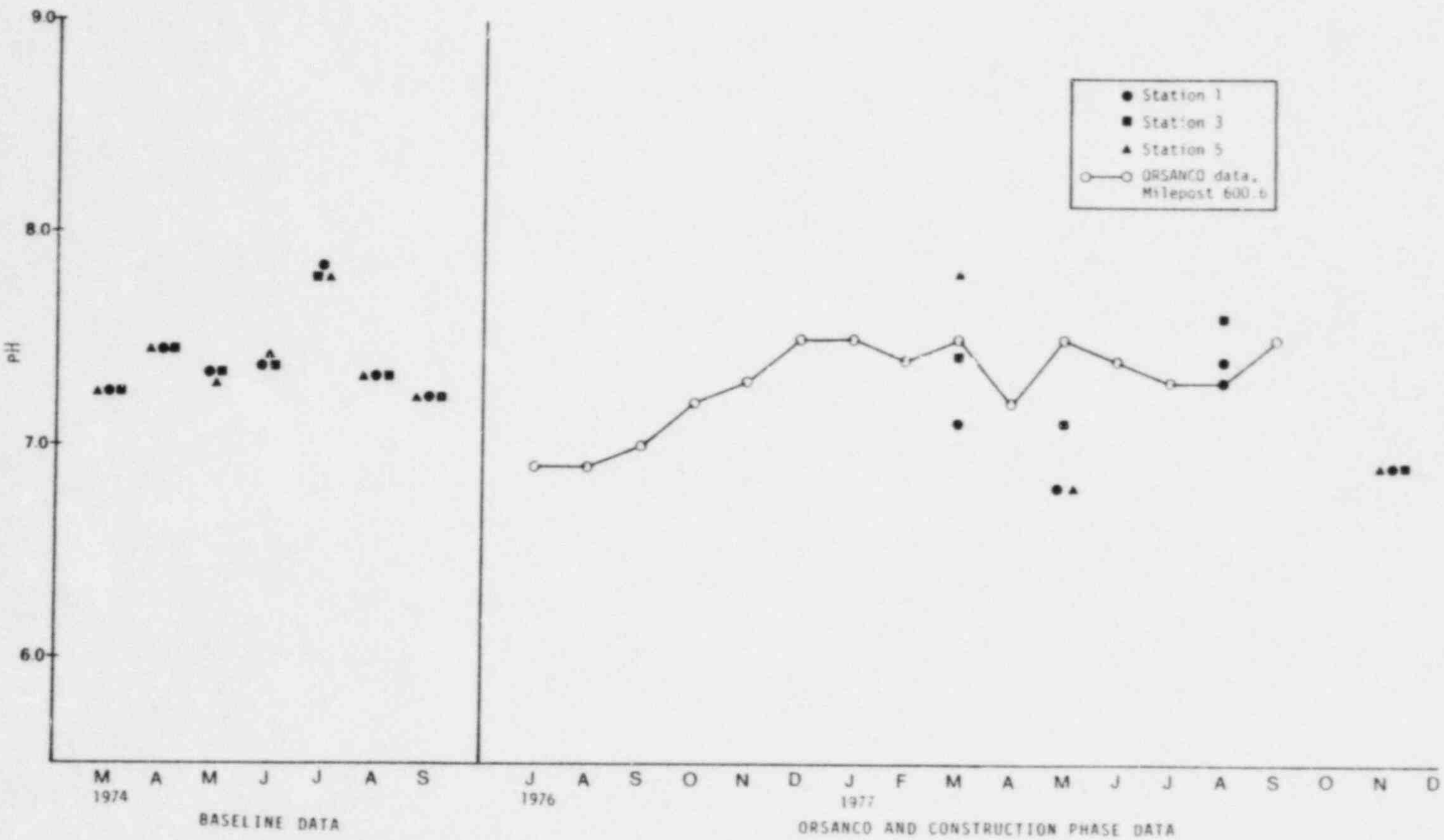

Figure A-1. Comparison of baseline, ORSANCO, and ABI pH data (average values) taken in the Ohio River near the Marble Hill Plant site.

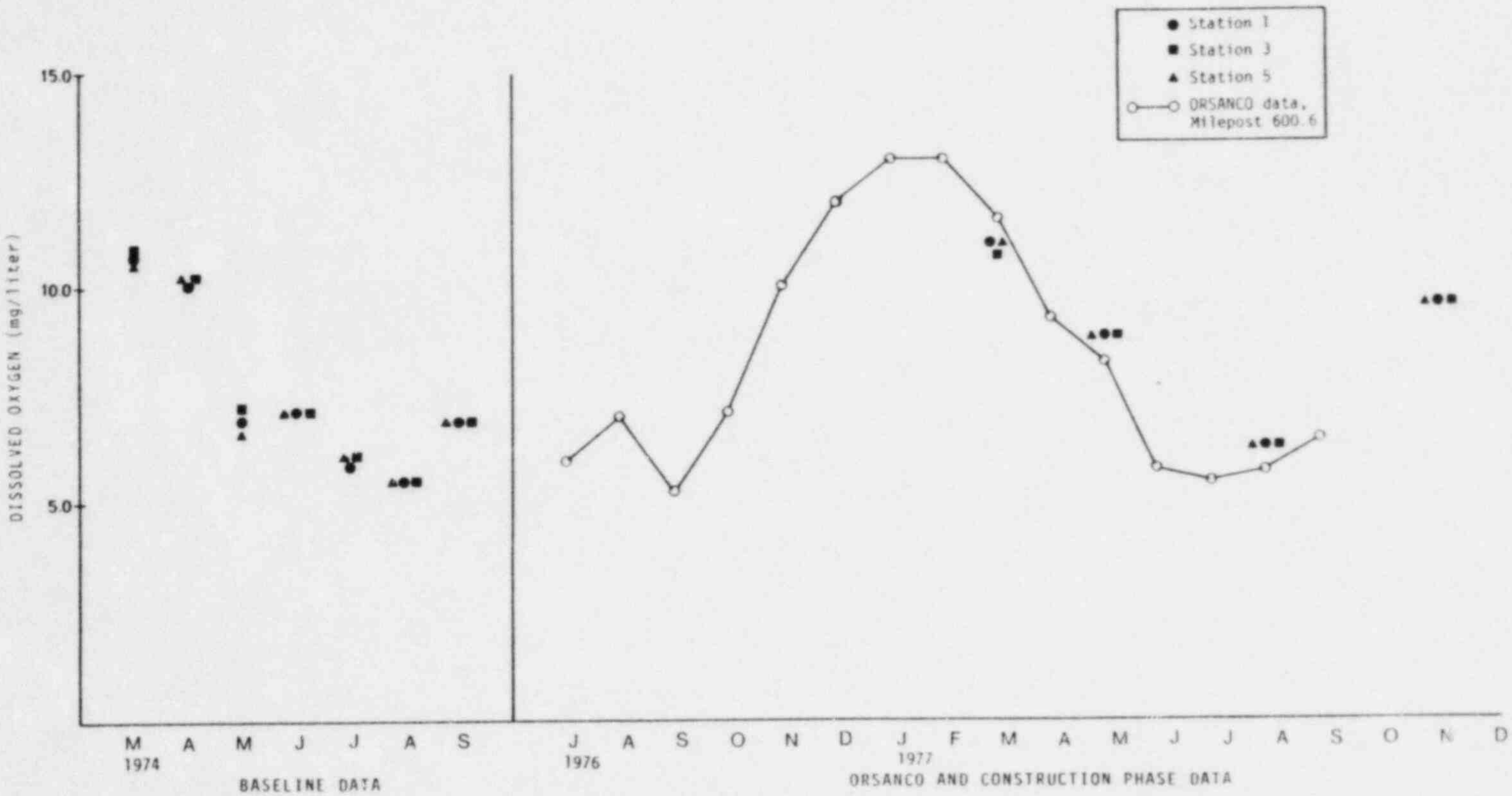

Figure A-2. Comparison of baseline, ORSANCO, and ABI dissolved oxygen (average values) taken in the Ohio River near the Marble Hill Plant site.

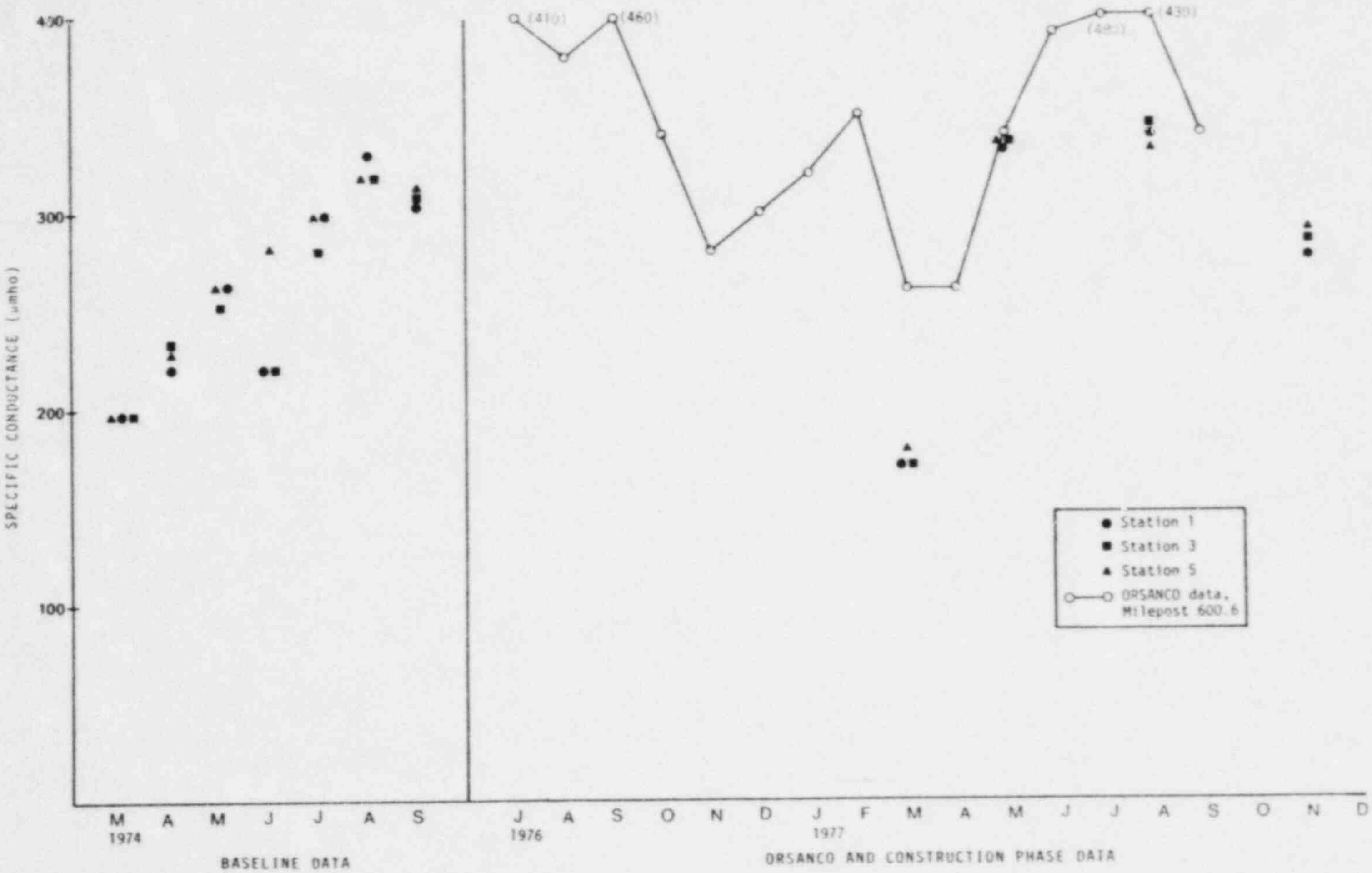

Figure A-3. Comparison of baseline, ORSANCO, and ABI specific conductance data (average values) taken in the Ohio River near the Marble Hill Plant site.

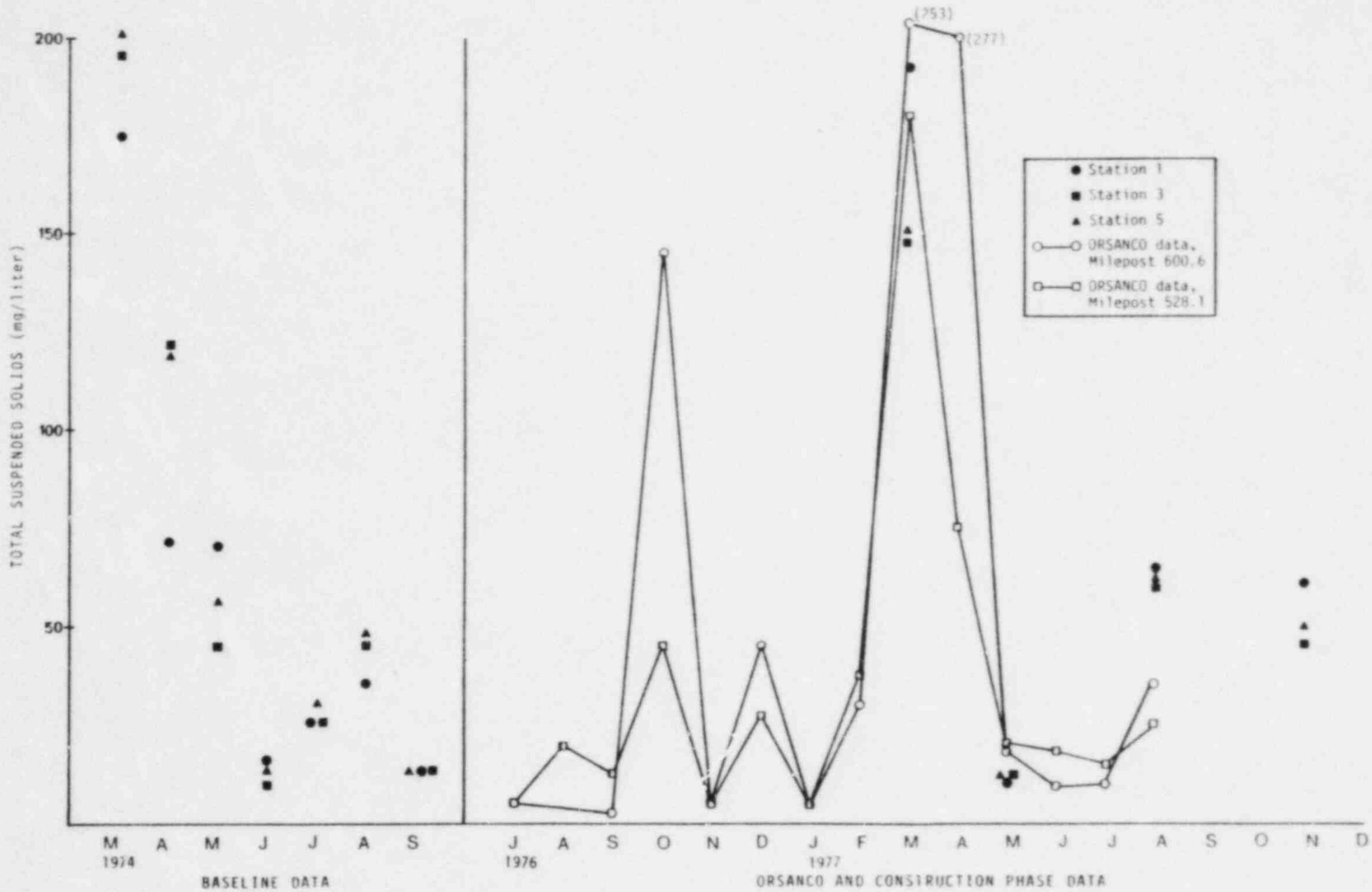

Figure A-4. Comparison of baseline, ORSANCO, and ABI total suspended solids data (average values) taken in the Ohio River near the Marble Hill Plant site.

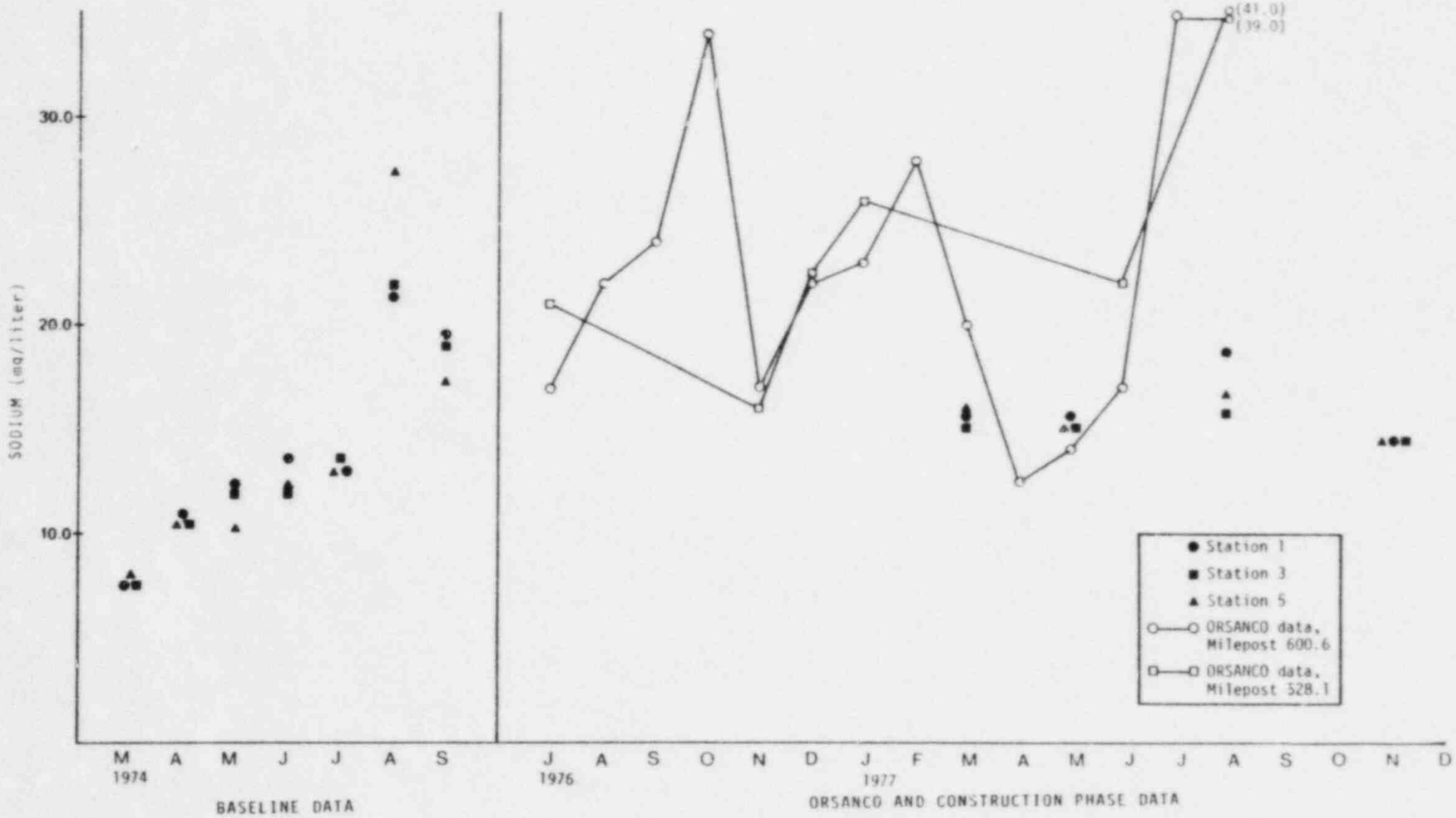

Figure A-5. Comparison of baseline, ORSANCO and ABI sodium data (average values) taken in the Ohio River near the Marble Hill Plant site.

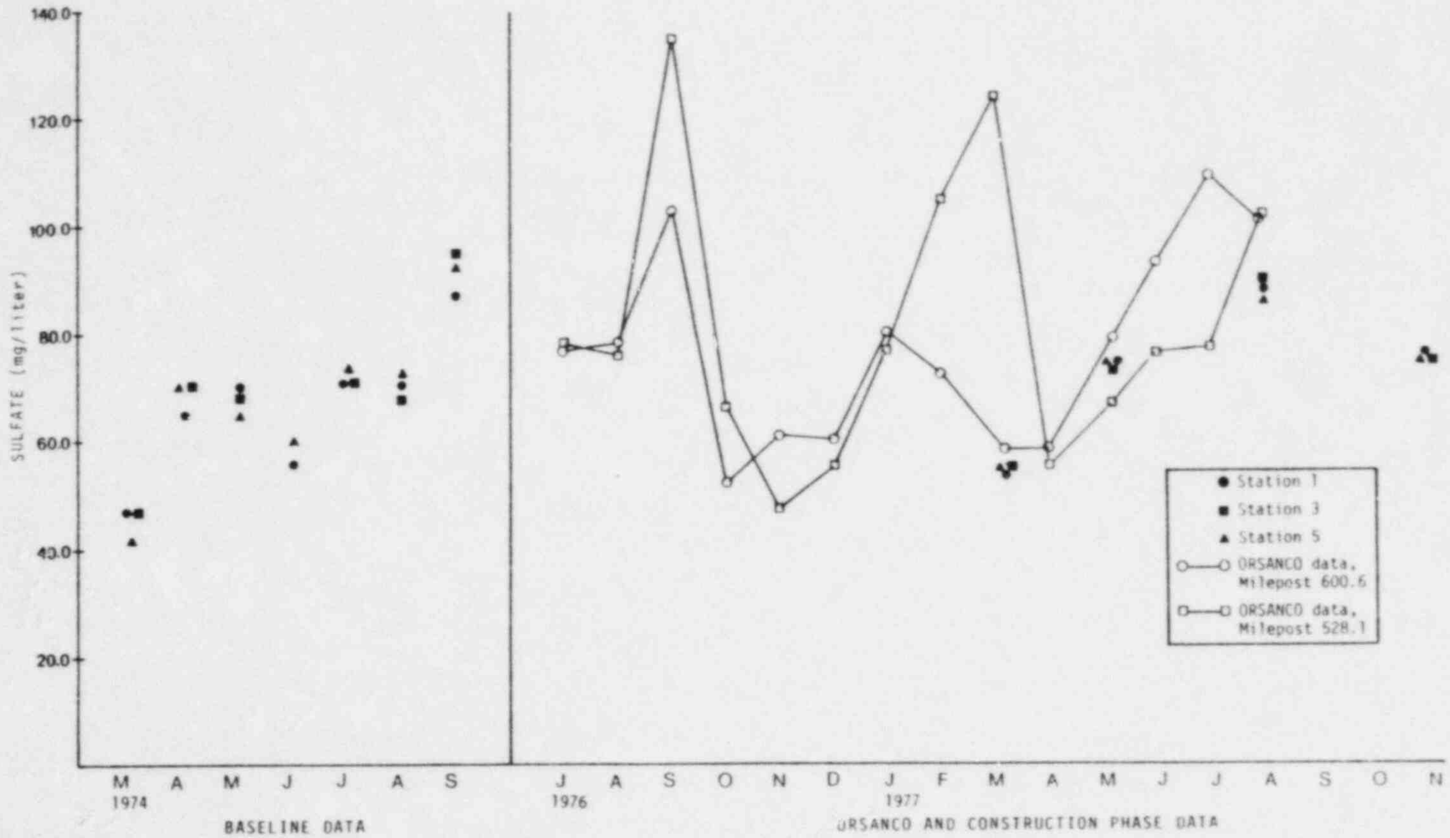

Figure A-6. Comparison of baseline, ORSANCO, and ABI sulfate data (average values) taken in the Ohio River near the Marble Hill Plant site.

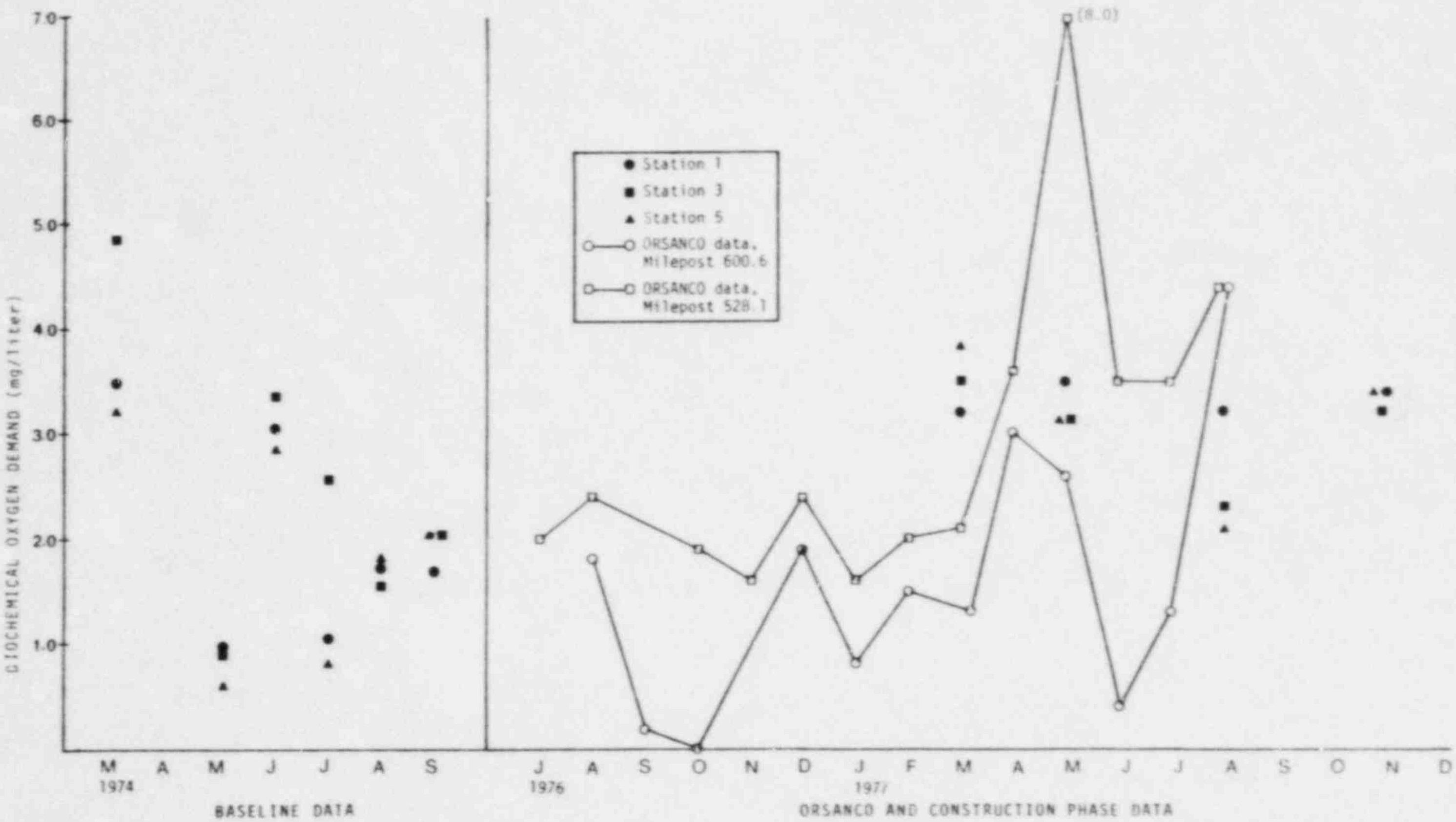

Figure A-7. Comparison of baseline, ORSANCO, and ABI biochemical oxygen demand data (average values) taken in the Ohio River near the Marble Hill Plant site.

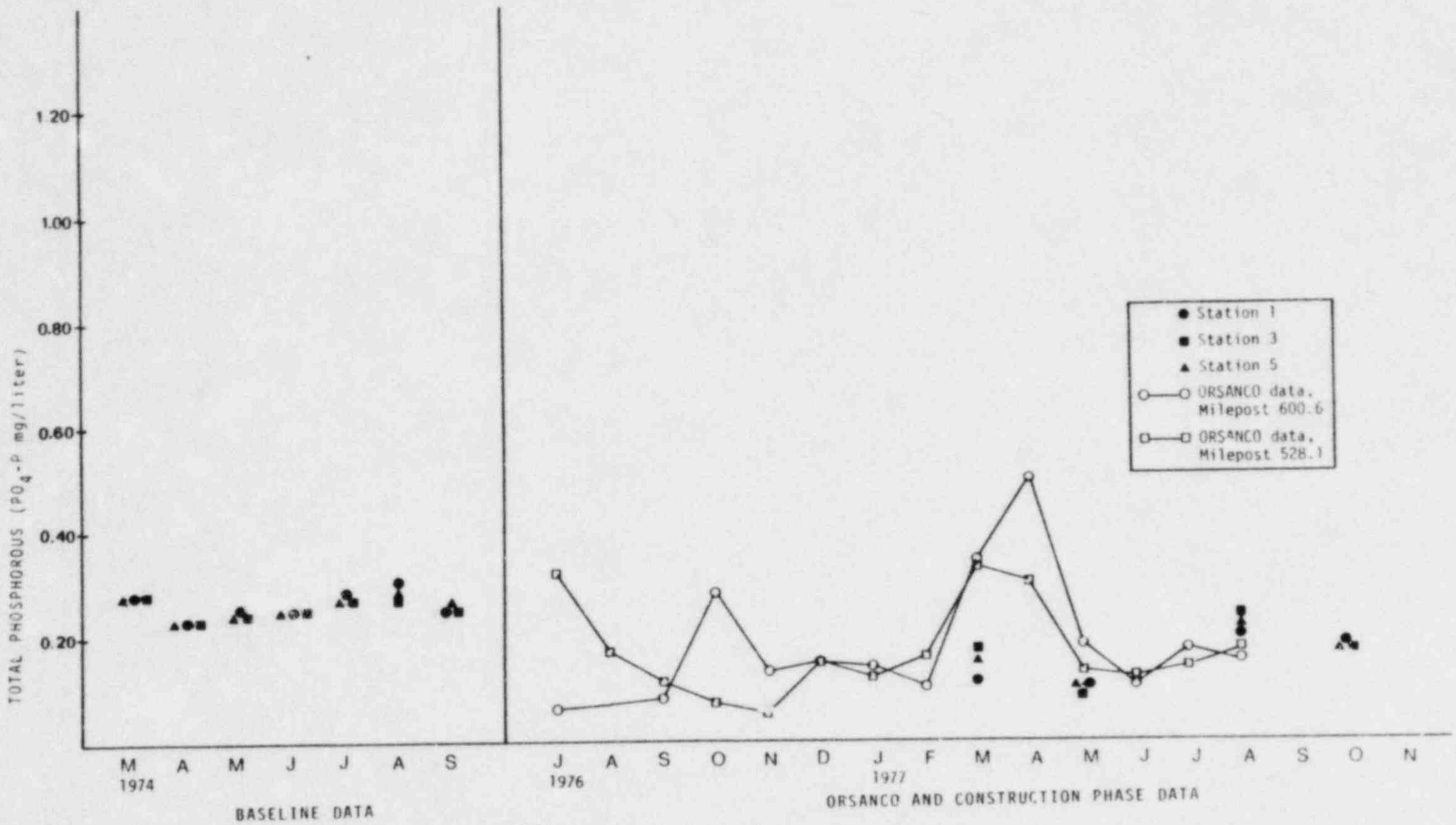

Figure A-8. Comparison of baseline, ORSANCO, and ABI total phosphorous data (average values) taken in the Ohio River near the Marble Hill Plant site.

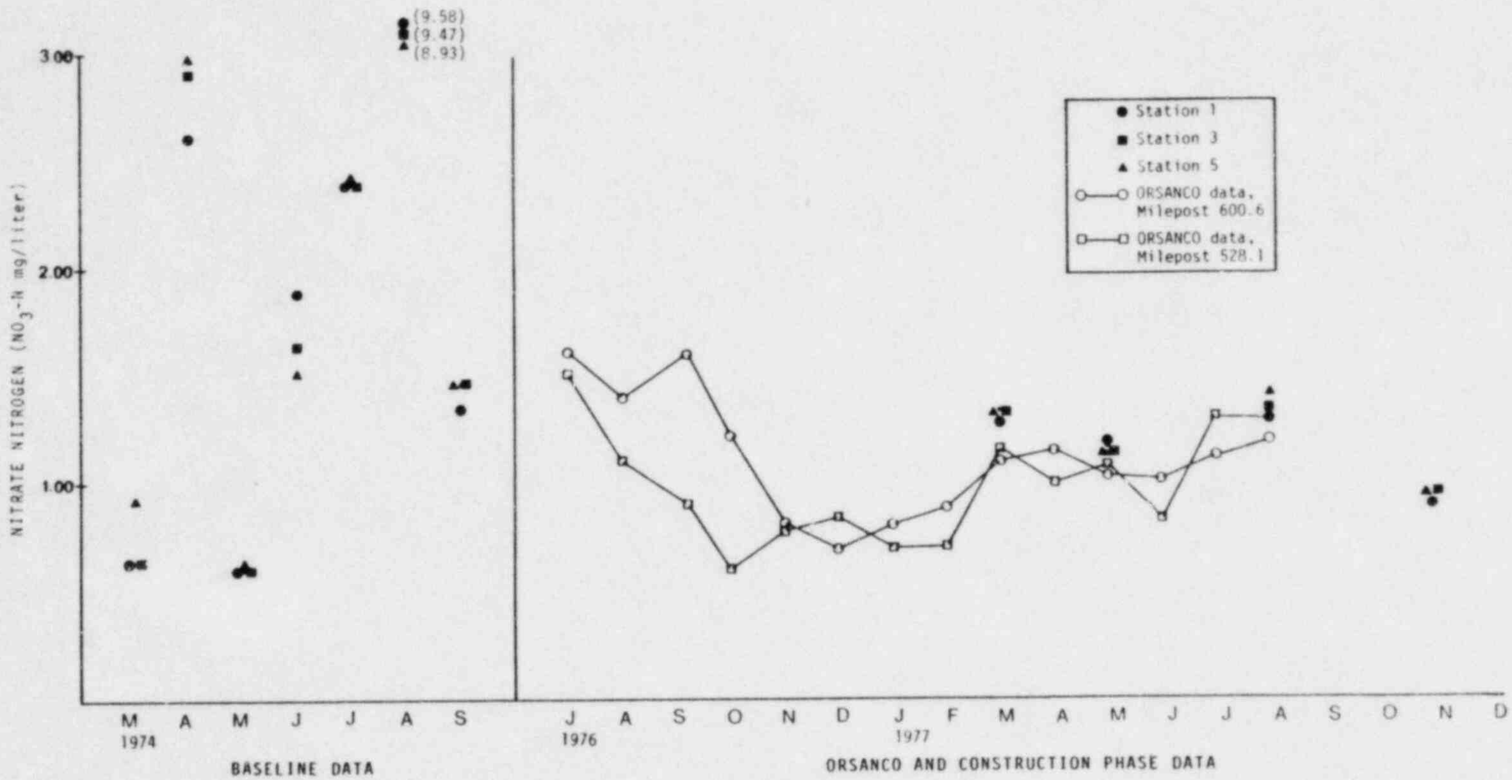

Figure A-9. Comparison of baseline, ORSANCO, and ABI nitrate nitrogen data (average values) taken in the Ohio River near the Marble Hill Plant site.

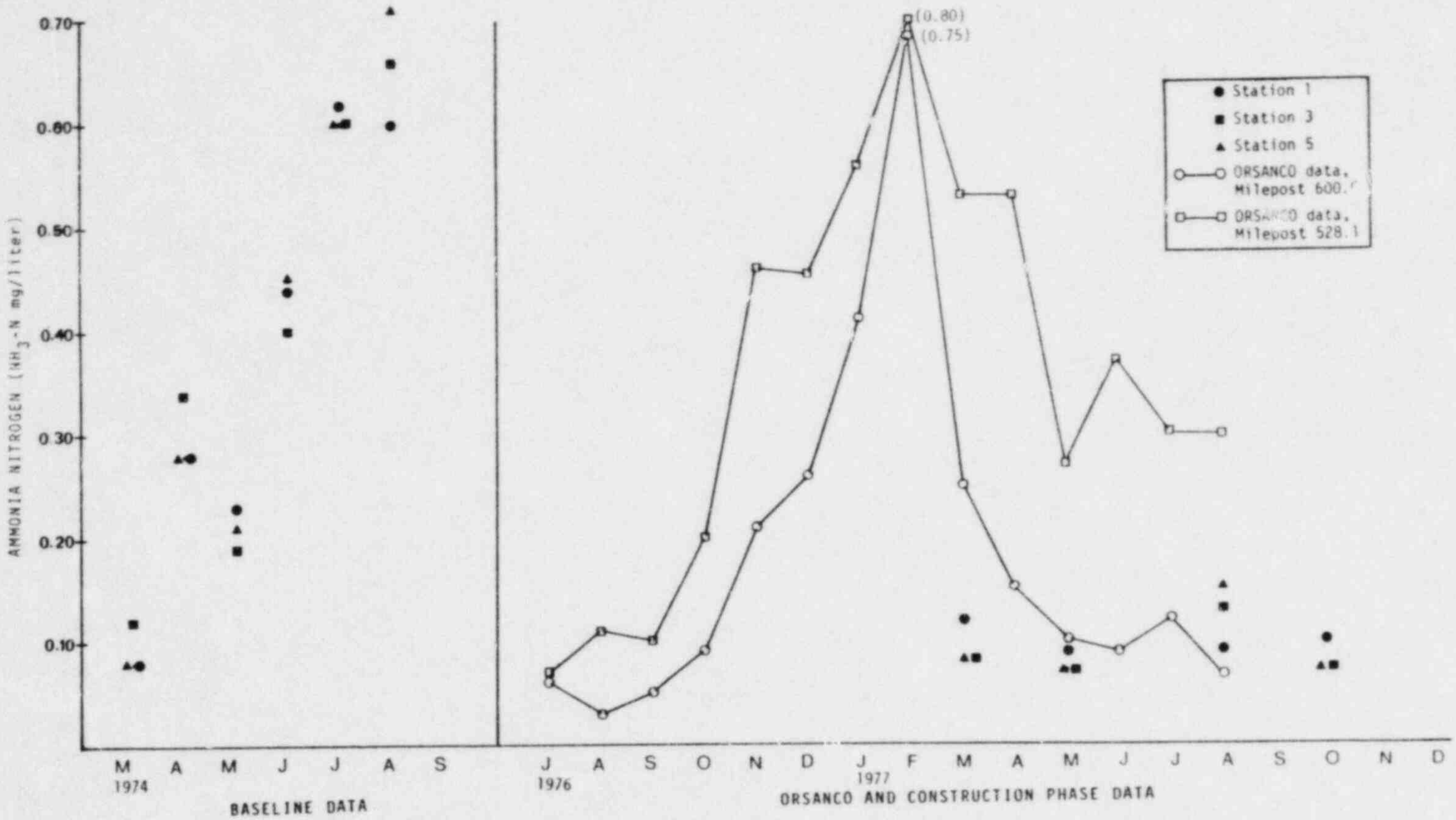

Figure A-10. Comparison of baseline, ORSANCO, and ABI ammonia nitrogen data (average values) taken in the Ohio River near the Marble Hill Plant site.

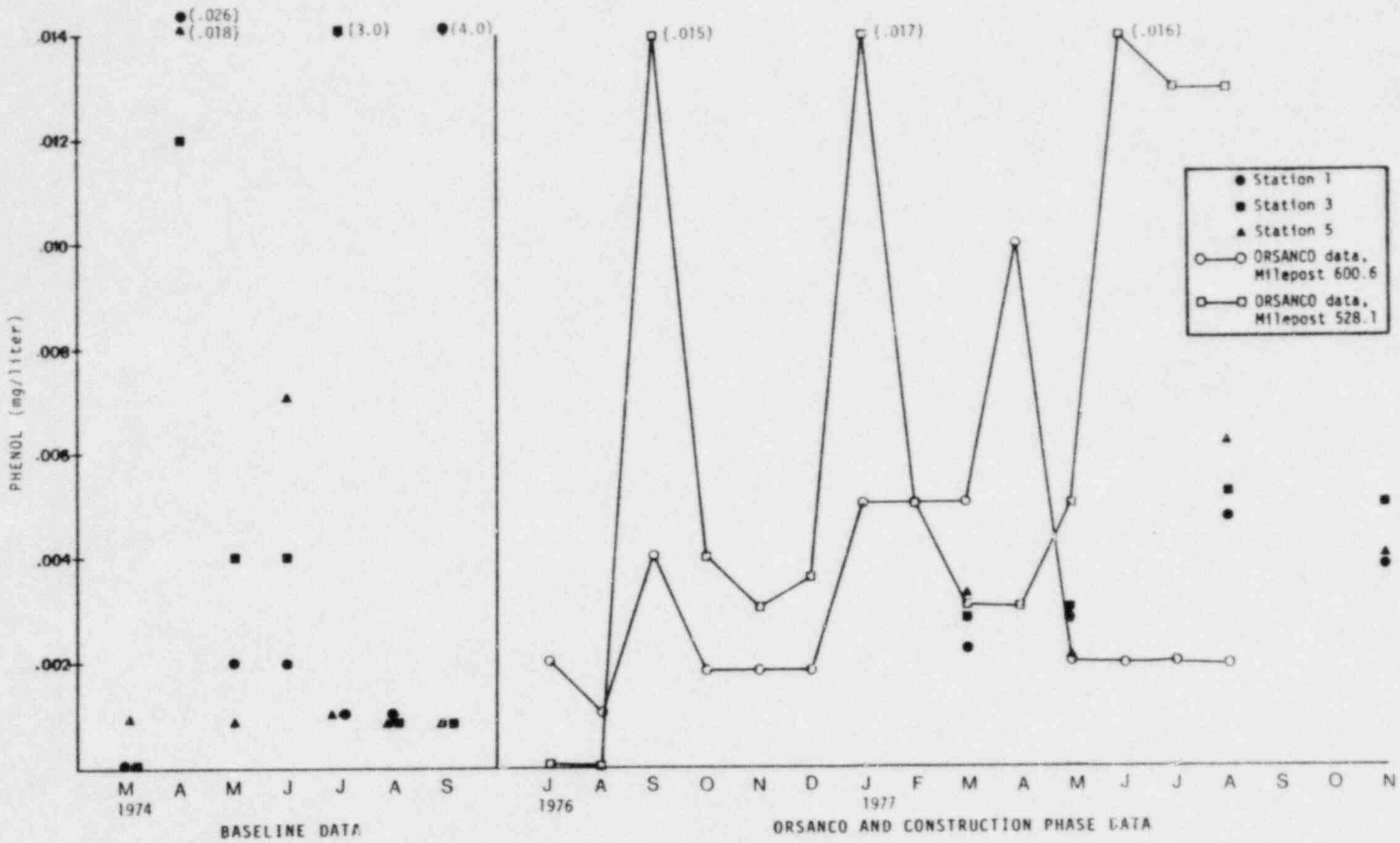

Figure A-11. Comparison of baseline, ORSANCO, and ABI phenol data (average values) taken in the Ohio River near the Marble Hill Plant site.

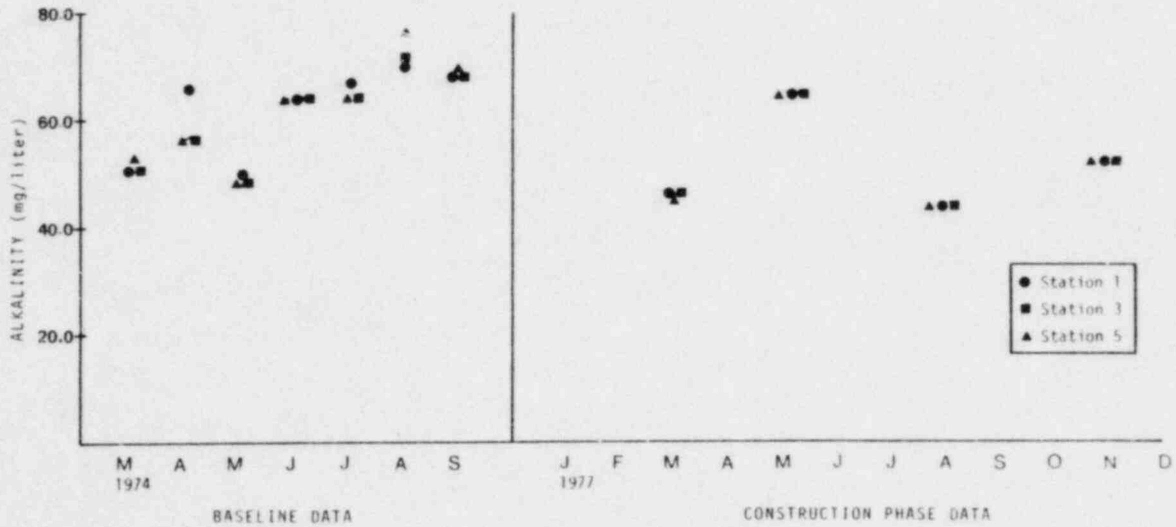

Figure A-12. Comparison of baseline and ABI alkalinity data (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

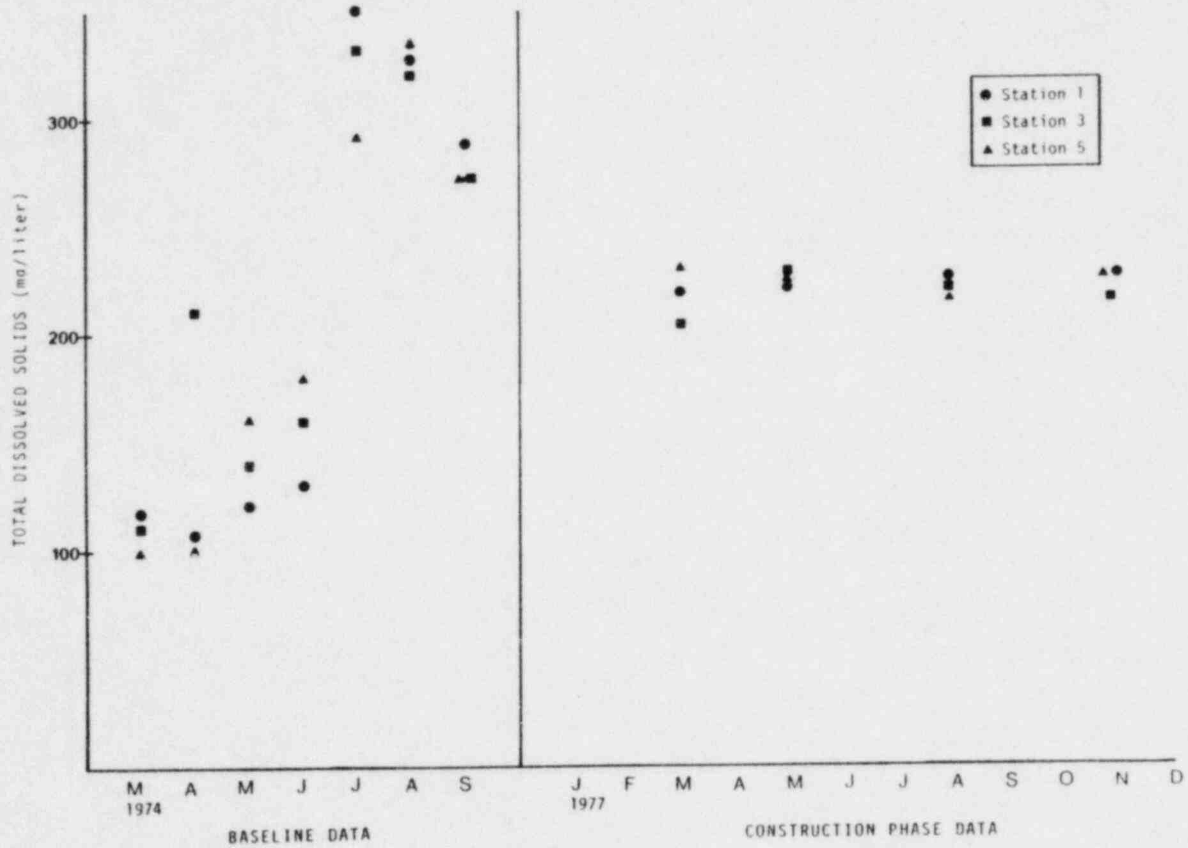

Figure A-13. Comparison of baseline and ABI dissolved solids (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

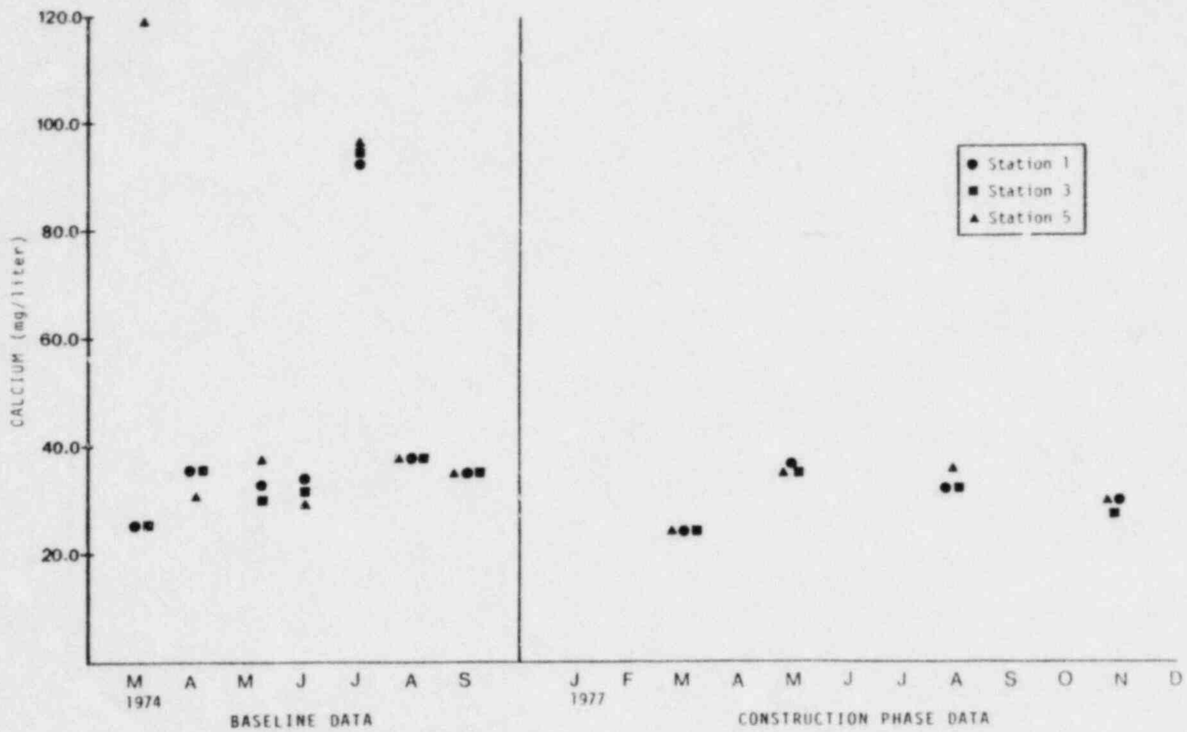

Figure A-14. Comparison of baseline and ABI calcium (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

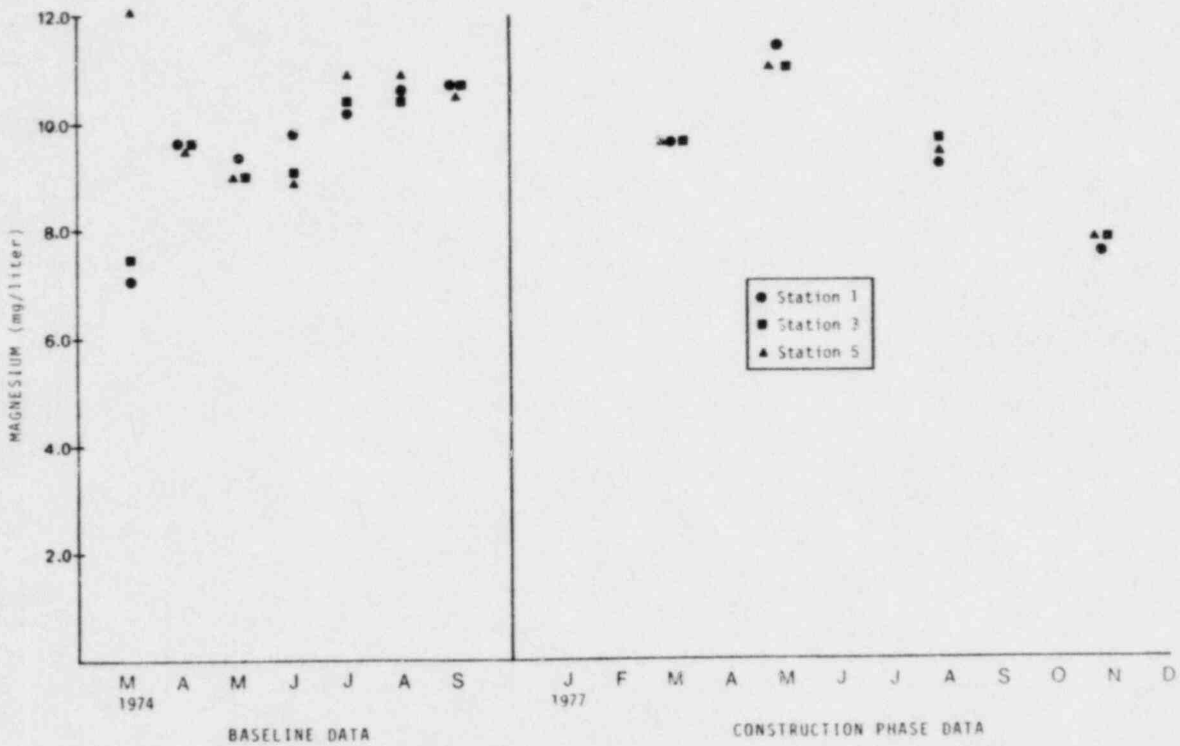

Figure A-15. Comparison of baseline and ABI magnesium (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

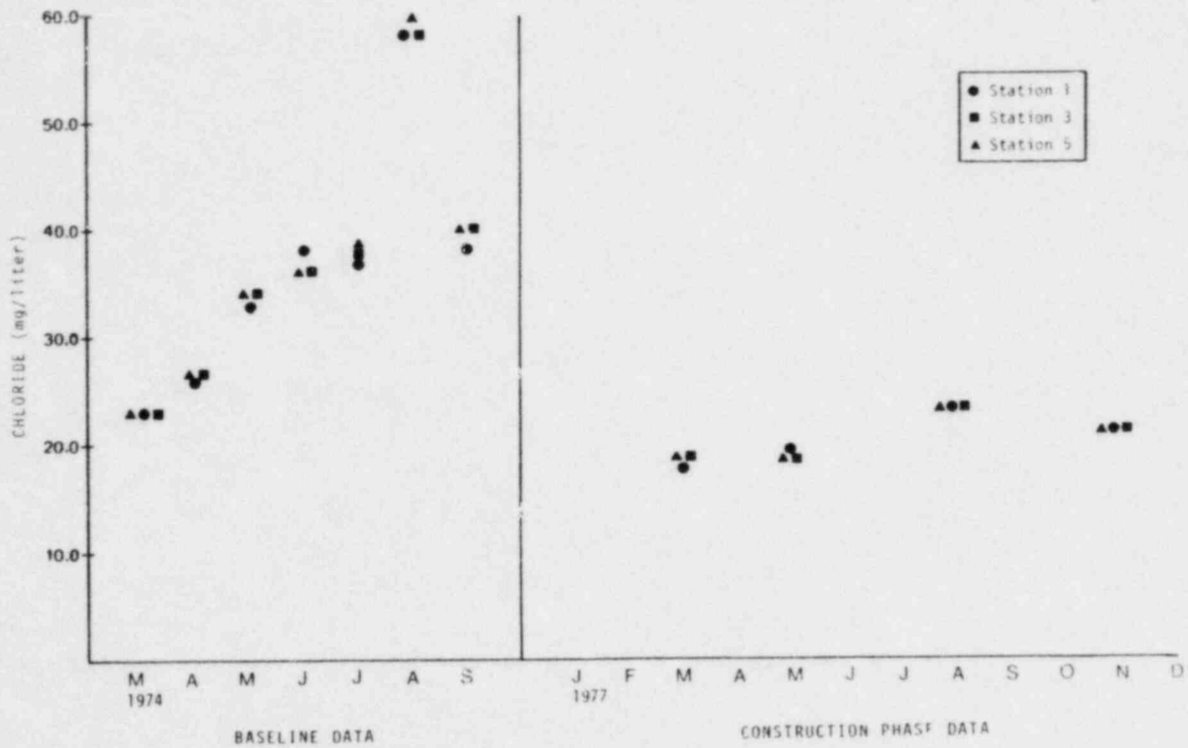

Figure A-16. Comparison of baseline and ABI chloride (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

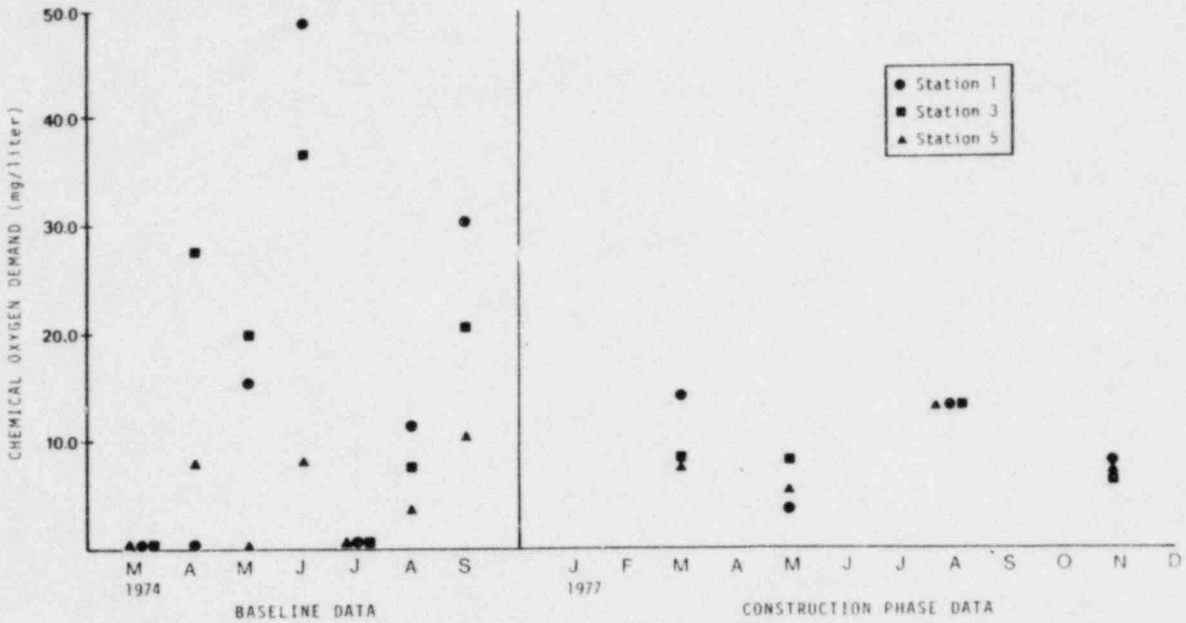

Figure A-17. Comparison of baseline and ABI chemical oxygen demand (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

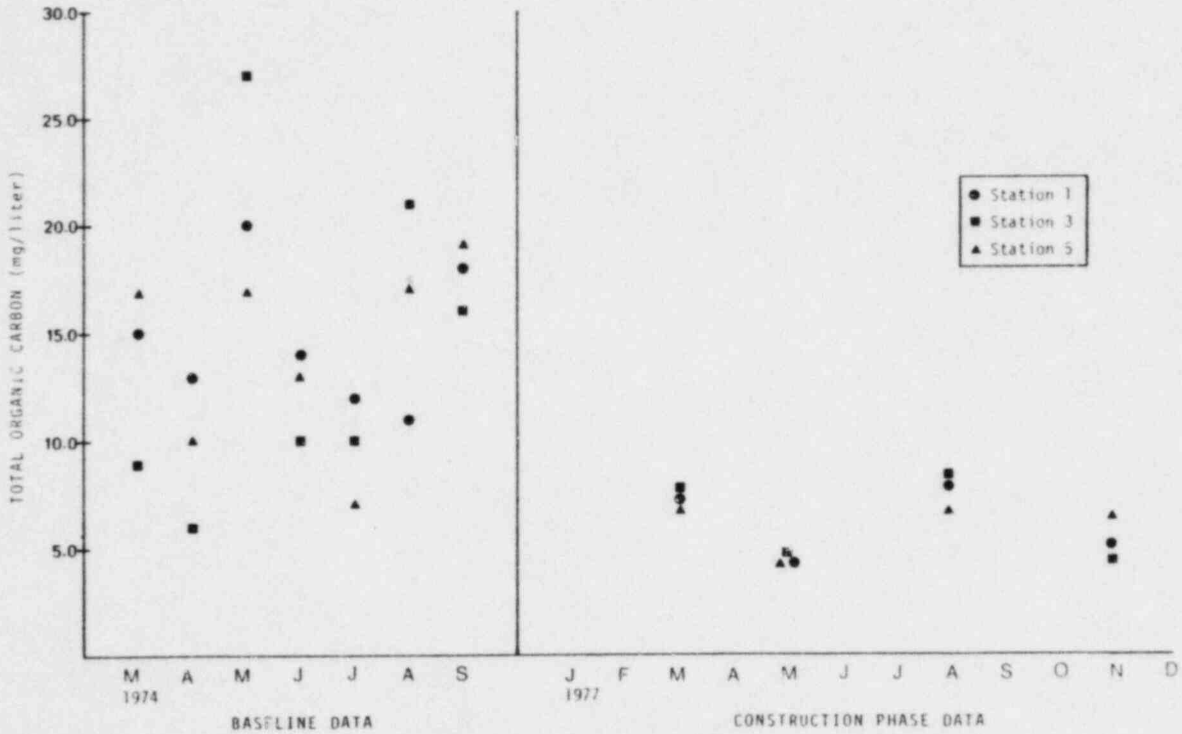

Figure A-18. Comparison of baseline and ABI total organic carbon (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

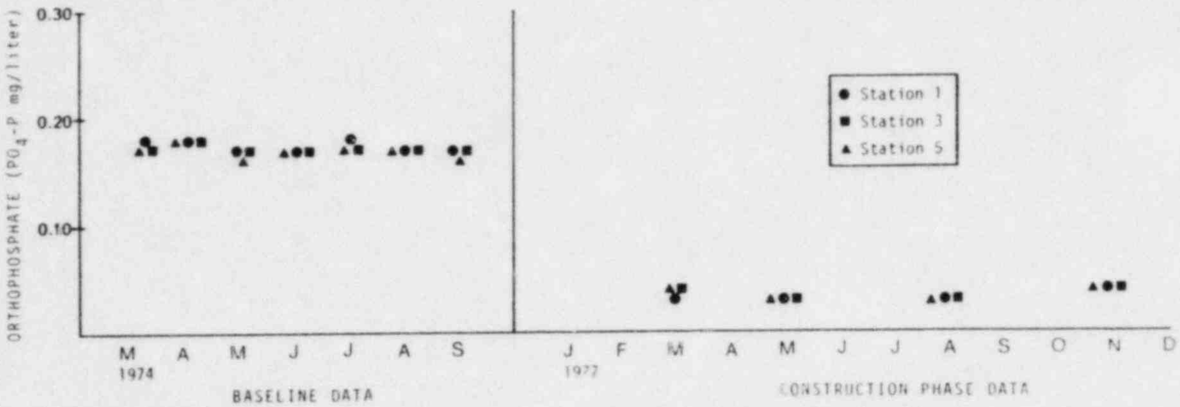

Figure A-19. Comparison of baseline and ABI orthophosphate (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

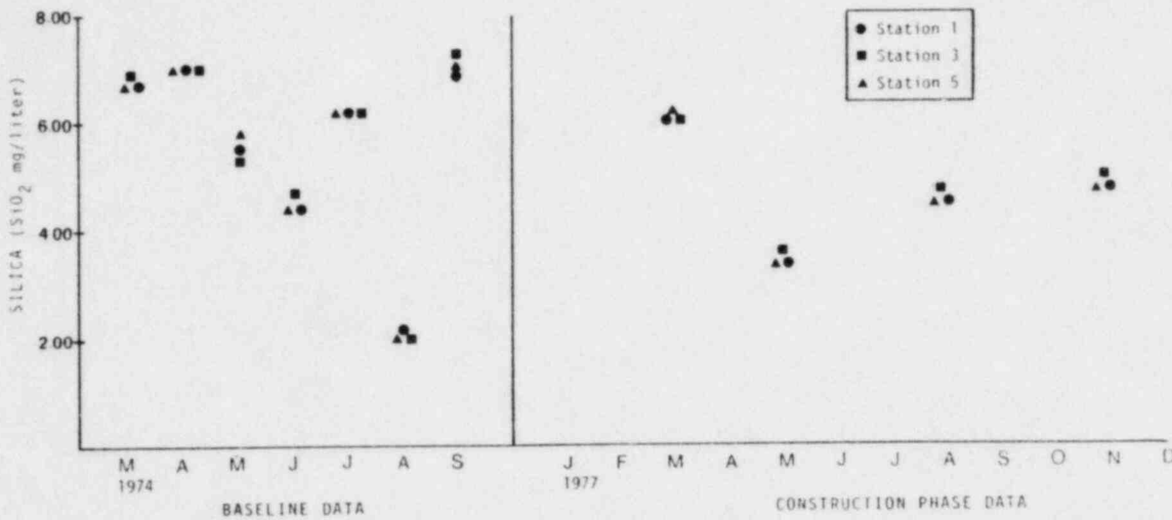

Figure A-20. Comparison of baseline and ABI silica (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

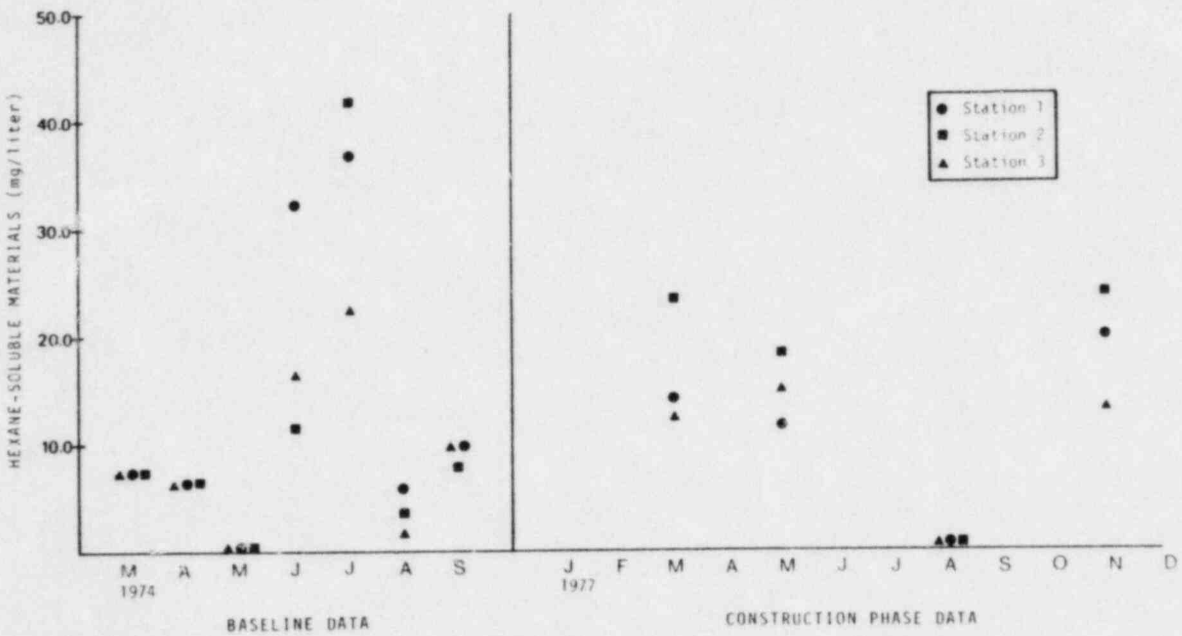

Figure A-21. Comparison of baseline and ABI hexane-soluble materials (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

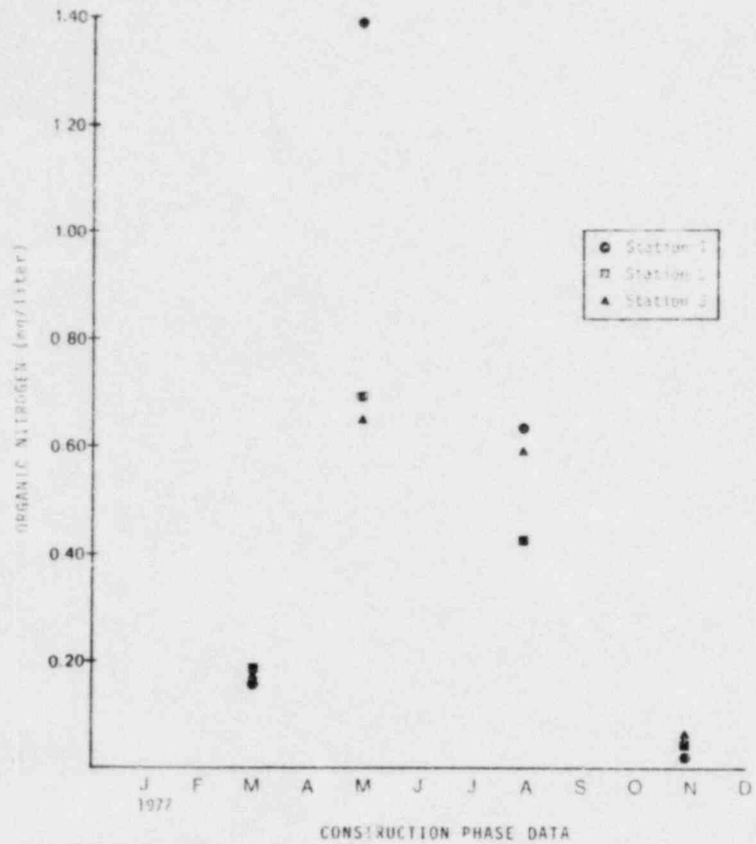

Figure A-22. ABI quarterly organic nitrogen data from samples taken in the Ohio River near the Marble Hill Plant site.

Figure A-23. Area of the upstream sedimentation study at Station 8, March 1977.

Figure A-24. Area of the downstream sedimentation study at Station 8, March 1977.

Figure A-25. Area of the upstream sedimentation study at Station 8, November 1977.

Figure A-26. Area of the downstream sedimentation study at Station 8, November 1977.

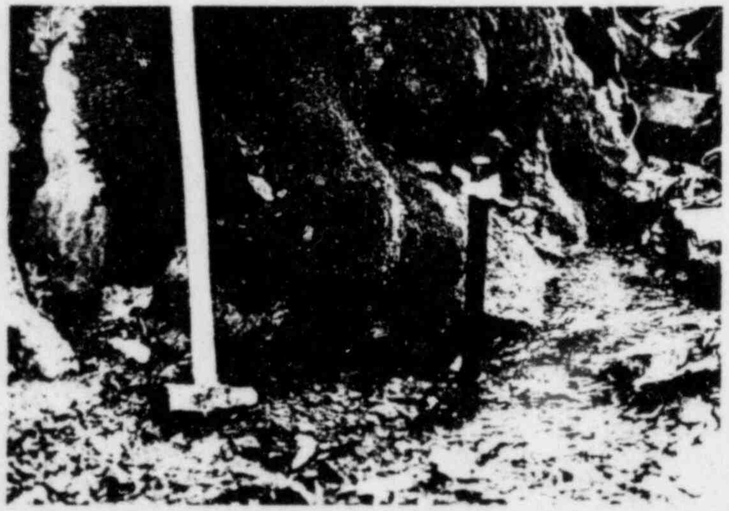

Figure A-27. Upstream sedimentation study rod at Station 8, March 1977. Water less than 5 cm deep.

Figure A-28. Upstream sedimentation study rod at Station 8, May 1977. No water in stream and no significant sedimentation noted.

Figure A-29. Upstream sedimentation study rod at Station 8, August 1977. No water in stream and no significant sedimentation noted.

Figure A-30. Upstream sedimentation study rod at Station 8, November 1977. Accumulated sediment measured to a depth of 14.9 cm.

Figure A-31. Downstream sedimentation study rod at Station 8, March 1977. Water standing in isolated, shallow pools.

Figure A-32. Downstream sedimentation study rod at Station 8, May 1977. No water in stream and no significant sedimentation noted.

Figure A-33. Downstream sedimentation study rod at Station 8, August 1977. No water in stream and no significant sedimentation noted.

Figure A-34. Downstream sedimentation study rod at Station 8, November 1977. Accumulated sediment measured to a depth of 2.6 cm.

Figure A-35. Sedimentation at the intersection of stream bed (Station 8) and projected water intake line, November 1977. Sediment depth was over 30 cm.

TABLE A-1

RESULTS OF WATER CHEMISTRY ANALYSIS AT LITTLE SALUDA CREEK STATION 6[a]
MARBLE HILL PLANT

Chemical parameter	Results From Environmental Report (PSI, 1976) March - September 1974	Results from 1977 Quarterly Sampling, Applied Biology, Inc.[b]
Dissolved oxygen	7.0 - 12.98	9.2 - 13.2
Biochemical oxygen demand	0.6 - 8.05	1.0 - 2.9
Chemical oxygen demand	0.0 - 11.4	2.6 - 5.3
pH (standard units)	7.54 - 8.80	7.5 - 8.0
Alkalinity	184.0 - 275.2	192.4 - 245.0
Specific conductance (μmho)	311 - 429	218 - 445
Silica (SiO_2)	4.6 - 9.18	6.50 - 9.14
Chlorides	18.1 - 21.8	4.4 - 13.8
Sulfate	23.2 - 31.0	33.0 - 64.0
Orthophosphates (PO_4-P)	0.15 - 0.19	<0.01 - 0.02
Total phosphorous (PO_4-P)	0.20 - 0.28	0.02 - 0.09
Total organic carbon	7 - 50	1.71 - 5.33
Ammonia nitrogen	0.03 - 0.06	<0.02 - 0.08
Total suspended solids	2 - 74	5 - 39
Nitrate nitrogen	0.05 - 1.85	0.66 - 1.52
Calcium	42.3 - 138.8	59.0 - 71.7
Magnesium	21.9 - 28.3	26.7 - 31.0
Sodium	2.5 - 3.6	1.4 - 6.9
Phenols	<0.001- 0.10	<0.003- 0.006
Hexane-soluble material	<1.0 - 28.3	1.4 - 17.3
Free residual chlorine	Not determined	<0.01
Chloramines	<0.01	<0.01
Total dissolved solids	170 - 354	248 - 359
Organic nitrogen	Not determined	<0.03 - 1.00

[a] Results are in mg/l except when noted.

[b] Results are reported in mg/liter as a minimum to maximum range.

B. BACTERIA

INTRODUCTION

This study was conducted to monitor bacterial populations indicative of the sanitary quality of waters near the Marble Hill site. Since certain coliforms and streptococcal bacteria are normally found in the intestinal tract of man and other warm-blooded animals, these bacteria make good indicators of fecal contamination. Quantification of these fecal contaminants can be used to evaluate the disease-producing potential of the water.

MATERIALS AND METHODS

Bacterial analyses were performed on duplicate samples from Stations 1, 3, 6, and 8. Samples for bacterial examinations were collected in presterilized polyethylene containers, placed immediately in an iced cooler, and shipped to the laboratory for analysis. The analyses were begun approximately 6 to 10 hours after collection of samples.

In the laboratory, the water samples were shaken vigorously to achieve homogeneity and serially diluted with sterile buffered water. The membrane filter technique (APHA, 1976) was used to analyze the appropriate dilutions for the number of total coliforms, fecal coliforms, and fecal streptococci. The following media, incubation conditions, and colonial appearance criteria were used for these analyses:

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

RESULTS AND DISCUSSION

The results of the 1977 quarterly bacterial analysis conducted at Stations 1, 3, 6, and 8 are tabulated in Appendix Tables B-1 through B-4. Total coliforms, fecal coliforms, and fecal streptococci are reported as counts per 100 ml of sample. Total and fecal coliform results from Stations 1 and 3 are graphically compared to baseline data (PSI, 1976) and current ORSANCO data in Figures B-1 and B-2. Fecal streptococci results are compared only to baseline data (Figure B-3) since ORSANCO does not report counts for these organisms.

Counts for total coliforms, fecal coliforms, and fecal streptococci did not vary appreciably between Ohio River stations for any sampling date except March. An inconsistently high value determined for total coliforms at Station 1 in March was not seen on any subsequent sampling date. Quarterly values for all three parameters compared favorably with corresponding ORSANCO data and were similar to values obtained during the 1974 baseline study (Figures B-1 through B-3). Counts for total and fecal coliforms at Station 6 in Little Saluda Creek were consistently less than those for Ohio River Stations 1 and 3 and were of the same order of magnitude as 1974 baseline values (PSI, 1976).

Station 8, which is located in an intermittent stream near the Marble Hill Plant site, exhibited bacterial counts which were not consistent during the entire 1977 sampling period with values at either the Ohio River stations or Little Saluda Creek. Values for total and fecal coliforms and fecal streptococci at Station 8 were similar to those at Station 6 in March and November, while in August they were more comparable to values at Ohio River Stations 1 and 3. Samples were not taken at Station 8 in May because there was no water in the stream. These variations in bacterial population were probably due to the intermittent nature of the stream and the extreme effects which heavy rainfall and subsequent runoff have on its components. During March and November, when recent rains caused heavy runoff, bacterial components were similar to those in Little Saluda Creek, which was probably affected by the same runoff. During August subsurface seepage was probably the source of the stream, thus causing a shift in the bacterial population.

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

The National Technical Advisory Subcommittee in Public Water Supplies (1968) recommends the following maximum permissible values for total and fecal coliform counts:

	Surface public water supplies	Recreational waters: Primary contact	Recreational waters: Other than primary contact
Total coliforms	10,000/100 ml	-	-
Fecal coliforms	2,000/100 ml	200/100 ml	1,000/100 ml

The number of total coliforms determined for Ohio River Stations 1 and 3 exceeded the Federally recommended level during each of the quarterly samplings except May. These high counts were probably caused by heavy rain runoff since the velocity of the river was found to be much greater during March, August, and November samplings than during May. Fecal coliforms also exceeded the permissible maximum limit recommended for waters used for primary contact recreation during the same three sampling periods, but only in

November did the counts also exceed the recommended limit set for non-primary contact recreational waters. Except for November, both total and fecal coliform counts were well below recommended limits at Station 6 in Little Saluda Creek.

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, while fecal streptococci dominate in the excrement of animals. A ratio of fecal coliforms to fecal streptococci (FC/FS) 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.

FC/FS ratios for Ohio River Stations 1 and 3 greatly exceeded 4 during May and November, but ranged from 1 to 3 during March and August. FC/FS ratios for Little Saluda Creek were always either close to 0.6 or well below. These data suggest that domestic sewage is the principal bacterial pollutant in the Ohio River, while bacterial contamination in Little Saluda Creek is derived from the feces of warm-blooded animals other than man.

FC/FS ratios for Station 8 never exceeded 4 and were comparable to those at Station 6 in March and November. This fact suggests that the source of bacterial contamination is similar to that in Little Saluda Creek.

CONCLUSIONS

During periods of heavy runoff, total and fecal coliform levels in the Ohio River greatly exceeded the Federally recommended limits. Construction at the Marble Hill Plant site had no effect on either parameter during heavy runoff periods or during other sampling periods. Compared to control Station 1, Station 3 exhibited no increase in total coliform, fecal coliform, or fecal streptococci counts attributable to runoff from the plant site.

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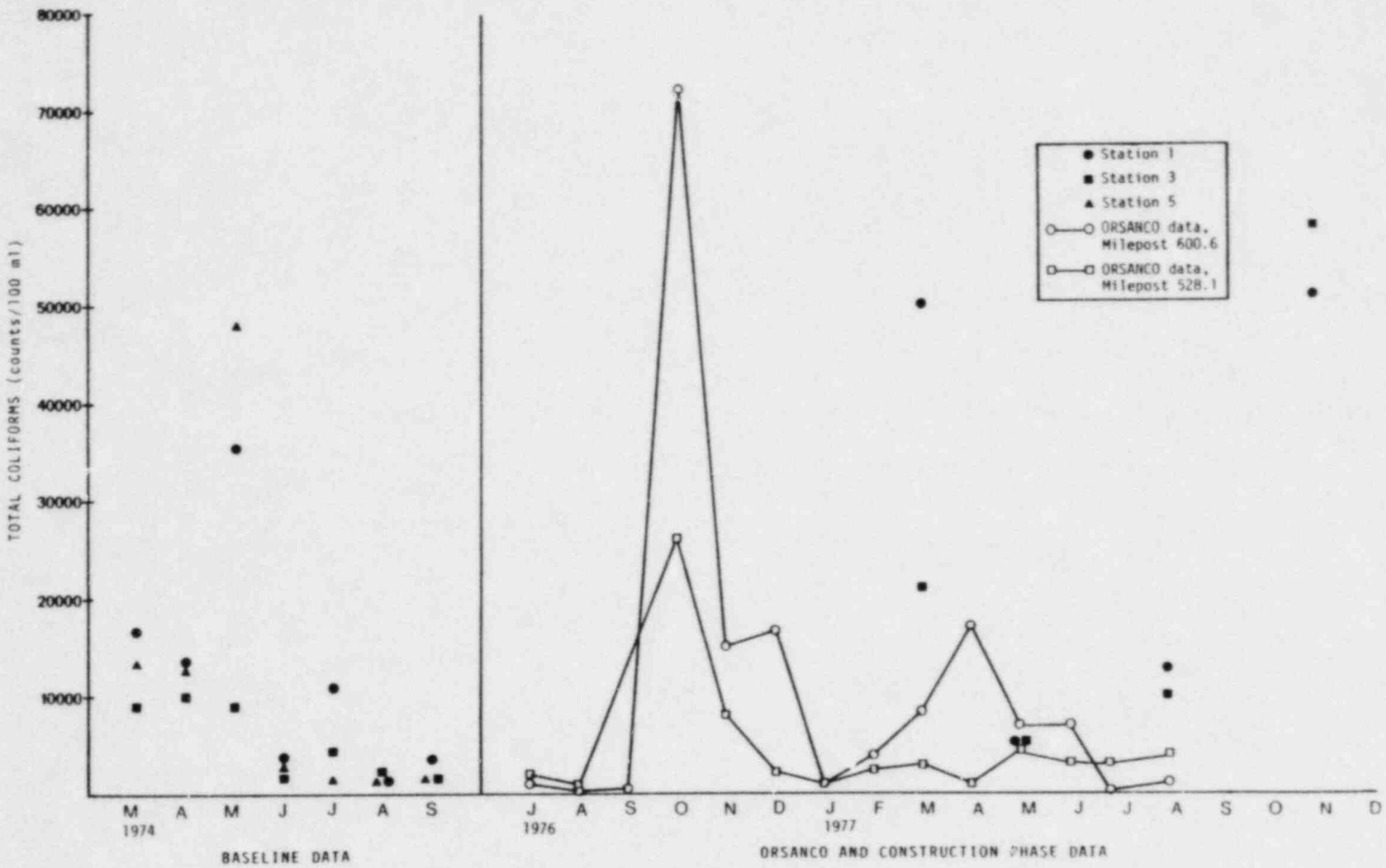

Figure B-1. Comparison of baseline, ORSANCO, and ABI total coliform counts (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

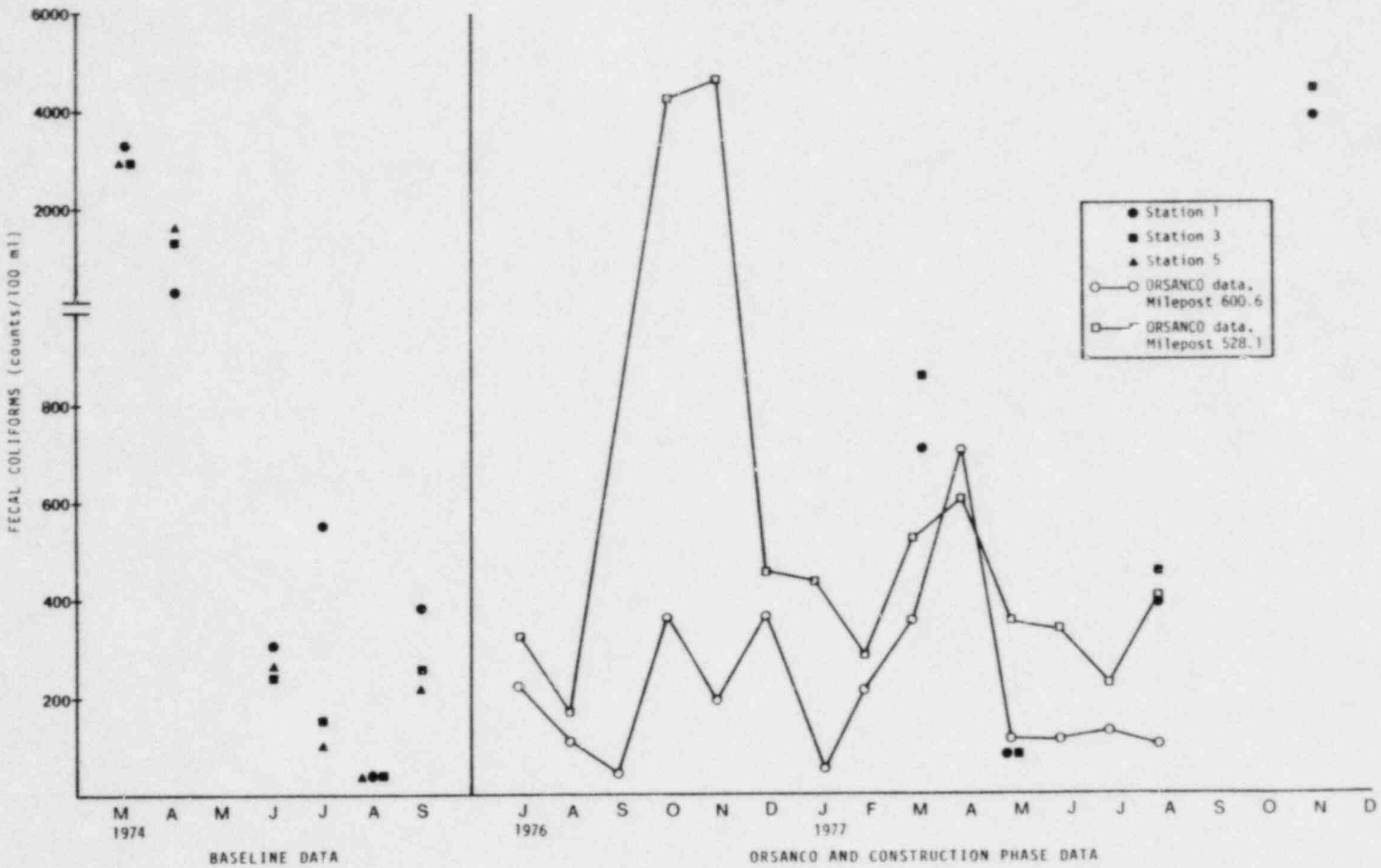

Figure B-2. Comparison of baseline, ORSANCO, and ABI fecal coliform counts (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

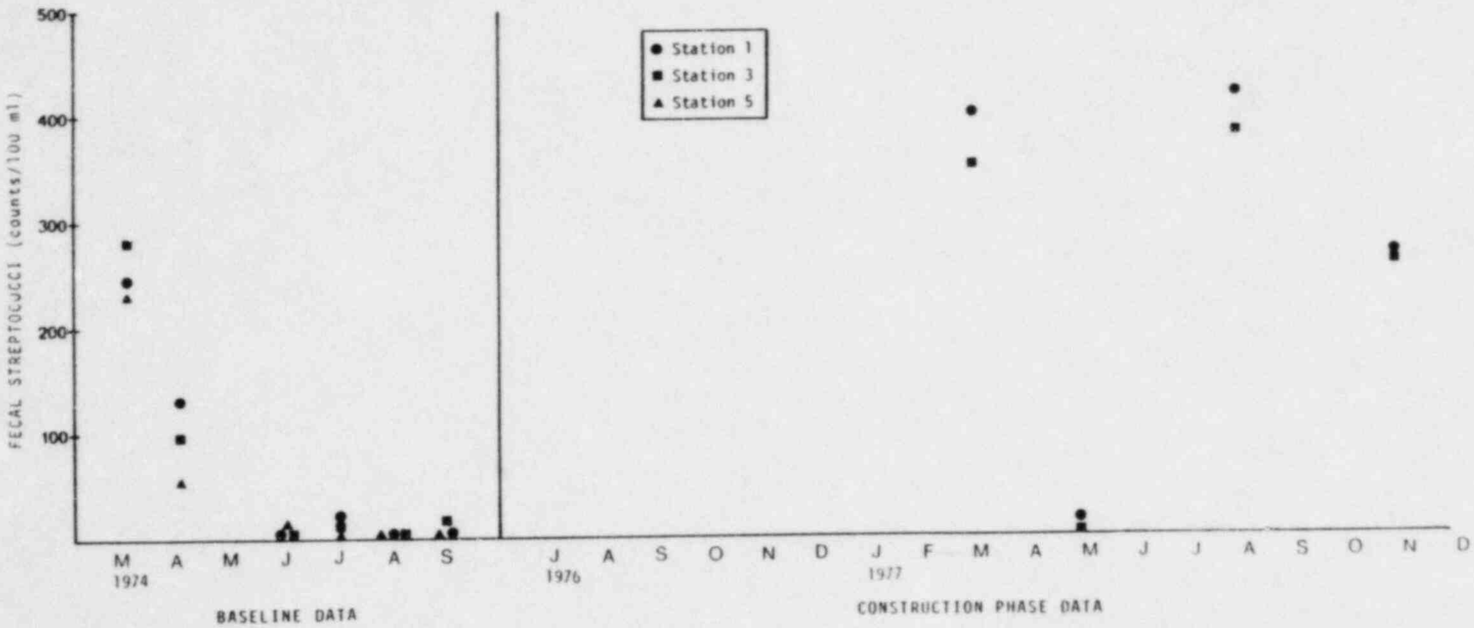

Figure B-3. Comparison of baseline and ABI fecal streptococci counts (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

C. PLANKTON

C.1 PHYTOPLANKTON

C.1.1 Introduction

The purpose of the phytoplankton study at the Marble Hill Plant site was to determine species composition, abundance, and biomass of phytoplankton in tne Ohio River and in Little Saluda Creek during plant construction at the site. These data were to be compared to baseline data (PSI, 1976) in an evaluation of plant construction effects on the phytoplankton. However, since plant construction began after the third quarterly sampling, complete evaluation of construction-related effects on the phytoplankton depends on the acquisition of additional data.

Phytoplankton consists of the chlorophyll-bearing algae which passively drift or have limited means of locomotion and are, therefore, largely at the mercy of waves and currents in aquatic environments. Phytoplankton fix solar energy and inorganic nutrients into protoplasm through photosynthesis and form the basis of aquatic food relationships along with macrophytes, which are important contributors only in shallow waters (Reid, 1961). Phytoplankters are consumed by zooplankters and other filter feeders which, in turn, provide food for larger carnivores. Thus, phytoplankton abundance and composition determine the quantity and quality of all larger organisms which ultimately depend upon phytoplankters for food in any aquatic ecosystem.

Many studies have shown that the drifting algae in small headwater streams are benthic algae, typically diatoms, washed off the stream bottom. However, studies of large rivers have shown that true plankters often predominate and that diatoms are almost always the dominant phytoplankton group (Hynes, 1972). Seasonally, diatoms are joined by true plankters of the green and blue-green algal classes and also by a variety of flagellates. The changing phytoplankton population of large rivers must constantly be replenished from sources such as eddies and backflow areas, resulting from turbulent river flow, and from backwater areas and tributaries joining the river.

C.1.2 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 (0.3 m) water samples were collected with a non-metallic Kemmerer sampling device and preserved in the field with buffered formalin (40 ml concentrated formaldehyde/1000-ml sample).

In the laboratory, each one-liter replicate sample was allowed to settle a minimum of 10 days, after which each sample was concentrated to less than 200 ml by siphoning. Duplicate subsamples (0.15 to 5.0 ml) of each replicate sample concentrate were settled in Utermohl chambers (Utermohl, 1958). The degree of sample concentration and the volume of subsamples were determined by the amount of detritus and number of phytoplankters in the sample. Strip counts of approximately 200 phytoplankters per Utermohl replicate (400 phytoplankters per replicate sample) were made at 560X magnification.

Except for filamentous and colonial greens and blue-greens, all phytoplankters were counted individually. Filamentous green and blue-green species were counted as 100μ 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 per ml was calculated as N by:

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

where: V_c = volume of sample concentrate (ml)

C = count

V_e = subsample volume (ml) x $\frac{\text{area of strips counted (mm}^2\text{)}}{\text{area of Utermohl chamber (mm}^2\text{)}}$

V_s = volume of sample (ml)

Total diatoms were counted in Utermohl chambers. Species identification and proportional counts of diatoms were made from permanent mounts at 1000X magnification. Total diatom counts were used with diatom species proportional counts to obtain density by species (APHA, 1976). Representative permanent diatom mounts and vouchers of all samples analyzed were retained as a reference.

Taxonomic references used in the identification of phytoplankton species were: Van Heurck (1896), Walton (1915), Hustedt (1930), Skuja (1948), Smith (1950), Prescott (1962), Patrick and Reimer (1966 and 1975), Weber (1966 and 1970), Drouet (1968), Whitford and Schumacher (1969), Taft and Taft (1971), Sreenivasa and Duthie (1973), Komarek (1974), and Prescott et al. (1975).

Phytoplankton biovolume was estimated from optical measurements. The average volume for each predominant phytoplankter (comprising 5% or more of the total population at any station) was determined by measuring five individuals. The average dimensions were then converted to volume using formulae for solids approximating the shape of each species (Kutkuhn, 1958; Hargraves and Wood, 1967; APHA, 1971; EPA, 1973). For phytoplankters comprising less than 5% of the total population at any station, at least one biovolume measurement was made. Biovolume was determined by multiplying the concentrations (cells/liter or cells/ml) of each predominant species by the average volume for that species and summing the values. Biomass was expressed as μg/l and calculated from biovolume by the following equations:

(1) biovolume (μ^3/l) = (N) (V_s)

since 1μg/l = 1×10^6 μ^3/l

(2) biomass (μg/l) = (N) (V_s) (10^{-6})

where: N = density of each species per liter

V_s = average volume of each species (μ^3)

C.1-3 RESULTS AND DISCUSSION

A total of 261 phytoplankton species (Table C.1-1) representing eight major taxa were observed in collections from the Ohio River (Stations 1, 3, and 5) and Little Saluda Creek (Station 6). The major taxa were 1) Bacillariophyta (diatoms), 2) Chrysophyta (yellow-brown algae), 3) Cryptophyta, 4) Xanthophyta, 5) Chlorophyta (greens), 6) Cyanophyta (blue-greens), 7) Euglenophyta (euglenoids), and 8) Pyrrhophyta (dinoflagellates). One additional major group, noted as Others, consisted mainly of unidentified phytoflagellate species.

Complete data by species for each of the four quarterly collections may be found in the Appendix: composition and abundance in Appendix Tables C.1-1 through C.1-4 and relative abundance, biovolume, and biomass in Appendix Tables C.1-5 through C.1-8.

Ohio River Stations

Total phytoplankton densities at Ohio River stations ranged from a low of 2,700 cells/ml in March to a high of 11,827 cells/ml in August (Tables C.1-2 through C.1-5). Both the maximum and minimum observed densities occurred at Station 3. Phytoplankton abundance in the river was highest in May and August and lowest in March (Figure C.1-1). Abundance in November was intermediate with respect to the other three quarters. Biomass ranged from a low of 994 μg/l at Station 1 in March to a high of 5,024 μg/l at Station 3 in August (Tables C.1-2 through C.1-5). Biomass levels exhibited the same trend as density with lowest values in March, increases from May to August, and decreases to intermediate levels in November (Figure C.1-2).

These patterns in phytoplankton abundance and biomass reflect typical seasonal changes in the phytoplankton community: low populations in the early spring following a winter minimum.

Increased productivity in response to increased water temperatures and day-length leads to a spring pulse in population levels. Phytoplankton abundance generally then remains high through the summer, decreasing toward a winter minimum in the late fall in response to shorter days and decreasing water temperatures.

Phytoplankton diversity (number of species) was comparable between river stations and increased slightly from March to November. The number of species observed at river stations ranged from 58 to 80 and differed by more than 15 only during the August quarterly sampling. The average number of species in the river increased from 61 in March to 69 in August and November. Diatoms (Bacillariophyta) were always dominant at all river stations. Greater numbers of diatom species were observed in March and November when water temperatures were lower, while a larger number of green (Chlorophyta) and blue-green (Cyanophyta) species were present during warm water temperature periods. This is typical of large rivers with sufficient temperature variation (Hynes, 1972) and reflects the ecological response of these phytoplankton groups to optimal temperature ranges for growth. Diatoms in general have relatively low temperature tolerance ranges; green algae tolerances cover a wider temperature range; and blue-green algae have more species tolerant of very high temperatures (Patrick, 1973).

Little Saluda Creek

Little Saluda Creek was clearly different from the Ohio River in physical and chemical parameters. These habitat differences contributed to the observed differences in phytoplankton density, relative abundance, and biomass. Phytoplankton density and biomass were much lower in Little Saluda Creek than in the river (Figures C.1-1 and C.1-2). Density ranged from 173 cells/ml in August to 1,011 cells/ml in November. Biomass ranged from 41 μg/l in May to 372 μg/l in November (Tables C.1-2 through C.1-5). Seasonal trends in abundance and biomass were opposite from those observed in the river, with highest density and biomass occurring in March and November instead of in May and August.

Diatoms were the most important phytoplankton component during all quarters; however, blue-greens and euglenoids were relatively more important in the creek than in the river. Diversity of species in Little Saluda Creek was also considerably below that observed in the river during all collections, excluding March. The number of species observed in Little Saluda Creek ranged from 66 in March to 40 in May. Excluding the large number of species present in March, the number of species in the creek was almost constant, increasing from 40 in May to 44 in November.

Community Composition

The phytoplankton community in the river was dominated throughout the study by diatoms (Bacillariophyta). Diatoms contributed more than 50% to the total phytoplankton on all sampling dates (Figure C.1-3). Diatom relative abundance was generally lowest in May, ranging from 53.5 to 71.2%, and highest in March, ranging from 86.3 to 88.5% (Tables C.1-2 through C.1-5). Diatoms were also the dominant algal group in Little Saluda Creek, ranging from 44.9% of the total phytoplankton in May to 81.3% in November. Diatom relative abundance was generally lower in Little Saluda Creek than in the river.

The dominant diatom species (contributing 5% or more to the total phytoplankton) were:

Cyclotella Meneghiniana	*Achnanthes* sp. 1
Cyclotella sp. 1	*Fragilaria capucina*
Melosira distans	*Gomphonema parvulum*
M. granulata	*Nitzschia dissipata*
Stephanodiscus sp. 1	*N. palea*
Achnanthes minutissima	*Rhoicosphenia curvata*

Many of these species were considered dominant in the baseline study (PSI, 1976) and other studies have indicated that the diatom genera *Cyclotella, Melosira, and Stephanodiscus* are typically dominant in the Ohio River and its tributaries (Williams and Scott, 1962; Weber and Moore, 1967).

ne major numerically dominant diatoms were *C. Meneghiniana, Cyclotella* sp.1, *M. distans, and M. granulata*. These four species were also most widespread in occurrence. *C. Meneghiniana* was always dominant at river stations and during two of the quarters in Little Saluda Creek. *Cyclotella* sp.1 was generally dominant only in the river, while *M. granulata* and *M. distans* were never dominant in Little Saluda Creek. *C. Meneghiniana* has been reported to be periphytic as well as truly planktonic in habit (Lowe, 1974). Holland (1968), Lowe (1974), and Palmer (1969) consider *Melosira* to be characteristically found in water with high nutrient concentrations. Palmer (1969) indicated that this is also true for *Cyclotella*. *M. granulata* is a summer form and was dominant during May and August, while *C. Meneghiniana* typically exhibits a fall maximum in distribution (Palmer, 1974) and accounted for more than 44% of the total phytoplankton in the river during August. Many of the remaining dominant diatom species are considered to be characteristic for waters with high nutrient levels and have generally been reported as periphytic in habit (Lowe, 1974). *A. minutissima, G. parvulum* and *N. dissipata* were generally dominant only in Little Saluda Creek.

Green algae (Chlorophyta) were the second most important phytoplankton group in the river in terms of density, relative abundance (Figure C.1-3) and biomass (Tables C.1-2 through C.1-5). Greens were most abundant in May when this group contributed 19.7 to 33.1% to the total phytoplankton. Greens continued to be an important component of the phytoplankton community in the river throughout August and November. In Little Saluda Creek, greens were also generally second to diatoms in density and relative abundance. However, blue-greens (Cyanophyta) were generally second to diatoms in terms of biomass (Tables C.1-2 through C.1-5).

The green algae *Chlamydomonas* sp. 3, *Chlorella* (?) sp., *Schroederia Judayi*, *Stichococcus* (?) sp., and coccoid green sp. 7 were numerically dominant phytoplankters in May. *Chlamydomonas* sp. 3 and *S. Judayi* were dominant in Little Saluda Creek, while the other three species were dominant in the river. Most of the more common species reported in the baseline data were observed during the present study.

The Cryptophyta, Cyanophyta (blue-greens), and Euglenophyta were the most important of the remaining algal groups. Blue-greens and euglenoids were more important in Little Saluda Creek than in the Ohio River, while cryptophytes were most important in the river (Figure C.1-3). *Oscillatoria* sp. 1, a blue-green, and euglenoid sp. 1 were numerically dominant phytoplankters in Little Saluda Creek in May. *Oscillatoria* sp. 1 was also dominant in November. Cryptophyte sp. 2 was numerically dominant at river Stations 1 and 5 in May and at Station 5 in November.

Although diatoms were the dominant algal group in both the Ohio River and Little Saluda Creek, differences between these two habitats were reflected in the distribution of numerically dominant species and in the relative importance of the major algal groups in these two habitats. These differences in community composition, in addition to the differences in total phytoplankton density and biomass, further emphasized the habitat differences between the river and the creek.

Interstation Variation and Ecological Relationships

Statistical evaluation of variation between Ohio River Stations 1, 3, and 5 indicated no significant differences in phytoplankton density between stations (Table C.1-6). Significant differences between quarters were evident. Tukey's comparison of quarterly mean phytoplankton density indicated that density in March was significantly less than that in all other quarters, and that density in March and November was significantly less than that in May and August. This result reflects a typical seasonal pattern in phytoplankton abundance.

Significant differences in biomass between months and between stations were indicated (Table C.1-7). Biomass was significantly greater at Station 3 than at Stations 1 and 5. This difference is clearly evident in Figure C.1-2, although the reason for it is not readily apparent. Increased diatom biomass may be responsible for this difference. However, the reason for the increase in diatom biomass was not apparent. As observed for phytoplankton density, biomass was significantly less in March than in all other quarters, and biomass was significantly less in March and November than in May and August.

Results of simple correlations of both density and biomass with selected physical and chemical parameters were similar (Tables C.1-8 and C.1-9). A significant positive correlation with water temperature in the Ohio River indicated that phytoplankton abundance increased with seasonally increasing water temperatures. A negative correlation with water temperature in Little Saluda Creek reflected its dissimilarity to the Ohio River.

A negative correlation with dissolved silica was indicated in the river. Silica is a nutrient required in diatom productivity, although nutrient levels in the Ohio River are probably high enough to promote growth at any time when other environmental requirements are met. Since the phytoplankton of large rivers like the Ohio River is typically diatomaceous, the negative correlation could reflect dissolution of dead diatom frustules, i.e., decrease in diatom numbers may result in increased dissolved silica.

Comparison with Baseline Data

Phytoplankton abundance (no./ml) currently reported (174 to 11,827/ml) was considerably higher than that in the baseline study (0 to 4,524/ml). Partially as a result of lower density, biomass reported in the baseline study was also considerably less. These differences may be the result of different laboratory analysis techniques Phytoplankton was enumerated in a Sedgwick-Rafter counting chamber in the baseline study, whereas a settling technique was used in the current analyses. The current density data were in agreement with previously reported ranges for the Ohio River and its tributaries (Weber and Moore, 1967; ABI, 1975 and 1977). Biovolume data for the present study also fall within the range reported for the Little Miami River by Weber and Moore (1967).

Trends in phytoplankton abundance and composition were similar to those reported in the baseline study:

1) diatoms were dominant,

2) numerically dominant diatoms were similar as were seasonal patterns of some diatom species,

3) many of the more common species of green algae were similar, although greens appeared to be a more important component of the phytoplankton than previously reported,

4) greens and blue-greens increased seasonally,

5) Little Saluda Creek showed reduced phytoplankton abundance and different community composition from those observed in the river.

C.1-4 CONCLUSIONS

Although density and biomass values currently reported were considerably higher than those reported in the baseline study, trends in phytoplankton composition and abundance were similar to baseline data. Plant construction effects on the phytoplankton community at the Marble Hill site were not evident from a comparison with baseline data or from analysis of current data. It should be noted, however, that construction at the site did not begin until after the third quarterly sampling had been conducted.

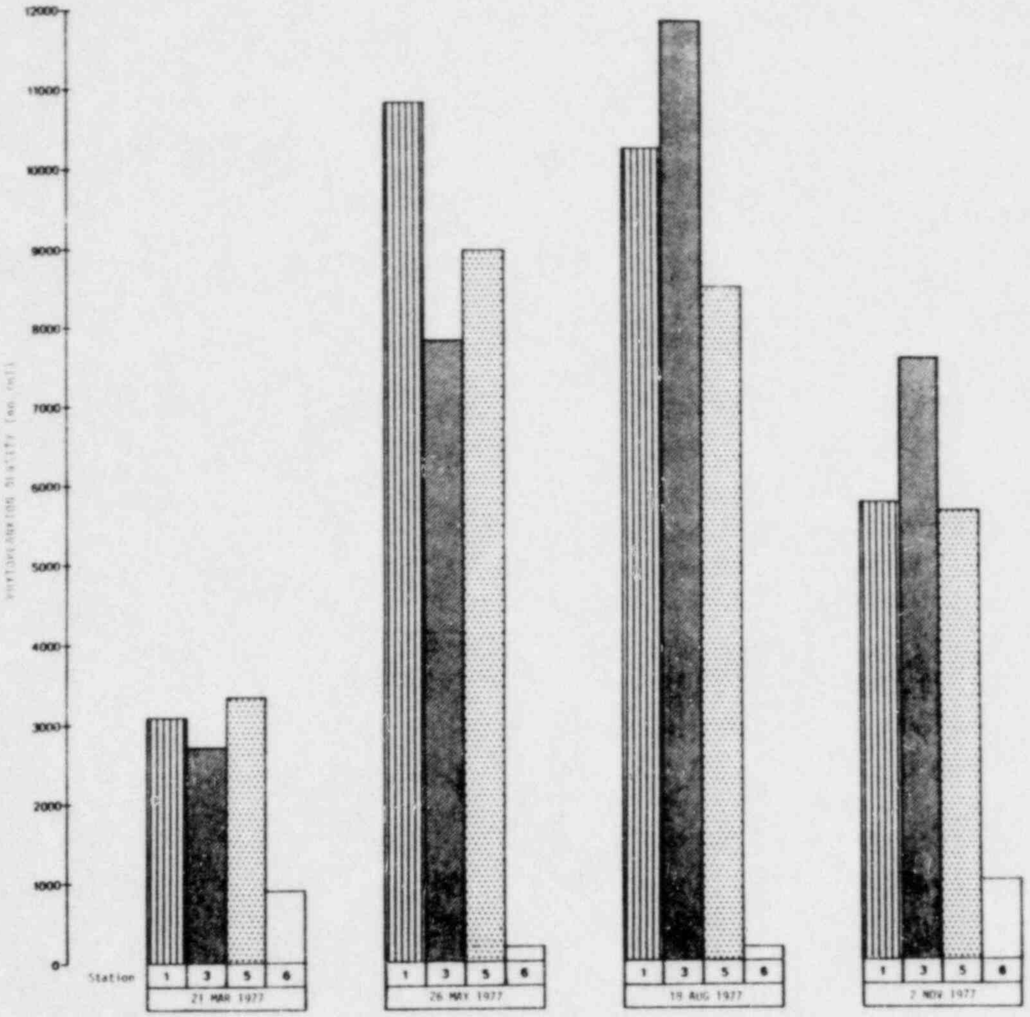

Figure C.1-1. Total phytoplankton density at Stations 1, 3, and 5 in the Ohio River and Station 6 in Little Saluda Creek, Marble Hill Plant site, 21 March-2 November 1977.

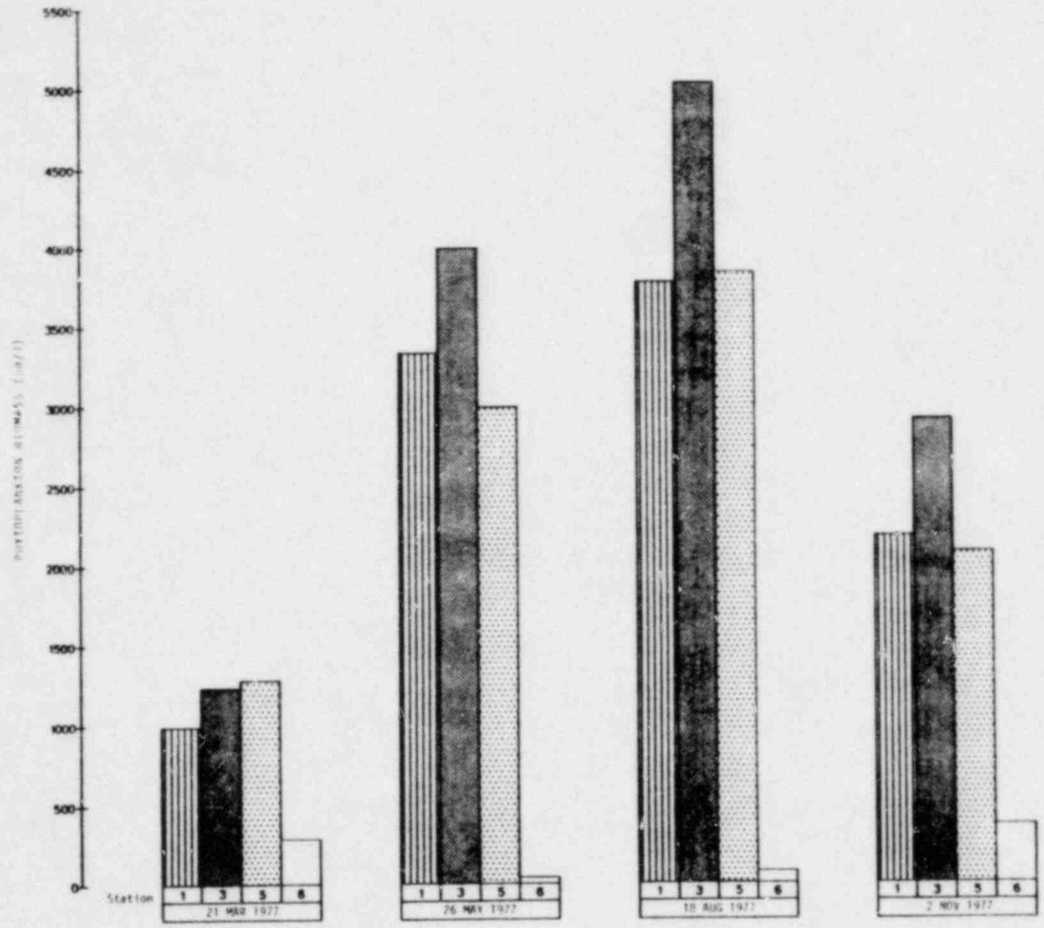

Figure C.1-2. Total phytoplankton biomass at Stations 1, 3, and 5 in the Ohio River and Station 6 in Little Saluda Creek, Marble Hill Plant site, 21 March-2 November 1977.

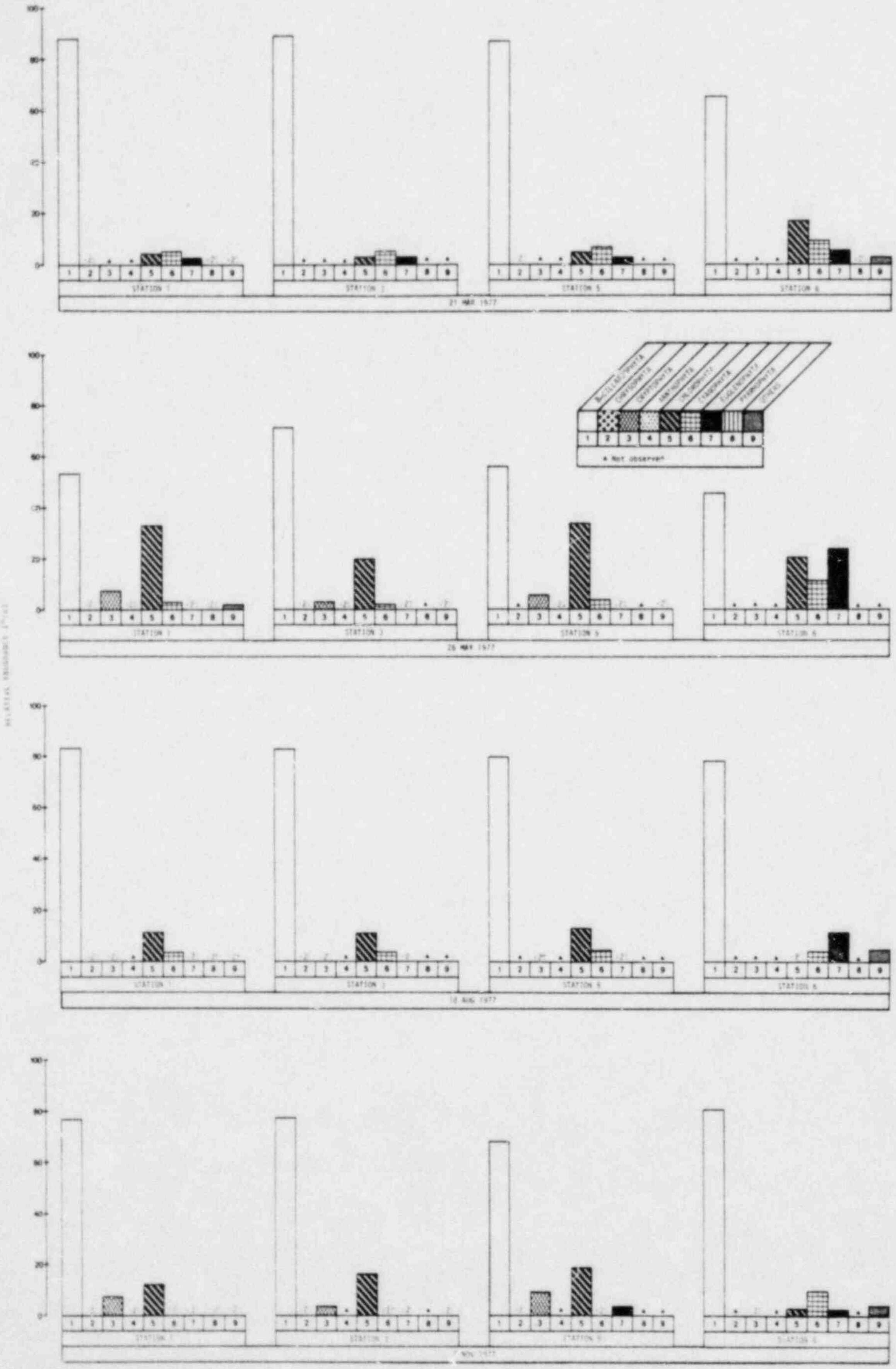

Figure C.1-3. Relative abundance of major phytoplankton groups at Stations 1, 3, and 5 in the Ohio River and Station 6 in Little Saluda Creek, Marble Hill Plant site, March-November 1977.

TABLE C.1-1

COMPOSITE SPECIES LIST OF PHYTOPLANKTON COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT
MARCH-NOVEMBER 1977

BACILLARIOPHYTA
Centrales
Amphiprora ? sp. 1
Coscinodiscus lacustris
Cyclotella bodanica ?
C. comta
C. Meneghiniana
C. pseudostelligera
C. stelligera
Cyclotella sp. 1
Cyclotella sp. 3
Melosira ambigua
M. distans
M. granulata
M. granulata v. *angustissima*
M. islandica subspec. *helvetica*
M. varians
Melosira sp. 1
Meridon circulare v. *constrictum*
Stephanodiscus astraea
Stephanodiscus sp. 1
unidentified centric sp. 1
Pennales
Achnanthes lanceolata
A. lanceolata v. *dubia*
A. minutissima
Achnanthes sp. 1
Achnanthes sp. 2
Achnanthes sp. 3
Amphora ovalis v. *pediculus*
Amphora sp. 1
Asterionella formosa
A. formosa v. *gracillima*
Caloneis lewisii v. ***inflata***
Cocconeis pediculus
C. placentula
C. placentula v. *lineata*
Cymbella affinis
C. minuta v. *silesiaca*
C. prostrata v. *auerswaldii*
Diatoma vulgare
D. vulgare v. *grande*
Eunotia exigua
Fragilaria capucina
F. crotonensis
Fragilaria sp. 1
Gomphonema acuminatum
G. dichotomum
G. olivaceum
G. parvulum
Gyrosigma acuminatum
Hantzschia sp. 1
Navicula cryptocephala
N. cryptocephala v. *veneta*
N. gysingensis
N. hungarica v. *capitata*
N. viridula v. *avenacea*
Navicula sp. 1
Navicula sp. 2
Navicula sp. 3
Navicula sp. 4
Navicula sp. 5
Navicula ? sp. 6
Navicula sp. 7
Nitzschia acicularis v. *closterioides*
N. acuta
N. amphibia
N. communis
N. communis v. *abbreviata*
N. dissipata
N. filiformis
N. hungarica
N. Kützingiana
N. palea
N. sublinearis
N. tryblionella v. *levidensis*
Nitzschia ? sp. 1
Rhoicosphenia curvata
Surirella angustata
S. ovalis

TABLE C.1-1
(continued)
COMPOSITE SPECIES LIST OF PHYTOPLANKTON COLLECTED IN THE
OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT
MARCH-NOVEMBER 1977

BACILLARIOPHYTA
Pennales (continued)
Surirella ovata
S. tenera
Synedra delicatissima
S. radians
S. rumpens
S. rumpens v. *familiaris*
S. socia
S. ulna v. *obtusa*
unidentified pennate sp. 1
unidentified pennate sp. 2
unidentified pennate sp. 3
unidentified pennate sp. 4

CHRYSOPHYTA
Dinobryon cylindricum
Mallomonas ? sp. 1
Stipitococcus vasiformis
chrysophyte sp. 1
chrysophyte statospore

CRYPTOPHYTA
Cryptomonas ovata
cryptophyte sp. 1
cryptophyte sp. 2

XANTHOPHYTA
Characiopsis acuta
xanthophyte sp. 1

CHLOROPHYTA
Actinastrum gracilimum
A. hantzschii v. *fluviatile*
Ankistrodesmus convolutus
A. falcatus
A. falcatus v. *acicularis*
A. falcatus v. *mirabilis*
A. fractus
Carteria cordiformis
Carteria klebsii
Carteria sp. 1
Characium sp. 1
Characium ? sp. 2
Characium ? sp.
Chlamydomonas globosa ?
Chlamydomonas sphagnicola ?
Chlamydomonas sp. 1
Chlamydomonas ? sp. 2
Chlamydomonas sp. 3
Chlamydomonas sp. 4
Chlamydomonas sp. 5
Chlorella ? sp.
Closteriopsis longissima
Closterium acutum v. *tenuius*
Coelastrum sphaericum
Cosmarium aphanichondrum ?
Curcigenia alternans
C. apiculata v. ?
Crucigenia fenestrata
C. quadrata
C. rectangularis
C. tetrapedia
Dictyosphaerium Ehrenbergianum
D. pulchellum
Franceia Droescheri
Franceia sp.
Gloeocystis planctonica
Golenkinia radiata
G. radiata v. *brevispina*
Kirchneriella contorta
K. lunaris
K. lunaris v. *irregularis*
K. obesa
K. obesa v. *major*
K. subsolitaria
Lagerheimia quadriseta
L. subsalsa
Micractinium pusillum
Oocystis Borgei
O. pusilla ?

TABLE C.1-1
(continued)
COMPOSITE SPECIES LIST OF PHYTOPLANKTON COLLECTED IN THE
OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT
MARCH-NOVEMBER 1977

CHLOROPHYTA (continued)

- *Oocystis* ? sp. 1
- *Oocystis* ? sp. 2
- *Oocystis* sp.
- *Pandorina morum*
- *Pediastrum duplex* v. *clathratum*
- *P. tetras*
- *Phacotus* ? sp.
- *Scenedesmus abundans*
- *S. abundans* v. *brevicauda*
- *S. abundans* v. *longicauda*
- *S. abundans* v.
- *S. acuminatus*
- *S. arcuatus*
- *S. arcuatus* v.
- *S. bijuga* v.
- *S. denticulatus*
- *S. dimorphus*
- *S. incrassatulus* v. *mononae*
- *S. quadricauda*
- *Scenedesmus* sp. 1
- *Scenedesmus* sp. 2
- *Schroederia Judayi*
- *S. setigera*
- *Selenastrum minutum*
- *S. Westii*
- *Sphaerocystis Schroeteri*
- *Stichococcus* ? sp.
- *Stigeoclonium* sp. 1
- *Tetraedron caudatum*
- *T. minimum*
- *T. muticum*
- *Tetrastrum anomalum*
- *T. elegans*
- *T. heteracanthum*
- *T. punctatum*
- *T. staurogeniaeforme*
- *Treubaria setigerum*
- *Westella* ? sp.
- coccoid green sp. 1 through sp. 4 and sp. 6 through sp. 9
- unidentified green 1
- unidentified green 2

CYANOPHYTA

- *Anabaena flos-aquae*
- *A. spiroides* v. *crassa*
- *Anabaena* sp. 1
- *Anacystis rupestris* v. *prasina*
- *Calothrix* sp.
- *Chroococcus dispersus* v. *minor*
- *C. limneticus*
- *Dactylococcopsis acicularis*
- *D. fascicularis* ?
- *D. Smithii*
- *Dactylococcopsis* sp. 1
- *Dactylococcopsis* ? sp.
- *Gomphosphaeria lacustris* v. *compacta*
- *Lyngbya contorta*
- *L. Diguetii*
- *L. limnetica*
- *Merismopedia tenuissima*
- *Microcystis incerta*
- *Nostoc* sp. 1
- *Oscillatoria* sp. 1
- *Oscillatoria* sp. 2
- *Oscillatoria* sp. 3
- *Oscillatoria* sp. 4
- *Phorimidium minnesotense*
- *Raphidiopsis curvata*
- *R. irregulare*
- *Rhabdoderma lineare*
- coccoid blue-green 1
- filamentous blue-green sp. 1

EUGLENOPHYTA

- *Euglena* sp. 1
- *Euglena* sp. 2
- *Euglena* sp. 3
- *Euglena* sp. 4
- *Lepocinclis sphagnophila* ?
- *Lepocinclis* sp.

TABLE C.1-1
(continued)
COMPOSITE SPECIES LIST OF PHYTOPLANKTON COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT
MARCH-NOVEMBER 1977

EUGLENOPHYTA (continued)
- *Phacus helikoides*
- *Trachelomonas robusta*
- *T. superba* v.
- *T. vermiculosa*
- *T. volvocina*
- *Trachelomonas* sp. 1 through sp. 8
- euglenoid sp. 1
- euglenoid sp. 2

PYRRHOPHYTA
- dinoflagellate sp. 1
- dinoflagellate sp. 2

OTHERS
- phytoflagellate sp. 1 through sp. 11
- unidentified algal cell 1
- unidentified algal cell 2

TABLE C.1-2

SUMMARY OF PHYTOPLANKTON DENSITY (no./ml), RELATIVE ABUNDANCE (%), AND BIOMASS (μg/l)
MARBLE HILL PLANT
21 MARCH 1977

Taxon	Station 1			Station 3			Station 5			Station 6		
	Density (no./ml)	Relative abundance (%)	Biomass (μg/l)	Density (no./ml)	Relative abundance (%)	Biomass (μg/l)	Density (no./ml)	Relative abundance (%)	Biomass (μg/l)	Density (no./ml)	Relative abundance (%)	Biomass (μg/l)
Bacillariophyta	2704.6	88.0	921.95	2395.8	88.5	1043.78	2880.8	86.3	1206.55	584.2	65.1	217.30
Chrysophyta	9.2	0.4	15.93	0.0	0.0	0.0	5.4	0.2	0.89	0.0	0.0	0.0
Chlorophyta	122.9	4.3	22.79	85.2	3.2	12.51	142.2	4.5	9.78	151.2	16.8	37.87
Cyanophyta	151.4	4.8	11.57	142.1	5.4	147.17	206.0	6.3	45.31	83.0	9.1	5.54
Euglenophyta	68.2	2.1	20.79	77.2	2.9	29.76	89.2	2.7	12.92	50.4	5.6	8.50
Pyrrhophyta	4.6	0.1	1.19	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.4	1.00
Others	9.1	0.3	0.49	0.0	0.0	0.0	0.0	0.0	0.0	37.1	3.0	19.63
Total	3070.0 ±446.5		994.71	2700.3 ±522.8		1233.22	3323.6 ±622.8		1275.45	899.8 ±142.8		289.84

TABLE C.1-3

SUMMARY OF PHYTOPLANKTON DENSITY (no./ml), RELATIVE ABUNDANCE (%), AND BIOMASS (µg/l)
MARBLE HILL PLANT
26 MAY 1977

	Station 1			Station 3			Station 5			Station 6		
Taxon	Density (no./ml)	Relative abundance (%)	Biomass (µg/l)	Density (no./ml)	Relative abundance (%)	Biomass (µg/l)	Density (no./ml)	Relative abundance (%)	Biomass (µg/l)	Density (no./ml)	Relative abundance (%)	Biomass (µg/l)
Bacillariophyta	5786.5	53.5	2254.02	5508.1	71.2	3294.31	5005.9	55.9	2107.38	88.8	44.9	31.34
Chrysophyta	8.3	0.1	5.03	113.6	1.5	25.09	0.0	0.0	0.0	0.0	0.0	0.0
Cryptophyta	821.9	7.6	44.14	261.8	3.3	14.14	503.0	5.6	27.16	0.0	0.0	0.0
Xanthophyta	16.6	0.2	53.16	11.6	0.1	37.15	10.6	0.1	33.95	0.0	0.0	0.0
Chlorophyta	3580.7	32.8	450.49	1580.1	19.7	257.89	2981.9	33.1	536.85	39.6	20.1	3.46
Cyanophyta	[illegible]7.8	2.9	65.73	162.6	2.1	53.14	344.8	3.8	17.10	21.7	11.1	6.07
Euglenophyta	6[illegible].8	0.6	13.76	32.9	0.3	23.68	10.6	0.1	2.25	46.9	23.9	0.76
Pyrrhophyta	16.6	0.2	50.69	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Others	230.6	2.1	391.82	148.4	1.8	282.45	125.5	1.4	265.24	0.0	0.0	0.0
Total	10824.8 ±1116.9		3328.84	781[illegible].1 ±1208.4		3987.85	8982.3 ±1670.6		2989.93	197.0 ±6.8		41.63

TABLE C.1-4

SUMMARY OF PHYTOPLANKTON DENSITY (no./ml), RELATIVE ABUNDANCE (%), AND BIOMASS (μg/l)
MARBLE HILL PLANT
18 AUGUST 1977

Taxon	Station 1 Density (no./ml)	Station 1 Relative abundance (%)	Station 1 Biomass (μg/l)	Station [illegible] Density (no./ml)	Station [illegible] Relative abundance (%)	Station [illegible] Biomass (μg/l)	Station 5 Density (no./ml)	Station 5 Relative abundance (%)	Station 5 Biomass (μg/l)	Station 6 Density (no./ml)	Station 6 Relative abundance (%)	Station 6 Biomass (μg/l)
Bacillariophyta	8472.1	82.9	3076.32	9728.2	82.6	3604.40	6801.9	79.8	2954.12	135.6	78.1	60.70
Chrysophyta	95.7	0.9	39.25	63.7	0.5	26.12	0.0	0.0	0.0	0.0	0.0	0.0
Cryptophyta	33.6	0.3	14.42	202.6	1.7	41.85	78.5	0.9	18.39	0.0	0.0	0.0
Chlorophyta	1159.1	11.2	374.13	1269.2	11.1	329.95	1076.2	12.9	361.08	1.7	0.9	0.64
Cyanophyta	395.0	3.8	138.74	464.2	3.9	488.16	366.7	4.4	413.49	7.4	4.2	0.63
Euglenophyta	32.0	0.3	37.14	99.1	0.9	534.39	155.0	1.9	89.96	20.2	11.6	16.31
Pyrrhophyta	11.2	0.1	54.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Others	10.4	0.1	30.82	0.0	0.0	0.0	0.0	0.0	0.0	8.8	5.1	0.93
Total	10209.1 ±829.1		3765.13	11827.0 ±1647.6		5024.87	8478.3 ±3127.2		3837.04	173.7 ±14.7		79.21

TABLE C.1-5

SUMMARY OF PHYTOPLANKTON DENSITY (no./ml), RELATIVE ABUNDANCE (%), AND BIOMASS (µg/l)
MARBLE HILL PLANT
2 NOVEMBER 1977

Taxon	Station 1 Density (no./ml)	Station 1 Relative abundance (%)	Station 1 Biomass (µg/l)	Station 3 Density (no./ml)	Station 3 Relative abundance (%)	Station 3 Biomass (µg/l)	Station 5 Density (no./ml)	Station 5 Relative abundance (%)	Station 5 Biomass (µg/l)	Station 6 Density (no./ml)	Station 6 Relative abundance (%)	Station 6 Biomass (µg/l)
Bacillariophyta	4413.3	76.8	1900.20	5833.2	77.8	2589.90	3822.8	68.1	1688.62	820.9	81.3	346.89
Chrysophyta	12.0	0.2	6.69	9.0	0.1	5.02	25.9	0.5	14.44	0.0	0.0	0.0
Chryptophyta	438.4	7.7	85.22	290.9	3.8	37.30	523.1	9.3	103.19	4.8	0.5	0.39
Xanthophyta	6.5	0.1	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chlorophyta	697.7	12.0	113.51	1221.5	16.1	196.09	1030.5	18.9	204.01	24.6	2.8	3.26
Cyanophyta	19.7	0.3	0.54	56.5	0.7	11.1	26.8	0.5	5.71	99.7	9.9	9.32
Euglenophyta	111.1	1.9	35.17	81.5	1.1	10.50	197.1	3.6	52.88	21.3	2.2	5.08
Pyrrhophyta	12.5	0.2	25.82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Others	25.0	0.4	4.39	54.1	0.7	47.83	0.0	0.0	0.0	40.3	4.0	7.32
Total	5736.2 ±1877.5		2171.78	7546.7 ±1002.7		2897.74	5626.2 ±409.3		2068.85	1011.6 ±80.1		372.26

TABLE C.1-6

ANALYSIS OF VARIANCE AND TUKEY'S TEST FOR PHYTOPLANKTON DENSITY
AT OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT
MARCH-NOVEMBER 1977

ANALYSIS OF VARIANCE

Source	Degrees of freedom	Sum of squares	Mean squares	F value
Stations (S)	2	3982175.18	1991087.59	0.85
Months (M)	3	186271373.10	62090457.70	26.39*
Station X Month Interaction (I)	6	21468649.12	3578108.19	1.52
Error	12	28233518.20	2352793.18	
Total	23	239955715.60		

* Significant at α = .05. N = 24; critical F_S = 3.89; critical F_M = 3.49; critical F_I = 3.00

TUKEY'S TEST

Quarterly Comparison

Month (mean)	May (9206.92)	August (10169.88)	November (6301.80)
March (3029.55)	6177.37*	7140.33*	3272.25*
May (9206.92)		962.96	2905.12*
August (10169.88)			3868.08*

* Significant at α = .05; Tukey's HSD = 2630.06.

TABLE C.1-7

ANALYSIS OF VARIANCE AND TUKEY'S TEST FOR PHYTOPLANKTON BIOMASS
AT OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT
MARCH - NOVEMBER 1977

ANALYSIS OF VARIANCE

Source	Degrees of freedom	Sum of squares	Mean squares	F value
Stations (S)	2	1429677.80	714838.90	7.94*
Months (M)	3	15690504.50	5230168.17	58.07*
Error	6	540392.53	90065.42	
Total	11	17660574.83		

*Significant at α = .05. N = 12; critical F_S = 5.14; critical F_M = 4.76.

TUKEY'S TEST

Station Comparison

Station (mean)	3 (3285.92)	5 (2542.82)
1 (2565.12)	720.80*	22.30
3 (3285.92)		743.10*

*Significant at α = .05. Tukey's HSD = 651.24.

TUKEY'S TEST

Quarterly Comparison

Month (mean)	May (3435.54)	August (4209.01)	November (2379.46)
March (1167.79)	2267.75*	3041.22*	1211.67*
May (3435.54)		773.47	1056.08*
August (4209.01)			1829.55*

*Significant at α = .05. Tukey's HSD = 849.01.

TABLE C.1-8

SIMPLE CORRELATION COEFFICIENTS (r) FOR PHYTOPLANKTON DENSITY AND SELECTED PHYSICAL AND CHEMICAL PARAMETERS
MARBLE HILL PLANT
MARCH - NOVEMBER 1977

Parameter	Ohio River (N = 12)	Little Saluda Creek (N = 4)
Temperature	0.756*	-0.986*
Current	-0.373	-
Secchi depth	0.475	-
Nitrate nitrogen	0.052	-0.182
Ammonia nitrogen	-0.068	0.331
Orthophosphate	-0.566	0.491
Dissolved silica	-0.785*	-0.146

*Significant at α =.05. Critical r = .950 for N = 4; critical r = .576 for N = 12.

TABLE C.1-9

SIMPLE CORRELATION COEFFICIENTS (r) FOR PHYTOPLANKTON BIOMASS
AND SELECTED PHYSICAL AND CHEMICAL PARAMETERS
MARBLE HILL PLANT
MARCH - NOVEMBER 1977

Parameter	Ohio River (N = 12)	Little Saluda Creek (N = 4)
Temperature	0.907*	-0.994*
Current	-0.321	-
Secchi depth	0.375	-
Nitrate nitrogen	0.129	-0.320
Ammonia nitrogen	-0.084	0.451
Orthophosphate	-0.542	0.391
Dissolved silica	-0.706*	-0.092

*Significant at α =.05. Critical r = .950 for N = 4; critical r = .576 for N = 12.

C.2 ZOOPLANKTON

C.2.1 Introduction

The purpose of the 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 and to relate these findings to baseline data in an evaluation of effects due to construction at the Marble Hill Plant site. However, construction effects could not be evaluated since construction was not underway during much of the sampling period.

Zooplankton collectively refers to microscopic and macroscopic aquatic animals that are free-floating or capable of limited self-locomotion. Zooplankton are an important link in the food web of aquatic environments; they are the major consumers of phytoplankton and in turn provide an important food source for larger macroinvertebrates and fishes. Zooplankton populations of a large river system, such as the Ohio River, are sometimes subjected to rapid changes in river morphometry, from turbulent waters and eddies to slow-moving pools. Zooplankton populations of a river community are therefore likely to vary considerably along the river's length in both space and time (Hynes, 1972).

C.2.2 Materials and Methods

Duplicate zooplankton samples were collected 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 bottom depths to accommodate potential variations in the spatial distributions of zooplankton. A plastic funnel was attached to the end of the weighted intake hose to minimize the effect of selective catches due to avoidance by stronger swimming zooplankters (Welch, 1948). A minimum of 20 liters from each depth at river Stations 1, 3, and 5 was filtered through an 80μ-mesh Wisconsin net suspended over a volumetric container. Concentrated samples from all three depths at each river station were consolidated into a 250-ml polyethylene bottle. Because water levels were low in Little Saluda Creek, a minimum of 60 liters of water was filtered from mid-depth only. Zooplankton samples were preserved immediately after collection in a 5% formalin solution buffered to pH 7-8 with sodium borate.

In the laboratory, the samples were settled for a minimum of 48 hours. The settled samples were concentrated to a volume of approximately 20 ml by siphoning and placed in vials for analysis. The final concentrate volume of the sample was based on the amount of detritus and density of zooplankters in the sample.

Zooplankton identifications and counts were made by placing a well-mixed measured aliquot of concentrate into a 1-ml Sedgwick-Rafter counting chamber. Entire Sedgwick-Rafter chambers were enumerated at 100X magnification. A minimum of two identically prepared chambers per replicate sample were examined. When necessary for species identification, zooplankters were removed from the counting chamber and dissected by use of a stereoscopic microscope. All zooplankters were identified to the lowest practical taxon. Taxonomic references used for zooplankton identifications include: Ahlstrom (1940, 1943), Rylov (1948), Pennak (1953, 1963), Brooks (1957), Corliss (1959), Edmondson (1959), Harding and Smith (1960), Borror and Delong (1964), Honiberg et al. (1964), Mackinnon and Hawes (1966), Barnes (1969), Deevey and Deevey (1971), Jahn and Jahn (1971), Kudo (1971), Usinger (1971), Meglitsch (1972), Mordukhai-Boltovskoi and Chirkova (1973), Fryer (1974), and McNair (1976).

Zooplankters per liter were calculated as N by:

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

where: C = count

V_s = volume of sample concentrate (ml)

V_c = volume of concentrate enumerated (ml)

V_i = initial volume of sample (liters)

Whole zooplankton samples were retained as vouchers.

C.2.3 Results and Discussion

Zooplankton composition, density, and relative abundance data for each station location and sampling date are presented in Appendix Tables C.2-1 through C.2-8. Sixty-seven zooplankton species in four major taxa (Protozoa, Rotifera, Cladocera and Copepoda) were recorded during the study (Table C.2-1). Species diversity values were highest in May and August, when abundance was also high. Zooplankton densities for the river stations ranged from a low of 10 organisms per liter at Station 3 in November to a high of 286 per liter at Station 5 in May. Differences in abundance between river stations were not statistically significant (Table C.2-6). Zooplankton numbers in Little Saluda Creek (Station 6) ranged from 3 organisms per liter in March to 5 per liter in May (Tables C.2-2 through C.2-5).

Zooplankton composition in Little Saluda Creek and at the river stations was similar with respect to the taxa present, but the relative abundance of the taxa varied between the river and the creek. Zooplankton densities at the river stations were consistently higher than those in Little Saluda Creek on all sampling dates. These data were in agreement with baseline studies at the Marble Hill site (PSI, 1976) and with other recent works on the Ohio River (ABI, 1975 and 1977).

Kofoid (1903) found that zooplankton abundance on the Illinois River over short distances (4.83 km) did not vary from the mean by more than 10%. This is typical for flowing-water environments where turbulence results in a more homogeneous distribution of organisms. Zooplankton composition and temporal changes in abundance near the Marble Hill site are characteristic of those in large rivers that are influenced by physical and climatic changes in light, temperature, water levels, turbulence, silt, and the availability of food.

Zooplankton densities (Figure C.2-1) indicated low winter/ early spring zooplankton production, followed by a sharp increase in abundance towards summer and a decrease in abundance in late fall collections. Zooplankton densities were generally low on 21 March 1977. The highest density on this date (55 zooplankters per liter) was recorded at Station 5. The numerically dominant taxonomic group was Protozoa, which comprised 79.1 to 82.2% of the total zooplankton collected at river Stations 1, 3, and 5 and accounted for 34% of the zooplankters at Station 6 in Little Saluda Creek (Table C.2-2). Sessile protozoans, including the genera *Vorticella, Carchesium,* and *Epistylis,* were observed at the river stations. High water levels on 21 March along with heavy silt loads and associated rapid currents most likely produced a scouring effect in the river and were responsible for the occurrence of these incidentally planktonic forms. Low densities of rotifers, cladocerans, copepods and other miscellaneous groups were observed. Damaged cladocerans (consisting of fragmented carapaces or other major structural damage) were consistently found at the river stations in March and were observed on all other sampling dates. These organisms most likely were present because the carapaces were swept off the river bottom by currents and resuspended in the water column. Data discussion is based on undamaged zooplankton analysis. Damaged counts are presented in Appendix Tables C.2-1, C.2-3, C.2-5, and C.2-7.

Zooplankton abundance was significantly higher on 26 May than on any other sampling date (Table C.2-6). Diversity of species was also highest on this date. Rotifers were the numerically dominant group (Figures C.2-2 and C.2-3) with densities ranging from 136 per liter at Station 1 to 143 per liter at Station 3 (Table C.2-3). *Keratella cochlearis* was the dominant rotifer species, with *Polyarthra* sp. and *Brachionus calyciflorus* prevalent in the river. In a study of 128 sampling stations on the major rivers and Great Lakes of the United States, Williams (1966) found *K. cochlearis* the most widely distributed and abundant rotifer collected. The second major contributor to the zooplankton in May was copepods, specifically naupliar and copepodite developmental stages. Protozoan densities were greatly reduced from those observed in March samples.

Samples collected on 17 August showed a decline in zooplankton numbers from May (Table C.2-4). Protozoans and rotifers contributed nearly equal densities to the total zooplankton populations on this date. The protozoans *Arcella, Centropyxis* and *Difflugia*, all typical of large rivers, were recorded at the river stations along with the sessile forms *Epistylis* and *Vorticella*. Rotifers of the genus *Brachionus* were prevalent, with *B. calyciflorus* the dominant species for all stations. *Keratella cochlearis* was observed only at the river stations. Copepod and cladoceran densities in August were less than those in May collections, but showed an increase in the number of adult forms collected.

On 9 November, zooplankton abundance was lower than that on any previous sampling date (Table C.2-5). Zooplankton counts ranged from 3 zooplankters per liter in Little Saluda Creek to 11 organisms per liter at river Station 5. Protozoans and rotifers dominated the samples (Figure C.2-3). The low abundance in November reflected trends observed during the baseline monitoring. Baseline data revealed low zooplankton production in the November through February collections, with samples rarely averaging more than 20 organisms per liter.

The May increase in total zooplankton densities, and rotifer abundance in particular, may be attributed to seasonal and other environmental factors. There was a significant positive correlation of rotifer densities with temperature (Table C.2-7). Hodgkinson (1970) suggested that temperatures may be the primary factor in determining seasonal succession in rotifers. Secondly, a significant negative relationship existed between current velocities and total zooplankton and rotifer abundance. Williams (1966) found that silt always reduced the numbers of rotifers and that rotifers were less common in rivers of high flow.

Hynes (1972) suggested that zooplankton of large river systems originate in still or gently flowing areas. Beach (1960) and Williams (1966) supported this concept and concluded that rotifer populations of flowing environments are not qualitatively different from those of lakes and impoundments. Numerous small streams and pools empty into the Ohio River. These areas of slow water replacement allow concentration of nutrients and may provide suitable sites for recruitment. These areas may thus provide the river with its initial source of zooplankton during periods of high productivity.

The phytoplankton counts at the river stations also showed an increase in May from the March collections. Williams (1966) demonstrated that comparisons of phytoplankton and rotifer densities indicate that stations with high phytoplankton populations generally have high rotifer populations. The opposite relationship was also found, indicating a direct or indirect dependence of rotifers on phytoplankton for food. Baseline data showed a phytoplankton increase in June and an associated rotifer population dominance.

Construction at the Marble Hill site was not in full operation during the zooplankton study and thus an evaluation of construction effects on zooplankton composition and abundance in the Ohio River could not be made at this time.

C.2.4. Conclusions

Zooplankton densities for the river stations ranged from a low of 10.5 organisms per liter in November at Station 3 to a concentration of 286 per liter in May at Station 5. The absence of significant differences in zooplankton abundance between river stations is generally a feature of flowing environments. Zooplankton populations in Little Saluda Creek varied from 2.9 organisms per liter in March to 4.5 per liter in May.

The zooplankton abundance and species diversity of the Ohio River in the vicinity of the Marble Hill site were consistent with those reported by other workers for eutrophic rivers. The seasonal patterns indicated summer peaks in zooplankton densities dominated by rotifers.

Zooplankton composition in Little Saluda Creek and at the river stations was qualitatively similar; however, zooplankton densities at the river stations were significantly higher than those in Little Saluda Creek on all sampling dates.

A significant positive correlation between water temperature and total zooplankton and rotifer abundance was observed, indicating increased seasonal abundance with increasing water temperatures. A significant negative correlation between current velocity and total zooplankton and rotifer densities may be attributable to increased silt loads during periods of high stream flow. Construction effects could not be evaluated since construction was not underway during much of this sampling period.

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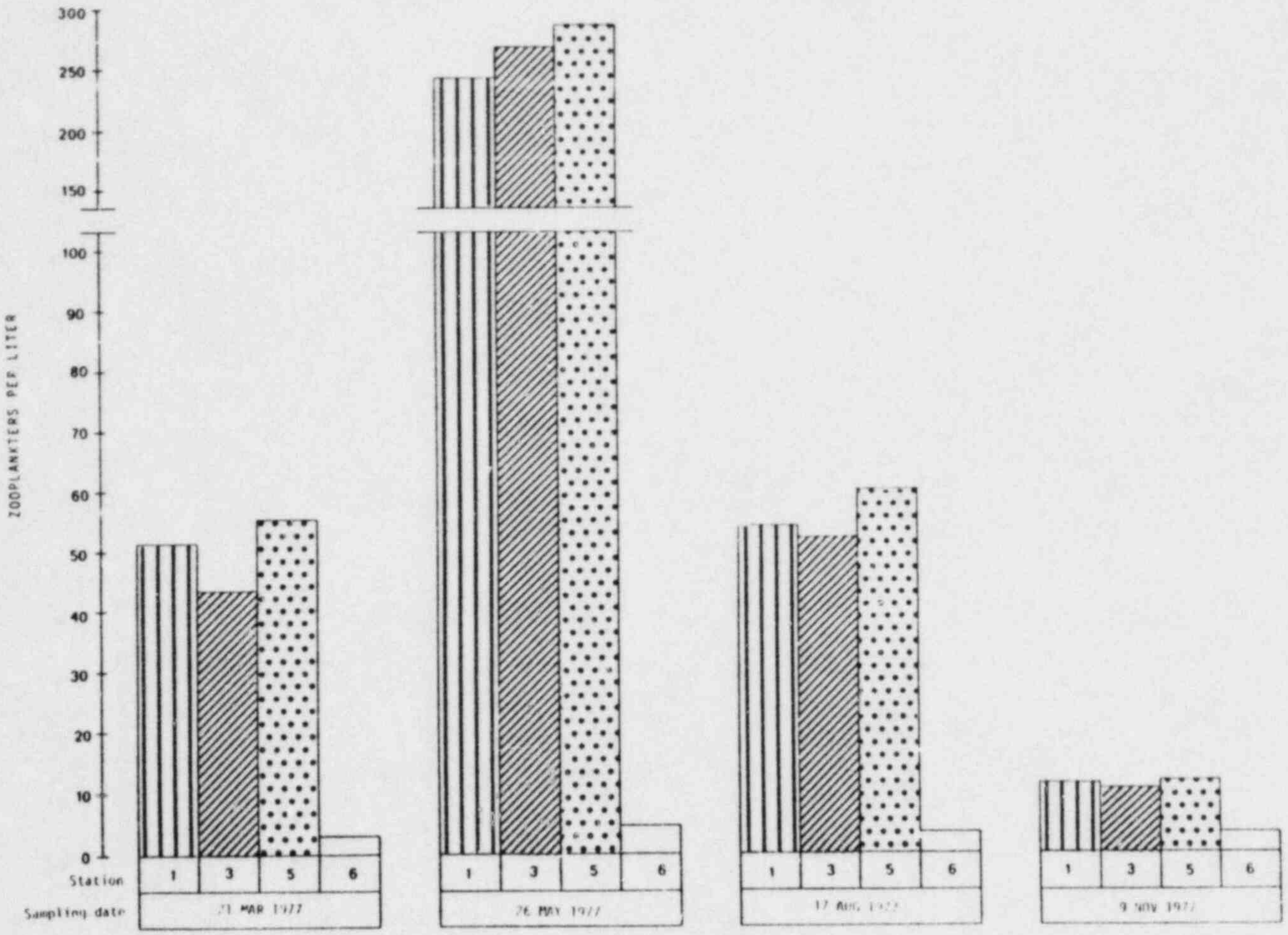

Figure C.2-1. Total zooplankton densities at Stations 1, 3, and 5 in the Ohio River and Station 6 in Little Saluda Creek, Marble Hill Plant site, 21 March-9 November 1977.

C-46

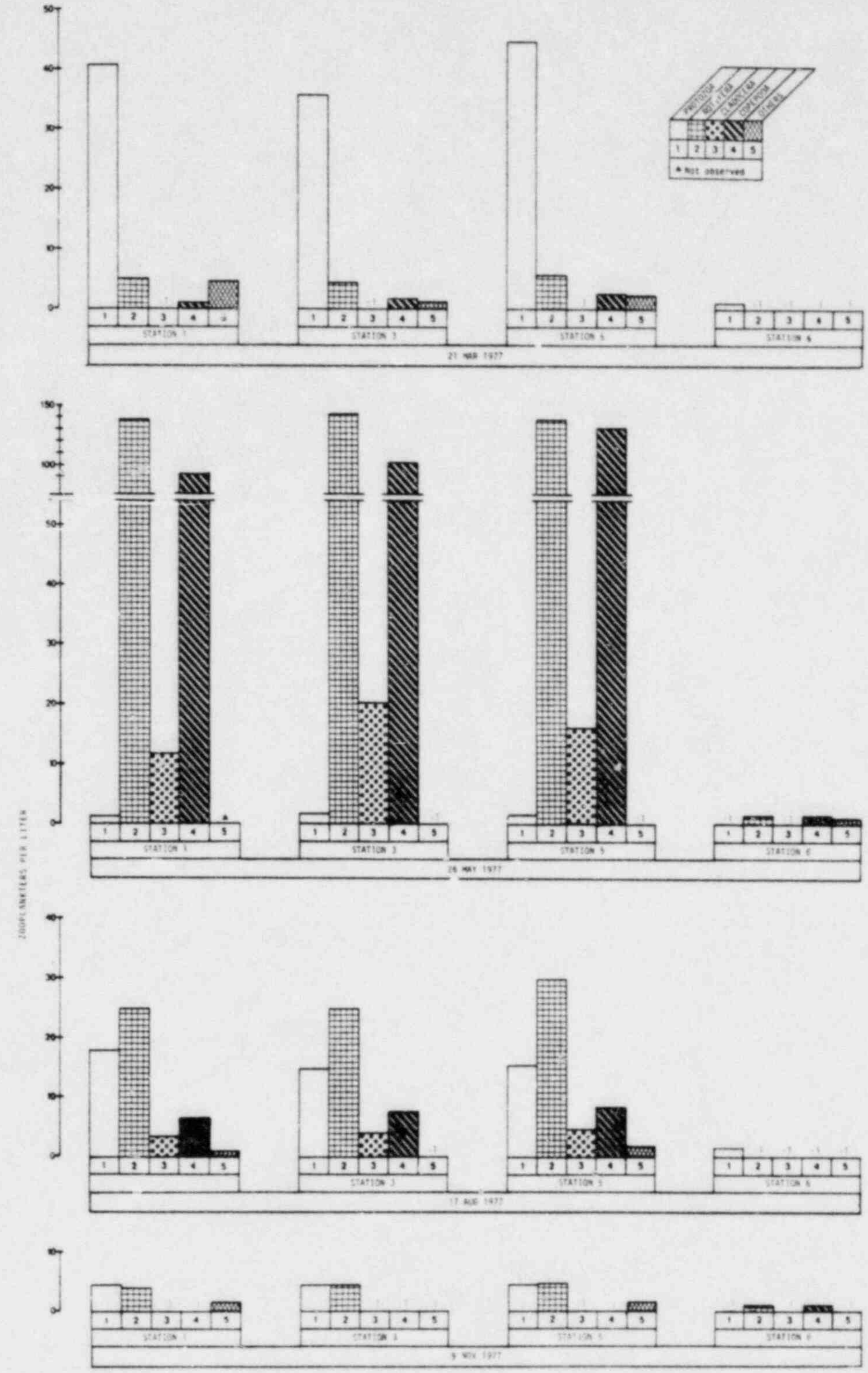

Figure C.2-2. Total densities of the major zooplankton groups at the Marble Hill Plant site, 21 March-9 November 1977.

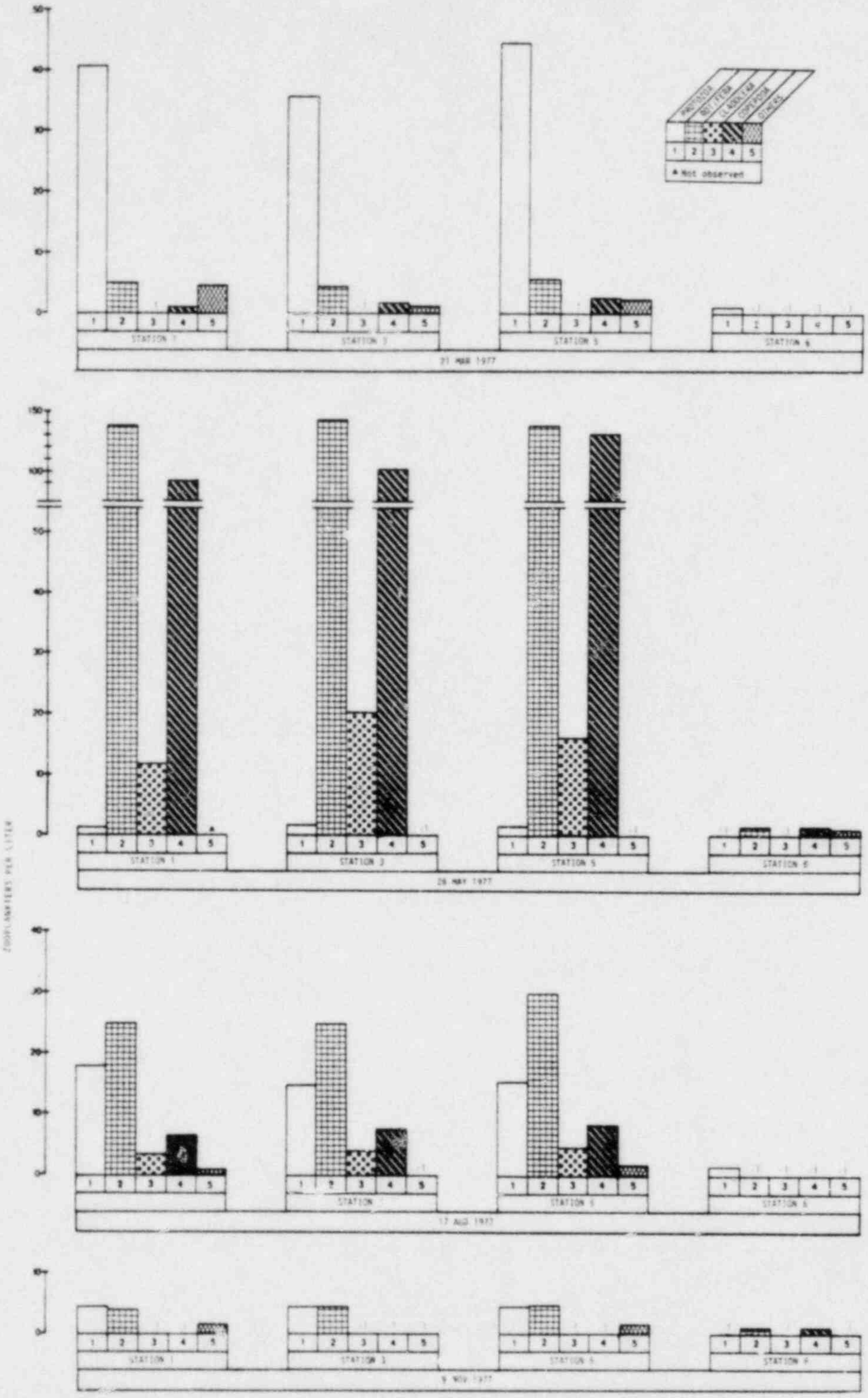

Figure C.2-2. Total densities of the major zooplankton groups at the Marble Hill Plant site, 21 March-9 November 1977.

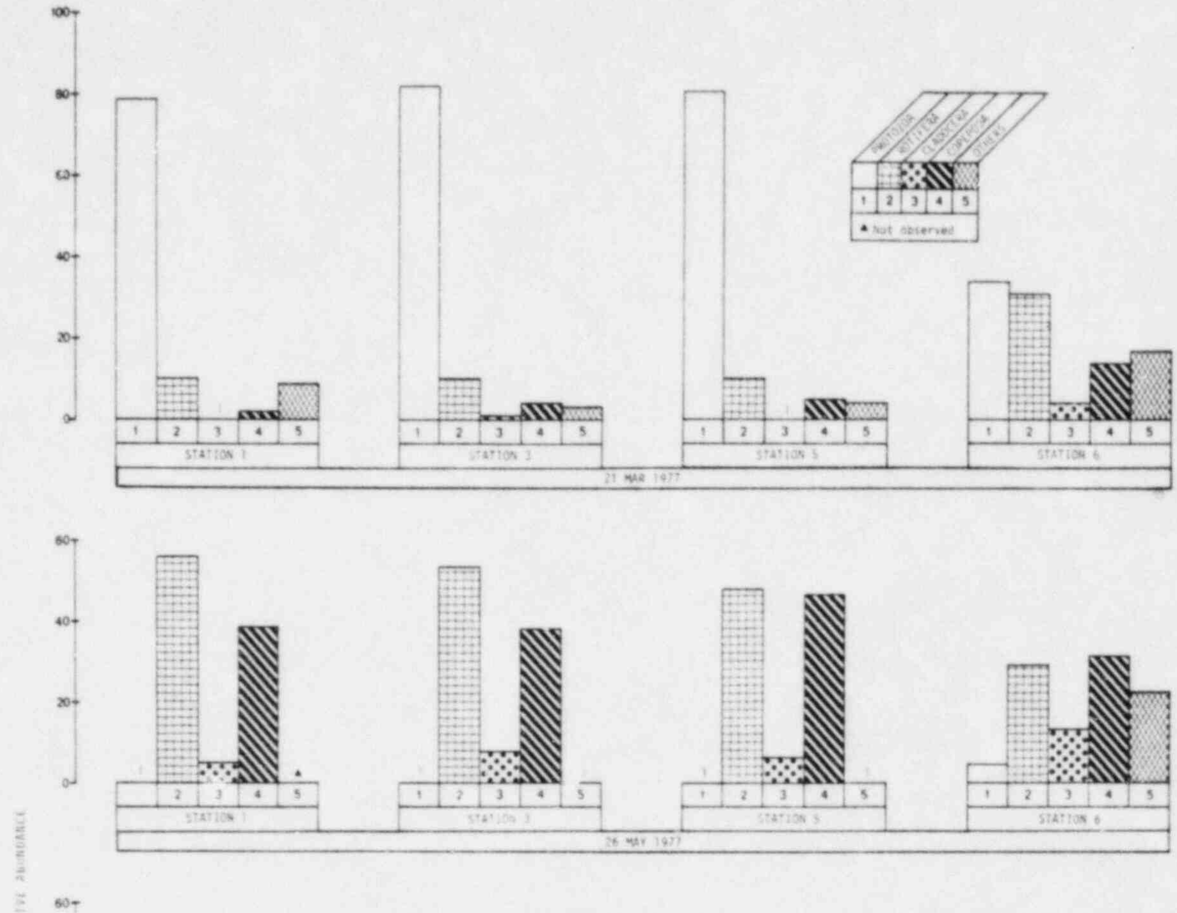

Figure C.2-3. Relative abundance of the major zooplankton groups at the Marble Hill Plant site, 21 March-9 November 1977.

TABLE C.2-1

COMPOSITE SPECIES LIST OF ZOOPLANKTON COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT
MARCH-NOVEMBER 1977

PROTOZOA

Acineta sp.
Arcella spp.
Arcellidae
Carchesium sp.
Centropyxis sp.
Difflugia spp.
Difflugiidae
Epistylis sp.
Podophrya sp.
Pyxicola sp.
Squalorophrya sp.
Suctorida
Tokophrya sp.
Vorticella sp.

ROTIFERA

Asplanchna sp.
Brachionus spp.
B. angularis
B. bidentata
B. calyciflorus
B. diversicornis
B. havanaensis
B. quadridentata
Filinia sp.
Kellicottia sp.
K. bostoniensis
K. longispina
Keratella spp.
K. cochlearis
K. quadrata
K. valga
Lecane sp.
Monostyla sp.
M. bulla
M. lunaris
Notholca sp.

ROTIFERA (cont.)

Platyias patulus
P. quadricornis
Polyarthra sp.
Trichocerca sp.
Trichotria sp.

CLADOCERA

Alona sp.
A. costata
A. rectangula
Bosmina longirostris
Bosminidae
Ceriodaphnia sp.
C. quadrangula
Chydorus sp.
C. sphaericus
Daphnia sp.
D. ambigua
D. parvula
Diaphanosoma brachyurum
D. leuchtenbergianum
Eubosmina sp.
E. coregoni
E. longispina
Ilyocryptus sp.
I. spinifer
Leydigia quadrangularis
Moina micrura
Sida crystallina
immature Cladocera

TABLE C. 2-1
(continued)
COMPOSITE SPECIES LIST OF ZOOPLANKTON COLLECTED IN THE
OHIO RIVER AND IN LITTLE SALUDA CREEDK
MARBLE HILL PLANT
MARCH-NOVEMBER 1977

COPEPODA
- Calanoida
  - *Diaptomus* sp.
  - *D. ashlandi*
  - *D. pallidus*
- Cyclopoida
  - *Cyclops* sp.
  - *C. bicuspidatus thomasi*
  - *C. vernalis*
  - *Eucyclops agilis*
  - *Macrocyclops albidus*
- Harpacticoida
  - *Nitocra* sp.
- Copepodites
- Nauplii

OTHERS
- Cnidaria
  - *Hydra* sp.
- Nematoda
  - *Criconema* sp.
- Ectoprocta statoblasts
- Tardigrada
- Oligochaeta
- Isopoda
  - *Lirceus fontinalis*
- Oribatoidae
- Hydracarina
- Chironomidae
- Diptera
- Hemiptera
- Hydropsychidae
- Thysanoptera

TABLE C.2-2

SUMMARY OF ZOOPLANKTON DENSITY (NO./LITER) AND RELATIVE ABUNDANCE (%)
MARBLE HILL PLANT
21 MARCH 1977

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	40.8	79.1	35.6	82.2	44.4	80.8	1.0	34.0
Rotifera	5.0	9.8	4.4	10.0	5.6	9.8	0.9	31.0
Cladocera	0.2	0.4	0.5	1.1	0.3	0.6	0.1	4.0
Copepoda	1.0	2.0	1.7	4.0	2.6	4.7	0.4	14.0
Others	4.4	8.7	1.2	2.7	2.3	4.1	0.5	17.0
Total	51.4		43.4		55.2		2.9	

TABLE C.2-3

SUMMARY OF ZOOPLANKTON DENSITY (NO./LITER) AND RELATIVE ABUNDANCE (%)
MARBLE HILL PLANT
26 MAY 1977

	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	1.2	0.5	1.3	0.4	1.2	0.4	0.2	4.4
Rotifera	136.2	56.2	143.3	53.3	137.4	47.7	1.3	28.9
Cladocera	11.8	4.9	20.2	7.5	16.2	5.7	0.6	13.3
Copepoda	92.7	38.4	102.5	38.3	131.5	46.0	1.4	31.2
Others	0.0	0.0	0.4	0.5	0.5	0.2	1.0	22.2
Total	241.9		267.7		286.8		4.5	

TABLE C.2-4

SUMMARY OF ZOOPLANKTON DENSITY (NO./LITER) AND RELATIVE ABUNDANCE (%)
MARBLE HILL PLANT
17 AUGUST 1977

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	17.7	32.8	14.7	28.2	15.3	25.5	1.3	39.5
Rotifera	25.0	46.1	25.0	48.0	30.0	49.8	0.8	24.1
Cladocera	3.3	6.3	4.0	7.8	4.8	8.2	0.2	6.0
Copepoda	6.8	12.7	7.7	14.8	8.2	13.7	0.9	27.4
Others	1.1	2.1	0.6	1.2	1.6	2.8	0.1	3.0
Total	53.9		52.0		59.9		3.3	

TABLE C.2-5

SUMMARY OF ZOOPLANKTON DENSITY (NO./LITER) AND RELATIVE ABUNDANCE (%)
MARBLE HILL PLANT
9 NOVEMBER 1977

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	4.5	40.1	4.2	39.9	4.4	37.3	0.6	18.8
Rotifera	4.0	35.7	4.5	42.7	4.6	38.8	1.0	31.3
Cladocera	0.5	4.5	0.4	3.9	0.8	6.5	0.2	6.2
Copepoda	0.6	5.4	0.7	6.7	0.9	7.5	1.0	31.3
Others	1.6	14.3	0.7	6.8	1.2	9.9	0.4	12.4
Total	11.2		10.5		11.9		3.2	

TABLE C.2-6

ANALYSIS OF VARIANCE AND TUKEY'S TEST FOR DIFFERENCES BETWEEN MEANS FOR ZOOPLANKTON DENSITY
MARBLE HILL PLANT
MARCH-NOVEMBER 1977

Analysis of Variance
Stations 1-5, All Quarters

Source	Degrees of freedom	Sum of squares	Mean squares	F values
Stations	2	787.14	393.57	0.4941
Months	3	238536.59	79512.19	99.8265*
Station x Month interaction	6	1440.68	240.11	0.3015
Error	12	9558.03	796.50	
Total	23	250322.45		

* Significant at $\alpha = .05$; critical F value = 3.49.

Tukey's Test

Month (mean)	March (49.33)	May (264.68)	August (53.98)	November (10.16)
March (49.33)	0	215.35*	4.65	39.17
May (264.68)		0	210.7*	254.52*
August (53.98)			0	43.82

* Significant at $\alpha = .05$; HSD = 48.39.

TABLE C.2-7

SIMPLE CORRELATION COEFFICIENTS FOR RIVER STATIONS
MARBLE HILL ZOOPLANKTON
MARCH-NOVEMBER 1977

Densities (no./l)	Temperature (°C)	Current velocity (cm/sec)
Total zooplankton	r = +0.64317*	-0.94422*
Rotifera	r = +0.6240*	-0.951617*
Protozoa	r = -0.57736*	+0.32739

* Significant at α = .05; critical r value = 0.576.

D. PERIPHYTON

INTRODUCTION

The purpose of the periphyton study at the Marble Hill site was to evaluate interstation and seasonal variability in periphyton species composition, density, diversity, equitability, and community biomass during power plant construction. Construction did not begin until after the third quarterly sampling. Therefore, these data are more reflective of natural variations than construction-related effects.

The term periphyton is used to describe all those organisms that attach, by various means, to any submerged substrate but do not penetrate into it (APHA, 1976). Examples of periphyton organisms include bacteria, yeasts, molds, algae, protozoa, and larger colonial forms such as bryozoa. Plants and certain parasitic organisms which have roots or otherwise penetrate the substrate are not included in the periphyton community.

In addition, periphyton includes any variety of free-living organisms (i.e., rotifers, worms, larvae) inhabiting the mat of attached forms. Due to the wide variety of plants and animals included in the periphyton community, and a similarly varied range of specialized adaptations, virtually all submerged substrates (living and non-living) may be colonized in temperate and near-temperate aquatic habitats such as those in the vicinity of the Marble Hill Plant site.

The periphyton community is widely accepted as a valuable indicator of water quality and related environmental conditions. Due to comparatively brief life cycles and intense competition for available substrate space by periphyton organisms, any natural or man-induced change in habitat parameters results in rapid qualitative and quantitative alterations in the periphyton community.

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, each of which contained eight standard (2.5 x 7.6 cm) microscope slides. Six slides were harvested from each station after a 3-week exposure period. For biomass determinations, three slides per station were preserved individually in jars containing approximately 100 ml of 5% buffered formalin solution. Two slides per station were similarly preserved for species identifications and counts. An additional slide was preserved to replace any sample slide broken during transit to the laboratory. At Station 6 (Little Saluda Creek), measured areas of natural substrate (approximately 100 cm^2) were scraped clean of periphyton. (Suitable substrate materials were not obtained at Station 6 in March.) For species identification, counts, and biomass determinations, a minimum of two replicate scrapings were washed separately into bottles of 5% buffered formalin solution. Natural substrate composition and habitat types were noted and included in the data.

In the laboratory, all diatometer slides were scraped on both sides, and detached organisms were washed back into the collection bottles. Samples were concentrated, by siphoning, to approximately 30 ml after at least 24 hours of settling. Natural substrate samples were also concentrated by settling.

Sample suspensions used for species identification and counts were transferred to graduated test tubes, allowed to resettle for at least 24 hours, and concentrated to a known volume by further siphoning. The inverted microscope technique (Utermohl, 1958) was used for species identifications and counts. Periphyton species other than diatoms were identified to the lowest possible taxon in 25-ml settling chambers. Total diatom and non-diatom species were enumerated by random strip counts at 400X magnification in two identically prepared chambers per sample replicate. A minimum of 400 individuals per replicate was routinely counted. Total live diatom counts were used with diatom species proportional counts (obtained from permanent slides at 1000X magnification) to obtain diatom density by species (APHA, 1976). Taxonomic references used in species identification included: Van Huerck (1896), Walton (1915), Hustedt (1930), Skuja (1948), Smith (1950), Edmondson (1959), Prescott (1962), Patrick and

Reimer (1966, 1975), Weber (1966), Taft and Taft (1971), Bick (1972), Sreenivasa and Duthie (1973), and Prescott, Croasdale and Vinyard (1975).

All algal species, excluding certain greens and blue-greens, were counted as individual cells. Filamentous green and blue-green species were measured in 100μ lengths with each length representing one counting unit. Colonial forms exclusive of diatoms were counted as naturally occurring colonies, unless otherwise noted. Non-algal species were counted as individual organisms. Periphyton density per 10 cm^2 was calculated as N by:

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

where: V_c = Volume of sample concentrate (ml)

C = Count

V_e = Volume of sample concentrate examined (ml)

A_s = Area of substrate sampled (10 cm^2 units)

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

Ash-free dry weights (biomass) were determined for three replicate artificial substrate samples per station at Stations 1, 3, and 5 and for natural substrate scrapings at Station 6 (APHA, 1976). Ash-free dry weight values were calculated as mg/10 cm^2.

Species diversity was calculated as the Shannon-Weaver mean diversity index ($\overline{d}$) which is recommended by EPA (1973). The equitability component of diversity (Lloyd & Ghelardi, 1964) was also applied to the data. A discussion of these calculations is contained in Section E.

RESULTS AND DISCUSSION

Periphyton species observed in the Marble Hill Plant site samples represented eight major groups: 1) Bacillariophyta (diatoms), 2) Chrysophyta (yellow-brown algae), 3) Chlorophyta (green algae), 4) Cyanophyta (blue-green algae), 5) Pyrrhophyta (dinoflagellates), 6) Euglenophyta (euglenoids), 7) Protozoa, and 8) Others (<10µ phytoflagellates). A total of 134 taxa were found (Table D-1). Major species groups included diatoms, green algae, and blue-green algae which represented 67.9%, 15.7%, and 8.2% of the total species list, respectively. Other groups represented 3.7%, or less, of the total. Complete collection data are contained in Appendix Tables D-1 through D-8.

Bacillariophyta (diatoms)

Diatoms were the dominant species group (i.e., representing 50% or more of the total periphyton count) in most of the samples collected. The diatom percentages of total periphyton counts ranged from 98% at Station 1 in November to 21% at Station 5 in August (Table D-2). The only other diatom representation of less than 50% occurred at

Station 3 in August. Dominance of diatoms is typical of freshwater periphyton communities in temperate zone climates (Patrick, 1966).

A general reduction in the relative percentage of diatoms observed at Ohio River Stations 1, 3, and 5 in August was attributable to a seasonal increase in water temperature and increased light intensity, which would favor growth of the better adapted blue-green algae (Figure D-1). The persistence of a high percentage of diatoms at Station 6 in August may have been influenced by partial shading and lower water temperatures (approximately 6°C cooler than those in the Ohio River).

A total of 91 diatom species, representing 23 genera, were identified. Species which were encountered most frequently and were often in comparatively high densities (2% or more of the total periphyton count) included:

Ohio River Stations

Cyclotella Meneghiniana
C. pseudostelligera
Melosira varians
Cocconeis placentula v. *euglypta*
Gomphonema angustatum
Gomphonema olivaceum
G. parvulum
Navicula cryptocephala
N. viridula v. *avenacea*
Nitzschia palea

Little Saluda Creek Station

Achnanthes minutissima
Rhoicosphenia curvata
Gomphonema parvulum
G. tenellum

These species are known to respond to variations in environmental parameters such as temperature, pH, current, and nutrient levels (Table D-3). Most species are described as being eurythermal (occurring within a temperature range of 15°C or greater). A wide range of temperature tolerance would serve to adapt these species to the seasonal fluctuations in water temperature which occur in the vicinity of the Marble Hill site. The only reported euthermic species (warm-water species occurring mostly at temperatures greater than 30°C) was *Cocconeis placentula* v. *euglypta* which was observed in highest densities in the warmer May and August sampling periods.

Most of the dominant diatom species were either alkaliphilous (occurring at a pH of around 7 with best growth over 7) or pH indifferent, which also reflects conditions near the Marble Hill site. Measured pH values were consistently near or about 7.0. Highly varied water current conditions in the Ohio River are reflected in the fact that most of the dominant diatom species were either indifferent to current, or were rheophilous (characteristic of running water, but also found in standing water).

Species for which nutrient data are available were characteristic of water with high nutrient concentrations. Patrick and Reimer (1966) noted that *Gomphonema* v. *parvulum* is often associated with nutrient-enriched waters, especially those enriched by sanitary and agricultural wastes.

Certain major diatom species from Ohio River stations showed marked seasonal variations in total density and percentage representation. Generally, trends of seasonal variation in the density and relative abundance of individual diatom species were comparable at all of the Ohio River stations (1, 3, and 5) although the sporadic appearance of certain species at single stations did produce limited qualitative differences. These differences probably did not reflect significant interstation effects.

Diatom composition at Station 6 consistently differed from that at the Ohio River stations in that there were always fewer species present, and certain species including *Achnanthes minutissima, Gomphonema tenellum,* and *Rhoicosphenia curvata* were more prevalent. These differences are attributable to environmental features, such as cooler water, partial shading, decreased flow rate, and a water chemistry less altered by the addition of organic and inorganic wastes, which were unique to Little Saluda Creek.

Chlorophyta (green algae)

Green algae were a consistent, although never dominant, component of both the Ohio River and Little Saluda Creek periphyton. A total of 21 species, representing 14 genera, were identified. The relative percentages of green algae ranged from 17 to less than 1% during the study period. No green alga was as consistently abundant or widespread as the major diatom species. Species which on various occasions accounted for 2% or more of the total periphyton included:

Characium obtusum	*Oocystis pusilla*
Characium sp.	*Stigeoclonium* sp.

Although present in only low densities in March, a small number of green algal species represented a comparatively large percentage of the total periphyton at the Ohio River stations due to generally sparse periphyton growth (Figure D-1). Much higher densities and increased species diversity of green algae were observed at all stations in May and August, reflecting the influence of seasonal warming. During these months, however, the relative percentage of green algae was diminished at all stations by much higher densities of either diatoms or blue-green algae, or a combination of both. In November, a general reduction in the density of green algae was attributable to cooler water temperatures.

Data on the environmental requirements of green and blue-green algae are very limited compared to the volume of information on diatoms. It has been observed, however, that factors such as pH values greater than 7, high carbonate alkalinity, and high concentrations of nitrogen and phosphorus may promote more rapid growth of diatoms and blue-green algae to such an extent that the green algae are unable to compete. This lack of competitiveness in an essentially eutrophic habitat may explain the low percentage of green algae observed in the present study.

Cyanophyta (blue-green algae)

Blue-green algae were a consistent and seasonally predominant component of the periphyton. Relative percentages ranged from 73 to less than 1%. A total of 11 species, representing 8 genera, were identified. Species most frequently encountered in relatively high densities (2% or more of the total periphyton) included:

Ohio River	Little Saluda Creek
Chamaesiphon ? sp.	*Lyngbya diguetti*
Lyngbya sp. 1	*Oscillatoria* sp. 1
Oscillatoria sp. 1	

As observed with green algae, the relative abundance of blue-green algae at Ohio River stations in March was enhanced by an overall paucity of periphyton growth, although blue-green densities were lowest at this time (Figure D-1). Blue-green species densities increased moderately at the Ohio River stations in May in response to seasonally elevated water temperatures and extended photoperiod. Diatoms, however, remained predominant. Blue-green cell density, species diversity, and percentage composition were highest in August. High densities of *Chamaesiphon* ? sp. accounted largely for blue-green predominance at Stations 3 and 5. In November, density and species diversity of blue-green algae were greatly reduced, and percentage representation was minimal for the sampling period.

Blue-green species densities and seasonal distribution in Little Saluda Creek differed from those at the Ohio River stations.

In May, rock scrapings contained a comparatively high percentage of *Lyngbya diguetii*, which appeared to be a major component of dense, well-established algal growth. Reduced blue-green densities observed in August may have resulted from lower water temperature, partial shading, and lower nutrient concentrations. Rock scrapings in November consisted predominantly of diatoms, although high density of *Lyngbya diguetii* was similar to that observed from scrapings in May.

Community Similarity

Morisita's community similarity index was used to compare the degree of species overlap in the quarterly composition of Ohio River station periphyton. Values equal to or greater than 0.50 indicate that community composition was similar on the basis of paired station comparisons. It is important to note that this index of comparison does not imply statistical significance. The only comparisons which suggested qualitative differences (Table D-4) were Station 1 x Station 3 and Station 1 x Station 5 in March, and Station 1 x Station 5 in May. However, the index values associated with these comparisons were close to 0.50 (0.44, 0.48, and 0.49, respectively). Generally, the species composition at Stations 1, 3, and 5 was considered comparable, with strongest similarity in November. No consistent qualitative differences attributable to plant construction were observed. Index comparisons were not made between Little Saluda Creek and the Ohio River due to the difference in habitats.

Total Periphyton Density

Total periphyton density varied greatly both between sampling quarters and between stations within quarters (Figure D-2). Ohio River station values ranged from $3330.0 \times 10^3/10\ cm^2$ at Station 5 in November to $1.1 \times 10^3/10\ cm^2$ at Station 5 in March. Values in Little Saluda Creek ranged from $15.9 \times 10^6/10\ cm^2$ in November to $1.7 \times 10^6/10\ cm^2$ in August.

Significant density differences between stations, between months, and significant interaction (stations x months) were indicated by analysis of variance comparison of Stations 1, 3, and 5 (Table D-5). Significant interaction means that differences between stations and between sampling dates were not consistent over the quarterly sampling period. Therefore, generalizations concerning overall interstation or seasonal differences must be made with certain qualifications. Tukey's HSD (honest significant difference) comparisons of mean periphyton densities (Table D-6) provided station-by-station and month-by-month comparisons which localized significant differences.

Results of interstation comparisons by quarters indicated that in March and May, there were no significant interstation differences between periphyton densities. In August, periphyton density was significantly higher at Station 5 than at Stations 1 and 3. In November, periphyton density was again significantly higher at Station

5 than at Stations 1 and 3, and density at Station 3 was significantly higher than that at Station 1 (Figure D-2).

Despite certain differences in patterns of seasonal variation observed at Stations 1, 3, and 5, a general trend toward increased densities in May and November was apparent. The very low densities at all Ohio River stations in March may be attributable to the prolonged influence of a very cold winter and to intensive scouring of diatometer slides due to elevated river water levels and flow rate. Increased densities in both May and November were clearly not the direct result of seasonal variations in water temperature and light conditions alone. Such variations can only be attributed to a complex interaction of many factors including flow rate, turbidity, nutrient concentrations, and ratios of inorganic ions, which vary continually in a flowing water environment.

Similar densities observed at Stations 1, 3, and 5 in March and May were consistent with the expected similarities of environmental conditions in a flowing water habitat. Increased densities at Station 5 in August and at Stations 3 and 5 in November were not readily explained by available environmental data. The Ohio River margin at Station 1 is straight and unobstructed in comparison with irregularities at Stations 3 and 5 produced by fallen trees and snags. A marked shoal also lies immediately downstream of Station 5. Over the course of 3-week exposure intervals, some slowing of current near the margins may have enhanced periphyton colonization and growth at Stations 3 and 5.

Marble Hill Plant construction was begun after the August sampling date. The occurrence of significant interstation differences in periphyton density both before and after the beginning of construction indicate that such variation cannot be attributed to construction-related effects.

Periphyton densities in Little Saluda Creek were highest in May and November. These samples were scraped from dense, well-established communities growing on the rocks in the stream. Decreased density in August may have reflected a seasonal decrease, but was probably caused by the lack of a consistently used, non-variable substrate. A major drawback in this type of sampling is the variability of natural substrates, i.e., no two rocks have exactly the same surface. Therefore, only qualitative results may be reliably obtained in natural substrate sampling. Overall, the present data suggest that substantial densities can be expected from rock scrapings in Little Saluda Creek.

Species Diversity

Species numbers (S), species diversity ($\bar{d}$) and equitability (e) values which were calculated for each sampling quarter are summarized in Table D-7. Values of H (diversity, to log base 10), H_{max} (maximum diversity), and J (evenness index, relative diversity) were derived for direct comparison with baseline data. Computation of $\overline{d}$ is identical to that of H (used in the baseline study) except that values are expressed to the more commonly used log base 2 (EPA, 1973). Species diversity (both in terms of $\overline{d}$ and H, which are in direct proportion) was highest at all Ohio River stations in March, when densities were very sparse and no species was strongly predominant. Equitability and species evenness were also highest in March due to comparable representation of most species.

Species composition, diversity, and evenness were comparable, by date, at all stations. Comparisons of H, H_{max}, and J values with the baseline data demonstrated a similar range of values, with similar reductions in the warmer months due to the predominance of comparatively few species. May, August, and November species diversity and equitability values at Station 6 (Little Saluda Creek) were generally lower than those at the Ohio River stations. No seasonal trend was evident at Station 6 since both the lowest and highest diversities occurred in warmer months (May and August, respectively).

Periphyton Biomass

Periphyton biomass values at Stations 1, 3, and 5 (Figure D-3) ranged from less than measurable (all stations in March) to 4.9 mg/10 cm^2 at Station 5 in November. Values were compared over the sampling period by analysis of variance (Table D-8), which showed significant differences between stations and between sampling quarters and significant interaction of the two. As in the case of periphyton cell density comparisons, significant interaction indicates that differences between stations were not consistent over the sampling programs, and seasonal effects varied between stations. Interstation and seasonal differences were therefore localized quarter-by-quarter and station-by-station by Tukey's HSD comparisons. These results (Table D-9) showed that biomass, as might be expected, varied in a manner generally similar to that observed for total cell densities.

The lack of significant seasonal decrease in biomass at Stations 3 and 5 in August corresponding to the observed decrease in cell densities probably reflected unavoidable bias introduced by the inclusion of organic detritus in biomass measurements. As in the case of periphyton density comparisons, variations in biomass between Ohio River stations cannot be attributed to plant construction-related effects since significant differences occurred both before and after the beginning of construction in August.

Periphyton biomass values of Little Saluda Creek samples were comparable to, although somewhat higher than, Ohio River station values in May and August. Maximum biomass in Little Saluda Creek occurred in November; this value was much higher than the maximum biomass in Ohio

River samples, which may be attributed to the greater density of long-term periphyton growth on natural rock substrates.

CONCLUSIONS

Periphyton communities which consisted mostly of diatoms, green algae, and blue-green algae were well diversified throughout the sampling period. Periphyton composition and total densities in the Ohio River were comparable to those in baseline data, although a larger proportion of non-diatom species were observed in the present study. Very sparse growth at Ohio River stations in March was attributed to low water temperature and current conditions which promoted scouring of diatometer slides. Seasonal changes in environmental conditions probably accounted for increased densities in May and November. Species diversity comparisons and Morisita's index values indicated that periphyton composition remained comparable at all Ohio River stations throughout the sampling period.

Periphyton species diversity in Little Saluda Creek was consistently lower than that in the Ohio River. Cell density and biomass were comparable to those at Ohio River stations in May and August, and higher in November.

Statistical comparisons of total periphyton densities and biomass between Ohio River stations indicated a high degree of natural variability. Differences between stations varied between quarters, however, which indicated a lack of consistent interstation effect. Plant construction effects were not evident since significant interstation differences in periphyton density and biomass occurred both before and after plant construction was begun.

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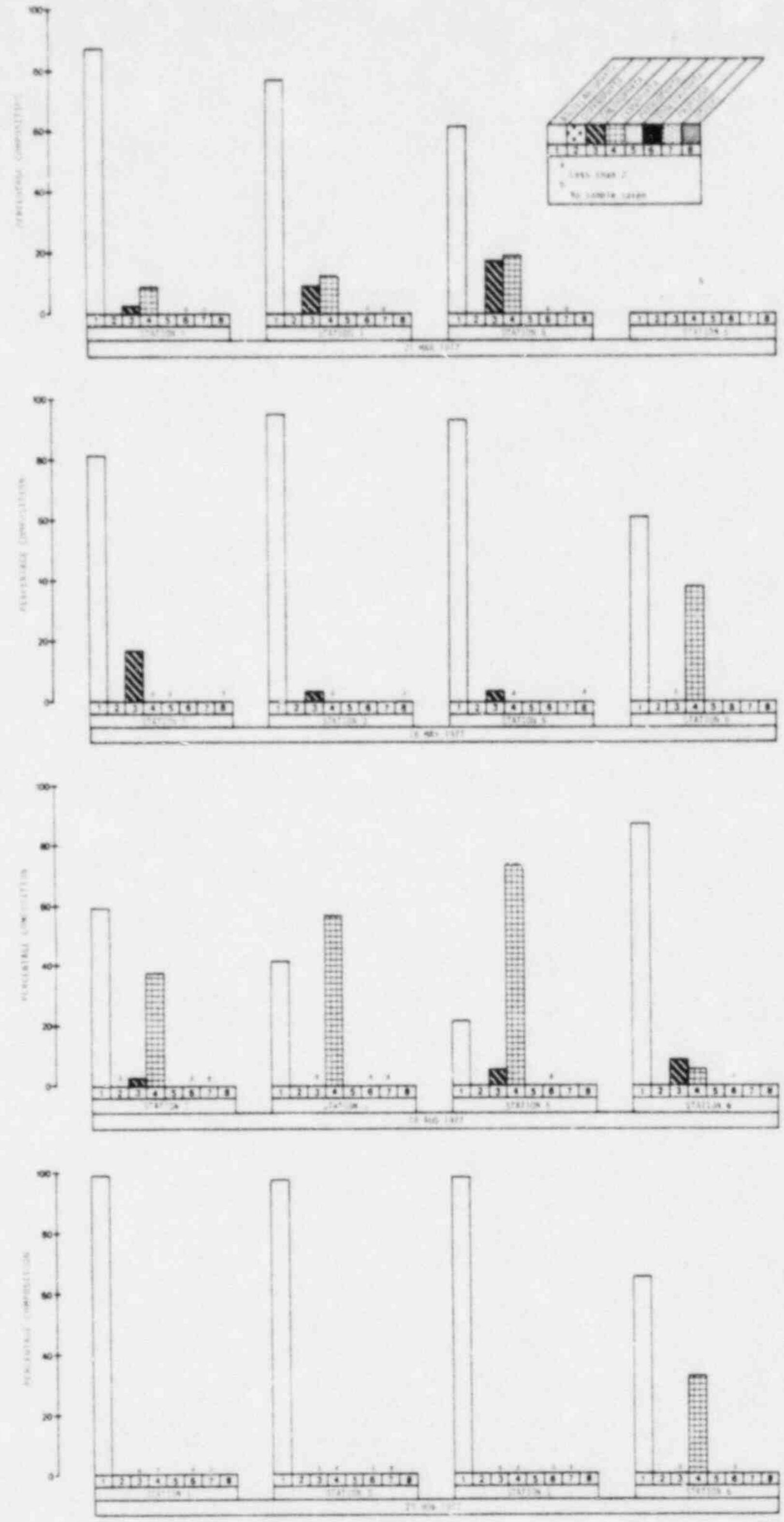

Figure D-1. Percentage composition at Stations 1, 3, and 5 in the Ohio River and Station 6 in Little Saluda Creek, Marble Hill Plant site, 21 March-2 November 1977.

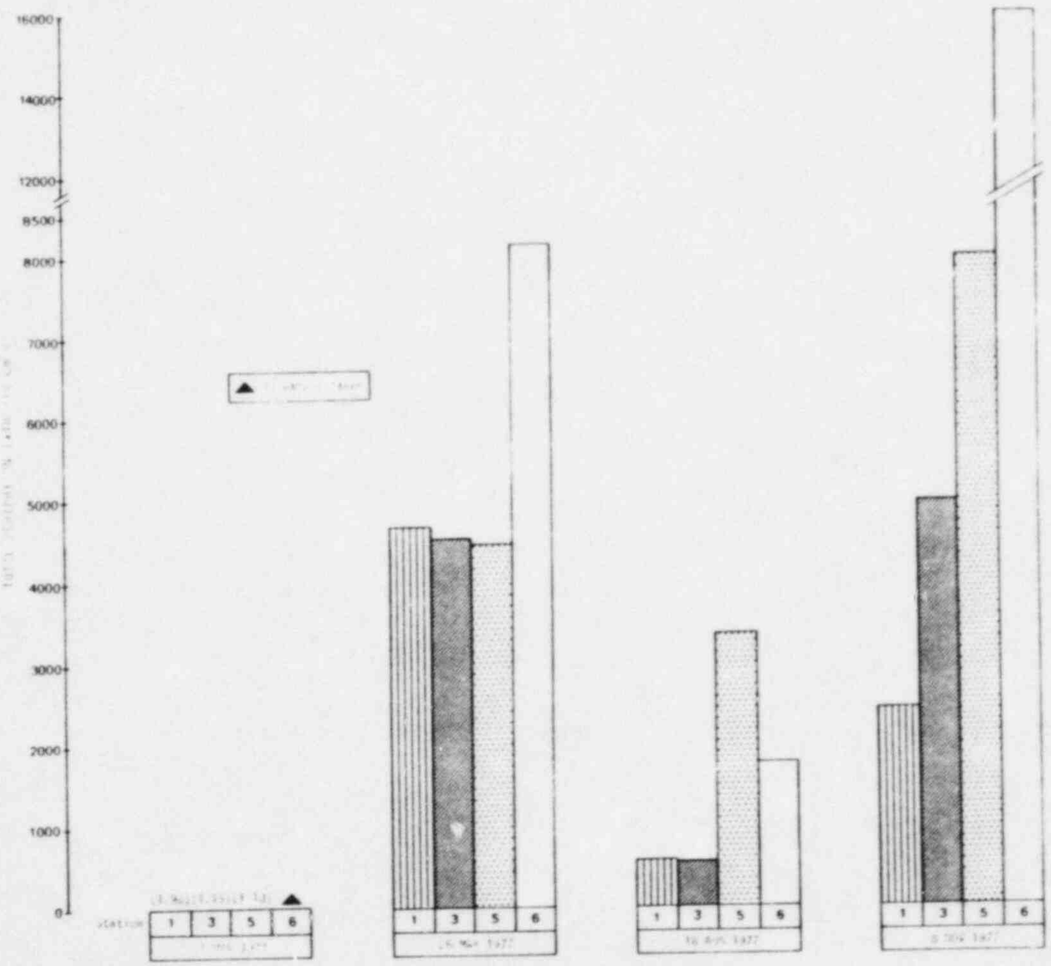

Figure D-2. Seasonal variation in total periphyton density in Ohio River Stations 1, 3, and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977.

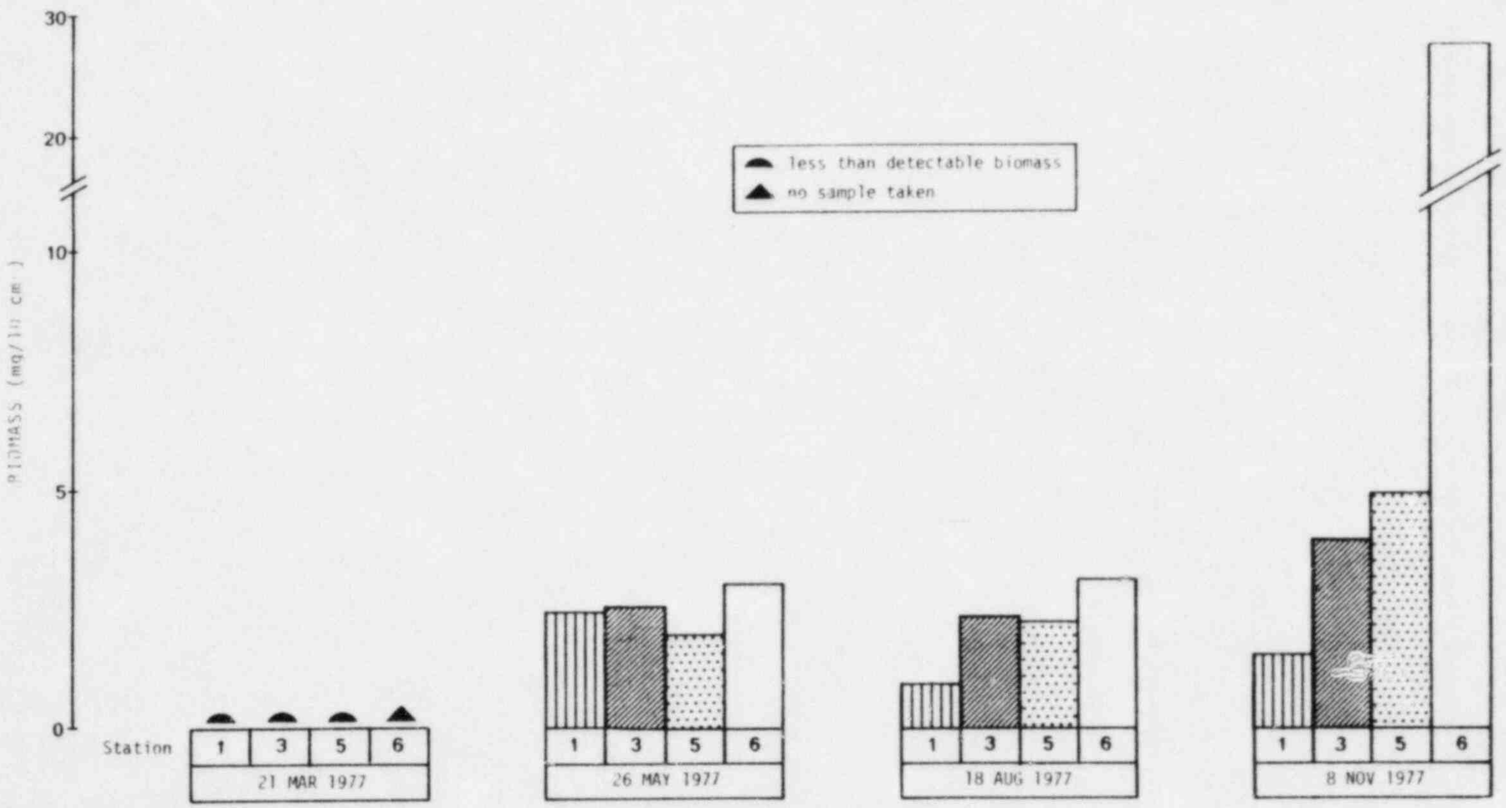

Figure D-3. Periphyton biomass in Ohio River Stations 1, 3, and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977.

TABLE D-1

COMPOSITE SPECIES LIST OF PERIPHYTON COLLECTED IN THE OHIO RIVER AND LITTLE SALUDA CREEK
MARBLE HILL PLANT
21 MARCH-8 NOVEMBER 1977

BACILLARIOPHYTA
Centrales
Coscinodiscus lacustris
Cyclotella catenata
C. glomerata
C. Kutzingiana
C. Kutzingiana v. *planetophora*
C. Meneghiniana
C. pseudostelligera
C. stelligera
Melosira ambigua
M. distans
M. granulata
M. granulata v. *angustissima*
M. varians
Stephanodiscus astraea
Pennales
Achnanthes exigua
A. lanceolata
A. lanceolata v. *dubia*
A. microcephala
A. minutissima
A. montana
Achnanthes sp. 1
Amphora ovalis v. *pediculus*
A. veneta
Asterionella formosa
Cocconeis placentula v. *euglypta*
C. placentula v. *lineatus*
C. pediculus
Cymatopleura elliptica
Cymbella affinis
C. minuta v. *silesiaca*
C. prostrata v. *auerswaldii*
C. tumida
Cymbella sp. 1
Diatoma vulgare
Eunotia sp.
Fragilaria gracillima
F. capucina
Fragilaria crotonensis
F. intermedia
F. vaucheriae
F. virescens
Gomphonema angustatum
G. angustatum v. *citera*
G. gracile
G. intricatum
G. olivaceum
G. olivaceum v. *calcarea*
G. parvulum
G. tenellum
Gomphonema sp. 1
Gyrosigma obtusatum
G. scalproides
Hantzschia amphioxys
Meridion circulare
Navicula cincta
N. confervacea
N. cryptocephala
N. cryptocephala v. *veneta*
N. graciloides
N. minima
N. minuscula
N. rhyncocephala
N. secreta v. *apiculata*
N. schroteri v. *escambia*
N. viridula v. *avenacea*
Navicula sp. 1
Navicula sp. 2
Navicula sp. 3
Nitzschia acicularis
N. amphibia
N. communis v. *abbreviata*
N. dissipata
N. filiformis
N. gracilis
N. palea
N. tryblionella v. *levidensis*
Pinnularia sp. 1

TABLE D-1
(continued)
COMPOSITE SPECIES LIST OF PERIPHYTON COLLECTED
IN THE OHIO RIVER AND LITTLE SALUDA CREEK
MARBLE HILL PLANT
21 MARCH-8 NOVEMBER 1977

BACILLARIOPHYTA (continued)
Pennales (continued)
Rhoicosphenia curvata
Surirella linearis
S. ovata
Synedra acus
S. delicatissima
S. fasciculata v. *truncata*
S. rumpens v. *familiaris*
S. socia
S. ulna
S. ulna v. *oxyrhynchus*
S. ulna v. *oxyrhynchus* f. *mediocontracta*
Synedra sp. 1
Tabellaria fenestrata
T. floculosa

CHRYSOPHYTA
Ophiocytium capitatum v. *longispinum*

CHLOROPHYTA
Ankistrodesmus falcatus
Characium ambiguum
C. obtusum
Characium sp.
Chlamydomonas sp.
Chlorella sp.
Cosmarium sp.
Dictyosphaerium Ehrenbergianum
Mougeotia sp.
Oocystis pusilla
Oedogonium sp.
Pediastrum tetras
Pseudulvella americana
Scenedesmus dimorphus
S. quadricauda
Scenedesmus sp.
Spirogyra sp.
Stigeoclonium sp.
Tetraedron caudatum v. *longispinum*
unidentified coccoid sp. (6-7μ diam.)
unidentified coccoid sp. (10-11μ diam.)

CYANOPHYTA
Anabaena sp.
Aphanothece nidulans
Chamaesiphon ? sp.
Lyngbya Diguetii
Lyngbya sp. 1
Merismopedia tenuissima
Oscillatoria sp. 1
Oscillatoria sp. 2
Phormidium minnesotense
Spirulina major
unidentified coccoid sp. 1 (colonies)

PYRRHOPHYTA
Glenodinium pulvisculus

EUGLENOPHYTA
Euglena sp.
Trachelomonas sp.
unidentified euglenoid sp. 1

PROTOZOA
Astrophrya arenaria
Ciliated protozoan
Paracineta crenata
Vorticella sp. 1
unidentified protozoan 1

OTHERS
unidentified flagellate 1

TABLE D-2

PERIPHYTON DENSITY AND RELATIVE ABUNDANCE DATA SUMMARY
FOR OHIO RIVER STATIONS 1, 3, AND 5 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT
21 MARCH-8 NOVEMBER 1977

	21 MARCH								26 MAY							
	Station 1		Station 3		Station 5		Station 6[a]		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 (%)	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	1.72	86.83	0.89	77.39	0.68	61.82			3796.31	81.14	4220.99	94.84	4218.73	94.89	4919.46	60.56
Chrysophyta	0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chlorophyta	0.05	2.54	0.10	8.7	0.19	17.27			767.83	16.41	147.56	3.27	169.27	3.81	132.24	1.63
Cyanophyta	0.17	8.60	0.14	12.17	0.21	19.09			42.37	0.90	45.65	1.01	28.93	0.65	3072.21	37.82
Pyrrhophyta	0.00	0.00	0.00	0.00	0.00	0.00			2.34	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Euglenophyta	0.03	1.52	0.01	0.87	0.01	0.91			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Protozoa	0.01	0.51	0.01	0.87	0.01	0.91			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Others	0.00	0.00	0.00	0.00	0.00	0.00			70.16	1.50	40.84	0.91	29.29	0.66	0.00	0.00
Total	1.98		1.15		1.10				4679.01		4512.12		4446.22		8123.91	

	18 AUGUST								8 NOVEMBER							
	Station 1		Station 3		Station 5		Station 6		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 (%)	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	412.23	59.46	232.20	41.34	711.89	21.35	1542.56	86.77	2384.62	98.78	4832.90	97.32	7833.41	97.92	10494.04	65.67
Chrysophyta	0.46	0.07	0.00	0.00	0.00	0.0[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chlorophyta	17.80	2.57	7.90	1.41	168.72	5.0	142.46	8.01	3.29	0.14	40.86	0.81	49.23	0.62	225.06	1.41
Cyanophyta	259.21	37.38	316.71	56.41	2447.14	73.4	88.62	4.98	9.63	0.40	56.53	1.14	78.16	0.98	5217.31	32.64
Pyrrhophyta	0.00	0.00	0.00	0.00	0.00	0.0[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euglenophyta	1.37	0.20	2.[illegible]	0.47	2.28	0.07	3.53	0.20	2.19	0.09	32.84	0.66	16.41	0.21	47.06	0.29
Protozoa	2.29	0.33	1.98	0.35	0.00	0.00	0.00	0.00	14.24	0.59	3.65	0.07	21.88	0.27	0.00	0.00
Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	693.66		561.38		3330.03		1777.17		2413.97		4966.86		7999.71		15984.27	

[a] No sample taken.

TABLE D-3

ENVIRONMENTAL REQUIREMENTS OF MAJOR DIATOM SPECIES
IDENTIFIED IN PERIPHYTON SAMPLES[a]
MARBLE HILL PLANT
21 MARCH-8 NOVEMBER 1977

Species	Occurrence: Ohio River	Occurrence: Little Saluda Creek	Temperature	pH	Current	Nutrients
Cyclotella Meneghiniana	✓		- - -	6.4 to 9.0 8 to 8.5 optimum	indifferent	- - -
C. pseudostelligera	✓		- - -	indifferent	limnophilous	- - -
Melosira varians	✓		eurythermal and oligothermal to mesothermal	6.4 to 9.0 8.5 optimum	indifferent	eutrophic
Achnanthes minutissima		✓	eurythermal	indifferent 7.5 to 7.8 optimum	indifferent	- - -
Cocconeis placentula v. *euglypta*	✓		euthermal	6.2 to 9.0	indifferent to rheophilous	- - -
Gomphonema angustatum	✓		eurythermal to metathermal and oligothermal to mesothermal	6.0 to 9.0 7.5 to 7.7 optimum	indifferent	eutrophic; oligotrophic and mesotrophic
G. olivaceum	✓		eurythermal and oligothermal to mesothermal	6.4 to 9.0	indifferent to rheophilous	eutrophic
G. parvulum	✓	✓	mesothermal and stenothermal	indifferent 4.2 to 9.0 7.8 to 8.2 optimum	rheophilous	nutrient enrichment, especially by sanitary or farm wastes
G. tenellum		✓	- - -	- - -	- - -	- - -
Navicula cryptocephala	✓		eurythermal and oligothermal to mesothermal	5.4 to 9.0 8.0 ca. optimum	indifferent	eutrophic
N. viridula v. *avenacea*	✓		eurythermal and oligothermal to mesothermal	6.9 to 8.2	rheophilous	- - -
Nitzschia palea	✓		eurythermal 0 to 30°C	indifferent 4.2 to 9.0 8.4 ca. optimum	indifferent	eutrophic
Rhoicosphenia curvata		✓	eurythermal	5.4 to 9.0 8.0 + optimum	indifferent to rheophilous	eutrophic

[a]Adapted from Lowe (1973).

TABLE D-4

MORISITA'S COMMUNITY SIMILARITY INDEX
VALUES FOR PERIPHYTON SAMPLES COLLECTED
FROM OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT
21 MARCH-8 NOVEMBER 1977

Comparison	Sampling date			
	21 March	26 May	18 August	8 November
Sta. 1 x Sta. 3	0.44	0.92	0.70	0.92
Sta. 1 x Sta. 5	0.48	0.49	0.68	0.97
Sta. 3 x Sta. 5	0.71	0.70	0.93	0.96

TABLE D-5

ANALYSIS OF VARIANCE OF TOTAL PERIPHYTON
DENSITIES IN OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT
21 MARCH-8 NOVEMBER 1977

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F	Critical F
Subgroups	11	0.1485648×10^9	0.1350589×10^8		
Stations	(2)	0.1696826×10^8	0.8484130×10^7	87.87*	3.89
Months	(3)	0.1074733×10^9	0.3582443×10^8	371.02*	3.49
Interaction (stations x months)	(6)	0.2412324×10^6	0.402054×10^7	41.64*	3.00
Error	12	0.1158667×10^7	0.9655558×10^5		
Total	23	0.1497234×10^9			

*Significant at $\alpha = .05$.

TABLE D-6

TUKEY'S HSD COMPARISON OF TOTAL PERIPHYTON DENSITIES IN OHIO RIVER STATIONS 1, 3, AND 5 BY STATIONS AND BY SAMPLING DATES[a]
MARBLE HILL PLANT
21 MARCH-8 NOVEMBER 1977

BY STATIONS ON 18 AUGUST

Station (mean)	1 (693.36)	3 (561.38)	5 (3330.03)	HSD = 828.35
1(693.36)	0.0	131.98	2636.67*	
3(561.38)		0.0	2768.65*	

BY STATIONS ON 8 NOVEMBER

Station (mean)	1 (2413.97)	3 (4966.86)	5 (7999.71)	HSD = 828.35
1(2413.97)	0.0	2552.89*	5585.74*	
3(4966.86)		0.0	3032.85*	

BY SAMPLING DATES AT STATION 1

Sampling dates (mean)	21 Mar (1.98)	26 May (4679.01)	18 Aug (693.36)	8 Nov (2413.97)	HSD=922.83
21 Mar (1.98)	0.00	4677.03*	691.38	2411.99*	
26 May (4679.01)		0.00	3985.65*	2265.04*	
18 Aug (693.36)			0.00	1720.61*	

TABLE D-6
(continued)
TUKEY'S HSD COMPARISON OF TOTAL PERIPHYTON
DENSITIES IN OHIO RIVER STATIONS 1, 3, AND 5
BY STATIONS AND BY SAMPLING DATES[a]
MARBLE HILL PLANT
21 MARCH-8 NOVEMBER 1977

BY SAMPLING DATES AT STATION 3

Sampling dates (mean)	21 Mar (1.15)	26 May (4512.14)	18 Aug (561.38)	8 Nov (4966.86)	HSD=922.83
21 Mar (1.15)	0.0	4510.99*	560.23	4965.71*	
26 May (4512.14)		0.0	3950.76*	454.72	
18 Aug (561.38)			0.0	4405.38*	

BY SAMPLING DATES AT STATION 5

Sampling dates (mean)	21 Mar (1.10)	26 May (4446.22)	18 Aug (3330.03)	8 Nov (7999.71)	HSD=922.83
21 Mar (1.10)	0.00	4445.12*	3328.93*	7998.61*	
26 May (4446.22)		0.0	1116.9*	3553.49*	
18 Aug (3330.03)			0.0	4669.68*	

[a]Only comparisons which contain significant differences are shown.

*Significant at α = .05.

TABLE D-7

PERIPHYTON SPECIES DIVERSITY INDEX AND SPECIES EVENNESS VALUES[a]
MARBLE HILL PLANT
21 MARCH-8 NOVEMBER 1977

Station	21 MARCH						26 MAY					
	S	$\bar{d}$	e	H	H max	J	S	$\bar{d}$	e	H	H max	J
1	35	4.3428	0.85	1.3073	1.5441	0.8466	48	3.5246	0.35	1.0610	1.6812	0.6311
3	32	4.3904	0.97	1.3216	1.5052	0.8780	42	3.7333	0.46	1.1238	1.6833	0.6676
5	40	4.5482	0.87	1.3691	1.6021	0.8546	36	3.2480	0.38	0.9778	1.5563	0.6283
6	-	-	-	-	-	-	10	1.6500	0.40	0.4967	1.0000	0.4967

Station	18 AUGUST						8 NOVEMBER					
	S	$\bar{d}$	e	H	H max	J	S	$\bar{d}$	e	H	H max	J
1	47	3.5936	0.37	1.0818	1.6721	0.6470	34	2.5468	0.24	0.7666	1.5315	0.5006
3	54	3.3956	0.28	1.0222	1.7324	0.5901	36	2.8942	0.29	0.8712	1.5563	0.5598
5	41	2.3459	0.17	0.7062	1.6128	0.4379	32	2.8478	0.31	0.8573	1.5052	0.5696
6	27	2.8998	0.39	0.8729	1.4314	0.6098	17	2.0287	0.32	0.6107	1.2304	0.4963

[a]S = number of species.

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

e = Equitability.

H = $\frac{\bar{d}}{3.321928}$ which converts $\log_2$ to $\log_{10}$ for comparison with baseline Shannon diversity index values.

H max = Maximum diversity possible in a community composed of S species.

J = Evenness index, relative diversity = $\frac{H}{H\ max}$.

TABLE D-8

ANALYSIS OF VARIANCE OF PERIPHYTON
BIOMASS IN OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT
26 MAY-8 NOVEMBER 1977

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F	Critical F
Subgroups	8	0.3658963×10^2	0.4573704x10		
Stations	(2)	0.1189852×10^2	0.5949260x10	29.419*	3.49
Months	(2)	0.1345852×10^2	0.6729260x10	33.277*	3.49
Interaction (stations x months)	(4)	0.1123259×10^2	0.2808150x10	13.886*	2.87
Error	18	0.3640000×10^2	0.0202222x10		
Total	26	0.4022963×10^2			

*Significant at $\alpha = .05$.

TABLE D-9

TUKEY'S HSD COMPARISON OF MEAN PERIPHYTON BIOMASS IN OHIO RIVER STATIONS 1, 3, AND 5 BY STATIONS AND BY SAMPLING DATES[a]
MARBLE HILL PLANT
26 MAY-8 NOVEMBER 1977

BY STATIONS ON 18 AUGUST

Stations (mean)	1 (0.8)	3 (2.3)	5 (2.2)	HSD = 0.9
1 (0.8)	0.0	1.5*	1.4*	
3 (2.3)		0.0	0.1	

BY STATIONS ON 8 NOVEMBER

Stations (mean)	1 (1.5)	3 (3.9)	5 (4.9)	HSD = 0.9
1 (1.5)	0.0	2.4*	3.4*	
3 (3.9)		0.0	1.0*	

BY SAMPLING DATES AT STATION 1

Sampling dates (mean)	26 May (2.4)	18 Aug (0.8)	8 Nov (1.5)	HSD = 0.9
26 May (2.4)	0.0	1.6*	0.9*	
18 Aug (0.8)		0.0	0.7	

TABLE D-9
(continued)
TUKEY'S HSD COMPARISON OF MEAN PERIPHYTON BIOMASS IN OHIO RIVER STATIONS 1, 3, AND 5 BY STATIONS AND BY SAMPLING DATES[a]
MARBLE HILL PLANT
26 MAY - 8 NOVEMBER 1977

BY SAMPLING DATES AT STATION 3

Sampling dates (mean)	26 May (2.5)	18 Aug (2.3)	8 Nov (3.9)	HSD = 0.9
26 May (2.5)	0.0	0.2	1.4*	
18 Aug (2.3)		0.0	1.6*	

BY SAMPLING DATES AT STATION 5

Sampling dates (mean)	26 May (1.9)	18 Aug (2.2)	8 Nov (4.9)	HSD = 0.9
26 May (1.9)	0.0	0.3	3.0*	
18 Aug (2.2)		0.0	2.7*	

[a]Only comparisons which contain significant differences are shown.

*Significant at $\alpha = .05$.

E. BENTHOS AND MACROINVERTEBRATES

INTRODUCTION

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

Macroinvertebrates are animals large enough to be seen by the unaided eye and can be 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 available substrata in a body of water.

The major taxonomic groups of freshwater macroinvertebrates are insects, oligochaete worms, molluscs, flatworms, and crustaceans. Macroinvertebrates may occupy a diverse variety of microhabitats and substrata in a freshwater ecosystem (sand, mud, vascular plants, logs, debris, etc.).

Macroinvertebrates may also occupy virtually all levels of the trophic structure of an ecosystem and include omnivorous, herbivorous, and carnivorous species. They may be deposit or detritus feeders, parasites, scavengers, grazers, or predators. As important members of the food web, their well-being is reflected in the well-being of higher forms such as fish (EPA, 1973).

A community of macroinvertebrates in an aquatic system is sensitive to external stress. Because of their limited mobility and relatively long life span, their community characteristics are a function of environmental conditions during the recent past. Thus they serve as useful indicators of environmental perturbation (EPA, 1973). Macroinvertebrate communities have been shown to reflect the influence of temperature, salinity, depth, current, substratum, and chemical and organic pollutants.

MATERIALS AND METHODS

Benthos

Benthic macroinvertebrates were collected and analyzed in accordance with methods recommended by APHA (1971), EPA (1973), and NESP (1975). At least two replicate samples were taken at each station.

Benthic sampling at Stations 1, 3, and 5 in the Ohio River was performed with a Ponar grab, which was lowered to the bottom on a wire cable (Figure E-1). This device is a 9" x 9" metal box equipped with jaws that close when tripped by contact with the bottom substratum. The Ponar grab is well suited for use in hard sediments (Flannagan, 1970) like those encountered in the Ohio River. The enclosed sample was then raised to the surface and 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 of 5% formalin (Williams, 1974). These stains color animal tissue red and enable faster, more accurate hand sorting of benthic samples. Preserved samples were placed in labeled containers and taken to the laboratory where they were hand-sorted and the macroinvertebrates identified to the lowest practical taxon.

Taxonomic references used in identification included Johannsen (1934-37), Frison (1935), Ross (1944), Burks (1953), Pennak (1953), Needham and Westfall (1955), Usinger (1956), Eddy and Hodson (1961), Brinkhurst (1964 and 1965), Brinkhurst and Cook (1966), Mason (1971), Starrett (1971), Brown (1972), Burch (1972 and 1973), Holsinger (1972), Parrish (1975), Hobbs (1976), and Williams (1976).

At Station 6, benthic sampling was conducted with a Surber square-foot sampler (Figure E-2). This sampler is used in shallow, riffle and pool areas of flowing streams, such as Little Saluda Creek. The unit consists of a square-foot metal frame (30.5 x 30.5 cm) hinged at one side to another frame of equal size (Surber, 1937 and 1970; Henderson, 1949). A strong, closely-woven, 30 mesh nylon fabric is fastened to one frame, and this is joined to a more open netting to form a collecting bag about 69 cm (27 in.) long. Triangular cloth sides fill the space between the frames when the unit is open.

In operation, the frame supporting the net is held vertically, and the other frame is placed against the bottom substrate. The net opening faces upstream. Within the framed area, rocks and other bottom deposits are shifted and picked to a depth of at least 2 inches. The organisms dislodged are swept into the open mouth of the collecting bag by the current. Samples collected with the Surber sampler were preserved and analyzed in the same manner as the Ponar grab samples.

Attempts were made to sample the pool habitats of the creek with a Ponar grab, but the rocky bottom of the stream prevented proper operation of the grab.

Macroinvertebrates

Those macroinvertebrates which voluntarily or involuntarily leave the bottom substrate and drift with the current were quantitatively sampled at all stations.

Drift sampling at the three Ohio River stations (1, 3, and 5) was conducted using a pair of 20-cm diameter, 505μ-mesh bongo nets towed from a boat (Figure E-3). Samples were taken in conjunction with fish egg and larvae collections, which were made on 10 occasions between 30 April and 27 July 1977. Tows were made at each station for 10 minutes each at the surface, mid-depth, and bottom of the river. The volume of flow through each net was measured with a General Oceanics Model 2030 flowmeter which was fixed in the mouth of the net. No portion of Little Saluda Creek was suitable for the use of this apparatus; therefore only qualitative samples were taken with a dip net at Station 6. Data obtained in these collections will be found in Appendix G. Analysis of the data is contained in Section J.

Long-term drift community analysis was conducted using multiple-plate artificial substrate samplers (Hester and Dendy, 1965; Fullner 1971). These samplers consist of tempered hardboard plates and spacers stacked on an eye bolt and suspended in the water from floats anchored to the bottom (Figure E-4). At Stations 1, 3, and 5, the samplers were suspended approximately one meter below the surface of the water. 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 a 3-week period. Two replicate samplers were then retrieved from each station and scraped clean. The colonizing organisms were preserved and analyzed using the same method previously outlined for benthic samples.

Benthos/Macroinvertebrate Analysis

Biomass analyses were conducted on all samples. The biomass of each major macroinvertebrate group constituting the sample was obtained by drying for 4 hours at 105°C, then weighing to the nearest 0.001 g on a Mettler H32 analytical balance (EPA, 1973). Data were reported as biomass per replicate and also as biomass per square meter.

Biomass per square meter, as well as density of individuals per square meter, was calculated by multiplying the total per replicate by the appropriate conversion figure (one square meter equals the area sampled by 19.1 Ponar, 10.76 Surber, or 6.15 Hester-Dendy samples).

Volume of water filtered through the bongo nets was calculated by:

$$\text{Volume } (m^3) = A\ V\ T\ (0.000001)$$

where A = Area of the mouth of the net (cm^2)

V = Velocity of current (cm/sec)

T = Time (sec)

The Shannon-Weaver index of diversity and the equitability component were applied to the density data. Diversity indices are an additional tool for measuring the quality of the environment and the effect of induced stress on the structure of a community of macroinvertebrates. Their use is based on the generally observed phenomenon that in undisturbed environments, there will be relatively few species with large numbers of individuals and a large number of species represented by only a few individuals each. Many forms of stress tend to reduce diversity by making the environment unsuitable for some species or by giving other species a competitive advantage.

Species diversity has two components: the number of species (species richness) and the distribution of individuals among the species (species eveness). The inclusion of the latter component renders the diversity index independent of sample size.

The Shannon-Weaver Index of diversity ($\bar{d}$) (Lloyd, Zar, and Karr, 1968) calculates mean diversity and is recommended by the EPA (1973).

$$d = \frac{C}{N} (N \log_{10} N - \Sigma n_i \log_{10} n_i)$$

where: C = 3.321928 (converts base 10 log to base 2)

N = Total number of individuals

n_i = Total number of individuals of the i^{th} species.

Mean diversity as calculated above is affected by both species richness and evenness and may range from 0 to 3.321928 log N.

To evaluate the component of diversity due to the distribution of individuals among the species (equitability), the calculated $\bar{d}$ is compared with a hypothetical maximum $\bar{d}$ based on a model distribution frequently observed in nature (MacArthur, 1957). Sample data are not expected to conform to the MacArthur model, since it is only being used as a measure against which the distribution of abundance is compared. Equitability values may range from zero to one except in rare cases where the distribution in the sample is more equitable than in the MacArthur model.

Equitability is computed by:

$$e = \frac{s'}{s}$$

where: s = Number of taxa in the sample

s' = Hypothetical maximum number of taxa in the sample based on a table devised by Lloyd and Ghelardi (1964).

Data from EPA biologists have shown that diversity indices in unpolluted water generally range from 3 to 4 and are usually below one in polluted waters. Equitability levels below 0.5 have not been encountered in waters known to be free of oxygen-demanding wastes. In such waters, equitability usually ranges from 0.6 to 0.8, while equitability in polluted waters is generally 0.0 to 0.3.

RESULTS AND DISCUSSION

The macroinvertebrate fauna collected during construction phase ecological monitoring near the Marble Hill Plant site was composed of oligochaete worms, molluscs, small crustaceans, immature insects, flatworms, and mites. No endangered or commercially valuable species were present. Complete collection data are given in Appendix Tables E-1 through E-24.

A total of 7768 individuals of 54 benthic and drift macroinvertebrate species was collected (Table E-1). Although seasonal differences were apparent, no statistically significant between-station differences were found in temperature, pH, conductivity, current velocity, or dissolved oxygen concentration data collected at the three Ohio River stations (Table E-2). Each of the chemical/physical factors has been demonstrated to influence macroinvertebrate species distribution under given circumstances. Chemical/physical data from Little Saluda Creek (Station 6) were frequently quite different from the data collected in the Ohio River because the habitat at Station 6 was entirely different from that at Stations 1, 3, and 5. Data from the two different habitats were therefore not comparable. In general, Station 6 was cooler, more alkaline, more conductive, and of lower current velocity and dissolved oxygen concentration. Complete data will be found in Appendix Tables A-1 through A-9.

The bottom of the Ohio River near the proposed Marble Hill Plant was very similar at Stations 1, 3, and 5. At deeper water stations the substrate was generally composed of mud with small stones and unoccupied *Corbicula* shells. Stones and shells were least abundant at Station 1, while Station 3 had mainly *Corbicula* shells and some stones. Station 5 had mostly stones and some shell. Shallow water substrates were generally composed of mud and a few stones. Stones were most abundant at Station 5 and least abundant at Station

1. Station 6 was a shallow stream with a rocky bottom. Small pools in the stream were generally only 1/3 to 1/2 meter deep and had the same rocky substrate.

Benthos - Stations 1, 3, and 5

The benthic fauna of the Ohio River was generally sparse and patchy in distribution. Density of individuals ranged from 10 to 1635/m^2 in deep water and from 182 to 2782/m^2 in shallow water (Figure E-5). Densities were comparable with those reported in previous Ohio River studies:

Study	Mile Post	Density Range
present study	570	10-2782/m^2
PSI, 1976	570	10-2865/m^2
Anderson & Mason, 1968	462 approx.	650-2218/m^2
Mason et al., 1971	600.5	226-3950/m^2
Mason et al., 1971	462.8	280-2196/m^2
Corps of Engineers, 1977	511	10-4403/m^2

Substrate differences probably account for the slight differences in density among the above sampling locations. Density near the proposed Marble Hill Plant was highest in May or August (summer) and lowest in March (late winter). This pattern is typical of midwestern freshwater systems.

Biomass values were low as a result of the low density and ranged from 0.004 to 3.614 g/m^2 in shallow water (Figure E-6). The higher biomass values were caused by the rare capture of a large, heavy-bodied animal such as a mussel or crayfish. Biomass values were generally between 0.2 and 0.6 g/m^2.

Biomass values from the baseline study (PSI, 1976) were usually higher due to the more frequent appearance of molluscan species, particularly *Corbicula manilensis* (Asiatic clam), which sometimes occurred in considerable number. Although large numbers of unoccupied *Corbicula* shells were found (500-600/m^2 at Station 3), only a few living juveniles of this clam were found during the present study and those only in August and November. The paucity of Asiatic clams may be a result of the severe winter of 1977. Because an individual mollusc generally contributes a greater proportion of the total biomass than does an individual of any other group, *Corbicula* comprised a large portion of the biomass reported in the baseline study. *Corbicula* have been common and numerous in the Ohio River since their first appearance in 1957 (Sinclair, 1963).

River stations yielded between 1 and 14 species per sample (2 replicates). The smallest number of species was found in March, and the largest number of species occurred in August. The lower number of species in the first half of the year was also probably a result of the severe winter of 1977.

Diversity values ranged from 0.0 (Station 1, March) to 2.83 (Station 1, August). As with the number of species, diversity was generally higher in the second half of the year (Figure E-7). While diversity indices at the river stations could be regarded as generally low, they were comparable with indices calculated from data collected in previous studies:

Study	Mile Post	Diversity Index Range
present study	570	0.0 - 2.83
PSI, 1976	570	0.0 - 2.69
Mason et al., 1971	600.5	0.52- 2.84
Mason et al., 1971	462.8	0.32- 2.85
Corps of Engineers,	511	0.0 - 2.00
1977	511	0.0 - 2.00

With a few small exceptions, oligochaete worms dominated the fauna at each of the river stations (Tables E-3 and E-4). The dominant worms were *Limnodrilus*, although many unidentifiable juvenile tubificid worms and *Branchiura sowerbyi* were also present. The crustacean fauna at the river stations was composed primarily of the amphipod *Gammarus pseudolimnaeus*. The insect fauna was composed of several immature species of flies, mayflies, and caddis flies. Representatives of the mollusc, crustacean, and insect groups were usually far less abundant than the oligochaete worms.

As previously mentioned, molluscs did not appear in the samples until August. Molluscs were primarily the snail *Somatogyrus* and the introduced Asiatic clam *Corbicula manilensis*.

The Asiatic clam is a pest species which is benthic as an adult (density up to 25,000/ft^2) and planktonic as a microscopic larva or immature form (density up to 1000/ml). As a larva, it gains easy entry into any system carrying untreated water. The larva then attaches and develops into the adult stage. *Corbicula* has been implicated in the clogging of raw water lines and condensers in all parts of its range (Sinclair, 1971). In the Ohio River, *Corbicula* has a breeding season with peaks in early and late summer. The clams are particularly resistant to molluscacides and chlorine (Sinclair, 1963; Mattice, 1977).

The Asiatic clam was first taken in the Western Hemisphere in 1938 from the Columbia River, Washington (Gregg, 1947). In 1959, Ingram summarized the available literature and nuisance problems and recorded the clam's distribution throughout California, Lake Meade, the Columbia River, the Snake River, and irrigation canals and water supplies of Phoenix, Arizona. The clam had been established as a nuisance in irrigation systems as early as 1953 (Ingram, 1959). Clams were reported as clogging pumps at Tennessee Valley Authority steam plants in 1960. Earlier records revealed difficulties at the TVA Shawnee Steam Plant on the Ohio River in 1957, apparently caused by *Corbicula* (Sinclair, 1963). *Corbicula* is now found throughout Tennessee, the Ohio River and its tributaries, Texas, Florida, the Southeastern U.S., and the Delaware River.

With one exception, no significant between-station differences were found in density, biomass, or diversity of the three Ohio River stations. This was true for both shallow- and deep-water samples (Tables E-5 and E-6). The one exception was the density of shallow-water samples: density at Station 1 was found to be significantly smaller than the density at Stations 3 or 5. The reason for the reduced density probably lies in the difference between the substrates at the stations. The substrates at Stations 3 and 5 contained more rocks and shells than the substrate at Station 1, which was usually composed entirely of mud. The greater number of micro-habitats offered by the presence of stones and shells probably contributed to the greater density at Stations 3 and 5.

Within each station, the density, biomass, number of species, and diversity of the deep-water samples did not differ significantly from those of the shallow-water samples (Table E-7).

Macroinvertebrates - Stations 1, 3, and 5

The macroinvertebrate fauna of the three Ohio River stations was generally less dense than the benthic fauna. Overall density was highest in August and lowest in March and ranged from 12 to 1584 individuals/m^2 (Figure E-8). The number of individuals per sampler ranged from 0 to 125 during the baseline study and from 1 to 272 during the present study. No direct density comparison can be made, however, since the area of the baseline study's samplers is unknown.

Biomass followed the same pattern of variation as the density of individuals in that overall biomass was highest in August and lowest in March (Figure E-9). August biomass ranged from 0.572 to 2.116 g/m^2 and was significantly higher than the biomass found in other months, when values ranged from 0.001 to 0.855 g/m^2. Biomass of the macroinvertebrate fauna collected in the baseline study ranged from 0.0 to 1.241 g/m^2. August biomass values were larger due to the appearance of numerous caddis flies. This appearance is an annual occurrence well documented in previous Ohio River studies (Mason et al., 1971; PSI, 1976).

Despite the increased numbers of caddis flies, August diversity indices did not decline sharply as would be expected during such mass accumulations of animals of one type. Except in March, when diversity was 0.81 to 1.46, diversity indices were above 1.92 (Figure E-10). These indices show that overall diversity of the macroinvertebrate fauna was higher than that of the benthic fauna. Between 2 and 4 species were found in each sample. Diversity during the baseline study ranged from 0.0 to 2.69.

As is usual in drifting macroinvertebrate studies, insects dominated the fauna at every station in every month of sampling (Table E-8). The degree of dominance ranged from 70.1 to 100% of the fauna. Crustaceans, primarily amphipods, were of secondary importance, while worms and molluscs appeared in the samples on only one occasion.

Statistical analysis of the macroinvertebrate collection data revealed no significant between-station differences in density, biomass, or diversity (Table E-9). Seasonal differences in these parameters were apparent and expected. Correlations of increased density, biomass, and diversity with increased temperature, decreased dissolved oxygen concentration, and increased conductance were noted. These correlations were a function of seasonal influences and were not related to the construction of the Marble Hill Plant.

Benthos - Station 6

Density of the benthos in Little Saluda Creek was usually very high in riffle samples and much lower in pool samples. Benthic density in riffles was usually higher than benthic density at any of the river stations as well. As at the river stations, the highest density at Station 6 occurred in March (Table E-10). Biomass was also usually higher in the creek than at the river stations and always higher in riffles than in pools. Biomass values were highest in May and lowest in March and ranged from 0.172 to 6.209 g/m^2.

The number of species was always higher in riffles than in pools, and diversity indices ranged from 0.40 (March) to 1.66 (August). Diversity indices were generally low as a result of the dominance of the creek fauna by the isopod *Lirceus fontinalis*. Other animals numerous on occasion included the flatworm *Phagocata velata*, the water penny (beetle) *Psephenus herricki*, and the snail *Physa gyrina*.

Lirceus fontinalis comprised virtually all of the crustaceans in the creek which, on most sampling dates, meant more than 90% of the total fauna (Table E-11). Insects and worms were far less important in the creek than in the Ohio River.

Following is a brief comparison of data from the baseline study and the present study:

Parameter	Location	Range per sample: Baseline	Range per sample: Present study
Density	riffle	0-4469/m^2	1646 - 3658/m^2
	pool	0-3762/m^2	145 - 603/m^2
Biomass	riffle	0.0-26.969 g/m^2	1.786 - 6.209 g/m^2
	pool	0.0-33.922 g/m^2	0.172 - 0.516 g/m^2
Diversity	riffle	0- 2.12	0.40 - 1.65
	rool	0- 2.85	0.47 - 1.65

Generally, the baseline data varied over a much wider range and showed less difference between riffle and pool habitats than did the present study.

Two specimens of the mayfly *Epeorus* were found in Little Saluda Creek in March. The specimens were of very early instars and could not be positively identified to species level. However, this insect has been tentatively identified as *E. namatus* which was reported by Burks (1953) to be "rare in the midwest." Dr. W. P. McCafferty of Purdue University also tentatively identified the specimens as *E. namatus*. The mayfly is not endangered, as it is very common in the western and northeastern U.S. Little Saluda Creek is typical of the habitat where *Epeorus* is found.

Since no further specimens of this species were taken, little significance can be attached to their presence in Little Saluda Creek. Dr. McCafferty reported that he had seen *Epeorus* in Indiana (Lawrence Co.) only once in the past six years.

Macroinvertebrates - Station 6

Macroinvertebrate density in Little Saluda Creek ranged from 9 to 1602 individuals/m^2 in March and May, respectively (Table E-12). This range exceeded that encountered at the river stations. Biomass followed the same pattern of variation as density in that lowest values occurred in March and highest values occurred in May. Macroinvertebrate diversity in the creek did not follow the same pattern of variation as diversity at the river stations; although highest values for both were recorded in August, lowest values in the creek occurred in November rather than March.

As with the benthic fauna, crustaceans dominated the macroinvertebrate fauna to a great extent (Table E-13). Again, the bulk of the dominant crustaceans was composed of *Lirceus fontinalis*. Insects were usually of secondary importance.

Following is a brief comparison of data from the baseline study and the present study:

	Range per sampler	
Parameter	Baseline	Present study
Individuals	0-125	0-264
Biomass	0-1.241 g	0-0.463 g
Diversity	0-2.22	0.60-2.39

CONCLUSIONS

The benthic and macroinvertebrate fauna of the Ohio River is generally of low density, biomass, and diversity. The density and biomass of Little Saluda Creek were greater than those of the Ohio River, but diversity of the creek was lower because of the great number of isopods that were present. Data collected during the 1977 construction phase monitoring program compared well with baseline data and data from elsewhere in the Ohio River. Changes in the benthic and macroinvertebrate fauna were found to be determined by seasonal changes in the environment and not by the limited construction activity at the proposed Marble Hill Nuclear Generating Station.

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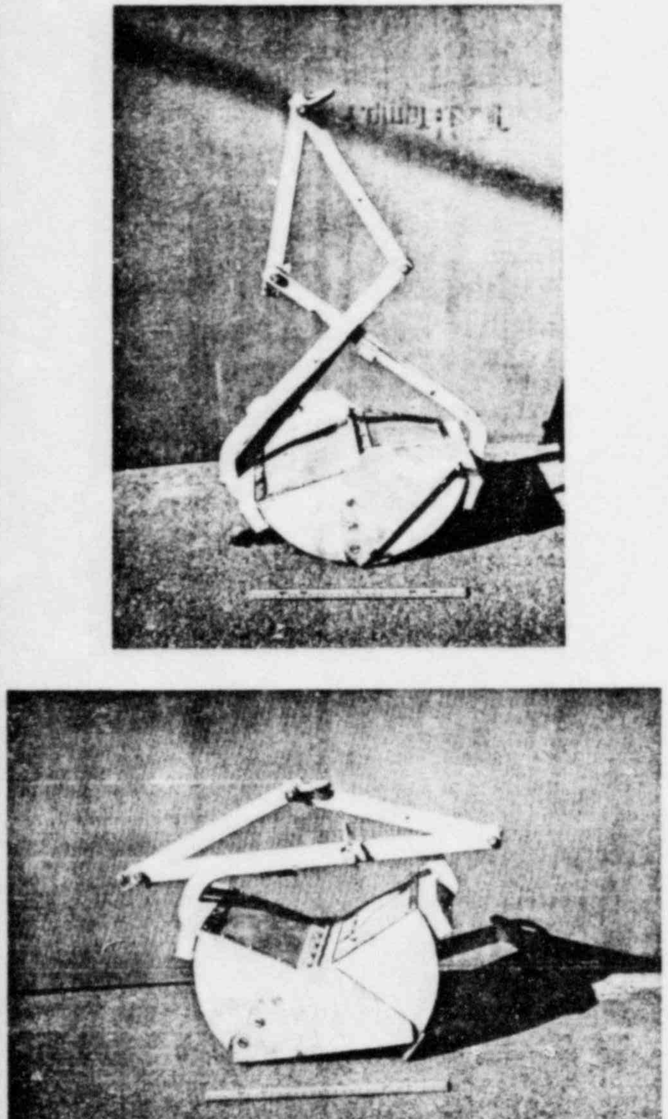

Figure E-1

Ponar grab in closed(upper) and open (lower) positions.

Figure E-2

Surber square-foot sampler in operation.

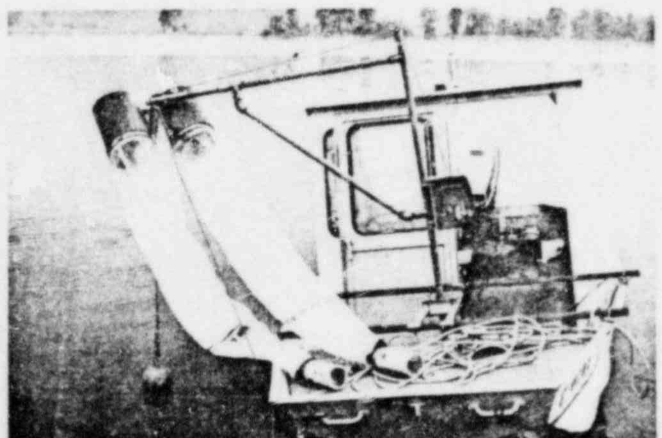

Figure E-3

Bongo Nets.

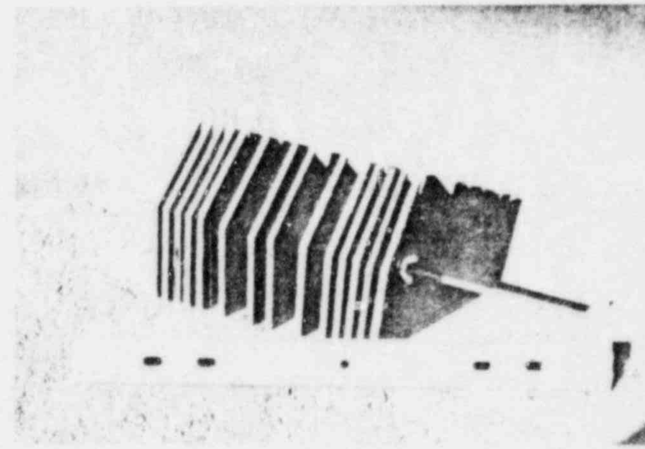

Figure E-4

Multiple-plate artificial substrate sampler of the type used in this study.

MARBLE HILL NUCLEAR
GENERATING STATION UNITS 1 & 2

SAMPLING EQUIPMENT

APPLIED BIOLOGY, INC.

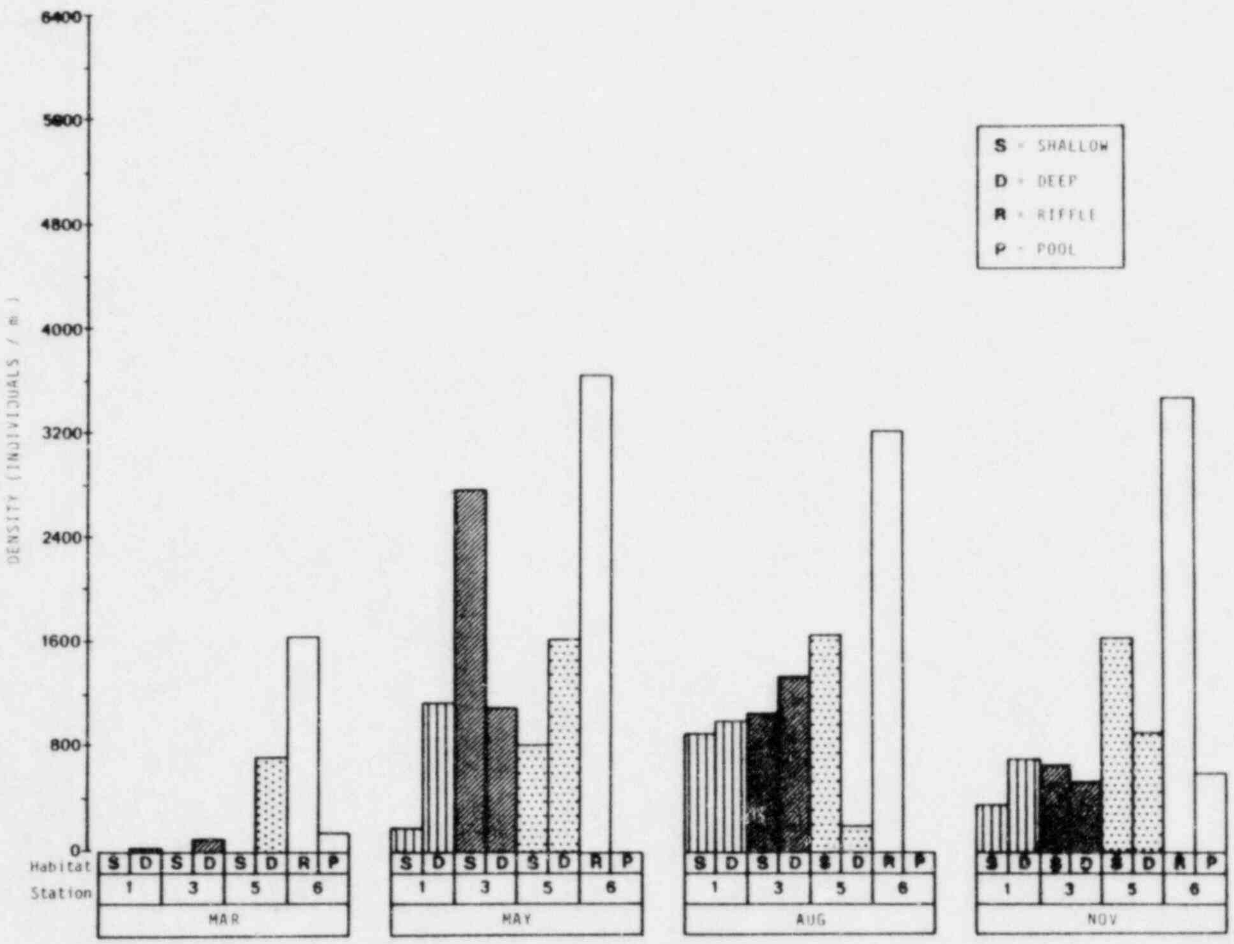

Figure E-5. Density of benthic macroinvertebrates, Marble Hill Plant site, 1977.

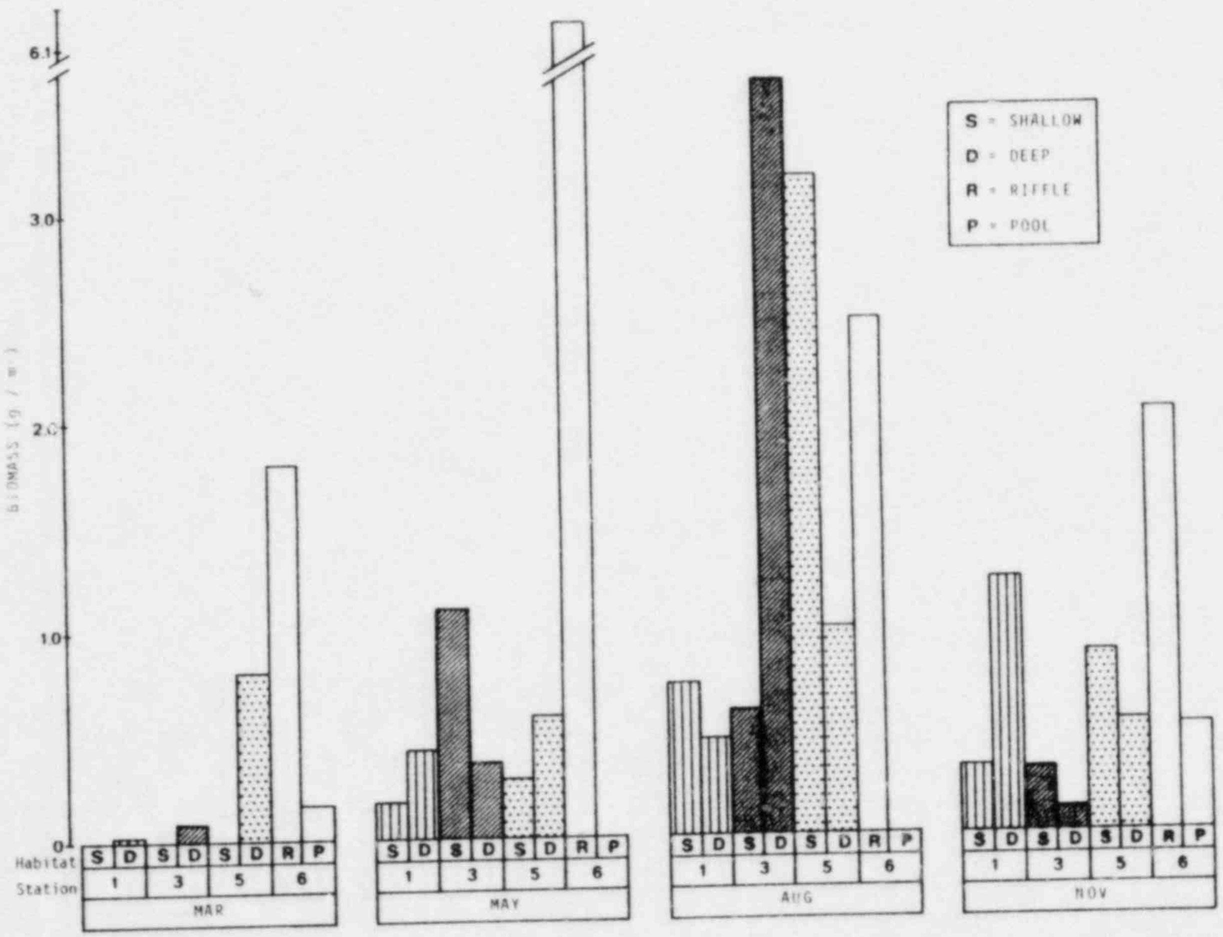

Figure E-6. Biomass of benthic macroinvertebrates, Marble Hill Plant site, 1977.

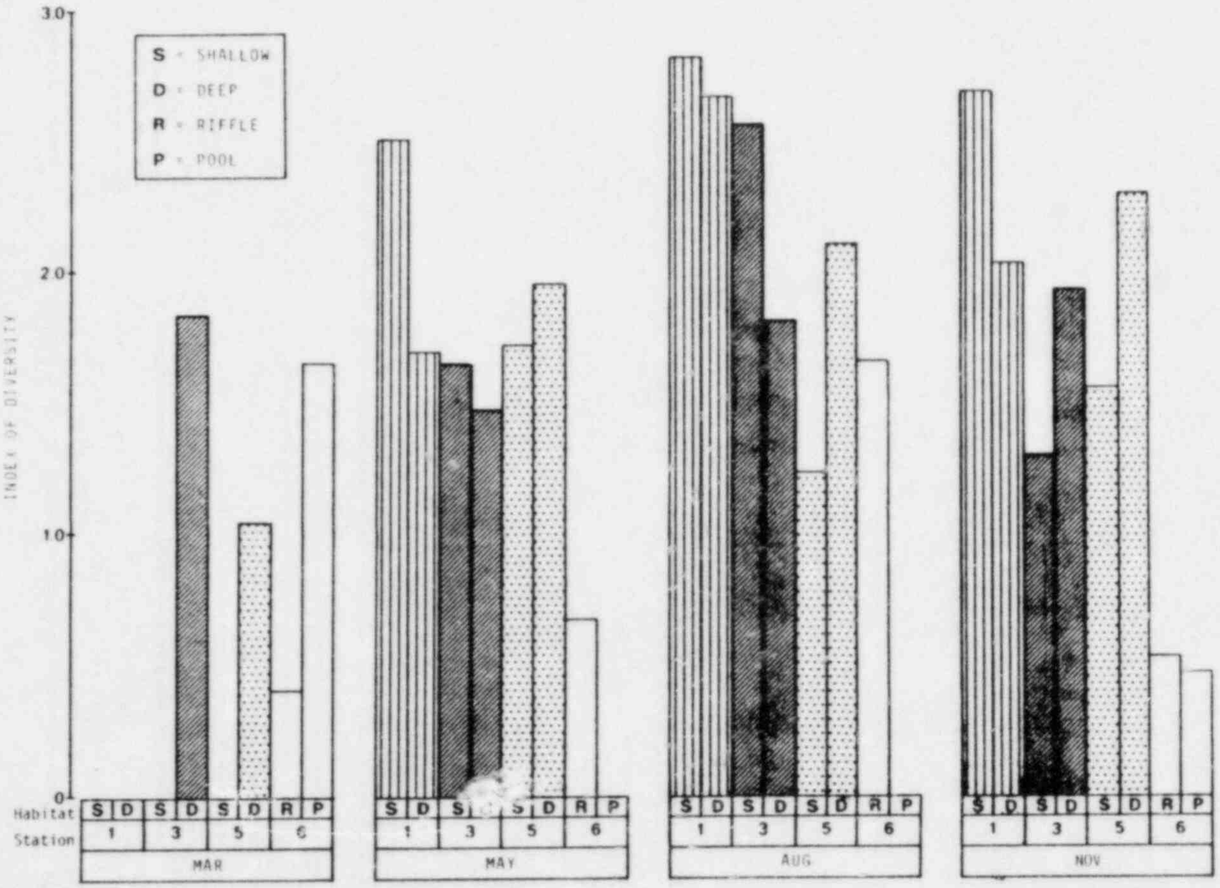

Figure E-7. Diversity of benthic macroinvertebrates, Marble Hill Plant site, 1977.

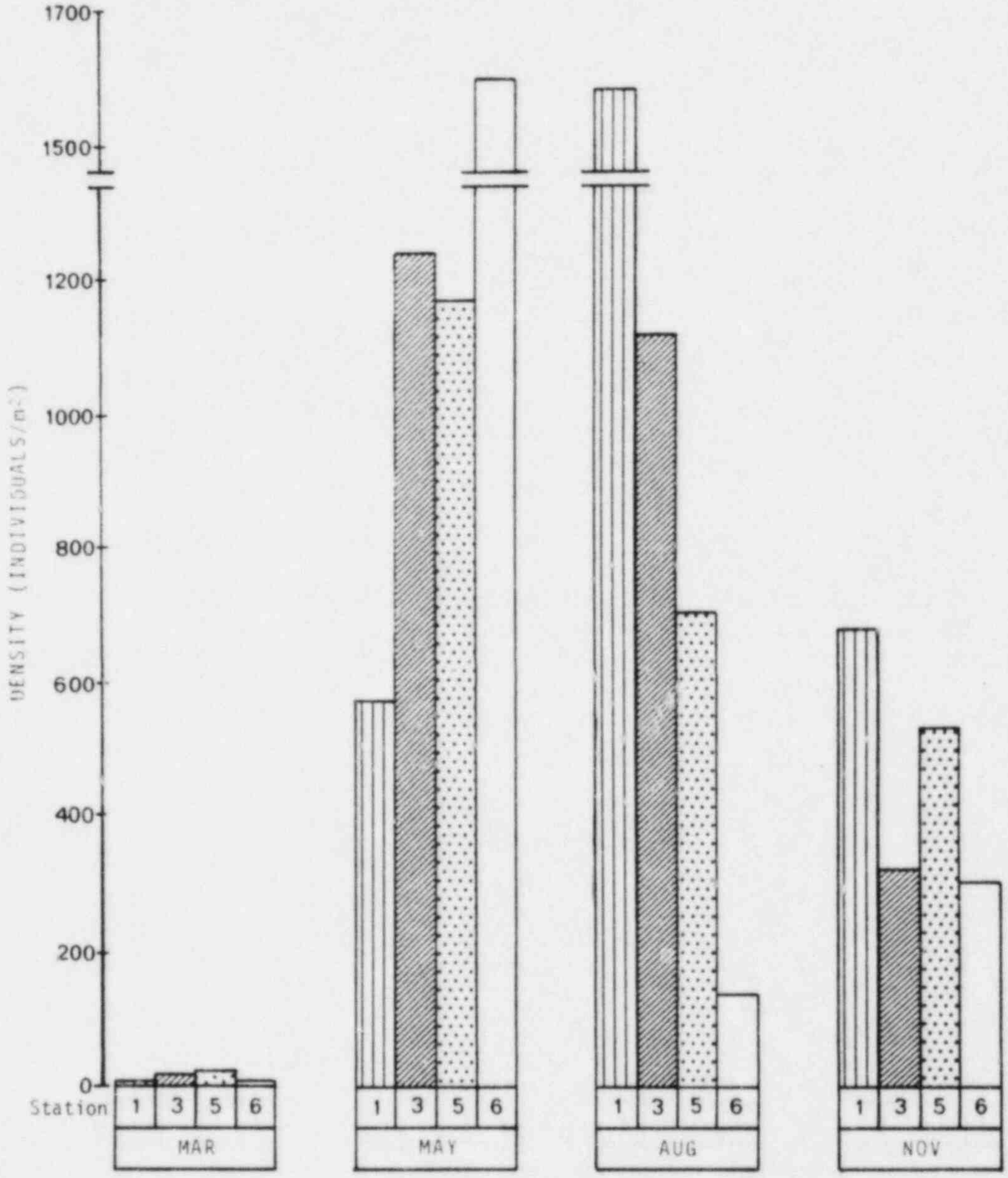

Figure E-8. Density of drift macroinvertebrates, Marble Hill Plant site, 1977.

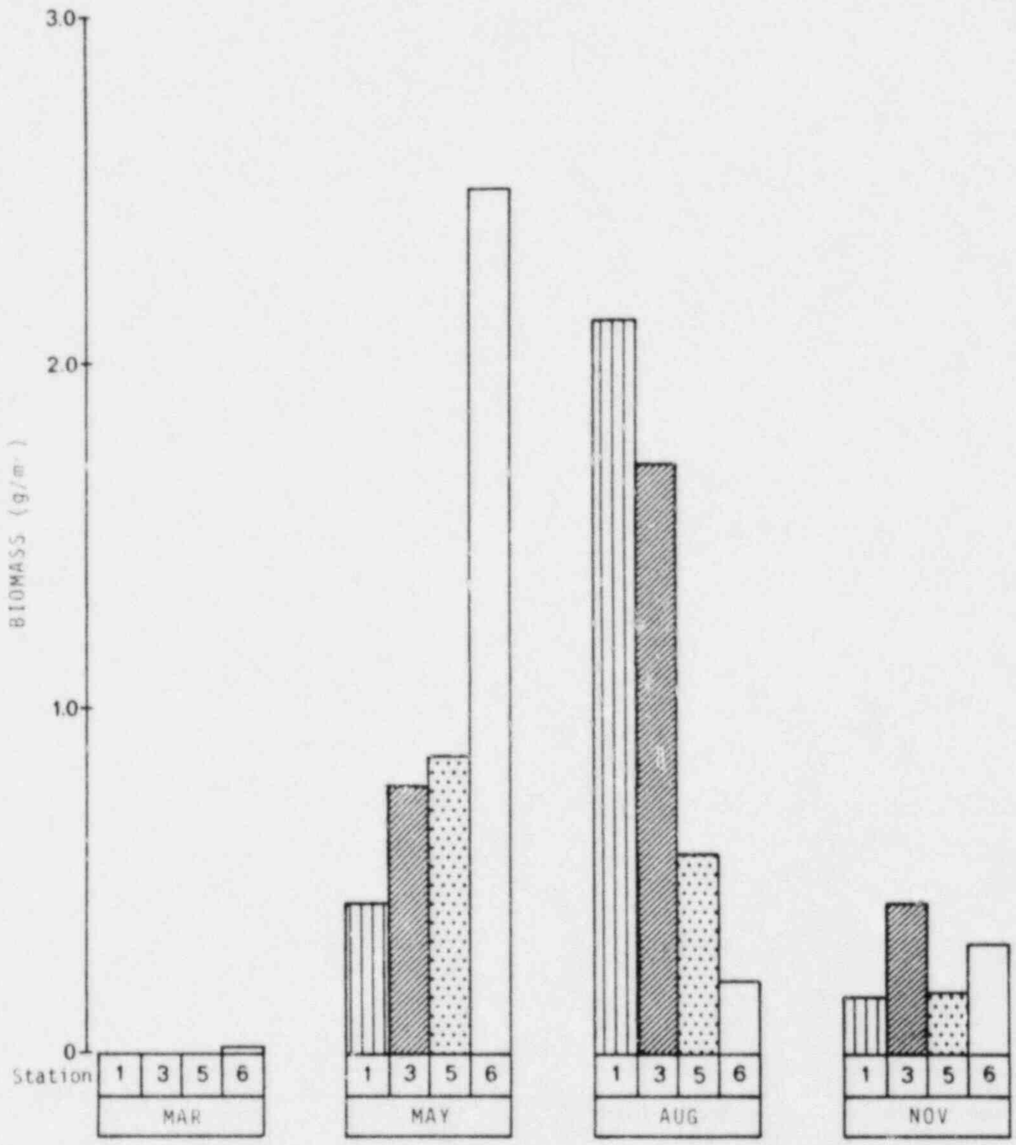

Figure E-9. Biomass of drift macroinvertebrates. Marble Hill Plant site, 1977.

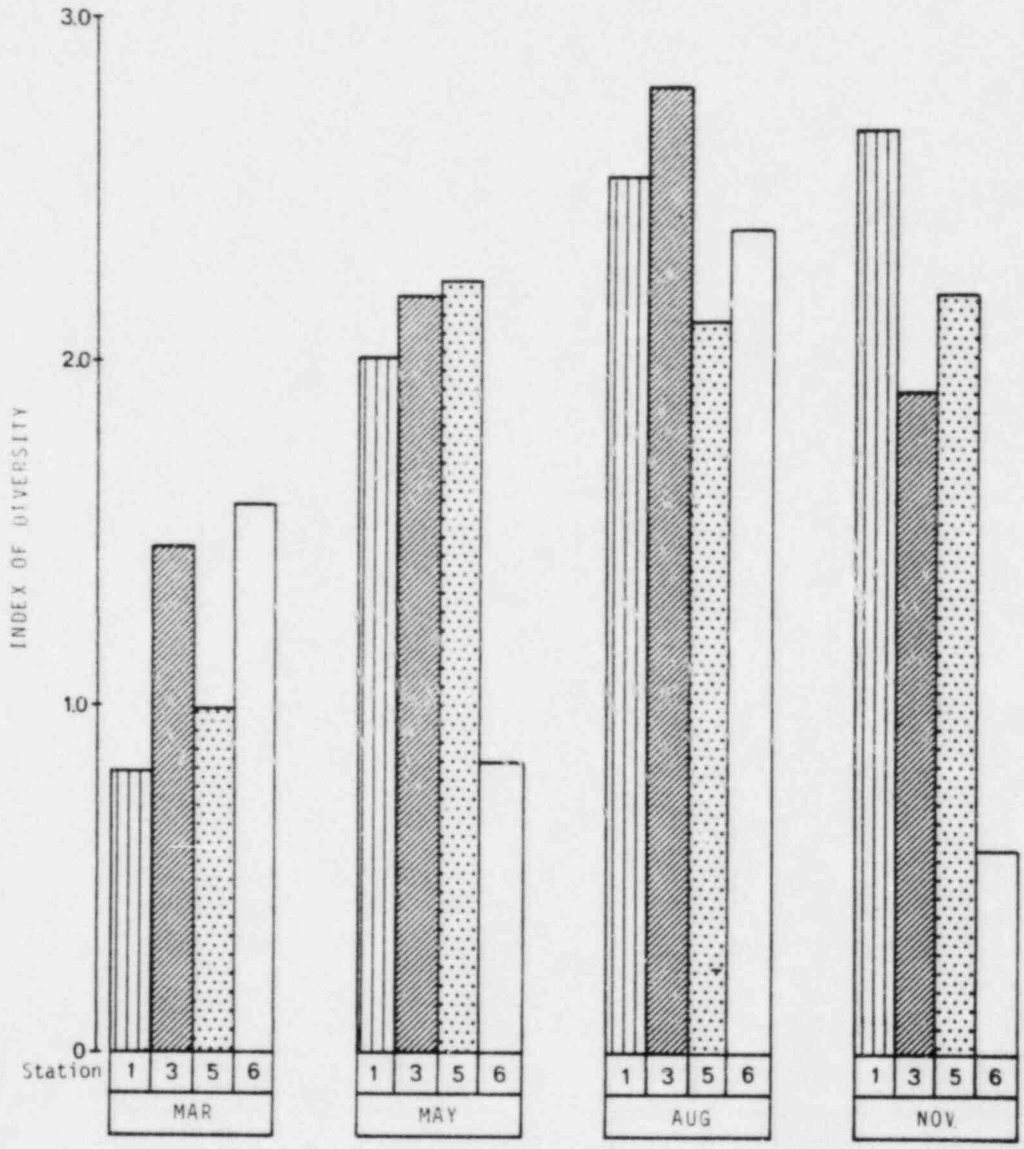

Figure E-10. Diversity of drift macroinvertebrates, Marble Hill Plant site, 1977.

TABLE E-1

OCCURRENCE OF BENTHIC AND MACROINVERTEBRATE SPECIES
MARBLE HILL PLANT, 1977

Species	Station 1	3	5	6
Class Hydrozoa				
hydroids *Hydra* sp.[a]	✓	✓	✓	
Class Oligochaeta				
worms *Branchiura sowerbyi*	✓	✓	✓	✓
Limnodrilus hoffmeisteri	✓	✓	✓	
L. maumeensis		✓		
immature tubificids	✓	✓	✓	✓
Class Hirudinea				
leeches *Erpobdella punctata*		✓		
Pisicola sp.		✓		
Class Turbellaria				
flatworms *Phagocata velata*	✓	✓	✓	✓
Class Arachnida				
mites *Limnochares* sp.			✓	
Class Crustacea				
cladocerans *Ceriodaphnia quadrangula*[a]	✓	✓	✓	
Daphnia ambigua[a]	✓	✓	✓	
D. galeata[a]	✓	✓	✓	
D. parvula[a]	✓	✓	✓	
D. pulex[a]	✓	✓	✓	
D. retrocurva[a]	✓	✓	✓	
Leptodora Kindti[a]	✓	✓	✓	
copepods *Cyclops bicuspidatus thomasi*[a]		✓		
ostracods *Cypridopsis* sp.		✓		
isopods *Lirceus fontinalis*		✓		✓
amphipods *Gammarus pseudolimnaeus*	✓	✓	✓	
Synurella dentata				✓
crayfish *Orconectes sloanii*		✓	✓	
Class Insecta				
Order Diptera				
midges *Ablabesmyia rhamphe*	✓	✓	✓	✓
Chaoborus punctipennis	✓		✓	✓
Cardiocladius sp.		✓		✓

TABLE E-1
(continued)
OCCURRENCE OF BENTHIC AND MACROINVERTEBRATE SPECIES
MARBLE HILL PLANT, 1977

Species		Station 1	3	5	6
Class Insecta					
Order Diptera					
midges (cont.)	*Cricotopus* sp.	√	√	√	
	Cryptochironomus fulvus	√	√	√	
	Coelotanypus sp.	√	√	√	
	Dicrotendipes modestus	√	√	√	√
	Endochironomus sp.	√	√	√	
	Eukiefferiella sp.	√	√	√	
	Micropsectra sp.	√	√	√	√
	Phaenopsectra sp.	√	√	√	
	Polypedilum halterale	√	√	√	√
	Probezzia sp.		√		
	Procladius sp.	√	√	√	√
	Xenochironomus sp.	√	√	√	
crane flies	*Tipula* sp.				√
Order Ephemeroptera					
mayflies	*Baetis* sp.				√
	B. (intercalaris?)	√	√		√
	Epeorus (namatus?)				√
	Hexagenia limbata		√	√	
	Stenonema heterotarsale			√	√
	S. interpunctatum	√	√	√	√
	Tricorythodes sp.			√	
Order Plecoptera					
stoneflies	*Isoperla clio*	√	√	√	√
Order Trichoptera					
caddis flies	*Agraylea* sp.	√			
	Cheumatopsyche sp.	√	√	√	√
	Hydropsyche orris	√	√	√	√
	Hydroptila waubesiana	√	√	√	√
	Neophylax ayanus	√			
	Neureclipsis crepuscularis	√	√	√	√
Order Odonata					
dragonflies	*Macromia illinoiensis*		√	√	
Order Coleoptera					
beetles	*Hydroporus* sp.				√
	Psephenus herricki				√
	Stenelmis (sexlineata?)				√

TABLE E-1
(continued)
OCCURRENCE OF BENTHIC AND MACROINVERTEBRATE SPECIES
MARBLE HILL PLANT, 1977

Species		Station 1	3	5	6
Class Gastropoda					
snails	*Ferrissia dalli*				√
	Gundlachia sp.	√			
	Physa gyrina				√
	Pleurocera acutum	√			
	Somatogyrus sp.	√	√	√	
Class Pelecypoda					
bivalves	*Amblema costata*			√	
	Corbicula manilensis	√	√		
	Sphaerium transversum	√	√	√	
Species/station		32	37	34	29
Total species: 54					
Individuals/station		1486	1542	1696	3044
Total individuals: 7768					

[a]Taken only in fish egg and larvae samples. Not included in species and individual totals.

TABLE E-2

TWO-WAY ANALYSIS OF VARIANCE OF CHEMICAL/PHYSICAL PARAMETERS
MEASURED IN CONJUNCTION WITH BIOTIC SAMPLING
OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT, 1977

Parameter	Comparison	Critical F value (α=.05)	Calculated F value (α=.05)
Temperature	Between seasons	4.76	320.185*
	Between stations	5.14	0.457 n.s.[a]
pH	Between seasons	4.76	7.629*
	Between stations	5.14	1.196 n.s.
Specific conductance	Between seasons	4.76	518.116*
	Between stations	5.14	0.695 n.s.
Current velocity	Between seasons	4.76	116.951*
	Between stations	5.14	4.882 n.s.
Dissolved oxygen	Between seasons	4.76	2269.632*
	Between stations	5.14	3.316 n.s.

[a] n.s. = not significant.

*Significant at α=.05.

TABLE E-3

STRUCTURE OF THE DEEP-WATER BENTHIC COMMUNITY
OHIO RIVER STATIONS
MARBLE HILL PLANT, 1977

		Number of individuals (% composition)				
Month	Station	Worms	Molluscs	Crustaceans	Insects	Others
March	1	(0.0)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)
	3	8 (88.9)	0 (0.0)	1 (11.1)	0 (0.0)	0 (0.0)
	5	70 (92.1)	0 (0.0)	6 (7.9)	0 (0.0)	0 (0.0)
May	1	96 (80.0)	0 (0.0)	12 (10.0)	12 (10.0)	0 (0.0)
	3	98 (84.5)	0 (0.0)	18 (15.6)	0 (0.0)	0 (0.0)
	5	120 (70.2)	0 (0.0)	43 (25.1)	8 (4.7)	0 (0.0)
August	1	58 (56.3)	21 (20.4)	0 (0.0)	16 (15.5)	8 (7.8)
	3	110 (78.0)	9 (6.4)	2 (1.4)	20 (14.2)	0 (0.0)
	5	1 (4.5)	5 (22.8)	1 (4.5)	14 (63.7)	1 (4.5)
November	1	42 (56.0)	11 (14.7)	2 (2.7)	20 (26.6)	0 (0.0)
	3	27 (46.6)	6 (10.3)	0 (0.0)	25 (43.1)	0 (0.0)
	5	52 (53.7)	11 (11.3)	4 (4.1)	30 (30.9)	0 (0.0)

TABLE E-4

STRUCTURE OF THE SHALLOW-WATER BENTHIC COMMUNITY
OHIO RIVER STATIONS
MARBLE HILL PLANT, 1977

Month	Station	Number of individuals (% composition)				
		Worms	Molluscs	Crustaceans	Insects	Others
March[a]	1	-	-	-	-	-
	3	-	-	-	-	-
	5	-	-	-	-	-
May	1	9 (47.4)	0 (0.0)	1 (5.3)	9 (47.4)	0 (0.0)
	3	250 (85.9)	0 (0.0)	24 (8.3)	10 (3.4)	7 (2.4)
	5	77 (88.5)	2 (2.3)	4 (4.6)	4 (4.6)	0 (0.0)
August	1	44 (46.4)	6 (6.2)	1 (1.0)	44 (46.4)	0 (0.0)
	3	77 (69.4)	12 (10.8)	0 (0.0)	16 (14.4)	6 (5.4)
	5	238 (86.5)	2 (0.7)	1 (0.4)	34 (12.4)	0 (0.0)
November	1	16 (42.1)	12 (31.6)	0 (0.0)	10 (26.3)	0 (0.0)
	3	55 (78.6)	6 (8.6)	1 (1.4)	8 (11.4)	0 (0.0)
	5	132 (76.8)	10 (5.8)	13 (7.6)	16 (9.4)	1 (0.6)

[a]Samples were not taken at shallow water stations during March because the river level was abnormally high.

TABLE E-5

STATISTICAL ANALYSIS OF DEEP-WATER BENTHOS COLLECTION DATA
MARBLE HILL PLANT, 1977

I. TWO-WAY ANOVA WITH REPLICATION

Density

Source	Degrees of freedom	Sum of squares	Mean square	$F(\alpha = .05)$
Seasons	3	8695.1	2898.4	5.312*
Stations	2	286.6	143.3	0.263 n.s.[a]
Interaction	6	6426.8	1071.1	1.963 n.s.[a]
Error	12	6547.5	545.7	
Total	23	21,956.0		

Biomass

Source	Degrees of freedom	Sum of squares	Mean square	$F(\alpha = .05)$
Seasons	3	0.019	0.006	1.169 n.s.
Stations	2	0.003	0.002	0.263 n.s.
Interaction	6	0.034	0.006	1.015 n.s.
Error	12	0.066	0.006	
Total	23	0.122		

Diversity

Source	Degrees of freedom	Sum of squares	Mean square	$F(\alpha = .05)$
Seasons	3	2.778	0.926	2.652 n.s.
Stations	2	0.145	0.073	0.208 n.s.

[a]n.s. = not significant.

*Significant at $\alpha = .05$.

TABLE E-5
(continued)
STATISTICAL ANALYSIS OF DEEP-WATER BENTHOS COLLECTION DATA
MARBLE HILL PLANT, 1977

II. CORRELATION

Comparison		
Community parameter	Physical/chemical parameter	Calculated r(α=.05)[b]
Density with	temperature	0.584 n.s.
	pH	-0.194 n.s.
	dissolved oxygen	-0.359 n.s.
	current velocity	-0.601 n.s.
	conductance	0.693 *
Biomass with	temperature	0.369 n.s.
	pH	0.409 n.s.
	dissolved oxygen	-0.556 n.s.
	current velocity	0.151 n.s.
	conductance	0.373 n.s.
Diversity with	temperature	0.476 n.s.
	pH	-0.137 n.s.
	dissolved oxygen	-0.558 n.s.
	current velocity	0.100 n.s.
	conductance	0.631 n.s.

[a]n.s. = not significant.

[b]Critical r value for all the above calculations was 0.671.

*Significant at α=.05.

TABLE E-6

STATISTICAL ANALYSIS OF SHALLOW-WATER BENTHOS COLLECTION DATA
MARBLE HILL PLANT, 1977

I. TWO-WAY ANOVA WITH REPLICATION

Density

Source	Degrees of freedom	Sum of squares	Mean square	F(α=.05)
Seasons	2	3397.0	1698.5	1.643 n.s.[a]
Stations	2	14009.3	7004.7	6.775 *
Interaction	4	20850.7	5212.7	5.042 *
Error	9	9305.0	1033.9	
Total	17	47562.0		

Biomass

Source	Degrees of freedom	Sum of squares	Mean square	F(α=.05)
Seasons	2	0.010	0.005	0.740 n.s.
Stations	2	0.006	0.003	0.443 n.s.
Interaction	4	0.042	0.011	1.526 n.s.
Error	9	0.062	0.007	
Total	17	0.120		

Diversity

Source	Degrees of freedom	Sum of squares	Mean square	F(α=.05)
Seasons	2	0.207	0.104	0.049 n.s.
Stations	2	2.193	1.097	5.220 n.s.

[a] n.s. = not significant.

*Significant at α=.05.

TABLE E-6
(continued)
STATISTICAL ANALYSIS OF SHALLOW-WATER BENTHOS COLLECTION DATA
MARBLE HILL PLANT, 1977

II. CORRELATION

Comparison		
Community parameter	Physical/chemical parameter	Calculated r(α = .05)[b]
Density with	temperature	0.235 n.s.
	pH	0.281 n.s.
	dissolved oxygen	-0.129 n.s
	current velocity	-0.226 n.s.
	conductance	0.258 n.s.
Biomass with	temperature	0.353 n.s.
	pH	0.412 n.s.
	dissolved oxygen	-0.528 n.s.
	current velocity	0.133 n.s.
	conductance	0.246 n.s.
Diversity with	temperature	0.175 n.s.
	pH	0.273 n.s.
	dissolved oxygen	-0.224 n.s.
	current velocity	0.119 n.s.
	conductance	0.186 n.s.

[a]n.s. = not significant.

[b]Critical r value for all the above calculations was 0.758.

*Significant at α = .05.

TABLE E-7

STATISTICAL COMPARISON OF SHALLOW- AND DEEP-WATER SAMPLING STATIONS[a]
MARBLE HILL PLANT, 1977

Community parameter	Depth	Mean sample value	Calculated $t(\alpha=.05)$
Biomass	Deep	0.930 g/m^2	-0.220 n.s.[b]
	Shallow	0.828 g/m^2	
Density	Deep	$959/m^2$	0.545 n.s.
	Shallow	$1124/m^2$	
Diversity	Deep	1.99	0.055 n.s.
	Shallow	2.01	
Number of species	Deep	7.8	1.710 n.s.
	Shallow	10.2	

[a]Comparison was based on data collected in May, August, and November, the only months in which both deep- and shallow-water samples were taken.

[b]n.s. = not significant. Critical t value was 2.120.

TABLE E-8

STRUCTURE OF THE MACROINVERTEBRATE COMMUNITY
OHIO RIVER STATIONS
MARBLE HILL PLANT, 1977

Month	Station	Number of individuals (% composition) Worms	Molluscs	Crustaceans	Insects	Others
March	1	0 (0.0)	0 (0.0)	0 (0.0)	4 (100.0)	0 (0.0)
	3	0 (0.0)	0 (0.0)	0 (0.0)	4 (100.0)	0 (0.0)
	5	0 (0.0)	0 (0.0)	0 (0.0)	9 (100.0)	0 (0.0)
May	1	0 (0.0)	0 (0.0)	81 (26.7)	222 (73.3)	0 (0.0)
	3	0 (0.0)	0 (0.0)	54 (26.7)	148 (73.3)	0 (0.0)
	5	0 (0.0)	0 (0.0)	109 (28.5)	273 (71.5)	0 (0.0)
August	1	0 (0.0)	0 (0.0)	0 (0.0)	506 (100.0)	0 (0.0)
	3	4 (1.1)	1 (0.3)	0 (0.0)	360 (98.6)	0 (0.0)
	5	0 (0.0)	0 (0.0)	0 (0.0)	231 (100.0)	0 (0.0)
November	1	0 (0.0)	0 (0.0)	38 (17.1)	184 (82.9)	0 (0.0)
	3	0 (0.0)	0 (0.0)	10 (5.7)	165 (94.3)	0 (0.0)
	5	0 (0.0)	0 (0.0)	52 (29.9)	122 (70.1)	0 (0.0)

TABLE E-9

STATISTICAL ANALYSIS OF MACROINVERTEBRATE COLLECTION DATA
MARBLE HILL PLANT, 1977

I. TWO-WAY ANOVA WITH REPLICATION

Density

Source	Degrees of freedom	Sum of squares	Mean square	F(α=.05)
Seasons	3	133336.3	44445.4	62.380*
Stations	2	3756.6	1878.3	2.636 n.s.[a]
Interaction	6	18728.4	3121.4	4.381*
Error	12	8550.0	712.5	
Total	23	164371.3		

Biomass

Source	Degrees of freedom	Sum of squares	Mean square	F(α=.05)
Seasons	3	0.194	0.065	21.887*
Stations	2	0.013	0.007	2.175 n.s.
Interaction	6	0.062	0.010	3.497*
Error	12	0.036	0.003	
Total	23	0.305		

Diversity

Source	Degrees of freedom	Sum of squares	Mean square	F(α=.05)
Seasons	3	3.505	1.168	10.096*
Stations	2	0.085	0.043	0.369 n.s.

[a]n.s. = not significant.

*Significant at α=.05.

TABLE E-9
(continued)
STATISTICAL ANALYSIS OF MACROINVERTEBRATE COLLECTION DATA
MARBLE HILL PLANT, 1977

II. CORRELATION

Comparison: Community parameter	Comparison: Physical/chemical parameter	Calculated r(α=.05)[b]
Density with	temperature	0.853*
	pH	-0.085 n.s.
	dissolved oxygen	-0.764*
	current velocity	-0.326 n.s.
	conductance	0.856*
Biomass with	temperature	0.762*
	pH	0.232 n.s.
	dissolved oxygen	-0.842*
	current velocity	-0.128 n.s.
	conductance	0.697*
Diversity with	temperature	0.687*
	pH	-0.231 n.s.
	dissolved oxygen	-0.699*
	current velocity	-0.006 n.s.
	conductance	0.848*

[a] n.s. = not significant.

[b] Critical r value for all the above calculations was 0.671.

* Significant at α=.05.

TABLE E-10

SUMMARY OF BENTHIC COLLECTION DATA
FROM LITTLE SALUDA CREEK
MARBLE HILL PLANT, 1977

Community parameter	Habitat	March	May	August	November
Density	Riffle	1646	3658	3228	3497
	Pool	145	-	-	603
Biomass	Riffle	1.786	6.209	2.453	2.012
	Pool	0.172	-	-	0.516
Diversity	Riffle	0.40	0.67	1.66	0.53
	Pool	1.65	-	-	0.47

TABLE E-11

STRUCTURE OF THE BENTHIC COMMUNITY
LITTLE SALUDA CREEK
MARBLE HILL PLANT, 1977

Month	Habitat	Number of individuals (% composition)				
		Worms	Molluscs	Crustaceans	Insects	Others
March	Riffle	3 (1.0)	0 (0.0)	291 (95.0)	6 (2.0)	6 (2.0)
	Pool	10 (37.0)	0 (0.0)	16 (59.3)	1 (3.7)	0 (0.0)
May	Riffle	2 (0.3)	0 (0.0)	628 (92.3)	36 (5.3)	14 (2.1)
	Pool[a]	-	-	-	-	-
August	Riffle	0 (0.0)	29 (4.8)	419 (69.8)	103 (17.2)	49 (8.2)
	Pool[a]	-	-	-	-	-
November	Riffle	0 (0.0)	0 (0.0)	609 (93.7)	8 (1.2)	33 (5.1)
	Pool	2 (1.8)	0 (0.0)	104 (92.8)	4 (3.6)	2 (1.8)

[a]Pool samples could not be taken during these months because low water levels prevented differentiation between riffle and pool habitats.

TABLE E-12

SUMMARY OF MACROINVERTEBRATE COLLECTION DATA
FROM LITTLE SALUDA CREEK
MARBLE HILL PLANT, 1977

Community parameter	March	May	August	November
Density	9	1602	141	304
Biomass	0.018	2.503	0.111	0.252
Diversity	1.59	0.84	2.39	0.60

TABLE E-13

STRUCTURE OF THE MACROINVERTEBRATE COMMUNITY
LITTLE SALUDA CREEK
MARBLE HILL PLANT, 1977

Date	Worms	Molluscs	Crustaceans	Insects	Others
March	0 (0.0)	0 (0.0)	1 (33.3)	2 (66.7)	0 (0.0)
May	6 (1.2)	0 (0.0)	46[illegible] (88.4)	14 (2.7)	40 (7.7)
August	0 (0.0)	2 (4.3)	26 (56.6)	18 (39.1)	0 (0.0)
November	0 (0.0)	0 (0.0)	94 (94.9)	5 (5.1)	0 (0.0)

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 composition and abundance of fishes in the vicinity of the Marble Hill Plant site during the initial phase of plant construction. Results of this study were to be compared with those obtained during the 1974 baseline study (PSI, 1976), to determine if changes in fish community composition have occurred as a result of plant construction activity. Since construction was not underway until the November sampling period of the 1977 study year, study results in this section augment the existing baseline data rather than interpret plant construction effects on fishes.

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 in length by 1.8 m in depth (100 by 6 ft). The nets were constructed of three 10.2-m panels of 25.4-, 38.1- and 50.8-mm^2 mesh (1-, 1.5- and 2-in^2) sewn end-to-end. The nets were submerged and held perpendicular to the shore from nearshore shallows to depths of about 3 m (10 ft). The nets were fished for two consecutive 24-hour periods, and the fishes were removed from the nets and analyzed after each 24-hour period.

Electrofishing

Collections were made at night by electrofishing during each quarterly sampling period at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6. River stations were sampled with an AC shocking assembly powered by a Winco 2400-watt, 230-volt, single-phase generator connected to two electrodes suspended approximately 2 m (6 ft) in front of the boat. With the aluminum hull at ground potential, an electric field was established between the electrodes and the boat. Current was pulsed by a deadman foot switch. The Little Saluda Creek station was electrofished with a Smith-Root Model VII backpack shocker which produced a 500-volt DC current pulsed between hand-held electrodes. 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: 150 m (164 yd) at the Ohio River stations and 100 m (109 yd) in Little Saluda Creek. Two replicate samples were taken at each station.

Seining

Collections were made by seining during each quarterly sampling period at Little Saluda Creek Station 6. The seine was 9.1 m in length by 1.2 m in depth (30 by 4 ft) and of 3-mm^2 (0.13-in^2) mesh. Two replicate seine hauls were made over a distance of 50 m (55 yd) during each sampling period.

Analytical Methods

Fishes were identified to species, counted, measured, weighed, and examined for ectoparasitic infestations. Live fishes were released after analyses unless needed for taxonomic verification.

Identifications were confirmed by literature sources including Trautman (1957), Hubbs and Lagler (1958), Moore (1968), Eddy (1969), Becker and Johnson (1970), Scott and Crossman (1973), Eddy and Underhill (1974), Clay (1975), and Pflieger (1975). Taxonomic nomenclature was in accordance with the American Fisheries Society's *List of Common and Scientific Names of Fishes* (Bailey et al., 1970). The standard length (SL) of each fish, the distance from the snout to the caudal fin base, was measured to the nearest millimeter. Weight was measured to the nearest gram. Fishes were individually analyzed, with the exception of small species (e.g., shiners). The range of standard lengths and the combined weight were recorded for individuals of each of these small species.

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

$$K = \frac{W \cdot 10^5}{L^3}$$

where: W = weight in grams

L = length in millimeters

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

RESULTS AND DISCUSSION

A total of 37 species of fishes in 10 families was collected by these methods during this study (Table F-1). The emerald shiner was the most abundant species found. The total numbers and relative abundance of fishes collected from Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6 by gill netting, electrofishing and seining are presented in Table F-2. Catches per unit effort during the four quarterly sampling periods are listed by method in Table F-3.

Gill Netting

Three hundred thirty-seven (337) fishes were collected by gill netting (Table F-4). Of the 25 species collected, none were dominant based on numbers of individuals found. The results of gill netting by date, station and replicate include standard lengths, weights and calculated condition factors and are presented in Appendix Tables F-1A through F-4B.

The fewest total number of fishes was collected in March (Figure F-1). On this occasion, high water levels and current velocities carried considerable debris downstream. This material accumulated in the nets, making them more visible and easily avoided by fish. Additionally, fishes may have congregated in less turbulent areas near the bottom offshore. The largest total number of fishes, representing 21 different species, was found in May.

Catch per unit effort (CPE) ranged from 0.000 to 0.813 fish per net-hour (Table F-3). The annual total CPE was 0.284 fish per net-hour at Station 1, 0.224 at Station 3, and 0.417 at Station 5. Although a larger number of fishes was collected at Station 5, there was no statistically significant difference (α=0.1) between stations on an annual basis due to wide variations in CPE between the different sampling periods. The larger number of fishes collected at Station 5 is attributed to the hydrography of the river at this location. A downstream obstruction just below Station 5 causes the water current to deflect away from shore, and fishes may concentrate nearshore in the area of decreased flow.

Sauger, gizzard shad and channel catfish were the only species which individually comprised over 10% of the total number of fishes collected (Table F-4).

Sauger

Sauger was the most abundant species found in the gill net collections, based on number of individuals, and comprised 15.7% of the total number of fishes. With the exception of two individuals, the sauger were all collected during August and November and the majority (58.8%) of these were found at Station 5.

Condition factors (K) for sauger ranged from 1.09 to 2 04 for all individuals collected.[a] Condition factors between stations were not statistically different (α=0.05): a mean of 1.51 at Station 1, 1.42 at Station 3 and 1.47 at Station 5. The sauger is a predatory species at the top of the aquatic food chain. It is a designated[b] game species and not commercially harvested. Life history aspects of the sauger are presented in Table F-5.

Gizzard shad

Gizzard shad accounted for 15.1% of the number of fishes found during gill netting (Table F-4). The majority (80.4%) of the gizzard shad were found during the May sampling period. Condition factors for gizzard shad ranged from 0.63 to 2.23. The mean condition factors were

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[a]Condition factors are only useful for comparative purposes and are hence of limited value (e.g., comparing stations) during a single year's study. The primary usefulness of condition factors will be for comparisons over longer periods of time

[b]Kentucky Department of Fish and Wildlife Resources.

1.30 at Station 1, 1.70 at Station 3, and 1.65 at Station 5. Station 1 gizzard shad had significantly (α=0.05) lower K values than those at Station 3. These fishes were in approximately the same length range (130-190 mm SL), but the Station 1 shad weighed less. The reason for this difference is not known. There was no significant difference (α=0.05) in gizzard shad K values between Stations 1 and 5 and between Stations 3 and 5. Gizzard shad are of neither sport nor commercial importance, although they are important as forage (i.e., food for larger fishes) when young. Life history aspects of this species are also presented in Table F-5.

Channel catfish

Channel catfish comprised 13.6% of the total fishes collected by gill netting (Table F-4). This species was found at each station during May, August and November. None were collected during the period of high water levels in March. Condition factors for channel catfish ranged from 0.98 to 2.57. Condition factors between stations were not statistically significant (α=0.05): a mean of 1.74 at Station 1, 1.82 at Station 3, and 1.80 at Station 5. The channel catfish is an omnivorous species of both sport and commercial[a] importance. Aspects of its life history are presented in Table F-5.

[a]Catfishes, carp, buffalo and freshwater drum are the predominant fishes caught commercially in the area. Commercial fishing in the area has been reduced substantially in recent years because of low monetary return and high effort involved, relative to other lines of employment. Landing statistics, as regards biomass and value of the catch, are not known to be available.

Other species

Species other than sauger, gizzard shad, and channel catfish individually comprised 8.3% (28 individuals) or less of the total number of fishes collected (Table F-4). These other species included longnose gar, carp, eight species of sucker, white bass, seven species of sunfish, and freshwater drum.

Electrofishing

At Ohio River Stations 1, 3 and 5, 46 fishes were collected by electrofishing (Table F-6). At Little Saluda Creek Station 6, 429 fishes were taken by electrofishing (Table F-7). Gizzard shad and emerald shiner were the dominant fishes collected at the Ohio River stations and emerald shiner in Little Saluda Creek. The results of electrofishing by date, station and replicate include standard lengths, weights and calculated condition factors for the larger individuals. These data are presented in Appendix Tables F-5 through F-12.

Ohio River

Eight species of fishes were collected by electrofishing at Ohio River Stations 1, 3 and 5 (Table F-6). Gizzard shad comprised 45.6% of the total number of fishes collected and emerald shiner 39.1%. The other species found were each represented by one or two individuals and included skipjack herring, three species of sucker, white bass and freshwater drum.

Catch per unit effort (CPE) ranged from 0.000 to 0.037 fish per meter of shoreline fished (Table F-3). The annual total CPE was 0.008 fish per meter at Station 1, 0.013 at Station 3, and 0.018 at Station 5. Although a larger number of fishes was collected at Station 5, there was no statistically significant difference (α=0.01) between stations on an annual basis due to wide variations in CPE between the different sampling periods. The increased number of fishes at Station 5 may be attributable to decreased flow, as previously discussed.

Little Saluda Creek

Eight species[a] of fish were collected by electrofishing at Little Saluda Creek Station 6 (Table F-7). All fishes collected in the creek by this method were members of the minnow family (Cyprinidae), with the exception of one bluegill. The emerald shiner was the dominant species, and comprised over 90% of the 429 fishes found. Life history aspects of this important forage species are presented in Table F-5.

Catch per unit effort ranged from 0.015[b] to 2.000 fish per meter of stream distance fished. The fewest fishes were collected

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[a]The two shiners listed as *Notropis* sp. are not counted as distinct species. Rosyface shiner and green sunfish (Table F-1) were also collected at this station, but not during the quantitative sampling.

[b]The CPE of 0.000 at Station 6 in May resulted from equipment malfunction and is not included in this range.

during the March sampling period, the most during the August sampling period. These catches probably represent low population levels following winter, and high population levels after juvenile recruitment in the summer.

Seining

At Little Saluda Creek Station 6, fishes were collected by seining (Table F-7). The results of seining by date and replicate include the number of individuals, range of standard lengths, and weights of the fishes collected. These data are presented in Appendix Tables F-13 through F-16.

Emerald shiner was the most abundant of the ten species found and comprised 86.2% of the total number of fishes collected by this method. Blacknose dace and creek chub were represented by 18 and 7 individuals, respectively. One or two individuals were found for each of stoneroller, pugnose and bluntnose minnows, smallmouth buffalo, black bullhead, and smallmouth bass.

Catch per unit effort (CPE) ranged from 0.000 fish per meter of stream distance in March to 1.660 in August (Table F-3). The total CPE for all sampling dates was 0.615.

Study Comparisons

The baseline study on fish at Marble Hill was conducted from March through August 1974 (PSI, 1976). The total number of fishes collected and the relative species abundance were generally similar in both studies (Table F-8), although the two sampling programs differed somewhat in certain areas.

One thousand ninety-one (1091) fishes and 28 taxa were collected during 1974 compared to 1058 fishes and 26 taxa[a] during 1977 (Table F-8). Variations between species occurrence (presence or absence) involved only those species in which one or a few individuals were collected in one study and not the other. Emerald shiners were the dominant species in both studies, based on relative abundance by number of individuals collected. No rare or endangered species were found during either study.

A total of 337 fishes was collected by gill netting during the 1977 study compared to 150 fishes during the 1974 study. Gill netting methodology during the two studies differed as to the months sampled, the number of stations sampled, the number of hours fished (i.e., effort expended) and the size and configuration of the various

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[a]Taxa (categories) included 37 species in 1977 as compared to 31 species in 1974, although the species of redhorse suckers were combined as *Moxostoma* sp. on the 1974 list.

meshes within the nets. Although there was generally considerable variation between any specific station during a specific sampling month (primarily because of the high mobility of fish), the mean catch per unit effort was nevertheless almost the same when months and stations sampled were the same. During both studies, Stations 1 and 5 were sampled in May and Stations 1, 3 and 5 in August. The mean CPE for these stations and months was 0.52 fish per net-hour during the 1974 study and 0.46 during 1977.

A total of 46 fishes was collected by electrofishing on the Ohio River during the 1977 study compared to 357 fishes during the 1974 study. Electrofishing methodology differed as to the months sampled, the stations sampled and the amount of effort expended, but the equipment employed and method of fishing were essentially the same. When months and stations sampled were the same (Stations 1 and 3 were sampled in March, May and August and Station 5 in March and August during both studies), the mean CPE was 0.41 fish per minute during 1974 and 0.10[a] during 1977. Reasons for the decreased catch in 1977 are not known. Because of the large numbers of fish found during gill netting, however, the small catch is not attributed to the presence of fewer fishes.

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[a]Calculated from an estimated 20 minutes per station per month during the 1977 sampling.

A total of 429 fishes was collected by back-pack electrofishing in Little Saluda Creek during the 1977 study. This method was not employed during the 1974 study.

A total of 246 fishes was collected by seining in Little Saluda Creek during the 1977 study, compared to 93 fishes during the 1974 study. Catches per unit effort are not directly comparable between the two studies because of differences in determining effort expended. However, members of the minnow family were the dominant species present during both studies.

Differences in the occurrence and relative abundance of species were minor, as previously noted, and may be due to yearly variations, the fortuitous occurrence or non-occurrence of schooling species (e.g., gizzard shad), and/or differences in the sampling programs. No differences were attributed to plant construction activity.

CONCLUSIONS

Fishes were collected quarterly at three Ohio River stations and one Little Saluda Creek station by gill netting, electrofishing and/or seining. A total of 1058 fishes comprising 37 species was collected by these methods. The emerald shiner was the most abundant species. No rare or endangered fishes were found.

The total number of fishes collected and the relative species abundance were similar to those found in the 1974 baseline study. Differences were not attributed to plant construction activity.

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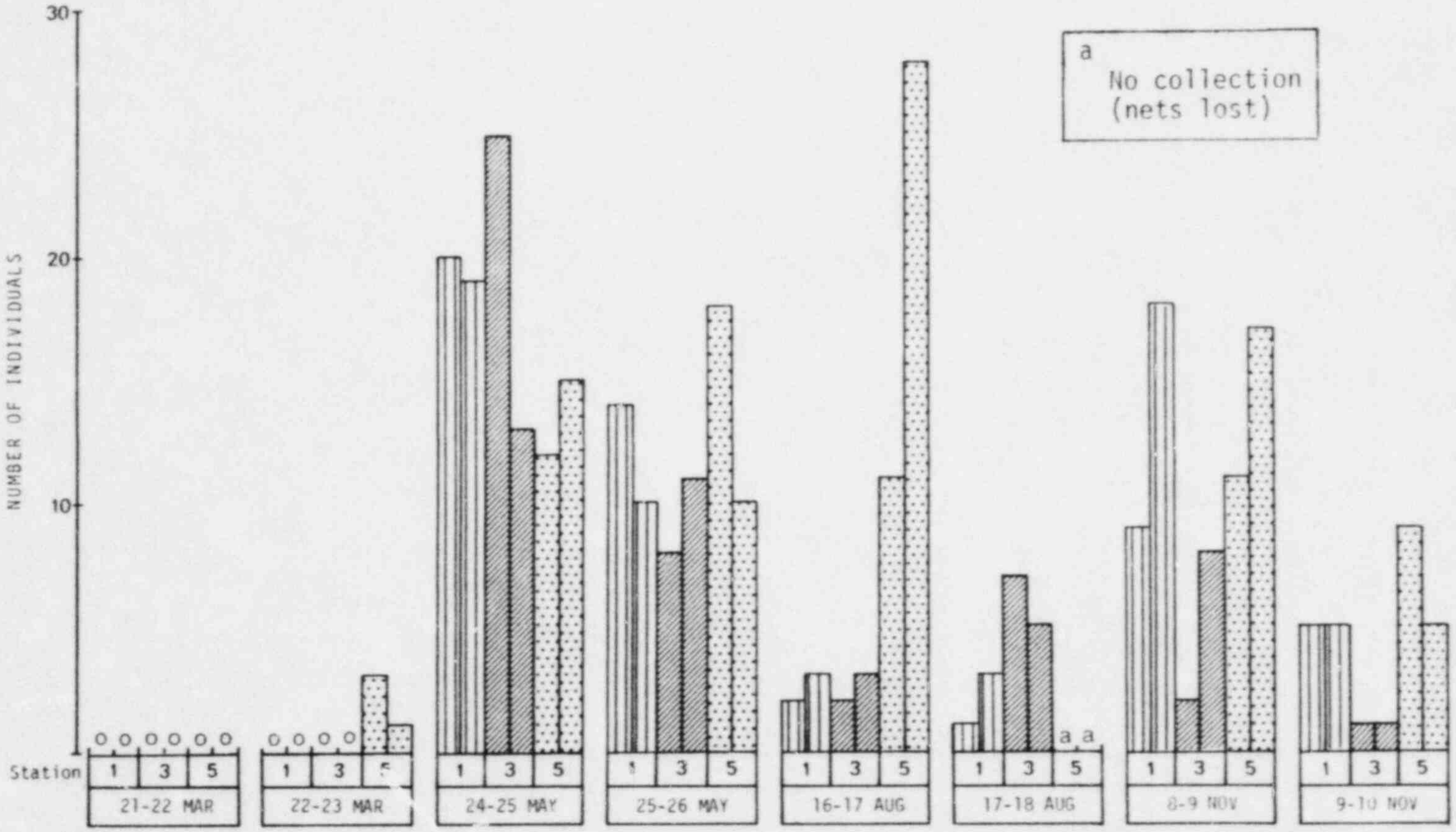

Figure F-1. Number of individuals collected per gill net per 24 hours at each of two replicates per station, Marble Hill Plant site, 1977.

TABLE F-1

SCIENTIFIC AND COMMON NAMES OF FISHES
COLLECTED BY ALL METHODS
IN THE VICINITY OF THE
MARBLE HILL PLANT
1977

Lepisosteidae-gars	
Lepisosteus osseus	longnose gar
Clupeidae-herrings	
Alosa chrysochloris	skipjack herring
Dorosoma cepedianum	gizzard shad
Hiodontidae-mooneyes	
Hiodon alosoides	goldeye
Cyprinidae-minnows and carps	
Campostoma anomalum	stoneroller
Cyprinus carpio	carp
Notropis atherinoides	emerald shiner
Notropis chrysocephalus	striped shiner
Notropis rubellus[a]	rosyface shiner
Notropis volucellus	mimic shiner
Notropis sp.	shiner
Opsopoeodus emiliae	pugnose minnow
Pimephales notatus	bluntnose minnow
Rhinichthys atratulus	blacknose dace
Semotilus atromaculatus	creek chub
Catostomidae-suckers	
Carpiodes carpio	river carpsucker
Carpiodes velifer	highfin carpsucker
Ictiobus bubalus	smallmouth buffalo
Ictiobus niger	black buffalo
Minytrema melanops	spotted sucker
Moxostoma anisurum	silver redhorse
Moxostoma carinatum	river redhorse
Moxostoma erythrurum	golden redhorse
Moxostoma macrolepidotum	shorthead redhorse

TABLE F-1
(continued)
SCIENTIFIC AND COMMON NAMES OF FISHES
COLLECTED BY ALL METHODS
IN THE VICINITY OF THE
MARBLE HILL PLANT
1977

Ictaluridae-freshwater catfishes	
Ictalurus melas	black bullhead
Ictalurus punctatus	channel catfish
Pylodictis olivaris	flathead catfish
Percichthyidae-temperate basses	
Morone chrysops	white bass
Centrarchidae-sunfishes	
Lepomis cyanellus[a]	green sunfish
Lepomis gibbosus	pumpkinseed
Lepomis gulosus	warmouth
Lepomis macrochirus	bluegill
Lepomis megalotis	longear sunfish
Micropterus dolomieui	smallmouth bass
Micropterus punctulatus	spotted bass
Micropterus salmoides	largemouth bass
Percidae-perches	
Perca flavescens[b]	yellow perch
Stizostedion canadense	sauger
Sciaenidae-drums	
Aplodinotus grunniens	freshwater drum

[a]Collected during qualitative sampling only.

[b]Collected during ichthyoplankton sampling only.

TABLE F-2

TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES COLLECTED BY GILL NETTING, ELECTROFISHING AND SEINING FROM OHIO RIVER STATIONS 1, 3 AND 5 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT
1977

Species	Station 1	Station 3	Station 5	Station 6	Total	Relative abundance %
Longnose gar	8	6	4	-	18	1.7
Skipjack herring	3	-	4	-	7	0.7
Gizzard shad	19	27	26	-	72	6.8
Goldeye	4	1	2	-	7	0.7
Stoneroller	-	-	-	3	3	0.3
Carp	5	2	3	-	10	0.9
Emerald shiner	5	8	5	600	618	58.4
Striped shiner	-	-	-	2	2	0.2
Mimic shiner	-	-	-	3	3	0.3
Shiner (*Notropis* sp.)	-	-	-	2	2	0.2
Pugnose minnow	-	-	-	2	2	0.2
Bluntnose minnow	-	-	-	1	1	0.1
Blacknose dace	-	-	-	28	28	2.6
Creek chub	-	-	-	28	28	2.6
River carpsucker	4	-	6	-	10	0.9
Highfin carpsucker	3	2	-	-	5	0.5
Smallmouth buffalo	1	-	1	1	3	0.3
Black buffalo	1	-	-	-	1	0.1
Spotted sucker	3	-	2	-	5	0.5
Silver redhorse	3	-	-	-	3	0.3
River redhorse	-	-	2	-	2	0.2
Golden redhorse	10	8	3	-	21	2.0
Shorthead redhorse	3	1	2	-	6	0.5
Black bullhead	-	-	-	2	2	0.2
Channel catfish	12	13	21	-	46	4.3
Flathead catfish	10	3	9	-	22	2.1
White bass	8	5	16	-	29	2.7
Pumpkinseed	-	-	1	-	1	0.1
Warmouth	-	1	2	-	3	0.3
Bluegill	-	-	1	2	3	0.3
Longear sunfish	-	-	2	-	2	0.2
Smallmouth bass	-	2	1	1	4	0.4
Spotted bass	-	3	2	-	5	0.5
Largemouth bass	1	2	-	-	3	0.3
Sauger	9	13	31	-	53	5.0
Freshwater drum	6	4	18	-	28	2.6
Totals	118	101	164	675	1058	100.0

TABLE F-3

CATCH PER UNIT EFFORT OF FISHES COLLECTED BY GILL NETTING, ELECTROFISHING AND SEINING FROM OHIO RIVER STATIONS 1, 3 AND 5 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT
1977

Sampling Method	Station	March	May	August	November	1977[a]
Gill netting (fish/net-hr)	1	0.000	0.656	0.094	0.385	0.284
	3	0.000	0.594	0.177	0.125	0.224
	5	0.047	0.573	0.813	0.438	0.417
Electrofishing (fish/m[b])	1	0.000	0.003	0.000	0.027	0.008
	3	0.003	0.003	0.010	0.033	0.013
	5	0.003	0.003	0.030	0.037	0.018
	6	0.015	0.000[c]	2.000	0.130	0.536
Seining (fish/m[b])	6	0.000	0.250	1.660	0.550	0.615

[a]Total fish per unit effort for the year.

[b]Shoreline or stream distance.

[c]Equipment malfunction.

TABLE F-4

TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES COLLECTED BY GILL NETTING FROM OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT
1977

Species	Station 1	Station 3	Station 5	Total	Relative abundance %
Longnose gar	8	6	4	18	5.3
Skipjack herring	3	-	3	6	1.8
Gizzard shad	17	21	13	51	15.1
Goldeye	4	1	2	7	2.1
Carp	5	2	3	10	3.0
River carpsucker	4	-	5	9	2.7
Highfin carpsucker	2	2	-	4	1.2
Black buffalo	1	-	-	1	0.3
Spotted sucker	3	-	2	5	1.5
Silver redhorse	3	-	-	3	0.9
River redhorse	-	-	2	2	0.6
Golden redhorse	10	8	3	21	6.2
Shorthead redhorse	3	1	2	6	1.8
Channel catfish	12	13	21	46	13.6
Flathead catfish	10	3	9	22	6.5
White bass	8	4	16	28	8.3
Pumpkinseed	-	-	1	1	0.3
Warmouth	-	1	2	3	0.9
Bluegill	-	-	1	1	0.3
Longear sunfish	-	-	2	2	0.6
Smallmouth bass	-	2	1	3	0.9
Spotted bass	-	3	2	5	1.5
Largemouth bass	1	2	-	3	0.9
Sauger	9	13	31	53	15.7
Freshwater drum	6	4	17	27	8.0
Totals	109	86	142	337	100.0

TABLE F-5

SUMMARY OF THE LIFE HISTORIES[a] OF REPRESENTATIVE FISH SP·CIES
COLLECTED IN THE OHIO RIVER NEAR THE
MARBLE HILL PLANT
1977

Species	Economic significance	Trophic classification	Habitat		Food		Spawning						
			Adult	Young	Adult	Young	Time	Water temp(°C)	Migration	Breeding site	Mating	Products	Parental care
Longnose gar	None	Carnivore	Quiet shallows of lakes and large rivers	Protected weedy areas along streams	Frogs, crayfish, crabs, fish	Insects	May to mid-June		Upstream to small, higher cradient streams	Small streams over weedy areas	Gregarious	Demersal adhesive eggs	None
Gizzard shad	None	Herbivore-important forage fish	Fertile reservoirs and large rivers	Shallow areas along shoreline	Phyto- and zooplankton, insect larva	Phyto- and zooplankton	May	17.2-22.8°C	Upstream to low gradien: streams	Small streams over sand and gravel	Gregarious	Demersal adhesive eggs	None
Goldeye	None	Omnivore-important forage fish	Open water of large rivers and deep pools of tributary streams	Same	Insects, molluscs, crustaceans, frogs, fish	Micro-crustaceans	April to May	10.0-12.8°C	Upstream to shallow-firm bottom areas	Mid-water	Pairs	Pelagic eggs	None
Carp	Sport, commercial	Omnivore	Lakes and reservoirs, rivers and streams	Same	Aquatic insects, plant material	Same	Late March to late June	16°-23°C	Not highly migratory	Shallow weedy areas	Gregarious	Demersal eggs	None
Emerald shiner	None	Omnivore	Reservoirs and lakes, large streams	Same	Small crustaceans, aquatic insects	Algae	Late May to early July		None	Shallow water over sand or firm mud	Gregarious	Demersal eggs	None
Smallmouth buffalo	Commercial	Omnivore	Large rivers, tributaries, and reservoirs	Not known	Insect larvae, algae and detritus	Not known	April to May		None	Not known	Not known	Not known	Not known
Shorthead redhorse	Commercial	Omnivore	Lakes or streams with gravelly or rocky bottoms	Not known	Insects	Not known	April	11.1°C	From larger bodies of water into smaller rivers or streams	Gravelly riffles	Gregarious	Demersal eggs	None
Channel catfish	Sport, commercial	Omnivore	Large streams with low gradients	Riffles or shallow parts of pools	Fish, insects, crayfish, molluscs, plant material	Small insects	May to July	23.9°-29.5°C	None	Holes, undercut banks, log jams, rocks	Pairs	Demersal eggs	Nest built by male; male protects young until they leave nest
White bass	Sport	Carnivore	Deep pools of streams and open water of lakes and reservoirs	Not known	Fish, insects	Small crustaceans and insects	March to June	14.4°-21.1°C	Upstream into tributary streams	Mid-water over gravelly and rocky bottoms	Gregarious	Demersal adhesive eggs	None
Bluegill	Sport	Omnivore	Pools and backwaters of streams, lakes and reservoirs	Protected shallow weedy areas	Insects, crustaceans, plant material, small fish	Small crustaceans	May tr August	19.4°-26.6°C	None	Shallow areas over any type of substrate	Pairs	Demersal eggs	Nest built by male; male guards eggs until they hatch
Largemouth bass	Sport	Carnivore	Lakes and reservoirs rivers and streams	Shallow areas along shorelines	Fish, crayfish large insects, frogs	Zooplankton, crustaceans, small insects	Mid-April to late May	15.5°-25°	Not highly migratory	Shallow areas along the shoreline	Pairs	Demersal adhesive eggs	Male constructs nest, guards eggs and fry
Sauger	Sport	Carnivore	Large rivers and lakes	Not known	Fish	Small crustaceans and insects	March to April	3.9°-6.1°C	Upstream	Shallow shoals over gravel-rubble substrate	Gregarious	Semibuoyant eggs	None
Freshwater drum	Commerciel, sport	Omnivore	Near bottom in large rivers, lakes and reservoirs	Not known, but presumably close to bottom	Fish, crayfish, molluscs, and insects	Zooplankton and insects	May to June	18°-24°C	From larger bodies of water to smaller rivers or streams	Not known	Not known	Pelagic	None

[a] Life history information based on Breder and Rosen (1966), Calhoun (1966), Pflieger (1975), Scott and Crossman (1973), Trautman (1957), and Swedberg and Walburg (1970).

TABLE F-6

TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES COLLECTED BY ELECTROFISHING FROM OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT
1977

Species	Station 1	Station 3	Station 5	Total	Relative abundance %
Skipjack herring	-	-	1	1	2.2
Gizzard shad	2	6	13	21	45.6
Emerald shiner	5	8	5	18	39.1
River carpsucker	-	-	1	1	2.2
Highfin carpsucker	1	-	-	1	2.2
Smallmouth buffalo	1	-	1	2	4.3
White bass	-	1	-	1	2.2
Freshwater drum	-	-	1	1	2.2
Totals	9	15	22	46	100.0

TABLE F-7

TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES COLLECTED
BY ELECTROFISHING AND SEINING FROM LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT
1977

Species	Electrofishing	Seining	Total	Relative abundance %
Stoneroller	1	2	3	0.4
Emerald shiner	388	212	600	88.9
Striped shiner	2	-	2	0.3
Mimic shiner	3	-	3	0.4
Shiner (*Notropis* sp.)	2	-	2	0.3
Pugnose minnow	1	1	2	0.3
Bluntnose minnow	-	1	1	0.1
Blacknose dace	10	18	28	4.1
Creek chub	21	7	28	4.1
Smallmouth buffalo	-	1	1	0.1
Black bullhead	-	2	2	0.3
Bluegill	1	1	2	0.3
Smallmouth bass	-	1	1	0.1
Totals	429	246	675	99.7[a]

[a] 0.3% loss due to rounding to one decimal place.

TABLE F-8

RELATIVE ABUNDANCE OF FISHES COLLECTED DURING 1974 AND 1977 IN THE VICINITY OF THE MARBLE HILL PLANT

Species	Relative abundance (%) 1974	1977	Difference
Longnose gar	2.2	1.7	0.5
Skipjack herring	1.6	0.7	0.9
Gizzard shad	27.5	6.8	20.7
Goldeye	0.7	0.7	0.0
Stoneroller	-	0.3	0.3
Carp	0.4	0.9	0.5
Emerald shiner	48.0	58.4	10.4
Shiner (*Notropis* spp.)[a]	0.6	0.7	0.1
Pugnose minnow	-	0.2	0.2
Bluntnose minnow	0.5	0.1	0.4
Blacknose dace	7.1	2.6	4.5
Creek chub	0.3	2.6	2.3
Carpsucker (*Carpiodes* spp.)	1.8	1.4	0.4
White sucker	0.3	-	0.3
Buffalo (*Ictiobus* spp.)	0.1	0.4	0.3
Spotted sucker	0.5	0.5	0.0
Redhorse (*Moxostoma* spp.)	0.5	3.0	2.5
Black bullhead	-	0.2	0.2
Channel catfish	0.9	4.3	3.4
Flathead catfish	0.1	2.1	2.0
White bass	0.5	2.7	2.2
Rock bass	0.1	-	0.1
Sunfishes (*Lepomis* spp.)	2.0	0.9	1.1
Smallmouth bass	0.3	0.4	0.1
Spotted bass	0.2	0.5	0.3
Largemouth bass	0.5	0.3	0.2
Crappie (*Pomoxis* spp.)	0.8	-	0.8
Yellow perch	0.1	-	0.1
Sauger	1.1	5.0	3.9
Walleye	0.1	-	0.1
Freshwater drum	1.2	2.6	1.4
Total	100.0	100.0	-
Number of fishes	1091	1058	-

[a]Exclusive of emerald shiner.

G. FISH EGGS AND LARVAE

INTRODUCTION

Changes in the physical and chemical composition of a water body can influence both the spawning success of fishes and subsequent survival of the eggs and larvae. In turn, 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 in the vicinity of the Marble Hill Plant site during the initial phase of plant construction. Results of this study were to be compared with those obtained during the 1974 baseline study (PSI, 1976), to determine if changes had occurred as a result of plant construction activity. However, spawning occurred prior to the start of construction during the 1977 study year, so the results discussed in this report augment the baseline data rather than interpret effects of construction.

MATERIALS AND METHODS

Fish egg and larva collections were made at Ohio River Stations 1, 3 and 5, and Little Saluda Creek Station 6, during the period from 30 April to 26 July 1977.

Quantitative collections were made at the Ohio River stations with bongo nets. Because water levels were low, quanitative collections were made at the Little Saluda Creek station with dip nets.

The bongo nets were of 505μ mesh, 20 cm in mouth diameter and 200 cm in length (Figure E-3). The nets were paired to enable synoptic replicate sampling. During each sampling period, 10-minute tows were made at each station at each of three depths: subsurface, mid-depth, and near-bottom. The tows were made near shore, where the fish eggs and larvae were most likely to be found.

The nets were towed upstream at approximately 150 cm/sec through the water. General Oceanics Model 2030 flowmeters were placed in the mouth of each net to enable the calculation of the volume of water through each net.

Fish eggs and larvae were preserved in the field in a 5% formalin solution and returned to the laboratory for microscopic analysis. Fish eggs were counted and examined for viability. Egg viability was determined based on whether the egg was clear (viable) or opaque (non-viable). Larval fishes were counted and identified to the lowest taxonomic classification practical by the following systematic method:

a. Larvae were sorted into family groupings.

b. Each family grouping was examined in detail and specimens sorted into developmental series for each species by tracing characteristics backwards from identifiable specimens to the smallest larva collected.

c. Each developmental series was examined and compared to the taxonomic literature, specifically Fish (1932), May and Gasaway (1967), Bailey et al. (1970), Scotton et al. (1973), Lippson and Moran (1974), Nelson and Cole (1975), and Hogue (1976).

d. Finally, each series was identified to the lowest practical taxon and photomicrographed.

Data were calculated as eggs and larvae per cubic meter for comparative purposes.

RESULTS AND DISCUSSION

Ten taxa[a] of fishes were collected from the Ohio River during fish egg and larva sampling (Table G-1). The highest densities of fish eggs, up to $0.85/m^3$, were found during the 17 May sampling period (Figure G-1). The highest densities of fish larvae, up to $2.03/m^3$, were found during the 30 April sampling period (Figure G-2). The majority (70%) of the larvae were identified as members of the sucker family (Catostomidae). Very few fish eggs or larvae were found after May. Detailed results of the fish egg and larva collections by date, station and depth are presented in Appendix Tables G-1 through G-10.

Qualitative sampling in Little Saluda Creek resulted in the collection of only 15 minnow larvae (blacknose dace). These were found during June and July sampling periods. No fish eggs were collected.

[a]Species genera and/or family.

Construction effects were not considered in the following discussion because no construction occurred prior to, or during, the sampling program. Comparisons with the baseline data (PSI, 1976) are in terms of temporal trends and species composition.

Ohio River Stations 1, 3 and 5

Ohio River Stations 1, 3 and 5 yielded fish egg densities ranging from 0.00 to 0.85 eggs/m^3 (Table G-2). Egg densities in the river were low (mean <0.01/m^3) during the first sampling period (30 April), and highest (mean 0.32/m^3) during the second sampling period (17 May; Figure G-1). Densities were down to an average of 0.14/m^3 on 25 May, no eggs were found in June, and only three were found in July. Eighty-seven (87) percent of all eggs were considered to be viable.

Fish larval densities at the Ohio River stations ranged from 0.00 to 2.03 larvae/m^3 (Tables G-3 through G-5). Larval densities were highest during the first sampling period (30 April) when an average 1.13 larvae/m^3 were found (Figure G-2). Larval densities averaged 0.18 and 0.31 larvae/m^3 on 17 May and 25 May, respectively. Very few (8) larvae were found during sampling in all of June and July. The high larval densities on 30 April indicate that both eggs and larvae were present prior to that date and the initiation of the sampling program.

Suckers, carp and gizzard shad comprised 91.3% of the total larval fishes collected. Suckers were the dominant species with an overall density of 0.12 larvae/m^3 and comprised 70% of all larval fishes found. Carp comprised 13.6% of the total and had an overall density of 0.02 larvae/m^3; gizzard shad comprised 7.7% of the total and 0.01 larvae/m^3. The remainder (8.7%) of the fishes collected each had densities of less than 0.01 larvae/m^3 and consisted of shiners, minnows other than carp and shiners, white bass, sunfishes, yellow perch, sauger and freshwater drum.

Egg densities averaged[a] 0.06 eggs/m^3 for all depths at Station 1, 0.08 at Station 3, and 0.15 at Station 5 (Figure G-3). The higher density of eggs at Station 5 was attributed to an increased adult fish population at this location, as substantiated by gill net collections. This concentration of adults could result in increased spawning activity and subsequent egg production for the area. Larval densities were very similar at each station, averaging[a] 0.35 larvae/m^3 at Station 1, 0.34 at Station 3, and 0.29 at Station 5 (Figure G-3). The fact that larval densities were similar at each station supports the hypothesis that larger egg concentrations at Station 5 were the result of increased spawning in the area, i.e., eggs produced at Station 5 would wash downstream prior to hatching while larvae collected at Station 5 were produced at some point upstream.

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[a]Exclusive of the 8 June and 8 July sampling periods when no eggs or larvae were collected.

Egg densities varied with water depth from a mean[a] of 0.06 eggs/m^3 for all stations at subsurface to 0.10 at mid-depth and 0.12 at near-bottom (Figure G-3). The larger densities at mid-depth and bottom are attributed to the demersal quality of the eggs of many of the resident fishes, such as the suckers and carp. Fish larval densities, on the other hand, were highest at the surface, averaging[a] 0.48 larvae/m^3, and decreased from bottom (0.32) to mid-depth (0.19), indicating the movement of the larval fishes up into the water column following hatching.

Little Saluda Creek Station 6

Qualitative samples taken at Little Saluda Creek Station 6 by dip netting revealed only one larval fish species, the blacknose dace. A total of 15 blacknose dace larvae were collected during the mid-June to mid-July sampling periods. No fish eggs were collected in Little Saluda Creek.

Other species known to occur in Little Saluda Creek are the stoneroller, emerald shiner, striped shiner, mimic shiner, pugnose minnow, creek chub, smallmouth buffalo, black bullhead, bluegill and smallmouth bass. Based on life history information, spawning of most of these species probably takes place in Little Saluda Creek.

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[a]Exclusive of the 8 June through 8 July sampling periods when no eggs or larvae were collected.

Study Comparisons

Fish egg and larva collections for the baseline study were made from 18 March to 31 July 1974 (PSI, 1976). Eggs and larvae collected during the baseline study were not related to the volume of water filtered, so they are not directly comparable to the results of the 1977 construction phase study. However, temporal trends and species compositions during the two studies are comparable. As previously mentioned, no construction had started prior to the completion of the 1977 study, so both studies may actually be considered baseline.

Temporal differences in fish egg and larval occurrence are apparent between the 1974 and 1977 studies. The 1974 study was initiated in mid-March and eggs were not collected until the 7 May sampling period (Figure G-4). The largest number (271) of eggs was found on 17 July, although no collections were taken from mid-June to mid-July. The temporal occurrence of fish larvae during 1974 was similar to that of the fish eggs (Figure G-4).

The design of the 1977 study was based on the temporal occurrence of fish eggs and larvae in the area as determined from the 1974 study. However, the largest density of eggs (mean $0.32/m^3$) during the 1977 study was found on 17 May, and the largest density of larvae (mean $1.13/m^3$) on 30 April (Figure G-5). By 25 May, both egg and larval densities were lower than previous values, and only a few eggs and larvae were collected during the remainder of the study after this date. The fact that the highest density of larvae was collected on 30 April 1977 indicates that both eggs and larvae were present in the river prior to the initiation of the 1977 sampling, and that spawning occurred earlier in 1977 than in 1974. The differences in times of egg and larval occurrence between the 1974 and 1977 study periods may result from physical variations in the aquatic system, such as water temperatures or the amount of flow. Additionally, the spawning periods for some species are relatively short, and may have occurred on or between sampling periods during one of the study years and not the other.

Species composition varied considerably between the two studies. Freshwater drum comprised 82.5% of the total number (1213) of larval fishes collected during 1974, followed by clupeids (probably gizzard shad; 6.5%), and minnows other than shiners and carp (5.0%). Carp and suckers comprised only 2.8% and 2.0%, respectively, during 1974. Suckers comprised 70.0% of the total number (673) of the larval fishes collected during 1977, followed by carp (13.6%) and gizzard shad (7.7%). Freshwater drum comprised only 3.8% of the total number of larval fishes found during 1977.

Although differences in species composition may have resulted from variations in spawning success of the different species, a more probable cause for the differences relates to sampling frequencies and the fortuitous occurrence of the larvae. Of the 17 sampling dates in

1974, 83% of the larvae (primarily freshwater drum) were taken on 17 July. Of the 10 sampling dates in 1977, 68% of the larvae (primarily suckers) were found on 30 April. Because the majority of the larvae were collected on only one sampling date during each of the two studies, the collections were probably fortuitous events that resulted in species composition calculations which do not reflect the actual composition over the course of the two spawning periods sampled.

Drift Macroinvertebrates

A total of 277,890 drift macroinvertebrates of 13 species were taken in conjunction with fish egg and larva sampling (Table G-7). Of this total, 99.8% of the individuals were composed of seven species of cladocerans, or water fleas. The remainder was composed of small crustaceans, insects, and hydroids. Complete collection data may be found in Appendix Tables G-11 through G-20.

When sampling began in late April, density was between 0.4 and 6.0 individuals/m^3 (Figures G-6 through G-8). Peak density occurred in early June when up to 1374 individuals/m^3 were taken. After mid-June, density returned to low values of 0 to 8 individuals/m^3. Greatest densities were encountered at middle or bottom depths.

Statistical analysis of the density data by two-way analysis of variance showed significant variation in drift macroinvertebrate density with sampling date (Table G-8). This effect was expected because cladoceran populations, which comprised the bulk of the community, are known to vary appreciably over the course of the year (Pennak, 1953).

Subsequent t-tests showed that density was significantly greater at Station 1 than at Stations 3 and 5. This difference may be attributable to the fact that Station 3 is located on the outside of a small bend in the river, where current velocities would be expected to be somewhat greater. At Station 5, a large obstruction in the river created strong currents offshore, approximating those at Station 3. Station 1 lies in an area more protected from maximum current velocities. Support for this possible explanation comes from the fact that no significant density differences were found between the surface, mid-depth, and bottom samples from Station 1 (Table G-8). A community with top-to-bottom uniformity would indicate less adverse current influence. At Stations 3 and 5, surface populations were significantly smaller than either mid-depth or bottom populations. Surface populations were probably smaller because current velocities are generally greatest at the surface of a river (Hynes, 1972). Current velocity measurements made at the time of collection support this observation.

Cladocerans, 99.8% of the drift community, are small crustaceans between 0.2 and 3.0 mm long. Most species feed on phytoplankton, but some (e.g., *Leptodora kindti*) feed on zooplankters. The importance of cladocerans in the aquatic food chain is as food for young fish. Various studies of young fish stomach contents show up to 95% cladocerans by volume. Few studies show less than 10%. Many cladoceran species are cosmopolitan and are frequently tolerant of a wide range of temperatures, pH, and dissolved oxygen concentrations (Pennak, 1953). As found in the present study, cladocerans are most abundant in spring and virtually absent from a habitat in summer and winter. Species vary greatly from one another in their seasonal abundance, and a single species may have quite different population abundance curves in two adjacent bodies of water. Furthermore, relative abundance and specific time of maximum and minimum populations may vary considerably within a single species in the same river from one year to the next (Pennak, 1953).

Since no construction was undertaken at Marble Hill until after the completion of the fish egg and larva/drift macroinvertebrate study, the data gathered during this study reflect a community uninfluenced by the proposed Marble Hill Plant. Because no drift macroinvertebrate study was performed during baseline work, the present study provides what is, essentially, baseline data to be compared to data gathered at a later date.

CONCLUSIONS

Ten taxa of fishes were collected from the Ohio River during fish egg and larva sampling. The highest densities of fish eggs were found during sampling in mid-May and the highest densities of fish larvae in late April. The majority of the larvae were identified as members of the sucker family. Few fish eggs or larvae were found after May.

Higher egg densities were found at Station 5 than at Stations 1 or 3, probably the result of increased spawning at Station 5. Larval densities were similar at the three stations. Egg densities were higher near the bottom, and larval densities were higher near the surface. This was attributed to the demersal quality of the eggs in many of the resident fishes, and to the movement by the larval fishes up into the water column after hatching.

Qualitative samples in Little Saluda Creek revealed only one larval fish species, the blacknose dace, although several other species are known to occur there. Spawning of most of these species probably also takes place in the creek.

Temporal and species composition differences were evident between the 1974 baseline and 1977 construction phase studies. The differences were attributed to physical variations in the aquatic system, variations in sampling frequencies, and the fortuitous occurrence of large numbers of larvae on particular occasions.

Thirteen species of macroinvertebrates were taken in conjunction with fish egg and larva sampling. The vast majority of these macroinvertebrates were cladocerans, small crustaceans of importance in the aquatic food chain. Peak macroinvertebrate densities occurred in June. Differences in densities between stations were attributed to variations in hydrography and water current velocities.

Since no plant construction was undertaken until after the completion of the 1977 fish egg and larva/drift macroinvertebrate study, the data gathered during this study reflect a community uninfluenced by the proposed Marble Hill Plant. The data acquired in 1977 therefore represent, in effect, additional baseline information.

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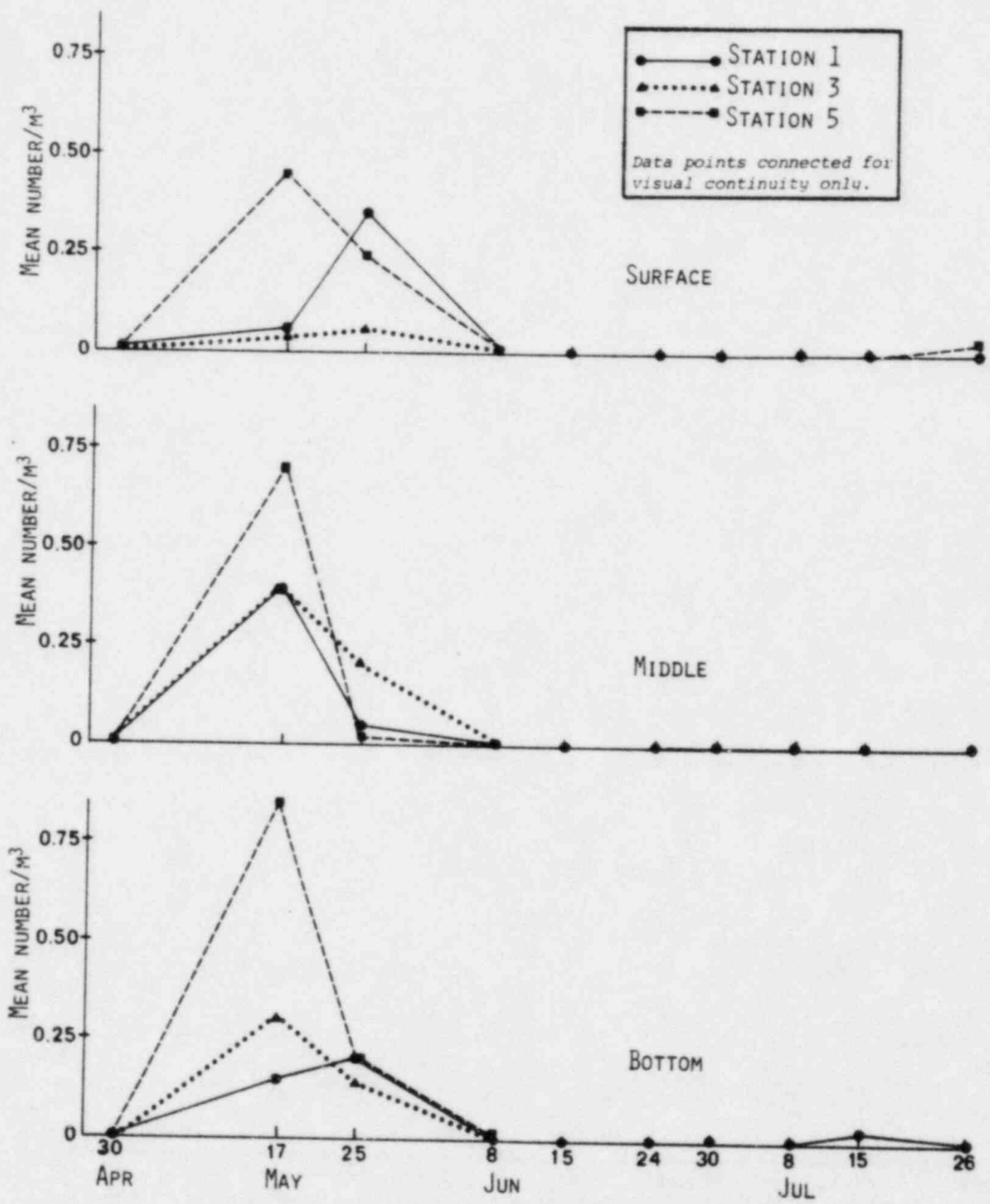

Figure G-1. Fish eggs collected in the Ohio River near the Marble Hill Plant site, April-July 1977.

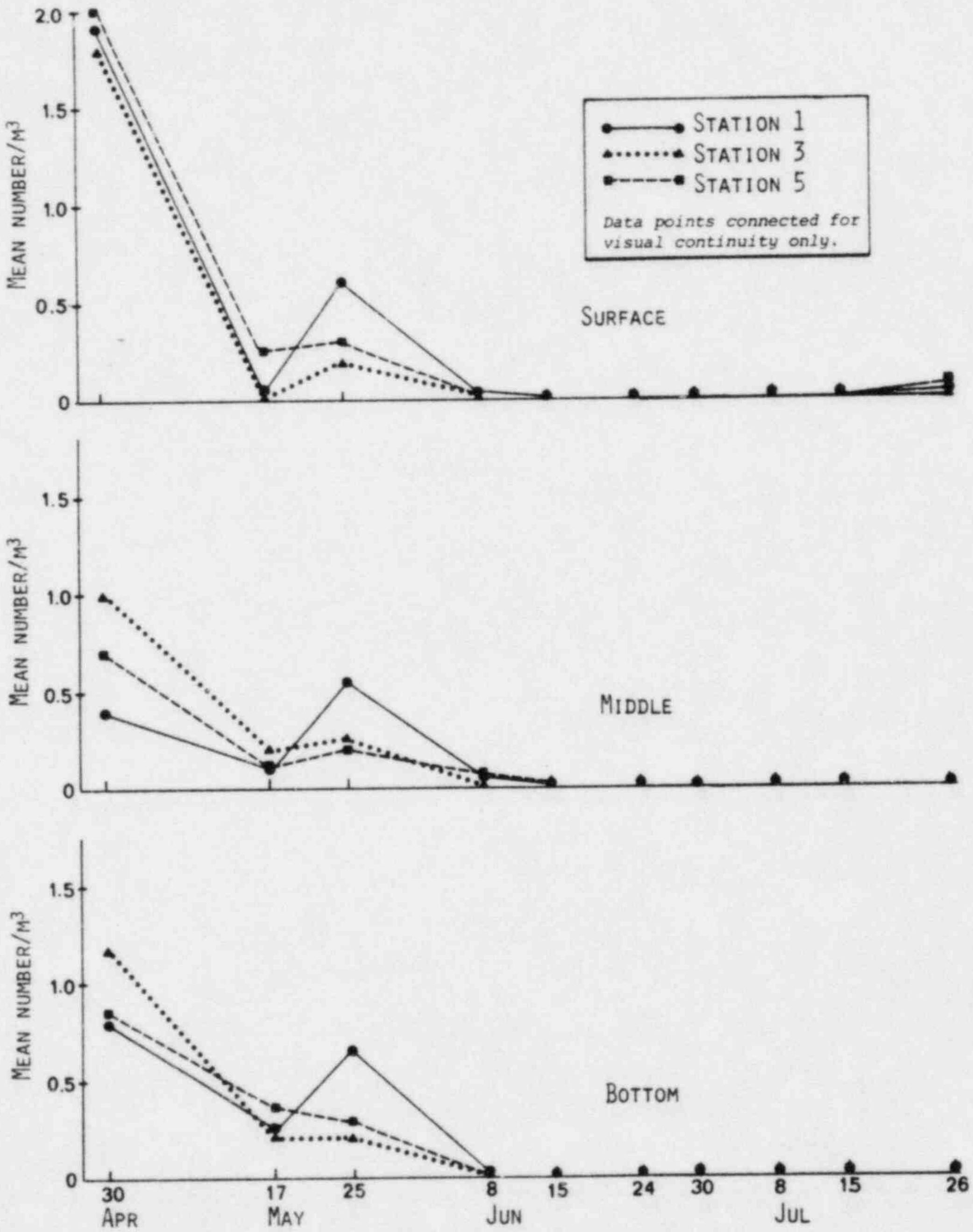

Figure G-2. Fish larvae collected in the Ohio River near the Marble Hill Plant site, April-July 1977.

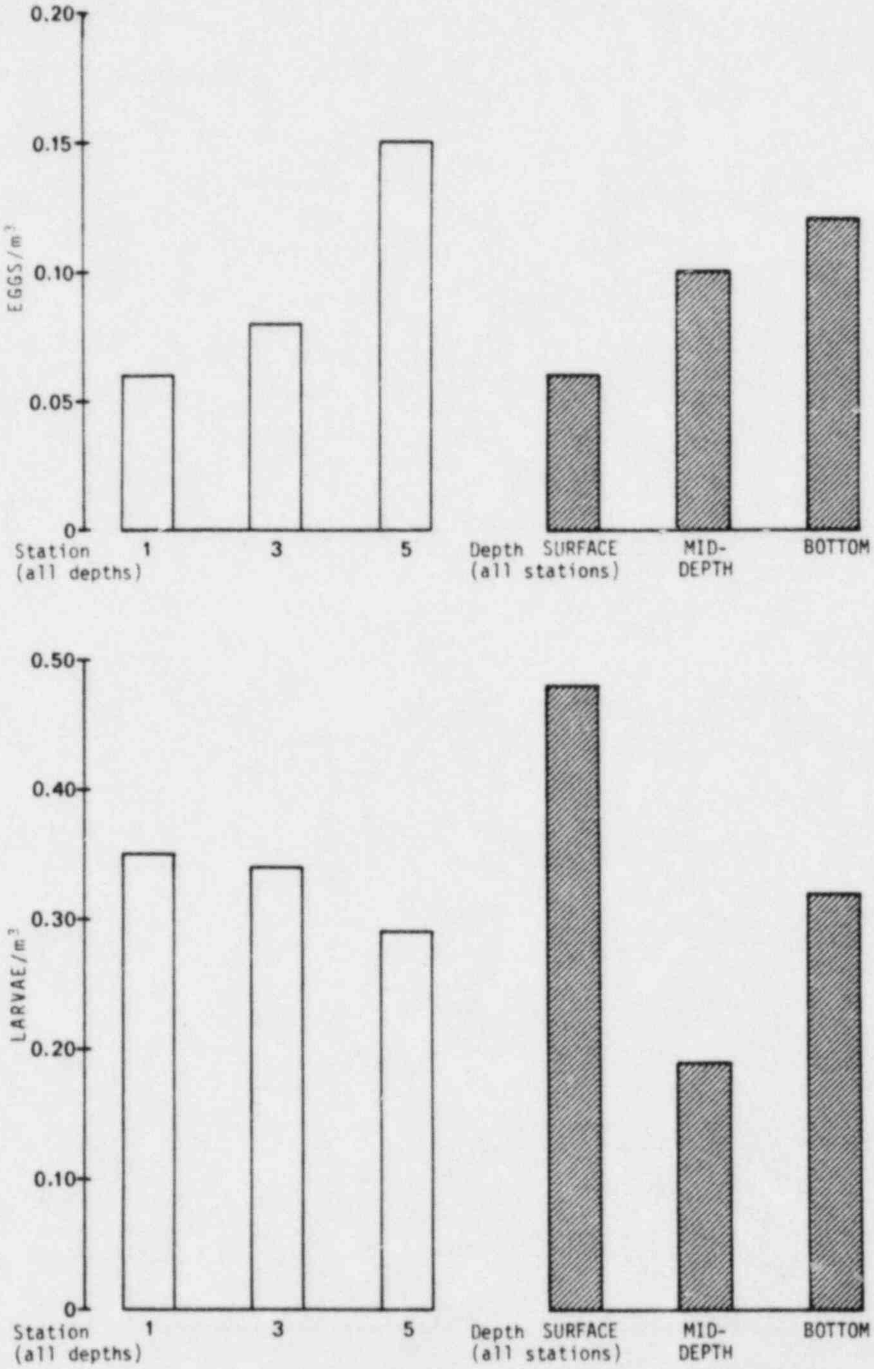

Figure G-3. Mean numbers of fish eggs and larvae per cubic meter collected by station and depth from the Ohio River, Marble Hill Plant site, 1977.

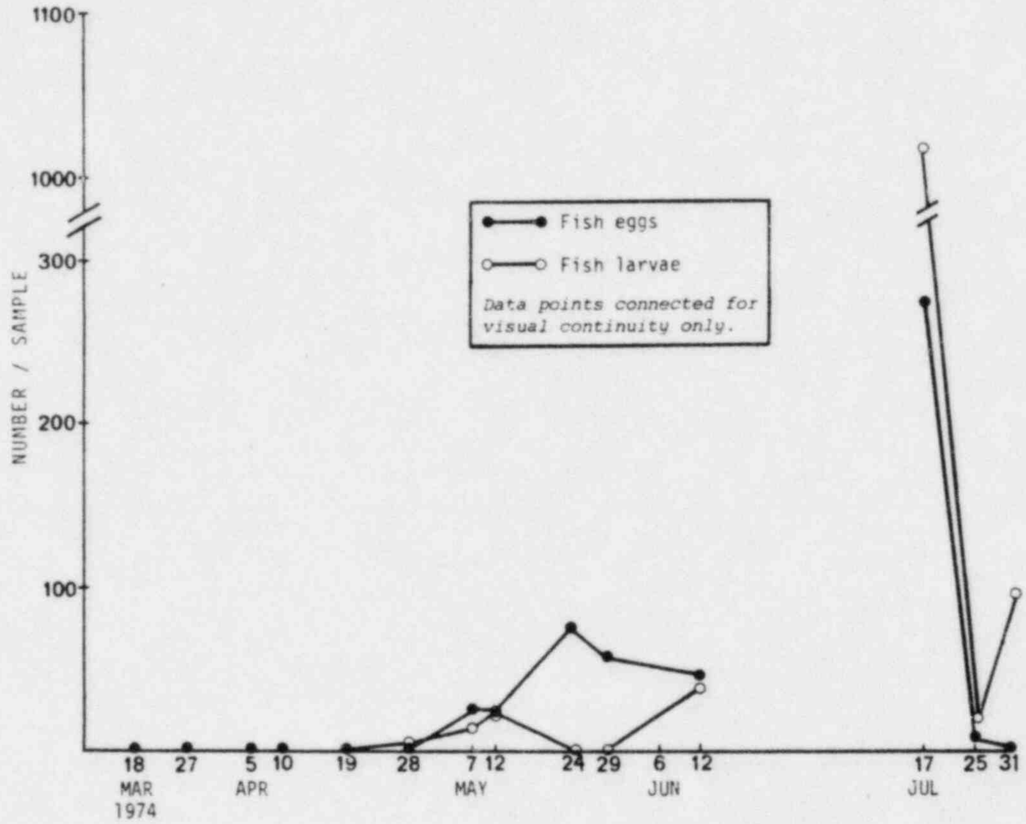

Figure G-4. Fish eggs and larvae collected by 15-minute drift net sets for baseline study (PSI, 1976), Marble Hill Plant site, 18 March-31 July 1974.

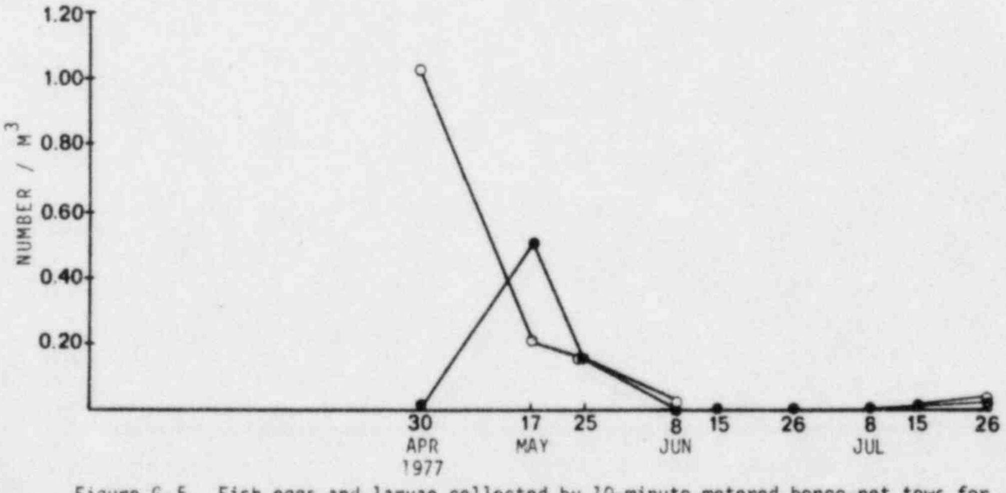

Figure G-5. Fish eggs and larvae collected by 10-minute metered bongo-net tows for construction phase study, Marble Hill Plant site, 30 April-26 July 1977.

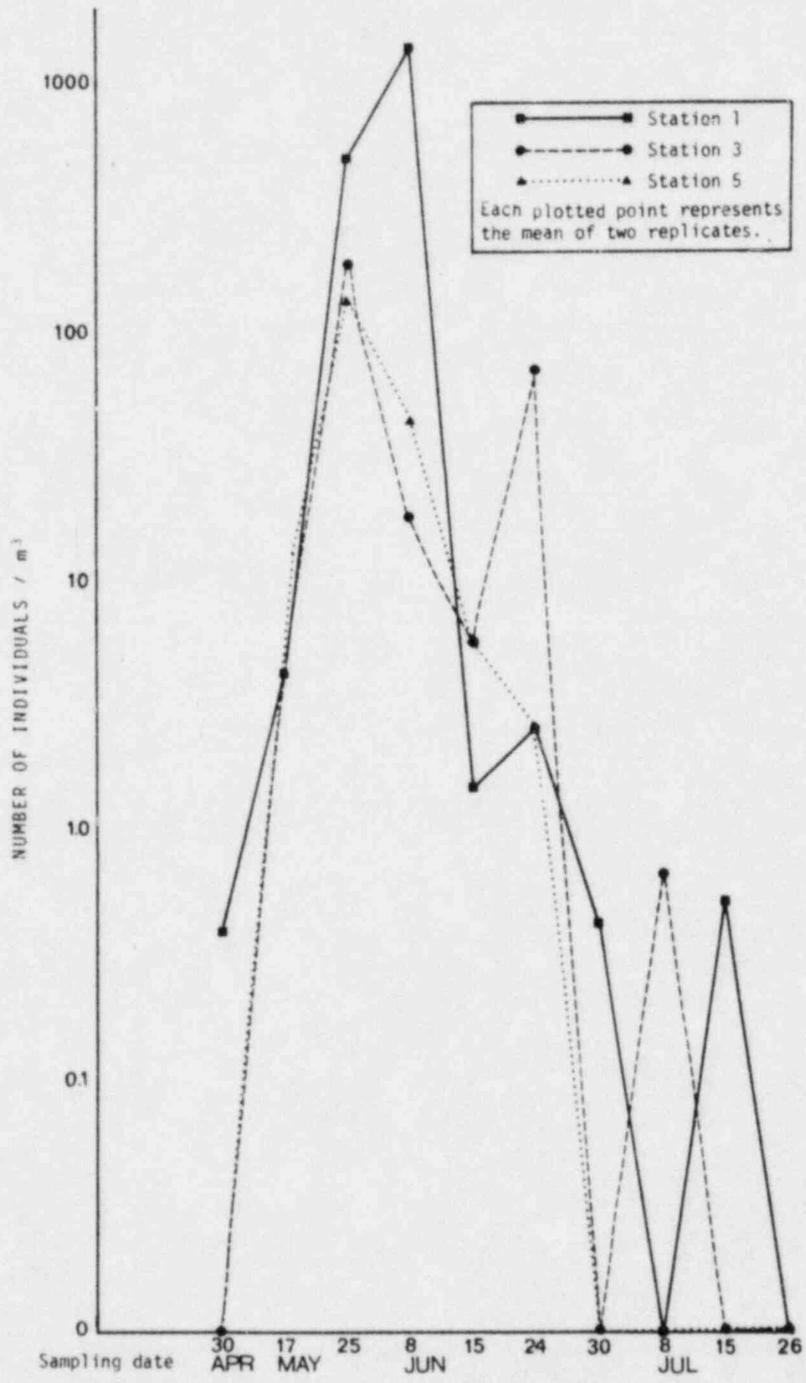

Figure G-6. Number of macroinvertebrates in surface bongo net samples, Marble Hill Plant, 1977.

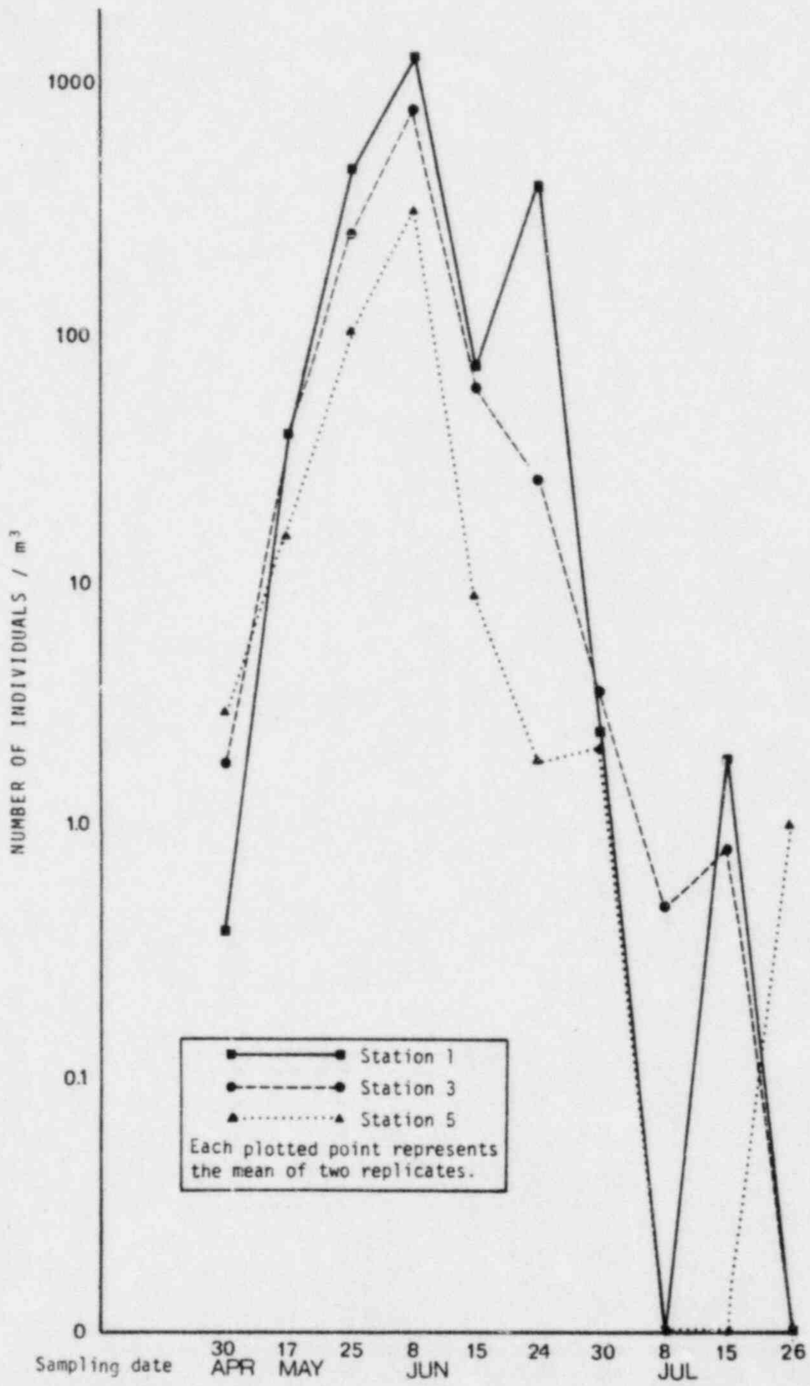

Figure G-7. Number of macroinvertebrates in mid-depth bongo net samples, Marble Hill Plant, 1977.

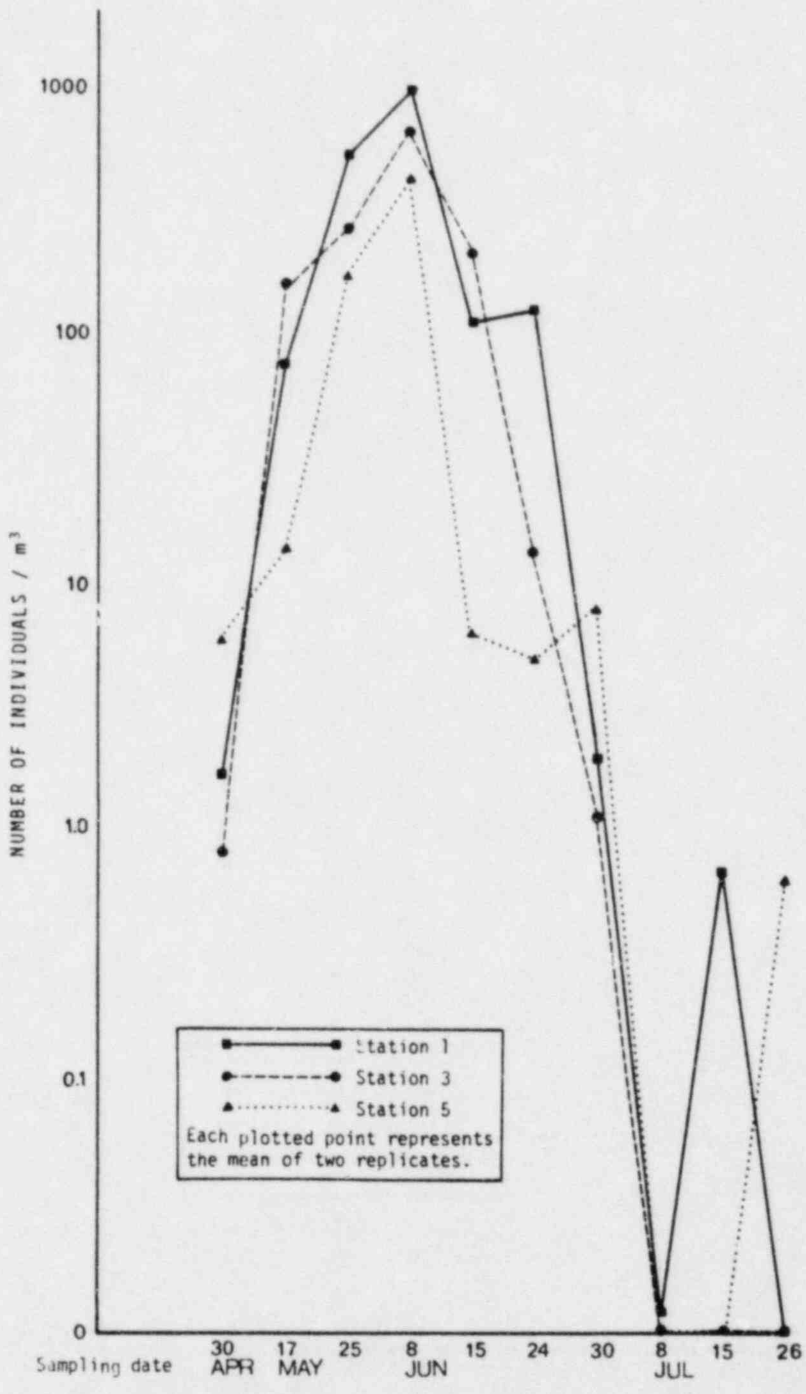

Figure G-8. Number of macroinvertebrates in bottom bongo net samples, Marble Hill Plant, 1977.

TABLE G-1

SCIENTIFIC AND COMMON NAMES OF LARVAL FISHES
COLLECTED IN THE VICINITY OF THE MARBLE HILL PLANT
1977

ORDER CLUPEIFORMES	
Clupeidae-herrings	
Dorosoma cepedianum	Gizzard shad
ORDER CYPRINIFORMES	
Cyprinidae-minnows and carp	
Cyprinus carpio	Carp
Notropis sp.	Shiners
Rhinichthys atratulus	Blacknose dace
Catostomidae-suckers	
Carpiodes and/or *Moxostoma* sp.[a]	Quillback and/or redhorse
ORDER PERCIFORMES	
Percichthyidae-temperate basses	
Morone chrysops	White bass
Centrarchidae-sunfishes	
Lepomis sp.	Sunfishes
Percidae-perches	
Perca flavescens	Yellow perch
Stizostedion canadense	Sauger
Sciaenidae-drums	
Aplodinotus grunniens	Freshwater drum

[a]Based on time of occurrence (April) and abundance of adults in the area.

TABLE G-2

MEAN NUMBER OF FISH EGGS COLLECTED PER CUBIC METER BY STATION AND DEPTH[a]
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT, 1977

Date	Station 1			Station 3			Station 5		
	S	M	B	S	M	B	S	M	B
30 APR	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17 MAY	0.03	0.27	0.12	0.03	0.45	0.30	0.36	0.51	0.85
25 MAY	0.15	0.06	0.17	0.06	0.21	0.15	0.21	0.03	0.20
8 JUN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15 JUN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24 JUN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30 JUN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8 JUL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15 JUL	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
26 JUL	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
Total	0.18	0.35	0.32	0.09	0.66	0.45	0.60	0.54	1.05

[a]S = Surface; M = Mid-depth; B = Bottom.

TABLE G-3

MEAN NUMBER OF FISH LARVAE COLLECTED PER CUBIC METER[a]
AND PERCENTAGE COMPOSITION BY DEPTH[b]
STATION 1, MARBLE HILL PLANT
1977

Category	30 April			17 May			25 May			8 June			15 June			24 June		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Gizzard shad							0.12	0.17	0.34									
Minnows[c]				0.03														
Carp		0.02		0.03	0.10	0.24	0.12	0.17	0.07									
Shiners							0.14				0.03							
Suckers	1.92	0.40	0.79				0.03	0.06	0.04									
White bass									0.07									
Sunfishes							0.03											
Yellow perch							0.03											
Sauger											0.04							
Freshwater drum							0.03	0.11	0.10		0.03							
Totals	1.92	0.42	0.79	0.06	0.10	0.24	0.50	0.51	0.62	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Category	30 June			8 July			15 July			26 July			Total			Percentage Composition		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Gizzard shad													0.12	0.17	0.34	4.8	15.0	20.6
Minnows[c]													0.03			1.2	0.0	0.0
Carp													0.15	0.29	0.31	6.1	25.7	18.8
Shiners													0.14	0.03		5.7	2.7	0.0
Suckers													1.95	0.46	0.83	78.6	40.7	50.3
White bass															0.07	0.0	0.0	4.2
Sunfishes													0.03			1.2	0.0	0.0
Yellow perch													0.03			1.2	0.0	0.0
Sauger														0.04		0.0	3.5	0.0
Freshwater drum													0.03	0.14	0.10	1.2	12.4	6.1
Totals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.48	1.13	1.65	100	100	100

[a]See Table G-6 for sample size.

[b]S = Surface; M = Mid-depth; B = Bottom.

[c]Other than carp and shiners.

TABLE G-4

MEAN NUMBER OF FISH LARVAE COLLECTED PER CUBIC METER[a]
AND PERCENTAGE COMPOSITION BY DEPTH[b]
STATION 3, MARBLE HILL PLANT
1977

Category	30 April			17 May			25 May			8 June			15 June			24 June		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Gizzard shad					0.06		0.17	0.03	0.15									
Minnows[c]																		
Carp					0.17	0.20	0.14	0.03	0.03									
Shiners	0.02								0.03									
Suckers	1.83	0.97	1.18															
White bass							0.03											
Sunfishes								0.06										
Yellow perch																		
Sauger		0.02																
Freshwater drum						0.04		0.03										
Totals	1.85	0.99	1.18	0.00	0.23	0.24	0.34	0.15	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Category	30 June			8 July			15 July			26 July			Total			Percentage Composition		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Gizzard shad													0.17	0.09	0.15	7.6	6.6	9.2
Minnows[c]																		
Carp													0.14	0.20	0.23	6.3	14.6	14.1
Shiners													0.02		0.03	0.9		1.8
Suckers													1.83	0.97	1.18	82.4	70.8	72.4
White bass													0.03			1.4		
Sunfishes										0.03			0.03	0.06		1.4	4.3	
Yellow perch																		
Sauger														0.02			1.5	
Freshwater drum														0.03	0.04		2.2	2.5
Totals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	2.22	1.37	1.63	100	100	100

[a]See Table G-6 for sample size.

[b]S = Surface; M = Mid-depth; B = Bottom.

[c]Other than carp and shiners.

TABLE G-5

MEAN NUMBER OF FISH LARVAE COLLECTED PER CUBIC METER[a]
AND PERCENTAGE COMPOSITION BY DEPTH[b]
STATION 5, MARBLE HILL PLANT
1977

Category	30 April			17 May			25 May			8 June			15 June			24 June		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Gizzard shad							0.03		0.03		0.04							
Minnows[c]																		
Carp				0.17	0.10	0.30			0.12									
Shiners						0.04												
Suckers	2.03	0.07	0.87	0.10					0.09									
White bass																		
Sunfishes				0.04														
Yellow perch																		
Sauger		0.02																
Freshwater drum					0.02		0.08	0.06	0.06									
Totals	2.03	0.09	0.87	0.31	0.12	0.34	0.11	0.06	0.30	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Category	30 June			8 July			15 July			26 July			Total			Percentage Composition		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Gizzard shad													0.03	0.04	0.03	1.2	12.9	2.0
Minnows[c]										0.05			0.05			2.0		
Carp													0.17	0.10	0.42	6.7	32.2	27.8
Shiners															0.04			2.6
Suckers													2.13	0.07	0.96	84.5	22.6	63.6
White bass																		
Sunfishes										0.02			0.06			2.4		
Yellow perch																		
Sauger														0.02			6.5	
Freshwater drum													0.08	0.08	0.06	3.2	25.8	4.0
Totals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	2.52	0.31	1.51	100	100	100

[a]See Table G-6 for sample size.

[b]S = Surface; M = Mid-depth; B = Bottom.

[c]Other than carp and shiners.

TABLE G-6

SAMPLE SIZE IN CUBIC METERS FOR FISH EGGS AND LARVAE
MARBLE HILL PLANT
30 APRIL - 26 JULY 1977

Station	Depth[a]	Date and replicate																			
		30 April		17 May		25 May		8 June		15 June		24 June		30 June		8 July		15 July		26 July	
		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1	S	25.3	25.7	16.9	16.6	16.8	18.0	14.2	13.8	14.0	14.6	23.5	24.2	21.9	22.6	18.8	19.6	18.2	19.3	20.4	21.5
	M	25.2	25.2	15.7	13.4	17.8	19.0	16.5	15.3	13.1	13.6	20.9	21.5	21.8	22.5	17.5	18.3	26.7	28.2	18.1	19.1
	B	24.3	24.4	15.2	18.2	16.4	14.5	20.0	17.1	11.1	11.5	27.0	27.5	22.4	21.2	22.2	23.3	16.1	16.9	16.0	17.0
3	S	23.5	24.1	20.4	15.5	17.7	18.1	11.4	11.7	14.9	15.6	20.4	20.9	15.9	16.5	21.9	22.9	27.2	28.8	17.4	18.3
	M	23.1	23.2	13.9	17.5	16.9	16.9	10.8	11.0	12.0	12.5	19.4	19.9	16.1	16.7	16.0	16.9	21.7	22.9	17.6	18.4
	B	22.0	22.2	14.8	15.2	17.1	17.4	12.6	13.0	17.7	17.7	19.6	20.2	17.2	18.6	17.1	18.0	22.6	23.5	18.0	18.9
5	S	20.1	20.4	15.1	15.5	18.6	19.1	11.7	12.1	19.2	19.8	19.5	20.2	17.6	18.2	22.6	23.5	23.8	25.0	22.2	22.9
	M	24.3	24.5	13.7	13.8	16.4	16.9	12.4	11.9	19.9	20.5	21.7	22.3	15.1	15.5	19.2	20.2	27.5	29.3	18.3	19.1
	B	22.4	22.5	13.4	13.8	17.2	17.6	12.0	12.1	18.2	18.8	19.4	20.1	15.4	15.9	23.0	24.1	26.5	28.1	17.3	18.2

[a] S = Surface; M=Mid-depth; B=Bottom.

TABLE G-7

OCCURRENCE OF DRIFT MACROINVERTEBRATE SPECIES
TAKEN DURING FISH EGG AND LARVAE SAMPLING
MARBLE HILL PLANT, 1977

Taxon	Station 1	3	5
Hydrozoa			
Hydra sp.	✓	✓	✓
Crustacea			
Cladocera			
Ceriodaphnia quadrangula	✓	✓	✓
Daphnia ambigua	✓	✓	✓
D. galeata	✓	✓	✓
D. parvula	✓	✓	✓
D. pulex	✓	✓	✓
D. retrocurva	✓	✓	✓
Leptodora kindti	✓	✓	✓
Copepoda			
Cyclops bicuspidatus thomasi		✓	
Ostracoda			
Cypridopsis sp.		✓	
Insecta			
Diptera			
Cricotopus sp.	✓	✓	
Dicrotendipes modestus	✓	✓	
Ephemeroptera			
Baetis sp.	✓		✓

TABLE G-8

STATISTICAL ANALYSIS OF DRIFT MACROINVERTEBRATE DENSITY DATA
MARBLE HILL PLANT, 1977

A. DATE/STATION COMPARISON

Two-Way ANOVA

Depth	Density comparison	Tabulated critical F value[a]	Calculated F value[a]
Surface	by sampling date	2.21	56.587*
	by station	3.32	61.255*
Mid-depth	by sampling date	2.21	87.577*
	by station	3.32	43.807*
Bottom	by sampling date	2.21	15.701*
	by station	3.32	6.087*

t - Tests

Station comparison	Tabulated critical t-value[a]	Calculated t-value[a]
Sta. 1 x Sta. 3	2.00	2.06*
Sta. 1 x Sta. 5	2.00	2.23*
Sta. 3 x Sta. 5	2.00	1.48 n.s.[b]

[a] α = .05.

[b] n.s. = not significant.

*Significant at α = .05.

TABLE G-8
(continued)
STATISTICAL ANALYSIS OF DRIFT MACROINVERTEBRATE DENSITY DATA
MARBLE HILL PLANT, 1977

B. DATE/DEPTH COMPARISON

Two-way ANOVA

Station	Density comparison	Tabulated critical F value[a]	Calculated F value[a]
1	by sampling date	2.21	45.730*
	by depth	3.32	0.299 n.s.[b]
3	by sampling date	2.21	51.185*
	by depth	3.32	24.174*
5	by sampling date	2.21	22.090*
	by depth	3.32	4.382*

t- Tests

Station	Depth comparison[c]	Calculated *t* value[a]
1	Surface x mid-depth	-0.256 n.s.
	Surface x bottom	-0.215 n.s.
	Mid-depth x bottom	0.050 n.s.
3	Surface x mid-depth	-1.529*
	Surface x bottom	-2.119*
	Mid-depth x bottom	-0.526 n.s.
5	Surface x mid-depth	-0.724*
	Surface x bottom	-1.321*
	Mid-depth x bottom	-0.626 n.s.

[a] $\alpha = .05$.

[b] n.s. = not significant.

[c] Critical value was 0.687.

*Significant at $\alpha = .05$.

H. MAMMALS

INTRODUCTION

The eastern cottontail rabbit (*Sylvilagus floridanus*), the eastern fox squirrel (*Sciurus niger*), and the eastern gray squirrel (*Sciurus carolinensis*) represent important game animals in the State of Indiana. For the years 1962-65, the average annual calculated kill of cottontails was about 1,540,000 (Mumford,1969), making cottontails the most important game animal in Indiana. Mumford (1969) reported annual Indiana harvests of eastern gray and fox squirrels to be approximately 300,000 and 1,130,000, respectively.

MATERIALS AND METHODS

Roadside counts of cottontail rabbits were conducted on three consecutive mornings during the May sampling trip. A route approximately 7.2 miles long around the perimeter of the Marble Hill site was chosen (Figure 1). On the first and third days, the route was followed in a counter-clockwise direction. A clockwise direction was followed on the second day. Counts were conducted in accordance with methods described by Lord (1959) and Kline (1965). The survey began about 20 minutes before sunrise and continued until about 20 minutes after sunrise. Pace was maintained below 20 mph during the survey.

Time-area counts of squirrels were conducted during the March and November sampling trips. Counts of 15 minutes duration each were made at five locations on each of two consecutive days in the woods on the east-facing slope of the Marble Hill site.

The distance to an observed squirrel was measured according to the method of Goodrum (1940), and the area of the field of view in which the squirrel was observed was calculated as follows:

$$\text{Observed area} = (0.75 \times \pi r_m^2)\ N$$

where: 0.75 = that portion of the area of a circle which the observer can see without moving

r_m = mean distance to observed squirrels

N = total number of observations

From these calculations, the number of squirrels per unit of observed area was estimated.

RESULTS AND DISCUSSION

During the May sampling trip, a total of 12 cottontail rabbits was observed (Appendix Table H-1). An average of 0.55 rabbits per mile of road was calculated. This average value was exactly half that calculated during baseline road counts (PSI, 1976). The route covered by the present survey was essentially the same as that used in the baseline survey.

Wind velocity, air temperature and rainfall were recorded at 12-hour intervals during the cottontail census. In general, rabbit counts have been found to increase with overnight temperature declines, decrease with higher wind velocities, and decrease with rainfall (Kline, 1965; Voris, 1956).

Wind velocity and overnight temperature declines were found to be very nearly the same for each of the three days of the cottontail census (Appendix Table H-1). There was no rainfall. Only wind direction varied appreciably. Although more rabbits were counted when the wind was from the southeast than from the north, the number of observations was too small for this variation to be considered significant.

The number of rabbits counted in a roadside census is naturally dependent on the size of the rabbit population of the surrounding area. Several factors such as degree of predation, disease, over-population, and severe weather are known to cause wide oscillation in rabbit populations from year to year. Severe weather may be the most significant factor in the present survey in light of the very cold winter of 1977. In any event, roadside counts made during the baseline study and the present study were too few to yield comparable data.

Small numbers of eastern fox squirrels were observed in March and November; only 0.36 and 0.24 squirrels per acre, respectively, were seen (Appendix Tables H-2 and H-3). Although eastern gray squirrels were reported in the baseline study, none were observed in 1977. It is possible that no grays live in the east slope woods since gray and fox squirrels are known to live apart from each other. In addition, grays prefer woodlands where ample ground cover exists (Hoffmeister and Mohr, 1957). The woods on the east-facing slope of the Marble Hill site are more open, a condition favorable to eastern fox squirrels.

The baseline study (PSI, 1976) determined an on-site density of one fox squirrel per acre. As in the case of the cottontail census, the number of time area counts made in that study was too few to yield comparable data. Data from the present study indicate that construction activities have not significantly altered the fox squirrel population on the site.

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