Attachment 20 to PLA-6219
Ecology III, Inc. 1987. Environmental Studies in the Vicinity of the Susquehanna Steam Electric Station. 1986 Annual Report

(NRC Document Request 60)

Ecology III, Inc.

ENVIRONMENTAL SERVICES

SUSQUEHANNA SES
BIOLOGICAL LABORATORY
R.D.#1 — BERWICK, PA 18603

ECOLOGICAL STUDIES OF THE SUSQUEHANNA RIVER IN THE VICINITY OF THE SUSQUEHANNA STEAM ELECTRIC STATION

1986 ANNUAL REPORT

Theodore V. Jacobsen, Editor

Prepared For

Pennsylvania Power and Light Company
Two North Ninth Street
Allentown, Pennsylvania 18101

Ecology III, Inc.
Susquehanna SES Biological Laboratory
R.D. 1, Berwick, Pennsylvania 18603

November 1987

CONTENTS

INTRODUCTION

The Susquehanna Steam Electric Station (Susquehanna SES) is a nuclear generating station with two boiling water reactors, each with an electrical generating capacity of 1,050 megawatts. It is located on a 536-hectare site in Salem Township, Luzerne County, 8 km northeast of Berwick, Pennsylvania. Under terms of an agreement finalized in January 1978, 90% of the Susquehanna SES is owned by the Pennsylvania Power and Light Company (PP&L) and 10% by the Allegheny Electric Cooperative, Inc.

Nonradiological monitoring was begun near the Susquehanna SES by PP&L in 1971. Ecology III, Inc. has conducted this monitoring since June 1985, with key personnel from the previous consultant, Ichthyological Associates, Inc. The preoperational objective of these studies was to establish a baseline of environmental conditions in the river and on the site prior to fuel load in the Unit 1 reactor. Fuel load was completed on 1 September 1982 and operational studies were begun using the same procedures. The environmental impact of the Susquehanna SES will be evaluated by comparing operational to preoperational data. Commercial production of electricity at Units 1 and 2 began on 8 June 1983 and 12 February 1985, respectively.

Throughout 1986, both aquatic and terrestrial studies were continued. Various physicochemical characteristics of the river were measured, and its algal, macroinvertebrate, and fish populations were monitored. Terrestrial investigations of the site dealt with studies of flora, vegetation, meteorology, and birds. Sampling procedures, data tabulations, and interpretation of the results are presented for each study in this annual progress report for 1986.

Most of the aquatic studies were conducted within 2 km of the intake structure and discharge diffuser of the Susquehanna SES. The slope of the riverbed in this stretch is 0.3 m/km and the average width is 300 m. Depth is relatively shallow in most areas (less than 2 m), but some pools may exceed 5 m even during low river flow. Beginning about 50 km upriver from the site, the "Wyoming Region" of the northern anthracite coalfield lies beneath or adjacent to the river. Acid mine drainages from this area, which enter from abandoned strip and shaft mines, continue to degrade the water quality at the site. Throughout this same area, domestic sewage, most of which has undergone primary treatment, also enters the river at several locations.

Terrestrial studies were done on the site or adjacent PP&L properties located within the Ridge and Valley Section of the Appalachian Valley Province. Elevations in the study area ranged from 150 m above mean sea level on the river floodplain to a maximum of 372 m on Council Cup Ridge, 3 km southeast of the site.

EXECUTIVE SUMMARY

The objective of the environmental studies during 1986 was to assess the impact of the Susquehanna SES upon the ecology of the Susquehanna River and local terrestrial areas. This was accomplished by comparison of preoperational and operational data. Aquatic studies were done at control sites upriver from the Susquehanna SES intake structure (SSES) and at indicator sites downriver from the discharge diffuser (Bell Bend). Most terrestrial studies were done on study plots surrounding the generating station. Brief summaries of the results of the 1986 studies follow.

River flow was high throughout much of 1986; monthly mean temperatures were above average in spring, but much below average in late summer. Physicochemical data were similar for all parameters at the control and indicator sites. This was the first year since sampling was initiated that a majority of the total iron samples were within criteria established for the river by the Pennsylvania Department of Environmental Resources (PaDER). There was no indication that the Susquehanna River was adversely affected by the effluent of the Susquehanna SES.

Comparison of preoperational (1977-82) and operational (1983-86) algae data did not reveal any adverse effects from operation of the Susquehanna SES on either the periphyton or phytoplankton communities in the Susquehanna River. Density variation and species composition of algae between sites in operational years were similar to those found in preoperational years. Decreases in density at both the SSES (control) and Bell Bend (indicator) sites during operational years were significantly correlated to natural changes in river level prior to sampling.

The Susquehanna SES has had no detectable impact on the macroinvertebrate community downriver from the discharge diffuser. Total mean density was greatest at Bell Bend IV (107,300 organisms/m^2) and was composed primarily of chironomids and naidids. Chironomids and naidids were also the dominant macroinvertebrates at Bell Bend III, but total mean density was only 59,700 org/m^2. At SSES I, total mean density (51,400 org/m^2) was less than half of that collected at Bell Bend IV. Total mean biomass at SSES I was 2.8 g/m^2; trichopterans composed 61% of the total. At both Bell Bend III and Bell Bend IV, total mean biomass was 1.9 g/m^2 and was composed of about 50% ephemeropterans. Biomass at Bell Bend has shown little variability in the operational years (1983-86).

Fish were sampled near the Susquehanna SES with an electrofisher and seine at SSES and Bell Bend in June, August, and October. While electrofishing, 895 specimens of 23 species were observed and 1,136 specimens (20 species) were captured by seine at SSES and Bell Bend. No significant differences ($P<0.05$) were found in the number of species present at the collection sites in either electrofishing or seining samples. Preoperational electrofishing and seining data, collected in June, August, and October 1976-82, were compared with data collected in the same months during operational years, 1983-86. These comparisons revealed no impact upon the fish community from operation of the Susquehanna SES.

Throughout 1986, 410 anglers were interviewed during 24 weekend and holiday surveys on a 6.0-km section of the Susquehanna River near the Susquehanna SES. Walleye was the most frequently caught fish (36.3% of the total catch), followed by channel catfish (24.5%), smallmouth bass (19.9%), common carp (5.8%), rock bass (3.7%), and white sucker (2.9%). Of these, walleye was most frequently harvested. Projected for 1986, an estimated 1,930 anglers fished 7,337 hours, caught 2,092 fish, and harvested 627. Operation of the Susquehanna SES had no observable impact on angler use of the Susquehanna River in the study area.

From 1972 through 1974 and 1977 through 1986, 708 species of vascular plants have been observed in the vicinity of the Susquehanna SES. In 1986, 388 taxa were found on six forest salt drift transects. Thirty-six plant parasitic diseases were observed on 49 host species. Disease frequency ranged from rare to abundant. These results were similar to those found in previous years. Meteorological records revealed that mean temperature was lowest in January, highest in July; rainfall was least in September and greatest in July. Fog occurred on 50 of 251 days of observation. Quantitative vegetation studies were conducted in three upland forests at the Susquehanna SES and at an upland forest near Elimsport, Pennsylvania, which served as a control site. In the upland forest plots, increases in tree density and decreases in sapling density occurred, which were attributed to normal successional changes. Other changes observed were due to natural forest dynamics (tree diseases, insect damage, etc.). None of the changes in the forest plots could be attributed to the operation of the Susquehanna SES.

In bird studies since 1977, 26 of the 241 species observed near the Susquehanna SES were listed as Pennsylvania species of special concern; 19 of these were observed in 1986. Two of these species, bald eagle and peregrine falcon, were also listed as endangered on the Federal List of Endangered Species. Breeding bird studies in two forest and two abandoned field plots revealed that 59 species nested or demonstrated other evidence of breeding in at least one of the study plots. Densities of most species nesting in abandoned field plots were higher in operational years as a result of plant succession. The nesting and winter densities of local residents were generally as high or higher than in preoperational years. Bird impaction studies at the Unit 1 and 2 cooling towers resulted in collection of 52 birds of 21 species. Most birds were collected during autumn migration (82%); these birds probably impacted on a tower when it was not emitting a visible plume. The impaction data suggest that cooling tower operation either deters bird impaction, impedes collection of impacted birds, or both.

PHYSICOCHEMICAL ANALYSES

by

Walter J. Soya

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Physicochemical data were collected from the Susquehanna River at a control site and two indicator sites relative to the Susquehanna SES. River flow was high throughout much of the year and monthly mean temperatures were above average in spring, but much below average in late summer. This was the first year since sampling was initiated that a majority of the total iron samples were within criteria established for the river by the Pennsylvania Department of Environmental Resources (PaDER). Aluminum, alkalinity, ammonia nitrogen, chromium, copper, dissolved oxygen, manganese, nickel, nitrate nitrogen, pH, temperature, total dissolved solids, and zinc data collected at the indicator sites were within PaDER criteria. Control and indicator site comparisons revealed that data were similar for all parameters. Data collected at the new Bell Bend I indicator site were similar to the original Bell Bend data; total dissolved solids, however, were slightly higher at Bell Bend I. There was no indication from these data that the Susquehanna River was adversely affected by the effluent of the Susquehanna SES.

INTRODUCTION

Water quality of the Susquehanna River near the Susquehanna SES has been monitored by the collection of physicochemical data since 1971. The objective from 1971 to September 1982 was to establish a baseline of preoperational river water quality prior to fuel load at the Susquehanna SES. These preoperational data are in annual reports from 1971 through 1982 (Ichthyological Associates 1972; Ichthyological Associates, Inc. 1973-74; Smith and Soya 1976; Jacobsen and Soya 1976-77; Soya and Jacobsen 1978-82; Soya et al. 1983). Since 1983, the objective has been to determine if operation of the Susquehanna SES has impacted the water quality of the river. This was done by comparing operational data from an indicator site with 1) preoperational data, 2) water quality criteria established by the Pennsylvania Department of Environmental Resources (PaDER), and 3) ambient data from a control site. Similar comparisons from previous years are in annual reports from 1983 through 1985 (Soya et al. 1984 and Soya and Jacobsen 1985-86); the 1986 comparisons are presented in this report.

PROCEDURES

Throughout 1986, physicochemical data were collected from the river at three sites: SSES control site, Bell Bend, and Bell Bend I indicator sites (Fig. A-1). River temperature, level, and flow were monitored at the Susquehanna SES Biological Laboratory. The laboratory is on the west bank, 495 m upriver from the center of the Susquehanna SES intake structure. The control site (SSES) is 230 m upriver from the intake structure and about 40 m from the west bank. The Bell Bend indicator site is 690 m downriver from the Susquehanna SES discharge diffuser and about 40 m from the west bank. The Bell Bend I indicator site is 400 m downriver from the discharge diffuser and about 55 m from the west bank.

The Bell Bend I site was added to the physicochemical monitoring program in March 1986. Results of a dye study performed in the Susquehanna River near the Susquehanna SES by Sutron (1985) revealed that the center of the discharge plume flowed downriver about 55 m from the west bank. Bell Bend I was established to obtain samples closer to the center of the plume and to avoid shallow river conditions near the original Bell Bend site.

Temperature and depth of the river were recorded continuously on 7-day graphs. Sensors for both recorders were located on the river bottom within 30 m of the bank. Temperature was read directly from the graph, whereas depth was converted to river level above mean sea level. River level data were used to calculate flow (Table A-1). Daily means of temperature and level were determined by averaging hourly values from 0100 through 2400 h. The daily minimum and maximum temperature and level and their respective hour of occurrence were tabulated. When either a minimum or maximum value remained constant for several hours in a day, only the first hour of occurrence was noted.

Physicochemical data were collected at the SSES, Bell Bend, and Bell Bend I sites once per week from April through September, and twice per month from January through March and October through December, with the exception that Bell Bend I was not sampled in January and February. The order of sampling and analysis at the three sites was determined randomly. All samples were collected between 1200 and 1400 h. A grab sample and dissolved oxygen sample of surface water were taken while drifting over each site in a boat; air and surface water temperature and prevailing weather conditions were recorded (Table A-1). River level and flow were tabulated with the SSES data.

Samples were immediately transported to the laboratory and analyzed for turbidity, dissolved oxygen, total alkalinity, pH, specific conductance, sulfate, and solids (total and total suspended). Aliquots of each grab sample were fixed for analyses of total and dissolved iron which were performed by personnel at the Pennsylvania Power and Light (PP&L) Water Laboratory, Hazleton, Pennsylvania. The dissolved iron procedure used since 1978 is presently under review; data collected in 1986 are reported, but will not be interpreted until the review is completed. All analyses (Table A-1) were conducted within the holding time recommended by the U.S. Environmental Protection Agency (EPA 1979) and associated calculations were maintained in bound notebooks.

The 1986 physicochemical data at the SSES control site were compared to data collected since 1973. Nonparametric statistics were used to determine if 1) year-to-year changes had occurred in any parameter and 2) if the changes constituted a trend. Friedman's two-way analysis of variance test was used in the first determination, and Page's distribution-free test for ordered alternatives was used in the second (Hollander and Wolfe 1973). These tests were based on monthly mean values; a 5% probability level was used to determine significance.

Personnel from the Susquehanna SES Biological Laboratory also collected surface river water samples monthly at SSES and Bell Bend (Fig. A-1) for analysis at the PP&L Water Laboratory. Water temperature and dissolved oxygen were measured by Biological Laboratory personnel; all other analyses were determined at the PP&L Water Laboratory according to either *Standard Methods* (APHA 1985) or *Methods for Chemical Analysis of Water and Wastes* (EPA 1979).

RESULTS AND DISCUSSION

River Temperature, Level, and Flow

In 1986, the river temperature ranged from 0.0 C, recorded on numerous days in January and February, to 27.3 C on 30 July (Table A-2). The lowest daily mean temperature, also 0.0 C, occurred on several days in January and February, whereas the highest, 26.6 C, occurred on 30 July. The daily mean temperature varied least in January and February and most in October. The monthly mean temperature was lowest, 0.4 C, in January and highest, 23.8 C, in July.

The minimum river level, 148.21 m above msl, occurred on 26 September (Table A-3). The maximum river level, 154.55 m above msl, was recorded on 16 March. The daily mean level varied least in September and most in March. The monthly mean level was highest, 150.72 m above msl, in March and lowest, 148.35 m above msl, in September.

River flow ranged from 44 m^3/s to 5,300 m^3/s (calculated from the minimum and maximum river levels). The daily mean flow was least, 48 m^3/s, on 26 September and greatest 5,228 m^3/s, on 16 March (Table A-4). The daily mean flow varied least in September and most in March. The monthly mean flow was lowest, 68 m^3/s, in September and highest, 1,309 m^3/s, in March.

Most noteworthy of these data was the high river flow throughout much of the year. Monthly flows were above average at the Susquehanna SES Biological Laboratory (since 1974) for each month except April, May, and September. Also of importance, monthly temperatures in 1986 were above average in the spring from March through June, but were much below average for July, August, and September. The means for the latter months collectively were the lowest in the last 10 years.

River Water Quality at the Susquehanna SES

The Susquehanna SES is located in a water quality recovery zone on the Susquehanna River. Severe degradation of the river occurs in the Wyoming Valley from the confluence with the Lackawanna River (48 km upriver from the Susquehanna SES) downriver to Nanticoke, Pennsylvania (22 km upriver), due mainly to abandoned coal mine drainages. Sewage effluents (raw, primary, and secondary) enter the river from several towns and cities as near as 6 km upriver. Pollution from solid waste in upriver tributaries also contributes to degradation (Malione et al. 1984). Although these pollutants continued to degrade water quality at the Susquehanna SES site in 1986, overall improvement has been documented since 1976 (Soya and Jacobsen 1986).

Analytical results for water samples collected at the SSES control and the Bell Bend and Bell Bend I indicator sites throughout 1986 are provided in Table A-5 and summarized in Table A-6. A comparison of the 1986 operational data (Table A-6) with preoperational data at both SSES and Bell Bend (Table A-7) revealed that the 1986 data were within the preoperational ranges of all parameters except percent saturation of dissolved oxygen. The maximum percent saturation of dissolved oxygen at SSES exceeded the preoperational range by one percentage point in 1986. This change would not result in any negative ecological impact.

River temperature, dissolved oxygen, total alkalinity, total iron, pH, and total dissolved solids were compared with water quality criteria established for this reach of the Susquehanna River (Table A-8) by the PaDER (1979). All of these parameters, except iron, were within the criteria at both the indicator and control sites in 1986 (Table A-6).

Total iron concentrations in 1986 exceeded the 1.5 mg/l PaDER criteria in only 18 of 38 samples (47%) at the control site and 13 of 38 samples (34%) at the Bell Bend indicator site. This was the first year since sampling was initiated that a majority of samples were within the PaDER criteria at both sites. For example, in 1973, only 1 of 152 samples collected at the SSES site was within the criteria; since then, total iron concentrations have gradually decreased. This improvement was due mainly to the termination of pumping acid mine water into the river after the Tropical Storm Agnes flood in June 1972. During preoperational sampling at the Bell Bend indicator site, 272 of 373 samples (73%) exceeded the criteria; since operation began, only 160 of 273 samples (59%) exceeded it. At the control site, 80% of the samples exceeded the criteria during the same preoperational period, and 65% exceeded it since operation. This also shows that more data have been within the criteria at the indicator site than at the control site since 1978.

In 1976, physicochemical data were first statistically tested to assess possible water quality trends (Jacobsen and Soya 1977). At that time, significant decreasing trends were found for turbidity, specific conductance, sulfate, and total iron, and increasing trends for total alkalinity, pH, and dissolved oxygen. These trends were linked to the termination of pumping acid mine water into the river after flooding from Tropical Storm Agnes in 1972. Prior to the flood, iron- and sulfur-rich water was pumped from deep abandoned coal shafts in the lower Wyoming Valley to maintain ground water levels. In the years since Agnes, mine water entered the river by gravity flow at five major seeps and boreholes. Data collected by the PaDER has shown that water quality from these discharges has improved since 1972 resulting in reduced impact to the river (Soya and Jacobsen 1985).

The decrease in mine drainage pollutants upriver is evident in the water quality at the Susquehanna SES site (Figs. A-2 through A-7). For the period 1973 through 1986, there has been a significant decreasing trend in turbidity, sulfate, total iron, and total suspended solids, and a significant increasing trend in total alkalinity and pH. In spite of decreased sampling effort in recent years which would tend to obscure trends, these six trends have remained significant (personal communication, Dr. F. M. Williams, Pennsylvania State University).

Control and Indicator Site Comparisons

Physicochemical data collected at the SSES control and Bell Bend indicator sites in 1986 are reported in Table A-5 and summarized in Table A-6. Data for individual samples, monthly means, annual means, and standard errors were similar for all parameters. Turbidity and concentrations of sulfate, total iron, and dissolved iron were slightly lower at the indicator site in a majority of samples. Dissolved oxygen and solids (total, suspended, and dissolved) data, from indicator site, were variable relative to the ambient, but no patterns were evident. These results indicate that the Susquehanna SES effluent did not adversely affect any of the above parameters.

Conductivity measured at the indicator site was, in all cases, equal to or greater than that at the control sites (Table A-5). It was higher in approximately 50% of the samples at both Bell Bend and Bell Bend I. The increase above ambient was from 5 to 20 µmhos/cm in a range of 185 to 415 µmhos/cm. These higher conductivities were caused by increased concentrations of dissolved solids in the Susquehanna SES effluent (river water is normally concentrated 3-4 times in the cooling towers). This increase in conductivity probably had no ecological impact because a natural range of 74 to 525 µmhos/cm was documented in preoperational studies at the Bell Bend site.

Bell Bend I

Most data collected at Bell Bend I were similar to those at Bell Bend (Table A-5). The turbidity, dissolved oxygen, total alkalinity, pH, conductivity, and sulfate data from both sites were usually very similar, and when differences did occur, there were no discernable patterns. Iron and solids data, however, were usually not as similar. Total iron, total solids, and total dissolved solids at Bell Bend I were higher than respective Bell Bend data in more than a majority of samples. Total iron concentrations at Bell Bend I, however, were lower than respective concentrations at SSES in a majority of samples. The higher total solids and total dissolved solids at Bell Bend I were probably caused by elevated concentrations in the Susquehanna SES effluent. However, as stated previously, all total dissolved solids data at both indicator sites were within PaDER criteria. Additional samples will be collected at both sites throughout 1987 to further evaluate the Bell Bend I site.

PP&L Data

Personnel from the PP&L Water Laboratory analyzed monthly samples collected at the SSES and Bell Bend sites for 44 water quality parameters (Table A-9). Concentrations of sulfate, iron, aluminum, and manganese show that acid mine drainage pollution persists at the site. The PaDER water quality criteria for total iron (1.5 mg/l) in the river was exceeded in 5 of 12 samples at both sites (Table A-8). All aluminum, alkalinity, ammonia nitrogen, chromium, copper, dissolved oxygen, manganese, nickel, nitrate nitrogen, pH, temperature, total dissolved solids, and zinc data collected at both the control and indicator sites were within the PaDER criteria in 1986. Major cation and anion composition at SSES was similar to that found in previous years (Soya and Jacobsen 1985). Calcium was the dominant cation (mean = 61.5 mg/l and 1.36 me/l). The dominant anion in each sample was bicarbonate (mean = 61.5 mg/l and 1.01 me/l). There were no discernable or consistent differences between the control and indicator sites throughout these twelve samples.

Conclusion

Based on 1986 data, the water quality of the Susquehanna River was not adversely affected by the effluent of the Susquehanna SES. Aluminum, alkalinity, ammonia nitrogen, chromium, copper, dissolved oxygen, manganese, nickel, nitrate nitrogen, pH, temperature, total dissolved solids, and zinc data collected at the Bell Bend indicator site were within criteria established for the river by the PaDER. This was the first year since sampling was initiated at Bell Bend that a majority of the total iron concentrations were within PaDER criteria.

Data collected at the new Bell Bend I indicator site were similar to data from the original Bell Bend site. Total dissolved solids, however, were slightly higher at Bell Bend I, but were still within PaDER criteria. Although specific conductance at the indicator sites was above ambient in approximately 50% of the samples, data were still within the preoperational range.

REFERENCES CITED

American Chain and Cable Company, Bristol Division. 1971. Instruction manual for indicating and recording liquid-level bubbler-type gauges in series "500" case. ACCO, Bristol Division, Waterbury, CT. Loose-leaf publ., n.p.

American Public Health Association. 1985. Standard methods for the examination of water and wastewater. 16th ed. APHA, Washington, D.C. 1268 pp.

Hewlett-Packard. 1972. HP-9830A STAT PAC. Vol. 1. Hewlett-Packard, Loveland, CO. 75 pp.

Hollander, M. and D. A. Wolfe. 1973. Nonparametric statistical methods. John Wiley and Sons, Inc., New York, NY. 503 pp.

Ichthyological Associates. 1972. An ecological study of the North Branch Susquehanna River in the vicinity of Berwick, Pennsylvania (Progress report for the period January-December 1971). Pa. Power and Light Co., Allentown, PA. 232 pp.

Ichthyological Associates, Inc. 1973. An ecological study of the North Branch Susquehanna River in the vicinity of Berwick, Pennsylvania (Progress report for the period January-December 1972). Pa. Power and Light Co., Allentown, PA. 658 pp.

________. 1974. An ecological study of the North Branch Susquehanna River in the vicinity of Berwick, Pennsylvania (Progress report for the period January-December 1973). Pa. Power and Light Co., Allentown, PA. 838 pp.

Jacobsen, T. V. and W. J. Soya. 1976. Physicochemical analyses. Pages 3-47 in T. V. Jacobsen (ed.), Ecological studies of the North Branch Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1975). Ichthyological Associates, Inc., Berwick, PA.

________ and ________. 1977. Physicochemical analyses. Pages 3-35 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1976). Ichthyological Associates, Inc., Berwick, PA.

Malione, B. R., C. P. McMorran, and S. E. Rudisill. 1984. Water quality and biological survey of the Susquehanna River basin from Waverly, New York to Sunbury, Pennsylvania. Publ. No. 89. Susquehanna River Basin Commission, Harrisburg, PA. 161 pp.

Pennsylvania Department of Environmental Resources. 1979. Water quality standards, chapter 93. Rules and Regulations, title 25. Article II, water resources. PaDER, Harrisburg, PA. 142 pp.

Smith, K. M. and W. J. Soya. 1976. Physicochemical analyses. Pages 3-41 in T. V. Jacobsen (ed.), Ecological studies of the North Branch Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Progress report for the period January-December 1974). Ichthyological Associates, Inc., Berwick, PA.

Soya, W. J. and T. V. Jacobsen. 1978. Physicochemical analyses. Pages 3-34 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1977). Ichthyological Associates, Inc., Berwick, PA.

________ and ________. 1979. Physicochemical analyses. Pages 3-42 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1978). Ichthyological Associates, Inc., Berwick, PA.

________ and ________. 1980. Physicochemical analyses. Pages 3-43 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1979). Ichthyological Associates, Inc., Berwick, PA.

________ and ________. 1981. Physicochemical analyses. Pages 3-44 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1980). Ichthyological Associates, Inc., Berwick, PA.

________ and ________. 1982. Physicochemical analyses. Pages 3-47 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1981 annual report). Ichthyological Associates, Inc., Berwick, PA.

________ and ________. 1985. Physicochemical analyses. Pages 7-53 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1984 annual report). Ichthyological Associates, Inc., Berwick, PA.

________ and ________. 1986. Physicochemical analyses. Pages 6-51 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1985 annual report). Ecology III, Inc., Berwick, PA.

Soya, W. J., B. P. Mangan, and T. V. Jacobsen. 1983. Physicochemical analyses. Pages 4-46 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1982 annual report). Ichthyological Associates, Inc., Berwick, PA.

________, ________, and ________. 1984. Physicochemical analyses. Pages 7-57 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1983 annual report). Ichthyological Associates, Inc., Berwick, PA.

Sutron Corporation. 1985. Study of travel time and mixing characteristics for the Susquehanna River below the Susquehanna Steam Electric Station. Sutron Report No. SCR85-0007. Sutron Corp., Herndon, VA.

U. S. Environmental Protection Agency. 1979. Methods for chemical analysis of water and wastes. EPA, Cincinnati, OH. 460 pp.

Table A-1

Physicochemical parameters and methods of analyses, 1986.

Parameter	Method	Reference
River Level	Seven-day continuous recording from an Acco Bristol, Model No. G500-15 bubbler-type water level gauge	ACCO (1971)
River Flow	River flow = 231.4857 + 321.2703 (river level -149) + 106.6087 (river level $-149)^2$	Hewlett Packard (1972)
River Temperature	Seven-day continuous recordings from a calibrated, Leeds and Northrup Speedomax Thermistor-type, Model R temperature recorder	APHA (1985)
	Calibrated, mercury thermometer	APHA (1985)
Air Temperature	Calibrated, mercury thermometer	APHA (1985)
Dissolved Oxygen	Membrane electrode	APHA (1985)
pH	Glass electrode	APHA (1985)
Total Alkalinity	Potentiometric titration	APHA (1985)
Specific Conductance	Self-contained conductivity meter	APHA (1985)
Sulfate	Turbidimetric	APHA (1985)
Total Iron	Atomic absorption spectrophotometric determination of extractable iron	APHA (1985)
Dissolved Iron	Atomic absorption spectrophotometric determination of dissolved iron	APHA (1985)
Total Solids	Evaporation, dried at 105 C	APHA (1985)
Total Suspended Solids	Solids retained on a glass fiber filter, dried at 105 C	APHA (1985)
Total Dissolved Solids	Calculation; total solids minus total suspended solids	--
Turbidity	Nephelometric	APHA (1985)

Table A-2

Daily minimum, maximum, and mean temperature (C) of the Susquehanna River at the Susquehanna SES Biological Laboratory, 1986.

DATE	MINIMUM	TIME	MAXIMUM	TIME	MEAN
JAN					
1	0.1	0300	0.7	1300	0.2
2	0.1	0100	0.5	1300	0.3
3	0.2	0100	0.9	1400	0.5
4	0.8	0100	1.0	1300	0.8
5	0.2	2400	1.0	1300	0.8
6	0.0	2000	0.5	1300	0.2
7	0.0	0100	0.1	1100	0.0
8	0.0	0100	0.2	1100	0.1
9	0.0	0100	0.3	1300	0.1
10	0.0	0100	0.1	0900	0.1
11	0.0	0100	0.5	1400	0.1
12	0.1	0100	1.1	1400	0.6
13	0.2	2400	1.0	1300	0.7
14	0.0	0300	0.2	1300	0.1
15	0.0	0100	0.2	1200	0.1
16	0.0	2400	0.5	1400	0.2
17	0.0	0100	0.3	1500	0.1
18	0.1	0100	1.0	1500	0.5
19	0.8	0100	1.9	2400	1.2
20	1.7	2300	1.9	0100	1.9
21	0.0	2100	1.7	0100	0.8
22	0.0	0100	0.6	1900	0.3
23	0.2	1000	0.8	1700	0.5
24	0.1	1000	0.6	0100	0.4
25	0.2	1000	0.4	0100	0.2
26	0.0	1100	0.2	0100	0.1
27	0.0	0100	0.1	1100	0.0
28	0.0	0100	0.0	0100	0.0
29	0.0	0100	0.0	0100	0.0
30	0.0	0100	0.1	1100	0.0
31	0.0	0100	0.2	1400	0.1
				JAN MEAN:	0.4
				SE:	0.08

DATE	MINIMUM	TIME	MAXIMUM	TIME	MEAN
FEB					
1	0.0	0100	0.1	1000	0.1
2	0.1	0100	0.4	1500	0.2
3	0.0	0400	0.5	1400	0.2
4	0.0	0400	0.1	0900	0.1
5	0.1	0100	0.3	1600	0.2
6	0.0	2400	0.6	1300	0.3
7	0.0	0100	0.0	0100	0.0
8	0.0	0100	0.1	1300	0.0
9	0.0	0100	0.1	1100	0.0
10	0.0	0100	0.3	1500	0.2
11	0.1	0400	0.3	1400	0.2
12	0.1	0100	0.3	1300	0.1
13	0.1	0100	0.3	1400	0.1
14	0.1	0100	0.1	0100	0.1
15	0.1	0100	0.6	1500	0.2
16	0.1	0100	0.3	1400	0.2
17	0.2	0100	0.7	1300	0.5
18	0.7	0100	1.0	2400	0.9
19	0.3	1800	1.1	1200	0.8
20	0.2	0800	0.6	0100	0.3
21	0.3	0100	1.0	2200	0.6
22	0.9	0500	1.0	0100	1.0
23	0.9	0100	1.2	2100	1.0
24	1.1	0600	1.8	2100	1.4
25	1.2	2400	1.6	0100	1.4
26	0.8	0800	1.2	0100	1.0
27	0.7	0800	1.1	1500	0.9
28	0.5	0800	0.9	0100	0.8
				FEB MEAN:	0.5
				SE:	0.08

DATE	MINIMUM	TIME	MAXIMUM	TIME	MEAN
MAR					
1	0.6	0800	1.1	1400	0.9
2	0.9	0700	1.0	0100	1.0
3	0.9	0100	1.9	1500	1.4
4	1.9	0100	2.1	1300	2.0
5	2.0	0100	2.9	1500	2.5
6	2.8	0100	3.0	0900	3.0
7	1.7	2400	2.9	0100	2.4
8	1.1	0600	1.9	1400	1.5
9	1.1	2300	1.4	1400	1.2
10	1.1	0100	2.8	1700	2.0
11	2.8	0100	4.1	1600	3.6
12	2.7	2400	3.9	0100	3.1
13	2.3	1800	2.7	0100	2.5
14	2.2	0500	2.9	2400	2.4
15	2.9	0100	3.6	1700	3.3
16	3.4	2300	3.8	1400	3.6
17	3.0	2400	3.4	1500	3.3
18	2.9	0300	3.3	1800	3.1
19	3.3	0100	4.7	2300	3.9
20	4.8	0100	5.0	1300	4.9
21	4.2	0700	4.9	0100	4.6
22	3.5	0800	4.2	0100	3.8
23	3.2	0700	3.9	1900	3.6
24	3.3	0700	4.0	1600	3.7
25	3.9	0800	5.0	2200	4.4
26	5.0	0100	6.7	2400	5.7
27	6.7	0100	7.4	1600	7.0
28	7.0	0100	8.1	1700	7.6
29	7.8	0500	9.0	1600	8.5
30	8.9	0500	9.9	1600	9.4
31	9.8	0100	10.9	1600	10.4
				MAR MEAN:	3.9
				SE:	0.44

DATE	MINIMUM	TIME	MAXIMUM	TIME	MEAN
APR					
1	10.3	0600	11.8	1800	11.1
2	11.4	0800	12.3	1600	11.9
3	11.7	0700	12.6	1600	12.2
4	11.7	2100	12.4	0100	12.1
5	11.0	2400	11.7	0100	11.5
6	9.8	2400	11.0	0100	10.4
7	9.4	0700	10.2	1500	9.9
8	9.7	0800	10.6	1600	10.1
9	9.5	2400	10.1	0100	9.8
10	8.8	2300	9.5	0100	9.1
11	8.1	1900	8.8	0100	8.3
12	7.8	2400	8.1	1300	8.0
13	7.3	0600	8.5	1400	8.0
14	8.0	0400	9.3	1500	8.7
15	8.9	1900	9.1	0700	9.0
16	8.0	2400	8.8	0100	8.4
17	6.7	2400	8.0	0100	7.3
18	6.4	0500	7.8	2100	7.0
19	7.8	0100	9.7	2300	8.6
20	9.7	0100	10.9	2200	10.2
21	11.0	0100	11.5	1700	11.2
22	10.2	2400	11.1	0100	10.9
23	8.3	2400	10.1	0100	9.3
24	8.1	0400	9.2	1500	8.7
25	9.1	0200	10.7	1900	9.9
26	10.7	0100	11.3	1600	11.0
27	11.1	0100	12.9	2000	12.1
28	12.8	0100	14.2	1600	13.6
29	14.1	0100	14.9	1600	14.6
30	14.3	0600	15.8	1400	15.2
				APR MEAN:	10.3
				SE:	0.37

Table A-2 (cont.)

DATE	MINIMUM	TIME	MAXIMUM	TIME	MEAN	DATE	MINIMUM	TIME	MAXIMUM	TIME	MEAN
MAY						JUN					
1	15.1	2400	16.2	1500	15.6	1	22.8	0700	24.7	1500	23.7
2	13.4	2400	15.1	0100	14.4	2	22.1	2400	23.9	0100	23.1
3	12.2	2200	13.4	1500	12.9	3	20.5	0800	21.9	1400	21.3
4	11.9	0300	12.9	1500	12.3	4	19.8	0600	21.7	1500	20.8
5	11.9	0100	14.0	1500	13.0	5	20.9	0400	21.9	1600	21.4
6	13.3	0300	15.0	1700	14.3	6	20.4	2400	21.6	1300	21.2
7	14.5	0500	16.8	1600	15.7	7	19.8	2200	20.4	0200	20.0
8	15.8	0600	17.2	1700	16.5	8	19.3	0700	20.3	2200	19.8
9	16.0	0500	17.8	1400	16.9	9	19.8	0800	20.8	1700	20.3
10	16.0	0500	18.0	1400	17.1	10	19.9	0900	21.0	1700	20.5
11	16.5	0700	18.3	1500	17.5	11	20.8	0100	21.8	1900	21.2
12	16.9	0600	19.0	1500	17.9	12	20.2	2400	21.7	0100	21.1
13	17.1	0600	19.4	1400	18.2	13	18.4	2300	20.1	0100	19.0
14	17.1	2400	18.0	0100	17.7	14	18.1	0600	19.9	1900	19.0
15	16.9	0400	17.3	1600	17.0	15	19.5	0700	20.4	1700	20.0
16	16.6	0500	17.8	1800	17.1	16	20.2	0600	21.4	1800	20.9
17	17.0	0600	19.1	1600	18.1	17	21.0	0700	22.0	1500	21.5
18	18.1	0700	20.9	1500	19.5	18	20.4	0800	21.2	1600	20.9
19	19.9	0500	22.1	1300	21.1	19	20.1	0500	21.1	1400	20.5
20	21.0	2300	21.6	0100	21.3	20	20.0	0500	21.0	1400	20.5
21	19.8	2400	20.9	0100	20.1	21	19.9	0600	21.4	1500	20.7
22	17.3	2400	19.7	0100	18.3	22	20.0	0600	21.8	1400	21.0
23	16.3	2400	17.3	0100	16.7	23	20.8	0400	22.3	1700	21.5
24	15.2	0800	16.4	1900	15.9	24	21.2	0500	22.6	1600	21.8
25	16.1	0800	17.2	2100	16.7	25	20.8	0600	21.9	1600	21.3
26	17.1	0500	18.5	2100	17.8	26	19.9	0700	21.9	1600	20.9
27	18.2	0600	19.0	1600	18.7	27	20.1	0600	22.1	1500	21.2
28	19.0	0100	20.2	1500	19.6	28	21.2	0600	22.7	1800	21.9
29	19.9	0500	21.8	1700	20.9	29	22.0	0700	24.1	1500	23.0
30	21.0	0600	23.0	1600	22.1	30	21.9	0700	23.1	1500	22.6
31	22.1	0400	23.8	1600	22.9						
				MAY MEAN:	17.5					JUN MEAN:	21.1
				SE:	0.47					SE:	0.20
JUL						AUG					
1	21.1	0700	23.3	1400	22.2	1	24.0	2400	25.2	0100	24.6
2	21.3	0900	22.4	1400	21.9	2	23.0	2400	23.9	0100	23.4
3	20.8	0700	21.9	1500	21.4	3	21.9	0900	22.9	0100	22.3
4	19.9	0700	21.7	1400	20.9	4	21.6	0900	22.4	1900	22.1
5	20.0	0600	22.4	1500	21.4	5	21.9	0700	23.0	1900	22.4
6	21.4	0700	24.0	1600	22.9	6	22.7	0500	23.3	1500	23.0
7	23.2	0600	26.0	1700	24.7	7	22.8	0200	24.0	1700	23.4
8	25.0	0700	27.2	1500	26.0	8	23.4	0900	24.4	1700	23.9
9	25.0	2400	26.0	0100	25.6	9	23.9	0100	25.0	1500	24.4
10	24.0	0700	25.9	1400	24.9	10	24.0	0700	24.9	1700	24.4
11	23.3	2400	24.2	0100	23.9	11	23.9	0600	25.0	1400	24.4
12	22.6	0100	23.3	0100	22.9	12	23.2	0700	23.9	0100	23.6
13	22.0	0700	23.7	1600	22.7	13	22.4	0700	23.8	1400	23.2
14	22.1	0600	23.4	1300	22.8	14	22.4	0600	24.2	1400	23.4
15	21.8	0700	23.2	1400	22.7	15	22.9	0600	23.7	1800	23.3
16	22.3	2200	22.8	0100	22.6	16	23.0	0300	23.9	1700	23.4
17	22.0	0400	23.0	1500	22.6	17	23.1	0700	24.0	1600	23.6
18	22.2	0600	23.8	1600	23.0	18	23.4	0600	24.9	1600	24.1
19	22.9	0700	24.4	1800	23.6	19	24.0	0300	25.0	1500	24.5
20	23.0	2400	23.9	0100	23.4	20	24.6	0400	25.3	1500	24.9
21	22.3	0600	23.6	1700	23.0	21	23.9	2400	25.0	0100	24.5
22	23.0	0300	24.5	1600	23.7	22	23.3	0600	24.3	1300	23.8
23	23.8	0200	25.7	1500	24.7	23	22.9	0600	24.0	1600	23.5
24	24.1	0700	25.9	1500	25.1	24	22.4	0100	23.6	0100	23.1
25	24.9	0900	25.4	1500	25.1	25	21.1	0800	22.2	0100	21.7
26	24.8	1100	25.4	1700	25.0	26	20.5	0700	22.4	1500	21.6
27	24.3	0700	26.1	1700	25.2	27	21.9	0200	22.5	1700	22.1
28	24.9	0500	26.8	1700	25.8	28	20.2	2400	21.9	0100	21.1
29	25.8	0600	27.2	1600	26.5	29	19.3	2400	21.3	1500	20.2
30	26.0	0600	27.3	1700	26.6	30	18.5	0800	21.0	1500	19.5
31	25.4	2400	26.4	0100	25.9	31	18.8	0700	21.5	1500	19.9
				JUL MEAN:	23.8					AUG MEAN:	23.0
				SE:	0.29					SE:	0.25

Table A-2 (cont.)

DATE	MINIMUM	TIME	MAXIMUM	TIME	MEAN	DATE	MINIMUM	TIME	MAXIMUM	TIME	MEAN
SEP						OCT					
1	19.3	0700	21.4	1500	20.3	1	19.9	0500	21.0	1500	20.5
2	19.9	0800	22.1	1400	20.9	2	20.3	0800	22.0	1500	20.9
3	20.2	0600	22.8	1500	21.2	3	20.0	2000	20.7	0100	20.2
4	20.4	2400	21.1	1700	20.9	4	19.6	0800	19.9	0100	19.8
5	20.0	2400	20.8	1900	20.4	5	18.2	2400	19.6	0100	19.1
6	19.7	0700	22.4	1600	20.6	6	16.5	2400	18.1	0100	17.5
7	18.7	2400	20.0	1700	19.3	7	15.1	2400	16.4	0100	15.8
8	18.0	0800	21.4	1600	19.3	8	14.8	0700	15.2	1400	15.0
9	17.7	0700	21.1	1600	19.1	9	14.8	0600	15.3	1400	15.0
10	17.8	0500	21.4	1600	19.4	10	13.8	2400	14.8	1300	14.3
11	19.3	0600	22.3	1600	20.8	11	13.0	0600	13.6	0100	13.2
12	20.8	0900	22.1	1600	21.3	12	12.8	0700	13.7	1400	13.3
13	19.9	0700	23.2	1600	21.3	13	13.4	0200	13.8	1600	13.6
14	19.4	0800	22.3	1600	20.7	14	13.6	0100	14.1	1500	13.8
15	19.0	0500	21.4	1700	20.0	15	12.8	2400	13.6	1300	13.2
16	17.8	2400	20.1	1600	19.2	16	12.4	0400	13.0	1200	12.7
17	17.0	0700	20.1	1600	18.3	17	12.1	2200	12.5	0100	12.3
18	16.4	0700	18.2	1300	17.5	18	11.9	0700	12.6	1400	12.1
19	17.0	0800	18.6	1800	17.7	19	11.3	0800	12.3	1500	11.8
20	16.9	0800	18.5	1700	17.7	20	11.1	0800	12.2	1500	11.7
21	17.2	2400	18.4	1700	17.9	21	11.2	0600	12.2	1400	11.7
22	16.9	0800	17.7	1800	17.3	22	11.6	0600	12.8	1400	12.1
23	17.1	0300	19.0	1400	18.0	23	12.0	0700	12.9	1500	12.5
24	17.9	0300	19.7	1800	18.6	24	12.2	2400	13.3	1400	12.7
25	18.0	0700	19.1	1600	18.5	25	11.6	0800	12.2	1400	12.0
26	18.2	0200	20.8	1700	19.2	26	11.8	0600	11.9	0100	11.9
27	18.8	2400	19.4	0100	19.2	27	11.9	0100	12.2	1400	12.0
28	18.7	0700	18.9	1300	18.8	28	12.1	0100	13.0	1400	12.5
29	18.6	0300	19.1	1700	18.8	29	12.1	0600	13.1	1400	12.6
30	18.6	0600	20.3	1600	19.5	30	12.2	2400	13.0	1300	12.6
						31	11.5	2400	12.3	1300	12.0
				SEP MEAN:	19.4					OCT MEAN:	14.2
				SE:	0.22					SE:	0.53
NOV						DEC					
1	11.1	0400	11.5	1500	11.2	1	3.7	1700	4.3	0100	3.9
2	10.4	2400	11.1	0100	11.0	2	3.2	1300	3.6	0100	3.3
3	10.1	0400	10.8	1200	10.3	3	3.2	0100	3.9	1400	3.7
4	9.2	2400	10.1	1100	9.9	4	3.7	2400	3.9	1200	3.8
5	8.2	2400	9.2	0100	8.8	5	3.2	0800	3.6	0100	3.3
6	8.0	2300	8.4	1300	8.2	6	3.0	0500	3.1	0100	3.0
7	7.9	0500	8.0	0100	8.0	7	2.9	0100	3.1	2200	3.0
8	7.9	0100	8.4	1900	8.2	8	3.1	0100	3.5	1600	3.3
9	8.5	0100	9.1	1700	8.9	9	3.5	0100	3.7	1000	3.6
10	8.6	2400	9.1	0100	8.9	10	3.8	0100	4.9	2000	4.1
11	7.2	2400	8.6	0100	7.9	11	3.4	1400	3.8	0100	3.5
12	6.9	2300	7.2	0100	7.1	12	3.0	2200	3.3	0100	3.2
13	5.7	2400	6.8	0100	6.3	13	2.0	2400	2.9	0100	2.4
14	4.6	2400	5.7	0100	5.1	14	1.2	2100	2.0	0100	1.5
15	4.1	2000	4.4	0100	4.2	15	0.2	1000	1.2	0100	0.7
16	4.1	0100	4.2	1300	4.2	16	0.7	0100	1.4	2400	1.1
17	4.2	0100	5.0	1400	4.8	17	1.4	0100	2.0	2200	1.8
18	4.9	0100	5.0	1100	4.9	18	2.0	0100	2.6	2000	2.3
19	4.1	2400	4.9	0100	4.8	19	2.5	0100	2.9	1400	2.8
20	3.4	2200	4.1	0100	3.7	20	2.8	0400	2.9	0100	2.8
21	3.1	2000	3.5	0100	3.3	21	2.7	0600	2.9	1200	2.8
22	3.0	0500	3.3	1400	3.2	22	1.9	2300	2.6	0100	2.2
23	3.0	0600	3.2	1500	3.1	23	1.4	2400	1.9	0100	1.7
24	3.3	0100	3.8	1700	3.6	24	1.3	0100	1.3	0100	1.3
25	3.8	0100	4.2	1700	4.0	25	1.4	0100	2.2	2400	1.9
26	4.1	0100	4.8	2400	4.3	26	2.1	0900	2.4	2200	2.2
27	4.9	0100	5.1	1100	5.0	27	2.4	0100	2.6	1600	2.5
28	4.9	0500	5.0	0100	4.9	28	2.3	2400	2.7	1300	2.6
29	4.7	0700	4.9	0100	4.8	29	2.1	0600	2.6	1800	2.4
30	4.3	2400	4.8	0100	4.6	30	2.3	2200	2.7	0100	2.5
						31	2.0	2400	2.4	1200	2.3
				NOV MEAN:	6.2					DEC MEAN:	2.6
				SE:	0.46					SE:	0.15

Table A-3

Daily minimum, maximum, and mean level (m above msl) of the Susquehanna River at the Susquehanna SES Biological Laboratory, 1986.

DATE	MINIMUM	TIME	MAXIMUM	TIME	MEAN	DATE	MINIMUM	TIME	MAXIMUM	TIME	MEAN
JAN						FEB					
1	148.82	0100	148.91	2300	148.86	1	149.04	0200	149.16	1000	149.10
2	148.91	0100	148.91	0100	148.91	2	149.07	0100	149.22	1800	149.17
3	148.85	0700	148.91	1800	148.89	3	149.22	0100	149.25	1600	149.23
4	148.88	1300	148.91	0100	148.90	4	149.28	0100	149.31	0700	149.30
5	148.85	2000	148.88	0100	148.88	5	149.31	0100	149.40	2300	149.34
6	148.82	0700	148.85	0100	148.84	6	149.40	0100	149.61	2300	149.48
7	148.79	0400	148.82	0100	148.80	7	149.61	0100	149.68	1800	149.65
8	148.70	0900	148.76	0100	148.72	8	149.46	2400	149.68	0100	149.56
9	148.61	1400	148.70	0100	148.65	9	149.28	2300	149.46	0100	149.38
10	148.58	1600	148.67	0100	148.62	10	149.28	0100	149.34	1000	149.32
11	148.61	0100	148.64	2300	148.61	11	149.31	0100	149.31	0100	149.31
12	148.64	0100	148.67	2100	148.64	12	149.16	1300	149.28	0100	149.21
13	148.67	0100	148.70	1400	148.68	13	149.13	2100	149.19	0100	149.16
14	148.64	1500	148.70	0100	148.69	14	149.00	1600	149.13	0100	149.07
15	148.64	1500	148.70	0100	148.66	15	148.91	1700	149.00	0100	148.96
16	148.64	1500	148.73	0600	148.68	16	148.85	1300	149.00	0100	148.90
17	148.55	2000	148.64	0100	148.62	17	148.88	0100	148.97	2100	148.92
18	148.49	1400	148.55	0100	148.51	18	148.94	0300	149.07	2000	149.00
19	148.52	0100	148.64	2400	148.57	19	149.07	0100	149.40	2400	149.23
20	148.64	0100	149.00	2300	148.82	20	149.40	0100	150.44	2400	149.85
21	149.04	0100	151.44	2400	150.27	21	150.53	0100	151.53	2400	151.14
22	151.26	2400	151.56	0600	151.45	22	151.60	0100	152.08	1400	151.95
23	150.77	2400	151.26	0100	151.00	23	151.38	2400	152.05	0100	151.73
24	150.28	2400	150.77	0100	150.51	24	150.83	2400	151.35	0100	151.07
25	149.92	1800	150.28	0100	150.06	25	150.47	2300	150.83	0100	150.63
26	149.89	2200	150.04	0700	149.96	26	150.16	2300	150.44	0100	150.29
27	149.77	2000	149.89	0100	149.81	27	149.95	2400	150.16	0100	150.05
28	149.71	1600	149.77	0100	149.74	28	149.74	2400	149.95	0100	149.85
29	149.52	1900	149.74	0100	149.63						
30	149.34	2200	149.52	0100	149.43						
31	149.07	2200	149.31	0100	149.15						
			JAN MEAN:		149.21				FEB MEAN:		149.71
				SE:	0.140					SE:	0.161
MAR						APR					
1	149.58	2200	149.74	0100	149.67	1	149.86	2200	149.98	0100	149.93
2	149.52	2300	149.58	0100	149.58	2	149.77	1800	149.86	0100	149.81
3	149.46	2200	149.52	0100	149.50	3	149.64	2100	149.74	0100	149.69
4	149.43	1900	149.46	0100	149.46	4	149.49	2400	149.61	0100	149.56
5	149.40	0100	149.43	1000	149.42	5	149.40	1600	149.49	0100	149.44
6	149.40	0100	149.40	0100	149.40	6	149.40	0100	149.40	0100	149.40
7	149.37	2100	149.40	0100	149.39	7	149.43	0100	149.64	2200	149.53
8	149.22	2100	149.37	0100	149.28	8	149.64	0100	149.71	0900	149.69
9	149.07	2200	149.19	0100	149.15	9	149.68	0300	149.71	0100	149.68
10	149.07	0100	149.16	2000	149.10	10	149.64	1000	149.68	0100	149.66
11	149.16	0100	150.35	2400	149.55	11	149.58	1700	149.64	0100	149.61
12	150.47	0100	151.26	1900	151.05	12	149.52	1500	149.58	0100	149.54
13	150.96	2200	151.20	0100	151.05	13	149.52	0100	149.52	0100	149.52
14	150.92	0200	151.47	2400	151.04	14	149.49	0100	149.49	0100	149.49
15	151.60	0100	154.43	2400	153.22	15	149.46	0100	149.46	0100	149.46
16	154.37	2400	154.55	0500	154.50	16	149.46	0100	149.89	2400	149.56
17	153.27	2400	154.34	0100	153.79	17	149.95	0100	152.27	2400	151.24
18	152.60	2400	153.24	0100	152.92	18	151.99	2400	152.45	0700	152.32
19	151.99	2400	152.57	0100	152.27	19	151.11	2400	151.96	0100	151.50
20	151.75	1700	151.96	0100	151.82	20	150.50	2400	151.08	0100	150.76
21	151.75	0100	151.81	1200	151.77	21	150.19	2300	150.47	0100	150.31
22	151.35	2200	151.72	0100	151.52	22	150.04	2000	150.19	0100	150.10
23	151.02	2400	151.32	0100	151.19	23	149.98	1900	150.04	0100	150.01
24	150.65	0100	151.02	0100	150.82	24	149.89	1300	149.98	0100	149.92
25	150.44	2100	150.65	0100	150.53	25	149.77	2100	149.89	0100	149.84
26	150.28	2000	150.44	0100	150.34	26	149.68	2200	149.77	0100	149.73
27	150.19	1800	150.28	0100	150.23	27	149.58	2000	149.68	0100	149.63
28	150.16	0300	150.19	0100	150.17	28	149.49	2200	149.58	0100	149.54
29	150.19	0100	150.25	1300	150.24	29	149.40	1900	149.49	0100	149.44
30	150.13	2400	150.25	0100	150.20	30	149.31	2400	149.40	0100	149.36
31	149.98	2400	150.13	0100	150.06						
			MAR MEAN:		150.72				APR MEAN:		149.91
				SE:	0.257					SE:	0.125

Table A-3 (cont.)

DATE	MINIMUM	TIME	MAXIMUM	TIME	MEAN	DATE	MINIMUM	TIME	MAXIMUM	TIME	MEAN
MAY						JUN					
1	149.22	2400	149.31	0100	149.27	1	148.91	1600	149.00	0100	148.94
2	149.16	1700	149.22	0100	149.19	2	148.88	0700	148.91	0100	148.89
3	149.10	1200	149.13	0100	149.11	3	148.85	0100	148.94	2200	148.88
4	149.07	0400	149.10	0100	149.07	4	148.94	0100	148.97	0300	148.97
5	149.04	0100	149.04	0100	149.04	5	148.97	0100	149.07	2400	149.00
6	148.97	1600	149.00	0100	148.99	6	149.07	0100	149.83	2400	149.45
7	148.97	0100	148.97	0100	148.97	7	149.89	0100	150.10	0500	150.03
8	148.91	0900	148.94	0100	148.93	8	149.92	1700	150.07	0100	149.99
9	148.85	1800	148.91	0100	148.89	9	149.83	2400	149.95	0500	149.92
10	148.79	1300	148.85	0100	148.81	10	149.61	2000	149.83	0100	149.70
11	148.76	0300	148.79	0100	148.76	11	149.46	2200	149.58	0100	149.53
12	148.73	0100	148.73	0100	148.73	12	149.40	0500	150.01	2400	149.56
13	148.70	0100	148.70	0100	148.70	13	150.04	0100	150.10	0300	150.10
14	148.67	0400	148.70	0100	148.67	14	150.10	0100	150.44	1500	150.31
15	148.64	0300	148.67	0100	148.64	15	149.86	2400	150.32	0100	150.07
16	148.58	1600	148.61	0100	148.60	16	149.61	2200	149.86	0100	149.71
17	148.61	0100	148.61	0100	148.61	17	149.55	0600	149.61	0100	149.58
18	148.61	0100	148.61	0100	148.61	18	149.49	1900	149.58	0100	149.52
19	148.61	0100	148.82	2200	148.69	19	149.40	2300	149.49	0100	149.46
20	148.85	0100	148.88	0700	148.88	20	149.25	1900	149.40	0100	149.31
21	148.91	0100	149.83	2400	149.22	21	149.10	2100	149.22	0100	149.15
22	149.89	0100	150.96	2200	150.53	22	149.04	1200	149.10	0100	149.05
23	150.65	2300	150.99	0100	150.82	23	149.04	0100	149.10	2100	149.06
24	150.32	2400	150.65	0100	150.51	24	149.10	0100	149.13	0300	149.12
25	149.98	0100	150.28	0100	150.13	25	148.97	2200	149.10	0100	149.03
26	149.74	2200	149.98	0100	149.85	26	148.85	2100	148.97	0100	148.90
27	149.52	2200	149.71	0100	149.61	27	148.82	1300	148.85	0100	148.84
28	149.37	2200	149.52	0100	149.44	28	148.79	0500	148.82	0100	148.80
29	149.19	2300	149.34	0100	149.26	29	148.79	0100	148.85	0300	148.82
30	149.10	1600	149.19	0100	149.13	30	148.73	2000	148.79	0100	148.76
31	149.00	1700	149.07	0100	149.03						
				MAY MEAN:	149.18					JUN MEAN:	149.35
				SE:	0.108					SE:	0.085
JUL						AUG					
1	148.73	0100	148.73	0100	148.73	1	149.00	0100	149.61	2400	149.21
2	148.73	0100	148.82	2000	148.77	2	149.71	0100	150.16	1800	150.04
3	148.82	0100	148.97	1100	148.93	3	150.01	0400	150.07	1200	150.04
4	148.85	2400	148.94	0100	148.89	4	149.80	2300	150.01	0100	149.89
5	148.82	0600	148.85	0100	148.83	5	149.55	2200	149.80	0100	149.67
6	148.79	0100	148.79	0100	148.79	6	149.34	2300	149.52	0100	149.44
7	148.76	2300	148.79	0100	148.79	7	149.13	0100	149.34	0100	149.23
8	148.70	1800	148.76	0100	148.73	8	148.97	2100	149.13	0100	149.04
9	148.67	0100	148.70	1200	148.68	9	148.97	0100	149.04	0400	149.02
10	148.64	1600	148.70	0100	148.66	10	148.88	1200	148.97	0100	148.91
11	148.61	0100	148.64	0100	148.62	11	148.94	0100	149.07	1900	149.03
12	148.61	0100	148.67	2300	148.62	12	148.97	1900	149.07	0100	149.01
13	148.64	0400	148.67	0100	148.64	13	148.91	1200	148.97	0100	148.93
14	148.67	0100	148.91	2200	148.79	14	148.82	2200	148.88	0100	148.85
15	148.91	0100	149.16	2400	148.98	15	148.76	1500	148.82	0100	148.79
16	149.13	1600	149.19	0400	149.15	16	148.67	1900	148.73	0100	148.70
17	149.00	2300	149.13	0100	149.06	17	148.61	0700	148.64	0100	148.62
18	148.91	2200	149.00	0100	148.97	18	148.61	0100	148.76	2300	148.65
19	148.91	0100	149.10	2400	148.98	19	148.76	0100	149.04	2300	148.91
20	149.10	0100	149.22	0800	149.17	20	149.00	1900	149.04	0100	149.03
21	149.22	0100	149.40	0700	149.36	21	148.91	2000	149.00	0100	148.96
22	149.25	2400	149.43	1100	149.35	22	148.85	1600	148.91	0100	148.88
23	149.00	2300	149.25	0100	149.12	23	148.76	1600	148.85	0100	148.79
24	148.82	2200	149.00	0100	148.91	24	148.76	0100	148.85	1000	148.82
25	148.67	0100	148.82	0100	148.75	25	148.76	0600	148.79	0100	148.77
26	148.64	0800	148.67	0100	148.66	26	148.73	1500	148.76	0100	148.75
27	148.58	1400	148.64	0100	148.60	27	148.67	1300	148.70	0100	148.68
28	148.58	0100	148.61	1200	148.59	28	148.61	1000	148.64	0100	148.62
29	148.55	0600	148.73	1500	148.66	29	148.55	1300	148.58	0100	148.56
30	148.73	0100	148.73	0100	148.73	30	148.49	1300	148.55	0100	148.50
31	148.73	0100	148.97	2400	148.82	31	148.46	0400	148.49	0100	148.46
				JUL MEAN:	148.85					AUG MEAN:	148.99
				SE:	0.038					SE:	0.076

Table A-3 (cont.)

DATE	MINIMUM	TIME	MAXIMUM	TIME	MEAN	DATE	MINIMUM	TIME	MAXIMUM	TIME	MEAN
SEP						OCT					
1	148.46	0100	148.46	0100	148.46	1	148.55	0100	148.55	0100	148.55
2	148.43	0900	148.46	0100	148.43	2	148.52	1300	148.55	0100	148.53
3	148.43	0100	148.43	0100	148.43	3	148.52	0100	148.61	2400	148.54
4	148.36	1600	148.39	0100	148.38	4	148.61	0100	149.07	2400	148.81
5	148.36	0100	148.36	0100	148.36	5	149.07	0100	149.22	2400	149.11
6	148.36	0100	148.36	0100	148.36	6	149.25	0100	149.55	2000	149.44
7	148.33	0100	148.33	0100	148.33	7	149.40	2200	149.55	0100	149.48
8	148.33	0100	148.33	0100	148.33	8	149.25	2100	149.37	0100	149.31
9	148.33	0100	148.33	0100	148.33	9	149.07	2400	149.25	0100	149.16
10	148.33	0100	148.36	1300	148.35	10	148.91	2100	149.07	0100	148.98
11	148.36	0100	148.36	0100	148.36	11	148.88	1300	148.91	0100	148.90
12	148.33	0500	148.36	0100	148.34	12	148.79	1900	148.85	0100	148.82
13	148.30	2200	148.33	0100	148.33	13	148.73	1600	148.79	0100	148.75
14	148.27	1900	148.30	0100	148.30	14	148.73	0100	148.73	0100	148.73
15	148.27	0100	148.27	0100	148.27	15	148.73	0100	148.73	0100	148.73
16	148.27	0100	148.27	0100	148.27	16	148.73	0100	148.73	0100	148.73
17	148.27	0100	148.27	0100	148.27	17	148.73	0100	148.73	0100	148.73
18	148.27	0100	148.27	0100	148.27	18	148.73	0100	148.73	0100	148.73
19	148.24	1600	148.27	0100	148.26	19	148.73	0100	148.73	0100	148.73
20	148.24	0100	148.24	0100	148.24	20	148.67	1300	148.70	0100	148.68
21	148.24	0100	148.24	0100	148.24	21	148.67	0100	148.67	0100	148.67
22	148.24	0100	148.24	0100	148.24	22	148.64	1300	148.67	0100	148.65
23	148.24	0100	148.30	1600	148.27	23	148.61	1300	148.64	0100	148.62
24	148.30	0100	148.30	0100	148.30	24	148.55	2200	148.61	0100	148.59
25	148.24	1600	148.30	0100	148.27	25	148.55	0100	148.55	0100	148.55
26	148.21	0400	148.27	1900	148.24	26	148.55	0100	148.55	0100	148.55
27	148.27	0100	148.46	2200	148.37	27	148.55	0100	148.61	1500	148.59
28	148.46	0100	148.61	2100	148.53	28	148.61	0100	148.64	1000	148.63
29	148.61	0100	148.64	0500	148.62	29	148.64	0100	148.70	1900	148.67
30	148.55	1300	148.61	0100	148.57	30	148.70	0100	148.73	2100	148.71
						31	148.73	0100	148.76	0500	148.75
				SEP MEAN:	148.35					OCT MEAN:	148.79
				SE:	0.018					SE:	0.046
NOV						DEC					
1	148.70	2200	148.73	0100	148.73	1	150.62	2200	151.02	0100	150.80
2	148.70	0100	148.70	0100	148.70	2	150.32	2300	150.59	0100	150.45
3	148.67	1600	148.70	0100	148.69	3	150.28	0300	150.47	2400	150.34
4	148.67	0100	148.67	0100	148.67	4	150.50	0100	150.83	2400	150.68
5	148.67	0100	148.67	0100	148.67	5	150.86	0100	151.02	1000	150.97
6	148.70	0100	148.70	0100	148.70	6	150.53	2300	150.89	0100	150.70
7	148.70	0100	148.70	0100	148.70	7	150.19	2200	150.50	0100	150.33
8	148.73	0100	149.00	2200	148.86	8	150.01	2000	150.16	0100	150.08
9	149.00	0100	149.58	2400	149.20	9	149.95	0800	149.98	0100	149.96
10	149.64	0100	150.07	2300	149.89	10	149.95	0100	150.01	2400	149.96
11	150.07	0100	150.16	1300	150.13	11	150.01	0100	150.10	1300	150.07
12	149.86	2200	150.13	0100	149.99	12	150.04	2200	150.10	0100	150.08
13	149.71	1900	149.86	0100	149.76	13	149.83	2300	150.04	0100	149.93
14	149.58	2100	149.71	0100	149.64	14	149.61	2100	149.83	0100	149.71
15	149.46	2100	149.58	0100	149.52	15	149.46	1100	149.61	0100	149.50
16	149.31	2400	149.46	0100	149.39	16	149.40	2000	149.46	0100	149.44
17	149.25	1300	149.31	0100	149.27	17	149.37	0300	149.40	0100	149.38
18	149.25	0100	149.31	2200	149.27	18	149.40	0100	149.46	2100	149.42
19	149.31	0100	149.34	0700	149.33	19	149.46	0100	149.55	2100	149.51
20	149.34	0100	149.43	2400	149.35	20	149.58	0100	149.64	0700	149.64
21	149.46	0100	150.35	2200	149.93	21	149.49	2400	149.61	0100	149.56
22	150.28	0700	150.47	2300	150.35	22	149.40	2300	149.49	0100	149.45
23	150.50	0100	150.62	1500	150.57	23	149.31	2300	149.40	0100	149.36
24	150.32	1800	150.56	0100	150.41	24	149.22	1700	149.31	0100	149.25
25	150.28	0100	150.50	2300	150.38	25	149.25	0100	149.52	2300	149.36
26	150.50	0100	150.80	2400	150.62	26	149.55	0100	150.13	2000	149.93
27	150.83	0100	152.30	2400	151.55	27	150.13	2100	150.19	0600	150.17
28	152.27	2400	152.54	1000	152.44	28	149.95	1900	150.13	0100	150.00
29	151.50	2300	152.20	0100	151.81	29	149.77	2300	149.92	0100	149.84
30	151.02	2400	151.47	0100	151.25	30	149.61	2400	149.77	0100	149.70
						31	149.52	1600	149.61	0100	149.57
				NOV MEAN:	149.79					DEC MEAN:	149.91
				SE:	0.185					SE:	0.085

Table A-4

Daily mean flow (m^3/s) of the Susquehanna River at the Susquehanna SES Biological Laboratory, 1986.

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	187	264	494	621	327	214	153	303	88	108	152	1153
2	204	288	453	563	295	198	162	683	84	105	145	921
3	196	311	421	506	269	193	209	681	82	107	142	851
4	200	339	400	443	254	222	199	601	74	173	137	1073
5	193	352	385	394	243	233	179	494	70	266	137	1276
6	183	409	377	377	229	396	169	395	70	392	145	1085
7	172	486	375	433	223	678	168	310	65	409	145	846
8	151	445	332	504	208	655	153	246	65	340	188	701
9	133	368	282	498	196	615	141	237	65	285	300	637
10	126	347	264	488	174	507	135	204	68	226	601	637
11	123	341	440	469	162	433	124	242	70	200	732	700
12	131	305	1340	438	153	446	125	235	66	178	654	705
13	141	286	1338	429	145	713	131	209	64	159	537	625
14	142	254	1331	415	138	835	167	186	58	153	481	516
15	135	218	3486	403	130	695	226	168	54	153	426	417
16	140	202	5228	446	121	514	282	145	54	153	371	395
17	124	206	4220	1483	122	454	252	124	54	153	326	370
18	100	232	3123	2474	122	429	223	132	54	153	326	384
19	114	312	2418	1702	142	400	224	203	52	153	351	423
20	177	584	1989	1129	193	340	289	241	49	141	357	479
21	809	1408	1941	835	307	283	363	217	49	137	621	446
22	1658	2109	1717	711	970	249	357	195	49	133	859	397
23	1303	1900	1444	663	1168	250	273	169	54	126	999	359
24	960	1356	1170	615	958	272	203	176	59	117	894	318
25	693	1040	970	576	729	241	157	162	53	108	877	359
26	641	824	855	523	581	202	134	157	48	108	1030	621
27	563	685	786	476	466	182	121	141	72	117	1744	754
28	526	584	754	435	394	171	118	125	105	126	2595	660
29	476		791	394	324	178	135	111	126	137	1975	576
30	390		768	360	275	161	153	99	113	146	1492	507
31	282		693		242		178	89		159		447
MEAN:	367	588	1309	660	331	379	190	248	68	175	658	633
SE:	66.8	95.2	217.6	83.4	48.0	35.1	11.7	28.3	3.5	14.3	108.4	45.6

Table A-5

Physicochemical data collected from the Susquehanna River at SSES, Bell Bend, and Bell Bend I, January through December 1986.

SSES

DATE	19 JAN	31 JAN		
TIME	1226	1325		
RIVER LEVEL(M ABOVE MSL)	148.55	149.13		
DISCHARGE(M^3/S)	109	275		
TEMPERATURE (C)				
AIR	12.0	0.5		
WATER	1.0	0.0		
WEATHER	FOG	CL. SUNNY		
			MEAN	SE
TURBIDITY (NTU)	7.1	6.8	7.0	0.2
OXYGEN				
DISSOLVED (MG/L)	12.40	13.20	12.80	0.400
PERCENT SATURATION	86	91	88	2.5
TOTAL ALKALINITY (MG/L)	68	42	55	13.0
PH	7.0	7.0	7.0	0.00
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	330	215	272	57.5
SULFATE (MG/L)	70	37	53	16.5
IRON (MG/L)				
TOTAL	1.76	1.26	1.51	0.250
DISSOLVED	1.00	0.72	0.86	0.140
PERCENT DISSOLVED	57	57	57	0.0
SOLIDS (MG/L)				
TOTAL	231	155	193	38.0
TOTAL SUSPENDED	3	6	4	1.5
TOTAL DISSOLVED	228	149	188	39.5

BELL BEND

DATE	19 JAN	31 JAN		
TIME	1231	1313		
TEMPERATURE (C)				
AIR	12.0	0.5		
WATER	1.0	0.0		
WEATHER	FOG	CL. SUNNY		
			MEAN	SE
TURBIDITY (NTU)	6.7	7.1	6.9	0.2
OXYGEN				
DISSOLVED (MG/L)	12.20	13.40	12.80	0.600
PERCENT SATURATION	85	93	89	4.0
TOTAL ALKALINITY (MG/L)	68	42	55	13.0
PH	7.0	7.0	7.0	0.00
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	330	220	275	55.0
SULFATE (MG/L)	70	38	54	16.0
IRON (MG/L)				
TOTAL	1.75	1.24	1.50	0.255
DISSOLVED	0.95	0.72	0.83	0.115
PERCENT DISSOLVED	54	58	56	2.0
SOLIDS (MG/L)				
TOTAL	236	152	194	42.0
TOTAL SUSPENDED	3	4	3	0.5
TOTAL DISSOLVED	233	148	190	42.5

BELL BEND 1

DATE	19 JAN	31 JAN		
TIME				
TEMPERATURE (C)				
AIR	--	--		
WATER	--	--		
WEATHER	FOG	CL. SUNNY		
			MEAN	SE
TURBIDITY (NTU)	--	--	--	--
OXYGEN				
DISSOLVED (MG/L)	--	--	--	--
PERCENT SATURATION	--	--	--	--
TOTAL ALKALINITY (MG/L)	--	--	--	--
PH	--	--	--	--
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	--	--	--	--
SULFATE (MG/L)	--	--	--	--
IRON (MG/L)				
TOTAL	--	--	--	--
DISSOLVED	--	--	--	--
PERCENT DISSOLVED	--	--	--	--
SOLIDS (MG/L)				
TOTAL	--	--	--	--
TOTAL SUSPENDED	--	--	--	--
TOTAL DISSOLVED	--	--	--	--

Table A-5 (cont.)

SSES				
DATE	14 FEB	28 FEB		
TIME	1320	1316		
RIVER LEVEL(M ABOVE MSL)	148.97	149.86		
DISCHARGE(M^3/S)	222	587		
TEMPERATURE (C)				
AIR	-1.5	-2.5		
WATER	0.5	1.0		
WEATHER	OVERCAST	OVERCAST		
			MEAN	SE
TURBIDITY (NTU)	4.3	7.2	5.7	1.5
OXYGEN				
DISSOLVED (MG/L)	13.20	12.70	12.95	0.250
PERCENT SATURATION	92	89	90	1.5
TOTAL ALKALINITY (MG/L)	48	33	40	7.5
PH	7.2	7.1	7.2	0.05
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	250	185	217	32.5
SULFATE (MG/L)	43	31	37	6.0
IRON (MG/L)				
TOTAL	1.17	1.17	1.17	0.000
DISSOLVED	0.73	0.61	0.67	0.060
PERCENT DISSOLVED	62	52	57	5.0
SOLIDS (MG/L)				
TOTAL	157	131	144	13.0
TOTAL SUSPENDED	4	8	6	2.0
TOTAL DISSOLVED	153	123	138	15.0

BELL BEND				
DATE	14 FEB	28 FEB		
TIME	1331	1321		
TEMPERATURE (C)				
AIR	-1.5	-2.5		
WATER	0.5	1.0		
WEATHER	OVERCAST	OVERCAST		
			MEAN	SE
TURBIDITY (NTU)	3.7	7.2	5.5	1.8
OXYGEN				
DISSOLVED (MG/L)	13.20	12.90	13.05	0.150
PERCENT SATURATION	92	91	91	0.5
TOTAL ALKALINITY (MG/L)	48	33	40	7.5
PH	7.2	7.1	7.2	0.05
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	255	185	220	35.0
SULFATE (MG/L)	43	30	36	6.5
IRON (MG/L)				
TOTAL	1.11	1.18	1.15	0.035
DISSOLVED	0.72	0.58	0.65	0.070
PERCENT DISSOLVED	65	49	57	8.0
SOLIDS (MG/L)				
TOTAL	153	133	143	10.0
TOTAL SUSPENDED	3	9	6	3.0
TOTAL DISSOLVED	150	124	137	13.0

BELL BEND 1				
DATE	14 FEB	28 FEB		
TIME				
TEMPERATURE (C)				
AIR	--	--		
WATER	--	--		
WEATHER	OVERCAST	OVERCAST		
			MEAN	SE
TURBIDITY (NTU)	--	--	--	--
OXYGEN				
DISSOLVED (MG/L)	--	--	--	--
PERCENT SATURATION	--	--	--	--
TOTAL ALKALINITY (MG/L)	--	--	--	--
PH	--	--	--	--
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	--	--	--	--
SULFATE (MG/L)	--	--	--	--
IRON (MG/L)				
TOTAL	--	--	--	--
DISSOLVED	--	--	--	--
PERCENT DISSOLVED	--	--	--	--
SOLIDS (MG/L)				
TOTAL	--	--	--	--
TOTAL SUSPENDED	--	--	--	--
TOTAL DISSOLVED	--	--	--	--

Table A-5 (cont.)

SSES

DATE	12 MAR	28 MAR		
TIME	1345	1221		
RIVER LEVEL(M ABOVE MSL)	151.20	150.16		
DISCHARGE(M^3/S)	1454	748		
TEMPERATURE (C)				
AIR	4.0	7.0		
WATER	3.0	8.5		
WEATHER	P. CLOUDY	CL. SUNNY		
			MEAN	SE
TURBIDITY (NTU)	64	12	38	26.0
OXYGEN				
DISSOLVED (MG/L)	12.70	11.30	12.00	0.700
PERCENT SATURATION	95	97	96	1.0
TOTAL ALKALINITY (MG/L)	33	42	38	4.5
PH	7.2	7.2	7.2	0.00
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	155	185	170	15.0
SULFATE (MG/L)	22	38	30	8.0
IRON (MG/L)				
TOTAL	5.79	1.62	3.71	2.085
DISSOLVED	0.21	0.47	0.34	0.130
PERCENT DISSOLVED	4	29	16	12.5
SOLIDS (MG/L)				
TOTAL	246	136	191	55.0
TOTAL SUSPENDED	136	19	77	58.5
TOTAL DISSOLVED	110	117	113	3.5

BELL BEND

DATE	12 MAR	28 MAR		
TIME	1355	1226		
TEMPERATURE (C)				
AIR	4.0	7.0		
WATER	3.0	8.5		
WEATHER	P. CLOUDY	CL. SUNNY		
			MEAN	SE
TURBIDITY (NTU)	62	12	37	25.0
OXYGEN				
DISSOLVED (MG/L)	13.00	11.20	12.10	0.900
PERCENT SATURATION	97	96	96	0.5
TOTAL ALKALINITY (MG/L)	33	42	38	4.5
PH	7.2	7.2	7.2	0.00
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	155	190	172	17.5
SULFATE (MG/L)	21	31	26	5.0
IRON (MG/L)				
TOTAL	5.82	1.61	3.72	2.105
DISSOLVED	0.13	0.43	0.28	0.150
PERCENT DISSOLVED	2	27	14	12.5
SOLIDS (MG/L)				
TOTAL	252	135	193	58.5
TOTAL SUSPENDED	144	20	82	62.0
TOTAL DISSOLVED	108	115	111	3.5

BELL BEND 1

DATE	12 MAR	28 MAR		
TIME	1352	1224		
TEMPERATURE (C)				
AIR	4.0	7.0		
WATER	3.0	8.5		
WEATHER	P. CLOUDY	CL. SUNNY		
			MEAN	SE
TURBIDITY (NTU)	62	12	37	25.0
OXYGEN				
DISSOLVED (MG/L)	12.80	11.20	12.00	0.800
PERCENT SATURATION	96	96	96	0.0
TOTAL ALKALINITY (MG/L)	33	42	38	4.5
PH	7.2	7.2	7.2	0.00
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	155	190	172	17.5
SULFATE (MG/L)	21	31	26	5.0
IRON (MG/L)				
TOTAL	6.35	1.62	3.98	2.365
DISSOLVED	0.21	0.45	0.33	0.120
PERCENT DISSOLVED	3	28	15	12.5
SOLIDS (MG/L)				
TOTAL	266	135	200	65.5
TOTAL SUSPENDED	151	19	85	66.0
TOTAL DISSOLVED	115	116	115	0.5

Table A-5 (cont.)

SSES

DATE	4 APR	10 APR	17 APR	24 APR		
TIME	1247	1326	1354	1326		
RIVER LEVEL(M ABOVE MSL)	149.55	149.64	151.47	149.89		
DISCHARGE(M^3/S)	440	481	1675	602		
TEMPERATURE (C)						
AIR	12.0	6.0	5.5	17.0		
WATER	12.0	9.5	7.5	10.0		
WEATHER	LGT. RAIN	OVERCAST	HVY. RAIN	CL. SUNNY		
					MEAN	SE
TURBIDITY (NTU)	8.5	5.4	36	6.4	14	7.3
OXYGEN						
DISSOLVED (MG/L)	9.90	10.80	11.40	11.90	11.00	0.430
PERCENT SATURATION	92	93	94	106	96	3.3
TOTAL ALKALINITY (MG/L)	48	47	38	37	42	2.9
PH	7.3	7.2	7.3	7.4	7.3	0.04
SPECIFIC CONDUCTANCE						
AT 25 C (μMHOS/CM)	210	220	160	195	196	13.1
SULFATE (MG/L)	37	37	22	34	32	3.6
IRON (MG/L)						
TOTAL	1.51	1.16	4.46	0.95	2.02	0.821
DISSOLVED	0.50	0.47	0.18	0.40	0.39	0.072
PERCENT DISSOLVED	33	41	4	42	30	8.9
SOLIDS (MG/L)						
TOTAL	149	143	251	123	166	28.7
TOTAL SUSPENDED	14	9	110	8	35	25.0
TOTAL DISSOLVED	135	134	141	115	131	5.6

BELL BEND

DATE	4 APR	10 APR	17 APR	24 APR		
TIME	1239	1331	1359	1330		
TEMPERATURE (C)						
AIR	12.0	6.0	5.5	17.0		
WATER	12.0	9.5	7.5	10.0		
WEATHER	LGT. RAIN	OVERCAST	HVY. RAIN	CL. SUNNY		
					MEAN	SE
TURBIDITY (NTU)	8.1	5.4	34	6.5	13	6.9
OXYGEN						
DISSOLVED (MG/L)	9.90	10.80	11.40	11.90	11.00	0.430
PERCENT SATURATION	92	93	94	106	96	3.3
TOTAL ALKALINITY (MG/L)	48	47	37	37	42	3.0
PH	7.3	7.2	7.3	7.4	7.3	0.04
SPECIFIC CONDUCTANCE						
AT 25 C (μMHOS/CM)	215	220	160	195	197	13.6
SULFATE (MG/L)	31	34	22	34	30	2.8
IRON (MG/L)						
TOTAL	1.46	1.16	4.33	0.96	1.98	0.791
DISSOLVED	0.48	0.45	0.18	0.38	0.37	0.067
PERCENT DISSOLVED	33	39	4	40	29	8.5
SOLIDS (MG/L)						
TOTAL	144	141	206	120	153	18.5
TOTAL SUSPENDED	14	10	111	10	36	24.9
TOTAL DISSOLVED	130	131	95	110	116	8.6

BELL BEND 1

DATE	4 APR	10 APR	17 APR	24 APR		
TIME	1241	1333	1357	1332		
TEMPERATURE (C)						
AIR	12.0	6.0	5.5	17.0		
WATER	12.0	9.5	7.5	10.0		
WEATHER	LGT. RAIN	OVERCAST	HVY. RAIN	CL. SUNNY		
					MEAN	SE
TURBIDITY (NTU)	7.9	5.4	36	6.8	14	7.3
OXYGEN						
DISSOLVED (MG/L)	9.90	10.80	11.30	11.90	10.98	0.423
PERCENT SATURATION	92	93	94	106	96	3.3
TOTAL ALKALINITY (MG/L)	48	47	37	37	42	3.0
PH	7.3	7.2	7.3	7.4	7.3	0.04
SPECIFIC CONDUCTANCE						
AT 25 C (μMHOS/CM)	215	220	160	195	197	13.6
SULFATE (MG/L)	36	34	22	34	31	3.2
IRON (MG/L)						
TOTAL	1.42	1.17	4.93	0.99	2.13	0.938
DISSOLVED	0.51	0.46	0.18	0.41	0.39	0.073
PERCENT DISSOLVED	36	39	4	41	30	8.7
SOLIDS (MG/L)						
TOTAL	142	149	243	123	164	26.8
TOTAL SUSPENDED	14	10	133	10	42	30.4
TOTAL DISSOLVED	128	139	110	113	122	6.8

Table A-5 (cont.)

SSES

DATE	1 MAY	8 MAY	15 MAY	22 MAY	29 MAY		
TIME	1321	1326	1253	1247	1340		
RIVER LEVEL(M ABOVE MSL)	149.25	148.91	148.64	150.62	149.25		
DISCHARGE(M^3/S)	318	203	130	1032	318		
TEMPERATURE (C)							
AIR	24.0	19.0	17.5	19.0	29.0		
WATER	17.0	18.0	18.0	18.0	22.0		
WEATHER	P.CLOUDY	P.CLOUDY	CL.SUNNY	OVERCAST	CL.SUNNY		
						MEAN	SE
TURBIDITY (NTU)	6.7	6.5	7.3	34	6.8	12	5.4
OXYGEN							
DISSOLVED (MG/L)	11.50	11.60	9.60	7.70	9.80	10.04	0.717
PERCENT SATURATION	117	122	102	81	111	107	7.2
TOTAL ALKALINITY (MG/L)	45	55	61	39	42	48	4.1
PH	7.6	7.7	7.4	7.0	7.3	7.4	0.12
SPECIFIC CONDUCTANCE							
AT 25 C (μMHOS/CM)	230	285	320	165	185	237	29.3
SULFATE (MG/L)	43	54	71	23	34	45	8.3
IRON (MG/L)							
TOTAL	1.22	1.39	1.34	4.20	1.37	1.90	0.575
DISSOLVED	0.58	0.42	0.22	0.22	0.51	0.39	0.074
PERCENT DISSOLVED	48	30	16	5	37	27	7.6
SOLIDS (MG/L)							
TOTAL	150	183	236	219	155	189	17.1
TOTAL SUSPENDED	7	10	8	83	14	24	14.7
TOTAL DISSOLVED	143	173	228	136	141	164	17.2

BELL BEND

DATE	1 MAY	8 MAY	15 MAY	22 MAY	29 MAY		
TIME	1329	1333	1300	1243	1335		
TEMPERATURE (C)							
AIR	24.0	19.0	17.5	19.0	29.0		
WATER	17.0	18.0	18.0	18.0	22.0		
WEATHER	P.CLOUDY	P.CLOUDY	CL.SUNNY	OVERCAST	CL.SUNNY		
						MEAN	SE
TURBIDITY (NTU)	5.9	6.5	6.8	34	6.3	12	5.5
OXYGEN							
DISSOLVED (MG/L)	11.50	12.00	9.50	7.60	9.80	10.08	0.783
PERCENT SATURATION	117	126	101	80	111	107	7.9
TOTAL ALKALINITY (MG/L)	45	55	63	39	42	49	4.5
PH	7.6	7.7	7.3	7.0	7.3	7.4	0.12
SPECIFIC CONDUCTANCE							
AT 25 C (μMHOS/CM)	235	290	320	165	185	239	29.6
SULFATE (MG/L)	43	54	71	23	34	45	8.3
IRON (MG/L)							
TOTAL	1.22	1.34	1.40	3.90	1.38	1.85	0.514
DISSOLVED	0.54	0.42	0.20	0.23	0.48	0.37	0.068
PERCENT DISSOLVED	44	31	14	6	35	26	7.0
SOLIDS (MG/L)							
TOTAL	149	180	246	200	153	186	17.7
TOTAL SUSPENDED	7	9	8	86	14	25	15.3
TOTAL DISSOLVED	142	171	238	114	139	161	21.3

BELL BEND 1

DATE	1 MAY	8 MAY	15 MAY	22 MAY	29 MAY		
TIME	1327	1331	1258	1241	1332		
TEMPERATURE (C)							
AIR	24.0	19.0	17.5	19.0	29.0		
WATER	17.0	18.0	18.0	18.0	22.0		
WEATHER	P.CLOUDY	P.CLOUDY	CL.SUNNY	OVERCAST	CL.SUNNY		
						MEAN	SE
TURBIDITY (NTU)	5.9	6.5	6.8	34	6.2	12	5.5
OXYGEN							
DISSOLVED (MG/L)	11.50	11.90	9.50	7.60	9.80	10.06	0.771
PERCENT SATURATION	117	125	101	80	111	107	7.8
TOTAL ALKALINITY (MG/L)	45	55	63	39	42	49	4.5
PH	7.6	7.7	7.4	7.0	7.3	7.4	0.12
SPECIFIC CONDUCTANCE							
AT 25 C (μMHOS/CM)	240	290	320	165	185	240	29.6
SULFATE (MG/L)	43	53	70	23	34	45	8.1
IRON (MG/L)							
TOTAL	1.27	1.40	1.36	4.54	1.16	1.95	0.650
DISSOLVED	0.62	0.43	0.21	0.17	0.48	0.38	0.085
PERCENT DISSOLVED	49	31	15	4	41	28	8.3
SOLIDS (MG/L)							
TOTAL	150	167	252	213	151	187	20.0
TOTAL SUSPENDED	7	9	7	96	12	26	17.5
TOTAL DISSOLVED	143	158	245	117	139	160	22.1

Table A-5 (cont.)

SSES

DATE	4 JUN	12 JUN	19 JUN	26 JUN		
TIME	1336	1309	1245	1325		
RIVER LEVEL(M ABOVE MSL)	148.97	149.46	149.46	148.88		
DISCHARGE(M^3/S)	222	402	402	194		
TEMPERATURE (C)						
AIR	26.0	19.0	26.0	23.0		
WATER	21.5	21.5	21.0	22.5		
WEATHER	CL. SUNNY	OVERCAST	CL. SUNNY	CL. SUNNY		
					MEAN	SE
TURBIDITY (NTU)	8.2	13	9.0	8.9	9.8	1.1
OXYGEN						
DISSOLVED (MG/L)	12.00	7.50	8.40	12.40	10.08	1.243
PERCENT SATURATION	136	84	94	146	115	15.3
TOTAL ALKALINITY (MG/L)	58	37	33	58	46	6.7
PH	8.4	7.3	7.3	8.4	7.9	0.32
SPECIFIC CONDUCTANCE						
AT 25 C (μMHOS/CM)	245	195	155	270	216	25.7
SULFATE (MG/L)	47	49	51	103	63	13.5
IRON (MG/L)						
TOTAL	1.36	2.11	1.89	1.29	1.66	0.200
DISSOLVED	0.29	0.42	0.47	0.20	0.34	0.061
PERCENT DISSOLVED	21	20	25	16	20	1.8
SOLIDS (MG/L)						
TOTAL	207	164	175	210	189	11.5
TOTAL SUSPENDED	15	31	28	20	23	3.7
TOTAL DISSOLVED	192	133	147	190	165	15.0

BELL BEND

DATE	4 JUN	12 JUN	19 JUN	26 JUN		
TIME	1344	1315	1249	1329		
TEMPERATURE (C)						
AIR	26.0	19.0	26.0	23.0		
WATER	21.5	21.5	21.0	22.5		
WEATHER	CL. SUNNY	OVERCAST	CL. SUNNY	CL. SUNNY		
					MEAN	SE
TURBIDITY (NTU)	7.2	13	9.0	8.8	9.5	1.2
OXYGEN						
DISSOLVED (MG/L)	11.90	7.40	8.40	12.50	10.05	1.264
PERCENT SATURATION	134	83	94	147	114	15.4
TOTAL ALKALINITY (MG/L)	58	37	33	58	46	6.7
PH	8.5	7.2	7.3	8.5	7.9	0.36
SPECIFIC CONDUCTANCE						
AT 25 C (μMHOS/CM)	250	195	155	270	217	26.2
SULFATE (MG/L)	47	49	50	103	62	13.6
IRON (MG/L)						
TOTAL	1.34	2.09	1.87	1.26	1.64	0.202
DISSOLVED	0.28	0.40	0.46	0.21	0.34	0.057
PERCENT DISSOLVED	21	19	25	17	20	1.7
SOLIDS (MG/L)						
TOTAL	198	160	174	210	185	11.3
TOTAL SUSPENDED	18	33	23	20	23	3.3
TOTAL DISSOLVED	180	127	151	190	162	14.3

BELL BEND 1

DATE	4 JUN	12 JUN	19 JUN	26 JUN		
TIME	1341	1319	1254	1331		
TEMPERATURE (C)						
AIR	26.0	19.0	26.0	23.0		
WATER	21.5	21.5	21.0	22.5		
WEATHER	CL. SUNNY	OVERCAST	CL. SUNNY	CL. SUNNY		
					MEAN	SE
TURBIDITY (NTU)	7.2	13	9.0	8.3	9.4	1.3
OXYGEN						
DISSOLVED (MG/L)	12.10	7.40	8.40	12.60	10.12	1.305
PERCENT SATURATION	137	83	94	148	115	15.9
TOTAL ALKALINITY (MG/L)	58	37	33	58	46	6.7
PH	8.5	7.2	7.3	8.5	7.9	0.36
SPECIFIC CONDUCTANCE						
AT 25 C (μMHOS/CM)	250	195	155	270	217	26.2
SULFATE (MG/L)	47	49	50	106	63	14.3
IRON (MG/L)						
TOTAL	1.17	2.04	1.75	1.19	1.54	0.215
DISSOLVED	0.31	0.42	0.47	0.24	0.36	0.052
PERCENT DISSOLVED	26	21	27	20	23	1.8
SOLIDS (MG/L)						
TOTAL	221	167	180	217	196	13.4
TOTAL SUSPENDED	16	29	23	18	21	2.9
TOTAL DISSOLVED	205	138	157	199	175	16.3

Table A-5 (cont.)

SSES

DATE	3 JUL	10 JUL	17 JUL	24 JUL	31 JUL		
TIME	1345	1240	1343	1325	1310		
RIVER LEVEL(M ABOVE MSL)	148.97	148.64	149.07	148.88	148.79		
DISCHARGE(M^3/S)	222	130	254	194	169		
TEMPERATURE (C)							
AIR	20.0	21.0	24.0	28.0	21.0		
WATER	21.0	25.0	23.5	25.5	24.0		
WEATHER	P.CLOUDY	P.CLOUDY	OVERCAST	CL.SUNNY	P.CLOUDY		
						MEAN	SE
TURBIDITY (NTU)	7.3	8.5	8.3	14	12	10	1.3
OXYGEN							
DISSOLVED (MG/L)	7.80	7.70	8.50	7.20	8.10	7.86	0.216
PERCENT SATURATION	87	89	99	88	95	92	2.3
TOTAL ALKALINITY (MG/L)	61	64	72	53	64	63	3.1
PH	7.4	7.5	7.6	7.4	7.6	7.5	0.04
SPECIFIC CONDUCTANCE							
AT 25 C (μMHOS/CM)	310	310	310	240	290	292	13.6
SULFATE (MG/L)	63	66	53	46	67	59	4.1
IRON (MG/L)							
TOTAL	1.60	1.36	1.50	1.77	1.62	1.57	0.068
DISSOLVED	0.39	0.22	0.21	0.49	0.23	0.31	0.056
PERCENT DISSOLVED	24	16	14	28	14	19	2.9
SOLIDS (MG/L)							
TOTAL	210	243	235	191	227	221	9.3
TOTAL SUSPENDED	11	11	15	17	18	14	1.5
TOTAL DISSOLVED	199	232	220	174	209	207	9.9

BELL BEND

DATE	3 JUL	10 JUL	17 JUL	24 JUL	31 JUL		
TIME	1350	1245	1338	1329	1320		
TEMPERATURE (C)							
AIR	20.0	21.0	24.0	28.0	21.0		
WATER	21.0	25.0	23.5	25.5	24.0		
WEATHER	P.CLOUDY	P.CLOUDY	OVERCAST	CL.SUNNY	P.CLOUDY		
						MEAN	SE
TURBIDITY (NTU)	7.3	8.5	8.2	13	10	9.4	1.0
OXYGEN							
DISSOLVED (MG/L)	7.80	7.70	8.60	7.50	8.30	7.98	0.203
PERCENT SATURATION	87	89	101	91	98	93	2.7
TOTAL ALKALINITY (MG/L)	61	64	72	54	64	63	2.9
PH	7.4	7.5	7.7	7.5	7.6	7.5	0.05
SPECIFIC CONDUCTANCE							
AT 25 C (μMHOS/CM)	320	320	315	240	290	297	15.3
SULFATE (MG/L)	63	66	44	44	63	56	4.9
IRON (MG/L)							
TOTAL	1.50	1.12	1.48	1.55	1.41	1.41	0.076
DISSOLVED	0.39	0.18	0.20	0.46	0.21	0.29	0.057
PERCENT DISSOLVED	26	16	14	30	15	20	3.3
SOLIDS (MG/L)							
TOTAL	220	248	224	185	223	220	10.1
TOTAL SUSPENDED	12	10	12	14	15	13	0.9
TOTAL DISSOLVED	208	238	212	171	208	207	10.7

BELL BEND 1

DATE	3 JUL	10 JUL	17 JUL	24 JUL	31 JUL		
TIME	1348	1250	1336	1331	1330		
TEMPERATURE (C)							
AIR	20.0	21.0	24.0	28.0	21.0		
WATER	21.0	25.0	23.5	25.5	24.0		
WEATHER	P.CLOUDY	P.CLOUDY	OVERCAST	CL.SUNNY	P.CLOUDY		
						MEAN	SE
TURBIDITY (NTU)	7.4	8.5	7.4	13	10	9.3	1.0
OXYGEN							
DISSOLVED (MG/L)	7.80	7.70	8.60	7.40	8.30	7.96	0.216
PERCENT SATURATION	87	89	101	90	98	93	2.7
TOTAL ALKALINITY (MG/L)	61	64	71	53	64	63	2.9
PH	7.4	7.5	7.7	7.6	7.6	7.6	0.05
SPECIFIC CONDUCTANCE							
AT 25 C (μMHOS/CM)	320	320	320	240	290	298	15.6
SULFATE (MG/L)	60	66	46	44	63	56	4.5
IRON (MG/L)							
TOTAL	1.60	1.07	1.24	1.57	1.31	1.36	0.101
DISSOLVED	0.41	0.17	0.22	0.48	0.21	0.30	0.062
PERCENT DISSOLVED	26	16	18	31	16	21	3.0
SOLIDS (MG/L)							
TOTAL	221	241	223	190	219	219	8.2
TOTAL SUSPENDED	13	8	16	14	19	14	1.8
TOTAL DISSOLVED	208	233	207	176	200	205	9.1

Table A-5 (cont.)

SSES						
DATE	7 AUG	14 AUG	21 AUG	28 AUG		
TIME	1311	1346	1336	1317		
RIVER LEVEL(M ABOVE MSL)	149.22	148.85	148.94	148.61		
DISCHARGE(M^3/S)	307	186	213	122		
TEMPERATURE (C)						
AIR	27.0	26.5	18.5	16.5		
WATER	24.5	24.5	24.5	22.5		
WEATHER	P. CLOUDY	P. CLOUDY	LGT. RAIN	OVERCAST		
					MEAN	SE
TURBIDITY (NTU)	17	8.9	8.2	7.9	10	2.2
OXYGEN						
DISSOLVED (MG/L)	7.90	9.70	7.90	8.60	8.53	0.425
PERCENT SATURATION	94	115	94	99	100	5.0
TOTAL ALKALINITY (MG/L)	41	55	68	62	56	5.8
PH	7.3	7.9	7.8	7.5	7.6	0.14
SPECIFIC CONDUCTANCE						
AT 25 C (µMHOS/CM)	195	255	270	270	247	17.9
SULFATE (MG/L)	61	54	44	50	52	3.6
IRON (MG/L)						
TOTAL	2.28	1.50	1.31	1.58	1.67	0.212
DISSOLVED	0.45	0.49	0.27	0.60	0.45	0.069
PERCENT DISSOLVED	20	33	21	38	28	4.5
SOLIDS (MG/L)						
TOTAL	166	190	188	216	190	10.2
TOTAL SUSPENDED	32	15	14	12	18	4.6
TOTAL DISSOLVED	134	175	174	204	172	14.4

BELL BEND						
DATE	7 AUG	14 AUG	21 AUG	28 AUG		
TIME	1307	1342	1331	1312		
TEMPERATURE (C)						
AIR	27.0	26.5	18.5	16.5		
WATER	24.5	24.5	24.5	22.5		
WEATHER	P. CLOUDY	P. CLOUDY	LGT. RAIN	OVERCAST		
					MEAN	SE
TURBIDITY (NTU)	15	8.7	8.7	7.8	10	1.7
OXYGEN						
DISSOLVED (MG/L)	7.90	9.90	7.90	8.60	8.58	0.471
PERCENT SATURATION	94	118	94	99	101	5.7
TOTAL ALKALINITY (MG/L)	41	53	68	62	56	5.9
PH	7.3	7.9	7.8	7.5	7.6	0.14
SPECIFIC CONDUCTANCE						
AT 25 C (µMHOS/CM)	200	260	275	275	252	17.9
SULFATE (MG/L)	61	40	40	53	48	5.2
IRON (MG/L)						
TOTAL	2.17	1.42	1.38	1.52	1.62	0.185
DISSOLVED	0.44	0.48	0.24	0.57	0.43	0.070
PERCENT DISSOLVED	20	34	17	37	27	5.0
SOLIDS (MG/L)						
TOTAL	170	195	188	218	193	9.9
TOTAL SUSPENDED	34	14	14	11	18	5.3
TOTAL DISSOLVED	136	181	174	207	174	14.7

BELL BEND 1						
DATE	7 AUG	14 AUG	21 AUG	28 AUG		
TIME	1305	1339	1329	1314		
TEMPERATURE (C)						
AIR	27.0	26.5	18.5	16.5		
WATER	24.5	24.5	24.5	22.5		
WEATHER	P. CLOUDY	P. CLOUDY	LGT. RAIN	OVERCAST		
					MEAN	SE
TURBIDITY (NTU)	15	8.7	8.4	7.9	10	1.7
OXYGEN						
DISSOLVED (MG/L)	7.90	9.80	7.90	8.60	8.55	0.448
PERCENT SATURATION	94	117	94	99	101	5.5
TOTAL ALKALINITY (MG/L)	41	54	68	62	56	5.8
PH	7.3	7.8	7.8	7.5	7.6	0.12
SPECIFIC CONDUCTANCE						
AT 25 C (µMHOS/CM)	200	265	280	275	255	18.6
SULFATE (MG/L)	61	40	43	51	49	4.7
IRON (MG/L)						
TOTAL	2.35	1.38	1.40	1.55	1.67	0.230
DISSOLVED	0.55	0.49	0.25	0.55	0.46	0.071
PERCENT DISSOLVED	23	36	18	35	28	4.5
SOLIDS (MG/L)						
TOTAL	172	192	195	221	195	10.1
TOTAL SUSPENDED	34	13	14	12	18	5.3
TOTAL DISSOLVED	138	179	181	209	177	14.6

Table A-5 (cont.)

SSES

DATE	4 SEP	11 SEP	18 SEP	25 SEP		
TIME	1323	1331	1242	1323		
RIVER LEVEL(M ABOVE MSL)	148.39	148.36	148.27	148.27		
DISCHARGE(M^3/S)	75	70	54	54		
TEMPERATURE (C)						
AIR	21.0	29.0	19.0	21.0		
WATER	21.0	21.0	18.0	19.0		
WEATHER	OVERCAST	P. CLOUDY	OVERCAST	OVERCAST		
					MEAN	SE
TURBIDITY (NTU)	8.6	7.0	8.3	7.5	7.9	0.4
OXYGEN						
DISSOLVED (MG/L)	8.10	8.90	8.40	7.80	8.30	0.235
PERCENT SATURATION	91	99	89	83	90	3.3
TOTAL ALKALINITY (MG/L)	70	73	74	72	72	0.9
PH	7.6	7.6	7.4	7.4	7.5	0.06
SPECIFIC CONDUCTANCE						
AT 25 C (µMHOS/CM)	355	395	415	425	397	15.5
SULFATE (MG/L)	66	77	97	86	81	6.6
IRON (MG/L)						
TOTAL	1.52	1.47	1.60	1.72	1.58	0.055
DISSOLVED	0.20	0.17	0.19	0.39	0.24	0.051
PERCENT DISSOLVED	13	12	12	23	15	2.7
SOLIDS (MG/L)						
TOTAL	259	256	317	291	281	14.4
TOTAL SUSPENDED	11	8	9	10	9	0.6
TOTAL DISSOLVED	248	248	308	281	271	14.5

BELL BEND

DATE	4 SEP	11 SEP	18 SEP	25 SEP		
TIME	1330	1326	1248	1319		
TEMPERATURE (C)						
AIR	20.5	29.0	18.5	21.5		
WATER	20.0	21.0	18.0	19.0		
WEATHER	OVERCAST	P. CLOUDY	OVERCAST	OVERCAST		
					MEAN	SE
TURBIDITY (NTU)	8.2	7.0	7.3	7.5	7.5	0.3
OXYGEN						
DISSOLVED (MG/L)	8.10	9.20	8.40	7.60	8.33	0.335
PERCENT SATURATION	91	102	89	81	91	4.3
TOTAL ALKALINITY (MG/L)	71	73	74	72	72	0.6
PH	7.6	7.6	7.4	7.4	7.5	0.06
SPECIFIC CONDUCTANCE						
AT 25 C (µMHOS/CM)	360	415	415	425	404	14.8
SULFATE (MG/L)	66	80	97	86	82	6.5
IRON (MG/L)						
TOTAL	1.40	1.32	1.35	1.63	1.43	0.070
DISSOLVED	0.19	0.18	0.17	0.38	0.23	0.050
PERCENT DISSOLVED	14	14	13	23	16	2.3
SOLIDS (MG/L)						
TOTAL	258	263	321	287	282	14.4
TOTAL SUSPENDED	11	9	9	10	10	0.5
TOTAL DISSOLVED	247	254	312	277	272	14.6

BELL BEND 1

DATE	4 SEP	11 SEP	18 SEP	25 SEP		
TIME	1328	1328	1246	1317		
TEMPERATURE (C)						
AIR	20.5	29.0	18.5	21.5		
WATER	20.0	21.0	18.0	19.0		
WEATHER	OVERCAST	P. CLOUDY	OVERCAST	OVERCAST		
					MEAN	SE
TURBIDITY (NTU)	8.3	7.0	7.3	7.5	7.5	0.3
OXYGEN						
DISSOLVED (MG/L)	8.20	9.20	8.50	7.80	8.42	0.295
PERCENT SATURATION	92	102	91	83	92	3.9
TOTAL ALKALINITY (MG/L)	71	73	74	72	72	0.6
PH	7.6	7.6	7.4	7.4	7.5	0.06
SPECIFIC CONDUCTANCE						
AT 25 C (µMHOS/CM)	360	415	430	425	407	16.1
SULFATE (MG/L)	66	83	97	86	83	6.4
IRON (MG/L)						
TOTAL	1.40	1.32	1.35	1.63	1.43	0.070
DISSOLVED	0.21	0.18	0.16	0.40	0.24	0.055
PERCENT DISSOLVED	15	14	12	25	16	2.9
SOLIDS (MG/L)						
TOTAL	263	267	320	293	286	13.2
TOTAL SUSPENDED	10	8	9	9	9	0.4
TOTAL DISSOLVED	253	259	311	284	277	13.2

Table A-5 (cont.)

SSES

DATE	16 OCT	30 OCT		
TIME	1238	1322		
RIVER LEVEL(M ABOVE MSL)	148.73	148.70		
DISCHARGE(M^3/S)	153	145		
TEMPERATURE (C)				
AIR	12.5	12.0		
WATER	13.5	13.0		
WEATHER	P.CLOUDY	P.CLOUDY		
			MEAN	SE
TURBIDITY (NTU)	5.8	5.4	5.6	0.2
OXYGEN				
DISSOLVED (MG/L)	9.80	10.90	10.35	0.550
PERCENT SATURATION	98	104	101	3.0
TOTAL ALKALINITY (MG/L)	64	69	66	2.5
PH	7.4	7.5	7.5	0.05
SPECIFIC CONDUCTANCE				
AT 25 C (μMHOS/CM)	270	290	280	10.0
SULFATE (MG/L)	46	49	47	1.5
IRON (MG/L)				
TOTAL	1.39	1.33	1.36	0.030
DISSOLVED	0.72	0.68	0.70	0.020
PERCENT DISSOLVED	52	51	51	0.5
SOLIDS (MG/L)				
TOTAL	183	200	191	8.5
TOTAL SUSPENDED	6	5	5	0.5
TOTAL DISSOLVED	177	195	186	9.0

BELL BEND

DATE	16 OCT	30 OCT		
TIME	1231	1315		
TEMPERATURE (C)				
AIR	12.5	16.0		
WATER	13.5	14.0		
WEATHER	P.CLOUDY	P.CLOUDY		
			MEAN	SE
TURBIDITY (NTU)	5.2	4.9	5.1	0.2
OXYGEN				
DISSOLVED (MG/L)	9.50	10.90	10.20	0.700
PERCENT SATURATION	95	104	99	4.5
TOTAL ALKALINITY (MG/L)	63	69	66	3.0
PH	7.4	7.5	7.5	0.05
SPECIFIC CONDUCTANCE				
AT 25 C (μMHOS/CM)	280	310	295	15.0
SULFATE (MG/L)	44	50	47	3.0
IRON (MG/L)				
TOTAL	1.32	1.34	1.33	0.010
DISSOLVED	0.69	0.67	0.68	0.010
PERCENT DISSOLVED	52	50	51	1.0
SOLIDS (MG/L)				
TOTAL	183	206	194	11.5
TOTAL SUSPENDED	6	7	6	0.5
TOTAL DISSOLVED	177	199	188	11.0

BELL BEND 1

DATE	16 OCT	30 OCT		
TIME	1229	1317		
TEMPERATURE (C)				
AIR	12.5	14.0		
WATER	13.6	13.5		
WEATHER	P.CLOUDY	P.CLOUDY		
			MEAN	SE
TURBIDITY (NTU)	5.5	4.3	4.9	0.6
OXYGEN				
DISSOLVED (MG/L)	9.70	10.90	10.30	0.600
PERCENT SATURATION	97	104	100	3.5
TOTAL ALKALINITY (MG/L)	63	69	66	3.0
PH	7.4	7.5	7.5	0.05
SPECIFIC CONDUCTANCE				
AT 25 C (μMHOS/CM)	280	310	295	15.0
SULFATE (MG/L)	44	50	47	3.0
IRON (MG/L)				
TOTAL	1.38	1.38	1.38	0.000
DISSOLVED	0.73	0.69	0.71	0.020
PERCENT DISSOLVED	53	50	51	1.5
SOLIDS (MG/L)				
TOTAL	186	206	196	10.0
TOTAL SUSPENDED	6	6	6	0.0
TOTAL DISSOLVED	180	200	190	10.0

Table A-5 (cont.)

SSES				
DATE	12 NOV	25 NOV		
TIME	1234	1247		
RIVER LEVEL(M ABOVE MSL)	150.01	150.38		
DISCHARGE(M^3/S)	665	878		
TEMPERATURE (C)				
AIR	5.5	6.5		
WATER	7.0	3.5		
WEATHER	P. CLOUDY	P. CLOUDY		
			MEAN	SE
TURBIDITY (NTU)	27	17	22	5.0
OXYGEN				
DISSOLVED (MG/L)	11.20	12.90	12.05	0.850
PERCENT SATURATION	93	98	95	2.5
TOTAL ALKALINITY (MG/L)	41	31	36	5.0
PH	7.4	7.3	7.4	0.05
SPECIFIC CONDUCTANCE				
AT 25 C (μMHOS/CM)	160	140	150	10.0
SULFATE (MG/L)	22	20	21	1.0
IRON (MG/L)				
TOTAL	2.91	1.82	2.37	0.545
DISSOLVED	0.27	0.27	0.27	0.000
PERCENT DISSOLVED	9	15	12	3.0
SOLIDS (MG/L)				
TOTAL	150	126	138	12.0
TOTAL SUSPENDED	50	30	40	10.0
TOTAL DISSOLVED	100	96	98	2.0

BELL BEND				
DATE	12 NOV	25 NOV		
TIME	1240	1253		
TEMPERATURE (C)				
AIR	5.5	6.5		
WATER	7.0	3.5		
WEATHER	P. CLOUDY	P. CLOUDY		
			MEAN	SE
TURBIDITY (NTU)	26	17	21	4.5
OXYGEN				
DISSOLVED (MG/L)	11.10	13.00	12.05	0.950
PERCENT SATURATION	92	99	95	3.5
TOTAL ALKALINITY (MG/L)	41	30	35	5.5
PH	7.4	7.3	7.4	0.05
SPECIFIC CONDUCTANCE				
AT 25 C (μMHOS/CM)	160	140	150	10.0
SULFATE (MG/L)	21	21	21	0.0
IRON (MG/L)				
TOTAL	2.39	1.71	2.05	0.340
DISSOLVED	0.27	0.29	0.28	0.010
PERCENT DISSOLVED	11	17	14	3.0
SOLIDS (MG/L)				
TOTAL	161	126	143	17.5
TOTAL SUSPENDED	39	27	33	6.0
TOTAL DISSOLVED	122	99	110	11.5

BELL BEND 1				
DATE	12 NOV	25 NOV		
TIME	1238	1250		
TEMPERATURE (C)				
AIR	5.5	6.5		
WATER	7.0	3.5		
WEATHER	P. CLOUDY	P. CLOUDY		
			MEAN	SE
TURBIDITY (NTU)	27	17	22	5.0
OXYGEN				
DISSOLVED (MG/L)	11.20	12.90	12.05	0.850
PERCENT SATURATION	93	98	95	2.5
TOTAL ALKALINITY (MG/L)	41	30	35	5.5
PH	7.4	7.3	7.4	0.05
SPECIFIC CONDUCTANCE				
AT 25 C (μMHOS/CM)	160	140	150	10.0
SULFATE (MG/L)	20	21	20	0.5
IRON (MG/L)				
TOTAL	2.51	1.91	2.21	0.300
DISSOLVED	0.28	0.28	0.28	0.000
PERCENT DISSOLVED	11	15	13	2.0
SOLIDS (MG/L)				
TOTAL	161	126	143	17.5
TOTAL SUSPENDED	49	30	39	9.5
TOTAL DISSOLVED	112	96	104	8.0

SSES

DATE	15 DEC	29 DEC		
TIME	1206	1251		
RIVER LEVEL(M ABOVE MSL)	149.46	149.83		
DISCHARGE(M^3/S)	402	572		
TEMPERATURE (C)				
AIR	1.5	3.5		
WATER	0.5	2.5		
WEATHER	P.CLOUDY	CL.SUNNY		
			MEAN	SE
TURBIDITY (NTU)	4.8	8.2	6.5	1.7
OXYGEN				
DISSOLVED (MG/L)	14.00	13.40	13.70	0.300
PERCENT SATURATION	98	99	98	0.5
TOTAL ALKALINITY (MG/L)	46	40	43	3.0
PH	7.4	7.4	7.4	0.00
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	190	160	175	15.0
SULFATE (MG/L)	31	23	27	4.0
IRON (MG/L)				
TOTAL	0.93	1.16	1.04	0.115
DISSOLVED	0.48	0.36	0.42	0.060
PERCENT DISSOLVED	52	31	41	10.5
SOLIDS (MG/L)				
TOTAL	137	132	134	2.5
TOTAL SUSPENDED	5	9	7	2.0
TOTAL DISSOLVED	132	123	127	4.5

BELL BEND

DATE	15 DEC	29 DEC		
TIME	1212	1247		
TEMPERATURE (C)				
AIR	1.5	3.5		
WATER	0.5	2.5		
WEATHER	P.CLOUDY	CL.SUNNY		
			MEAN	SE
TURBIDITY (NTU)	4.9	8.2	6.5	1.7
OXYGEN				
DISSOLVED (MG/L)	14.00	13.40	13.70	0.300
PERCENT SATURATION	98	99	98	0.5
TOTAL ALKALINITY (MG/L)	46	40	43	3.0
PH	7.4	7.4	7.4	0.00
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	190	160	175	15.0
SULFATE (MG/L)	30	23	26	3.5
IRON (MG/L)				
TOTAL	0.92	1.14	1.03	0.110
DISSOLVED	0.47	0.35	0.41	0.060
PERCENT DISSOLVED	51	31	41	10.0
SOLIDS (MG/L)				
TOTAL	138	132	135	3.0
TOTAL SUSPENDED	5	10	8	2.5
TOTAL DISSOLVED	133	122	127	5.5

BELL BEND 1

DATE	15 DEC	29 DEC		
TIME	1210	1244		
TEMPERATURE (C)				
AIR	1.5	3.5		
WATER	0.5	2.5		
WEATHER	P.CLOUDY	CL.SUNNY		
			MEAN	SE
TURBIDITY (NTU)	4.9	8.2	6.5	1.7
OXYGEN				
DISSOLVED (MG/L)	14.00	13.40	13.70	0.300
PERCENT SATURATION	98	99	98	0.5
TOTAL ALKALINITY (MG/L)	47	40	43	3.5
PH	7.4	7.4	7.4	0.00
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	190	160	175	15.0
SULFATE (MG/L)	29	23	26	3.0
IRON (MG/L)				
TOTAL	0.92	1.03	0.97	0.055
DISSOLVED	0.47	0.35	0.41	0.060
PERCENT DISSOLVED	51	34	42	8.5
SOLIDS (MG/L)				
TOTAL	138	129	133	4.5
TOTAL SUSPENDED	5	10	8	2.5
TOTAL DISSOLVED	133	119	126	7.0

Table A-6

Summary of physicochemical data collected from the Susquehanna River at SSES, Bell Bend, and Bell Bend I, 1986. Sampling began at Bell Bend I in March 1986.

	SSES			
PARAMETER	MINIMUM	MAXIMUM	MEAN	SE
TURBIDITY (NTU)	4.3	64	12	1.8
OXYGEN				
DISSOLVED (MG/L)	7.20	14.00	10.23	0.338
PERCENT SATURATION	81	146	98	2.2
TOTAL ALKALINITY (MG/L)	31	74	52	2.2
PH	7.0	8.4	7.4	0.05
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	140	425	247	12.2
SULFATE (MG/L)	20	103	49	3.3
IRON				
TOTAL (MG/L)	0.93	5.79	1.77	0.161
DISSOLVED (MG/L)	0.17	1.00	0.41	0.032
PERCENT DISSOLVED	4	62	28	2.7
SOLIDS (MG/L)				
TOTAL	123	317	193	7.9
TOTAL SUSPENDED	3	136	22	4.6
TOTAL DISSOLVED	96	308	171	8.3

	BELL BEND			
PARAMETER	MINIMUM	MAXIMUM	MEAN	SE
TURBIDITY (NTU)	3.7	62	11	1.8
OXYGEN				
DISSOLVED (MG/L)	7.40	14.00	10.26	0.342
PERCENT SATURATION	80	147	99	2.3
TOTAL ALKALINITY (MG/L)	30	74	52	2.2
PH	7.0	8.5	7.4	0.05
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	140	425	251	12.5
SULFATE (MG/L)	21	103	48	3.4
IRON				
TOTAL (MG/L)	0.92	5.82	1.70	0.157
DISSOLVED (MG/L)	0.13	0.95	0.40	0.031
PERCENT DISSOLVED	2	65	28	2.6
SOLIDS (MG/L)				
TOTAL	120	321	192	7.9
TOTAL SUSPENDED	3	144	21	4.8
TOTAL DISSOLVED	95	312	170	8.7

	BELL BEND 1			
PARAMETER	MINIMUM	MAXIMUM	MEAN	SE
TURBIDITY (NTU)	4.3	62	12	2.0
OXYGEN				
DISSOLVED (MG/L)	7.40	14.00	9.96	0.340
PERCENT SATURATION	80	148	100	2.5
TOTAL ALKALINITY (MG/L)	30	74	53	2.3
PH	7.0	8.5	7.5	0.05
SPECIFIC CONDUCTANCE				
AT 25 C (µMHOS/CM)	140	430	252	13.9
SULFATE (MG/L)	20	106	48	3.8
IRON				
TOTAL (MG/L)	0.92	6.35	1.78	0.202
DISSOLVED (MG/L)	0.16	0.73	0.37	0.027
PERCENT DISSOLVED	3	53	26	2.4
SOLIDS (MG/L)				
TOTAL	123	320	198	8.7
TOTAL SUSPENDED	5	151	25	5.9
TOTAL DISSOLVED	96	311	174	9.5

Table A-7

Comparison of physicochemical data collected from the Susquehanna River at SSES, Bell Bend, and Bell Bend I during preoperation (1978-82) and operation (1983-86) of the Susquehanna SES. Sampling began at Bell Bend I in March 1986.

SSES

	PREOPERATION				OPERATION			
PARAMETER	MINIMUM	MAXIMUM	MEAN	SE	MINIMUM	MAXIMUM	MEAN	SE
TURBIDITY (NTU)	3.3	450	17	1.8	3.3	320	16	1.8
OXYGEN								
DISSOLVED (MG/L)	5.20	14.70	10.26	0.098	6.15	15.20	10.29	0.125
PERCENT SATURATION	60	145	100	0.8	71	159	99	0.9
TOTAL ALKALINITY (MG/L)	16	87	55	0.7	16	88	53	0.9
PH	6.6	9.0	7.5	0.02	6.8	8.5	7.4	0.02
SPECIFIC CONDUCTANCE								
AT 25 C (μMHOS/CM)	76	540	293	5.4	90	515	277	6.2
SULFATE (MG/L)	8	158	63	1.8	11	150	58	1.9
IRON								
TOTAL (MG/L)	0.96	22.00	2.30	0.105	0.86	27.40	2.16	0.138
DISSOLVED (MG/L)	0.01	2.25	0.51	0.020	0.11	1.47	0.48	0.016
PERCENT DISSOLVED	1	98	28	1.2	2	79	29	1.1
SOLIDS (MG/L)								
TOTAL	106	736	222	4.2	106	745	216	4.9
TOTAL SUSPENDED	1	658	26	3.0	1	648	25	3.5
TOTAL DISSOLVED	61	363	194	3.8	54	360	191	4.4

BELL BEND

	PREOPERATION				OPERATION			
PARAMETER	MINIMUM	MAXIMUM	MEAN	SE	MINIMUM	MAXIMUM	MEAN	SE
TURBIDITY (NTU)	3.1	450	17	1.8	3.2	320	15	1.8
OXYGEN								
DISSOLVED (MG/L)	5.00	14.50	10.31	0.099	6.15	15.40	10.37	0.127
PERCENT SATURATION	58	157	100	0.8	71	157	99	1.0
TOTAL ALKALINITY (MG/L)	16	88	55	0.7	16	88	53	0.9
PH	6.6	8.9	7.5	0.02	6.8	8.6	7.4	0.02
SPECIFIC CONDUCTANCE								
AT 25 C (μMHOS/CM)	74	525	293	5.4	91	540	282	6.5
SULFATE (MG/L)	9	158	62	1.8	10	152	58	1.9
IRON								
TOTAL (MG/L)	0.72	22.50	2.22	0.104	0.85	25.40	2.07	0.132
DISSOLVED (MG/L)	0.01	2.23	0.50	0.019	0.11	1.50	0.47	0.015
PERCENT DISSOLVED	0	92	28	1.2	2	81	29	1.1
SOLIDS (MG/L)								
TOTAL	107	710	224	4.2	104	728	220	5.0
TOTAL SUSPENDED	1	649	26	2.9	1	620	25	3.4
TOTAL DISSOLVED	55	366	195	3.8	62	368	195	4.6

Table A-8

Pennsylvania Department of Environmental Resources water quality criteria applicable to selected physicochemical parameters monitored at SSES, Bell Bend, and Bell Bend I on the Susquehanna River, 1986.

Parameter	Criteria
Aluminum	Not to exceed 0.1 of the 96-hour LC_{50} for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.
Alkalinity	Equal to or greater than 20 mg/l as $CaCO_3$, except where natural conditions are less. Where discharges are to waters with 20 mg/l or less alkalinity, the discharges should not further reduce the alkalinity of the receiving waters.
Ammonia Nitrogen	The maximum total ammonia nitrogen concentration at all times shall be less than or equal to the numerical value given by: un-ionized ammonia nitrogen $(NH_3\text{-}N) \times (\log^{-1}[pK_T - pH] + 1)$, where: un-ionized ammonia nitrogen $= 0.12 \times f(T)/f(pH)$; $f(pH) = 1 + 10^{1.03(7.32 - pH)}$; $f(T) = 1,\ T \geq 10°\,C$; $f(T) = \dfrac{1 + 10^{(9.73 - pH)}}{1 + 10^{(pK_T - pH)}},\ T < 10°\,C$; and $pK_T = 0.090 + \left[\dfrac{2730}{(T + 273.2)}\right]$, the dissociation constant for ammonia in water.
Chromium	Not to exceed 0.05 mg/l as hexavalent chromium.
Copper	Not to exceed 0.1 of the 96-hour LC_{50} for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.
Dissolved Oxygen	Minimum daily average 5.0 mg/l; no value less than 4.0 mg/l. For the epilimnion of lakes, ponds and impoundments, minimum daily average of 5.0 mg/l, no values less than 4.0 mg/l.
Iron	Not to exceed 1.5 mg/l as total iron; not to exceed 0.3 mg/l as dissolved iron.
Manganese	Not to exceed 1.0 mg/l.
Nickel	Not to exceed 0.01 of the 96-hour LC_{50} for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.
Nitrite plus Nitrate	Not to exceed 10 mg/l as nitrogen.
pH	Not less than 6.0 and not more than 9.0.
Temperature	No rise when ambient temperature is 87°F or above; not more than a 5°F rise above ambient temperature until stream temperature reaches 87°F; not to be changed by more than 2°F during any one-hour period.
Total Dissolved Solids	Not more than 500 mg/l as a monthly average value; not more than 750 mg/l at any time.
Zinc	Not to exceed 0.01 of the 96-hour LC_{50} for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.

Table A-9

Physicochemical data collected monthly from the Susquehanna River at SSES and Bell Bend, 1986. Samples were analyzed at the Pennsylvania Power and Light Company Water Laboratory, Hazleton, Pennsylvania.

	SSES											
SAMPLE NUMBER	296	298	300	302	304	306	308	310	312	314	316	318
DATE	6 Jan	10 Feb	3 Mar	8 Apr	12 May	9 Jun	14 Jul	5 Aug	9 Sep	6 Oct	10 Nov	1 Dec
TIME	1045	1045	908	657	910	1055	1113	1055	1203	1000	921	1043
RIVER TEMPERATURE(C)	0.5	0.5	1.0	10.0	18.0	21.0	23.5	22.5	20.0	18.0	8.5	3.5
TURBIDITY(FTU)	5.0	7.9	7.9	6.5	7.0	30.0	8.0	28.0	7.2	16.0	21.0	25.0
PH	7.30	7.20	7.30	7.60	7.70	7.40	7.40	7.10	7.40	7.60	7.50	7.40
SPECIFIC CONDUCTANCE(μMHOS)	275.0	250.0	207.0	226.0	315.0	190.0	328.0	167.0	398.0	260.0	217.0	127.0
ANALYSIS (MG/L)												
SUSPENDED MATTER	4.6	6.5	5.6	13.5	9.0	64.9	11.4	62.9	8.5	51.0	67.6	35.5
AMMONIA NITROGEN	0.49	0.37	0.14	0.12	0.06	0.13	0.07	0.25	0.07	0.13	0.16	0.26
NITRATE NITROGEN	1.40	1.36	1.20	1.28	0.77	0.99	0.94	0.67	1.28	1.01	0.82	0.45
M. O. ALKALINITY	57.0	42.0	38.0	50.0	59.0	36.0	60.0	40.0	74.0	64.0	57.0	28.0
HARDNESS	112.7	85.2	79.9	90.1	122.6	71.9	128.8	65.1	156.1	98.6	84.0	49.4
SILICON DIOXIDE	4.75	4.18	4.29	3.16	0.39	3.28	2.09	4.12	1.75	2.94	1.47	4.12
CALCIUM	32.4	24.5	22.9	26.8	33.7	20.7	35.7	19.1	42.5	29.7	25.7	14.8
MAGNESIUM	7.7	5.8	5.5	5.6	9.3	4.9	9.6	4.2	12.1	5.9	4.8	3.0
SODIUM	11.2	12.7	9.2	8.7	13.3	7.5	14.7	7.1	16.6	11.7	8.8	4.3
POTASSIUM	1.5	1.6	1.4	1.3	1.5	1.7	2.0	1.6	2.1	2.6	1.9	1.7
BICARBONATE	69.5	51.2	46.4	61.0	72.0	43.9	73.2	48.8	90.3	78.1	69.5	34.2
SULFATE	48.7	36.0	32.5	32.4	58.0	32.7	66.5	22.6	70.5	31.0	22.5	17.0
CHLORIDE	16.4	20.6	13.4	12.7	18.2	10.9	20.0	10.3	23.7	17.6	14.0	6.7
NITRATE	6.19	6.01	5.30	5.66	3.42	4.36	4.17	2.97	5.67	4.48	3.63	2.00
PHOSPHATE	0.18	0.13	0.00	0.15	0.15	0.35	0.17	0.39	0.12	0.02	0.06	0.23
TOTAL MINERAL SOLIDS	198.5	162.8	140.8	157.5	209.9	130.3	228.2	121.2	265.3	184.0	152.4	88.0
DISSOLVED OXYGEN	12.70	12.70	13.50	10.60	10.80	7.50	6.00	7.60	8.60	8.00	10.70	13.20
ANALYSIS (ME/L)[a]												
POSITIVE IONS												
CALCIUM	1.62	1.22	1.14	1.34	1.68	1.03	1.78	0.95	2.12	1.48	1.28	0.74
MAGNESIUM	0.63	0.48	0.45	0.46	0.77	0.40	0.79	0.35	1.00	0.49	0.39	0.25
SODIUM	0.49	0.55	0.40	0.38	0.58	0.33	0.64	0.31	0.72	0.51	0.38	0.19
POTASSIUM	0.04	0.04	0.04	0.03	0.04	0.04	0.05	0.04	0.05	0.07	0.05	0.04
TOTAL	2.78	2.29	2.03	2.21	3.07	1.80	3.26	1.65	3.89	2.55	2.10	1.22
NEGATIVE IONS												
BICARBONATE	1.14	0.84	0.76	1.00	1.18	0.72	1.20	0.80	1.48	1.28	1.14	0.56
SULFATE	1.01	0.75	0.68	0.67	1.21	0.68	1.38	0.47	1.47	0.65	0.47	0.35
CHLORIDE	0.46	0.58	0.38	0.36	0.51	0.31	0.56	0.29	0.67	0.50	0.39	0.19
NITRATE	0.10	0.10	0.09	0.09	0.06	0.07	0.07	0.05	0.09	0.07	0.06	0.03
PHOSPHATE	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.01
TOTAL	2.72	2.27	1.91	2.12	2.96	1.79	3.22	1.62	3.71	2.50	2.06	1.14
TRACE METAL ANALYSIS (MG/L)												
IRON, TOTAL	1.26	1.16	1.08	1.14	1.45	2.96	1.48	2.75	1.43	2.52	2.80	1.84
IRON, DISSOLVED	0.42	0.70	0.75	0.53	0.28	0.28	0.42	0.30	0.24	0.25	0.21	0.27
ALUMINUM, TOTAL	<0.30	<0.20	0.20	<0.20	<0.20	1.20	0.20	1.00	<0.20	0.50	0.90	0.80
ALUMINUM, DISSOLVED	<0.30	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.20
MANGANESE, TOTAL	0.26	0.19	0.17	0.16	0.31	0.23	0.24	0.19	0.30	0.28	0.24	0.13
MANGANESE, DISSOLVED	0.26	0.19	0.17	0.16	0.24	0.09	0.18	0.06	0.24	0.06	0.06	0.06
COPPER, TOTAL	0.01	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	0.03	<0.02	<0.02	<0.02
COPPER, DISSOLVED	0.01	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	0.02	<0.02	<0.02	<0.02
ZINC, TOTAL	0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.02
ZINC, DISSOLVED	0.02	0.01	0.01	0.01	0.01	0.01	0.01	<0.01	0.01	0.01	<0.01	0.01
NICKEL, TOTAL	<0.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
NICKEL, DISSOLVED	<0.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
CHROMIUM, TOTAL	--	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
CHROMIUM, DISSOLVED	--	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
MOLYBDENUM, TOTAL	--	--	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
MOLYBDENUM, DISSOLVED	--	--	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10

Table A-9 (cont.)

	BELL BEND											
SAMPLE NUMBER	297	299	301	303	305	307	309	311	313	315	317	319
DATE	6 Jan	10 Feb	3 Mar	8 Apr	12 May	9 Jun	14 Jul	5 Aug	9 Sep	6 Oct	10 Nov	1 Dec
TIME	1050	1053	924	701	914	1103	1119	1100	1220	1004	939	1048
RIVER TEMPERATURE(C)	0.5	0.5	1.0	10.0	18.0	21.0	23.5	22.5	20.0	18.0	8.5	3.5
TURBIDITY(FTU)	4.9	7.7	6.5	6.8	7.1	30.0	7.0	26.0	7.3	14.0	21.0	26.0
PH	7.20	7.30	7.20	7.50	7.70	7.40	7.40	7.20	7.50	7.60	7.60	7.50
SPECIFIC CONDUCTANCE(μMHOS)	280.0	254.0	205.0	226.0	320.0	190.0	345.0	170.0	400.0	260.0	220.0	125.0
<u>ANALYSIS (MG/L)</u>												
SUSPENDED MATTER	3.6	6.9	6.1	14.3	8.9	68.9	10.6	59.3	8.3	41.0	75.9	35.9
AMMONIA NITROGEN	0.51	0.40	0.13	0.08	0.04	0.14	0.07	0.22	0.07	0.12	0.18	0.26
NITRATE NITROGEN	1.40	1.32	1.28	1.28	0.77	0.97	0.98	0.67	1.21	0.98	0.86	0.45
M. O. ALKALINITY	60.0	41.0	36.0	51.0	59.0	37.0	61.0	40.0	75.0	64.0	57.0	28.0
HARDNESS	114.1	85.7	79.7	89.7	125.1	71.8	135.8	65.1	159.9	98.6	85.7	48.9
SILICON DIOXIDE	4.80	4.29	4.41	3.11	0.37	3.33	2.20	4.12	1.86	2.94	1.47	4.12
CALCIUM	32.8	24.7	22.8	26.8	34.4	20.8	37.5	19.1	43.7	29.7	26.2	14.6
MAGNESIUM	7.8	5.8	5.5	5.5	9.5	4.8	10.2	4.2	12.3	5.9	4.9	3.0
SODIUM	11.5	13.1	9.4	8.6	13.6	7.5	15.3	7.0	17.1	11.5	8.9	4.3
POTASSIUM	1.4	1.7	1.4	1.3	1.5	1.7	2.1	1.6	2.2	2.6	1.9	1.7
BICARBONATE	73.2	50.0	43.9	62.2	72.0	45.1	74.4	48.8	91.5	78.1	69.5	34.2
SULFATE	50.5	36.0	32.5	32.0	60.6	32.0	73.0	21.4	74.0	30.0	25.0	17.0
CHLORIDE	17.0	21.8	13.4	12.7	18.8	9.7	20.6	9.7	24.9	17.6	14.6	6.1
NITRATE	6.19	5.84	5.66	5.66	3.42	4.30	4.32	2.97	5.37	4.35	3.81	2.00
PHOSPHATE	0.11	0.06	0.08	0.15	0.16	0.35	0.15	0.09	0.20	0.14	0.13	0.23
TOTAL MINERAL SOLIDS	205.3	163.4	139.0	158.1	214.3	129.6	239.8	119.0	273.1	182.8	156.4	87.2
DISSOLVED OXYGEN	12.80	13.20	13.60	10.40	10.60	7.40	6.00	7.50	8.60	8.00	10.70	13.10
<u>ANALYSIS (ME/L)[a]</u>												
POSITIVE IONS												
CALCIUM	1.64	1.23	1.14	1.34	1.72	1.04	1.87	0.95	2.18	1.48	1.31	0.73
MAGNESIUM	0.64	0.48	0.45	0.45	0.78	0.39	0.84	0.35	1.01	0.49	0.40	0.25
SODIUM	0.50	0.57	0.41	0.37	0.59	0.33	0.67	0.30	0.74	0.50	0.39	0.19
POTASSIUM	0.04	0.04	0.04	0.03	0.04	0.04	0.05	0.04	0.06	0.07	0.05	0.04
TOTAL	2.82	2.32	2.04	2.19	3.13	1.80	3.43	1.64	3.99	2.54	2.15	1.21
NEGATIVE IONS												
BICARBONATE	1.20	0.82	0.72	1.02	1.18	0.74	1.22	0.80	1.50	1.28	1.14	0.56
SULFATE	1.05	0.75	0.68	0.67	1.26	0.67	1.52	0.45	1.54	0.62	0.52	0.35
CHLORIDE	0.48	0.61	0.38	0.36	0.53	0.27	0.58	0.27	0.70	0.50	0.41	0.17
NITRATE	0.10	0.09	0.09	0.09	0.06	0.07	0.07	0.05	0.09	0.07	0.06	0.03
PHOSPHATE	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01
TOTAL	2.83	2.27	1.87	2.14	3.04	1.76	3.39	1.57	3.84	2.47	2.13	1.12
<u>TRACE METAL ANALYSIS (MG/L)</u>												
IRON, TOTAL	1.24	1.14	1.08	1.11	1.40	2.82	1.34	2.58	1.36	3.01	3.49	1.81
IRON, DISSOLVED	0.39	0.69	0.75	0.50	0.22	0.27	0.35	0.29	0.27	0.25	0.21	0.26
ALUMINUM, TOTAL	<0.30	<0.20	0.20	<0.20	<0.20	1.10	0.20	1.00	<0.20	0.70	1.00	0.80
ALUMINUM, DISSOLVED	<0.30	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.20
MANGANESE, TOTAL	0.26	0.18	0.18	0.15	0.30	0.21	0.23	0.19	0.27	0.33	0.31	0.12
MANGANESE, DISSOLVED	0.25	0.18	0.18	0.15	0.24	0.09	0.18	0.06	0.23	0.06	0.06	0.06
COPPER, TOTAL	0.01	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	0.03	<0.02	<0.02	<0.02
COPPER, DISSOLVED	0.01	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02
ZINC, TOTAL	0.02	0.02	0.03	0.02	0.09	0.03	0.02	0.03	0.02	0.02	0.03	0.02
ZINC, DISSOLVED	0.02	0.01	0.02	0.01	0.01	0.01	0.01	<0.01	0.01	0.01	<0.01	0.01
NICKEL, TOTAL	<0.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
NICKEL, DISSOLVED	<0.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
CHROMIUM, TOTAL	--	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
CHROMIUM, DISSOLVED	--	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
MOLYBDENUM, TOTAL	--	--	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
MOLYBDENUM, DISSOLVED	--	--	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10

[a]Millequivalents per liter (me/l) calculated by the Susquehanna SSES Biological Laboratory personnel

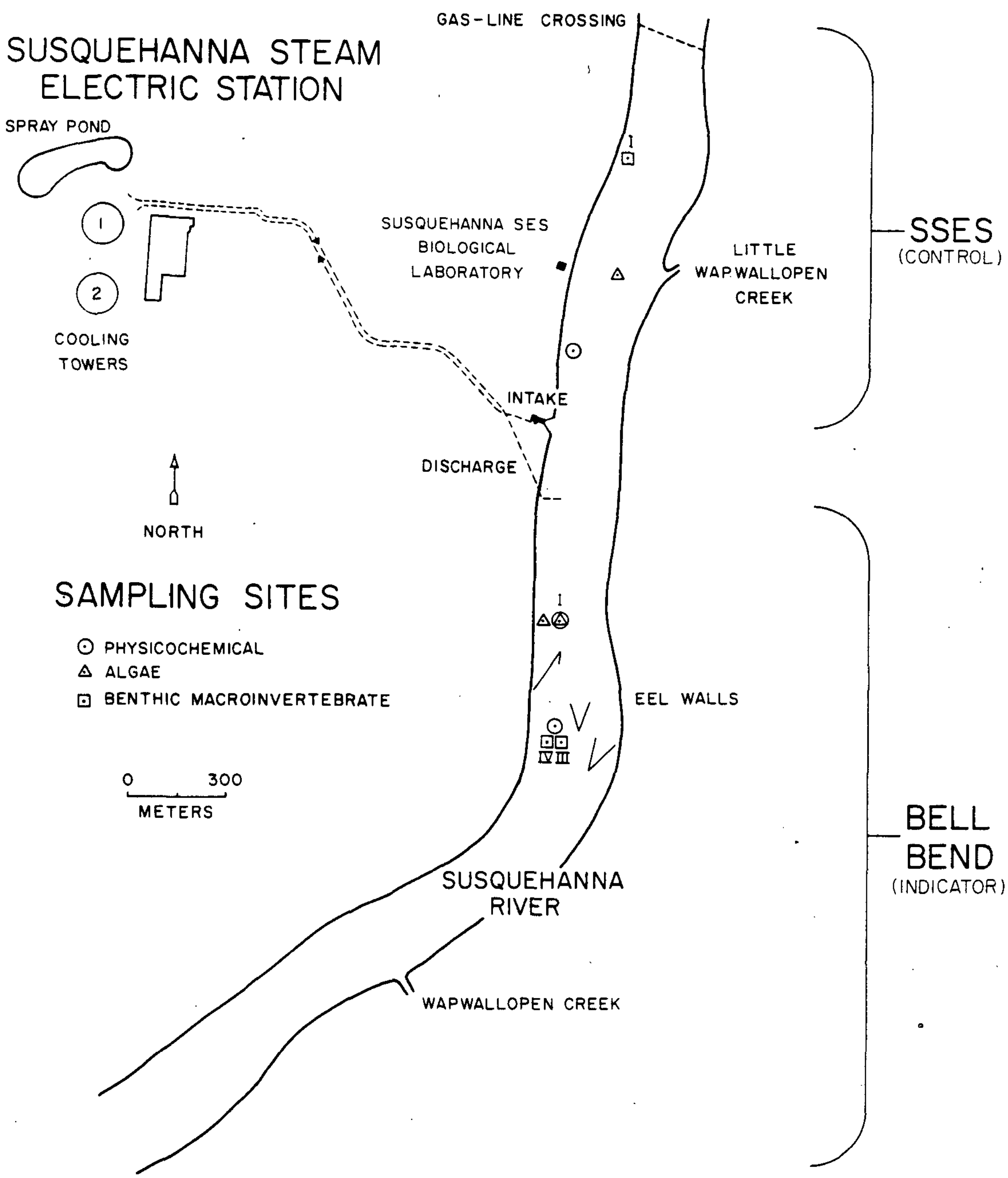

Fig. A-1

Physicochemical, algae, and benthic macroinvertebrate sampling sites at SSES and Bell Bend on the Susquehanna River, 1986.

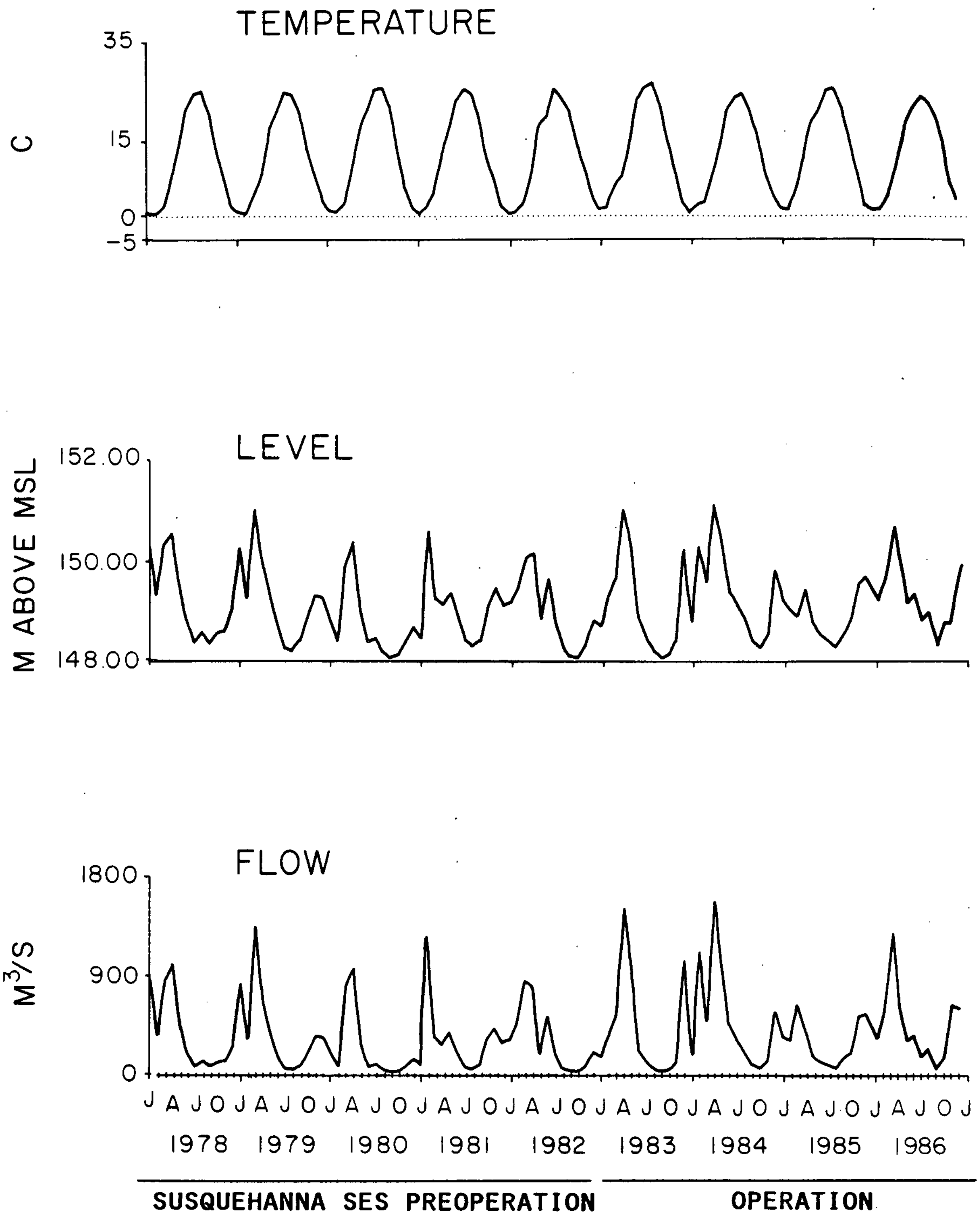

Fig. A-2

Monthly mean temperature, level, and flow of the Susquehanna River at the Susquehanna SES Biological Laboratory, 1978-86.

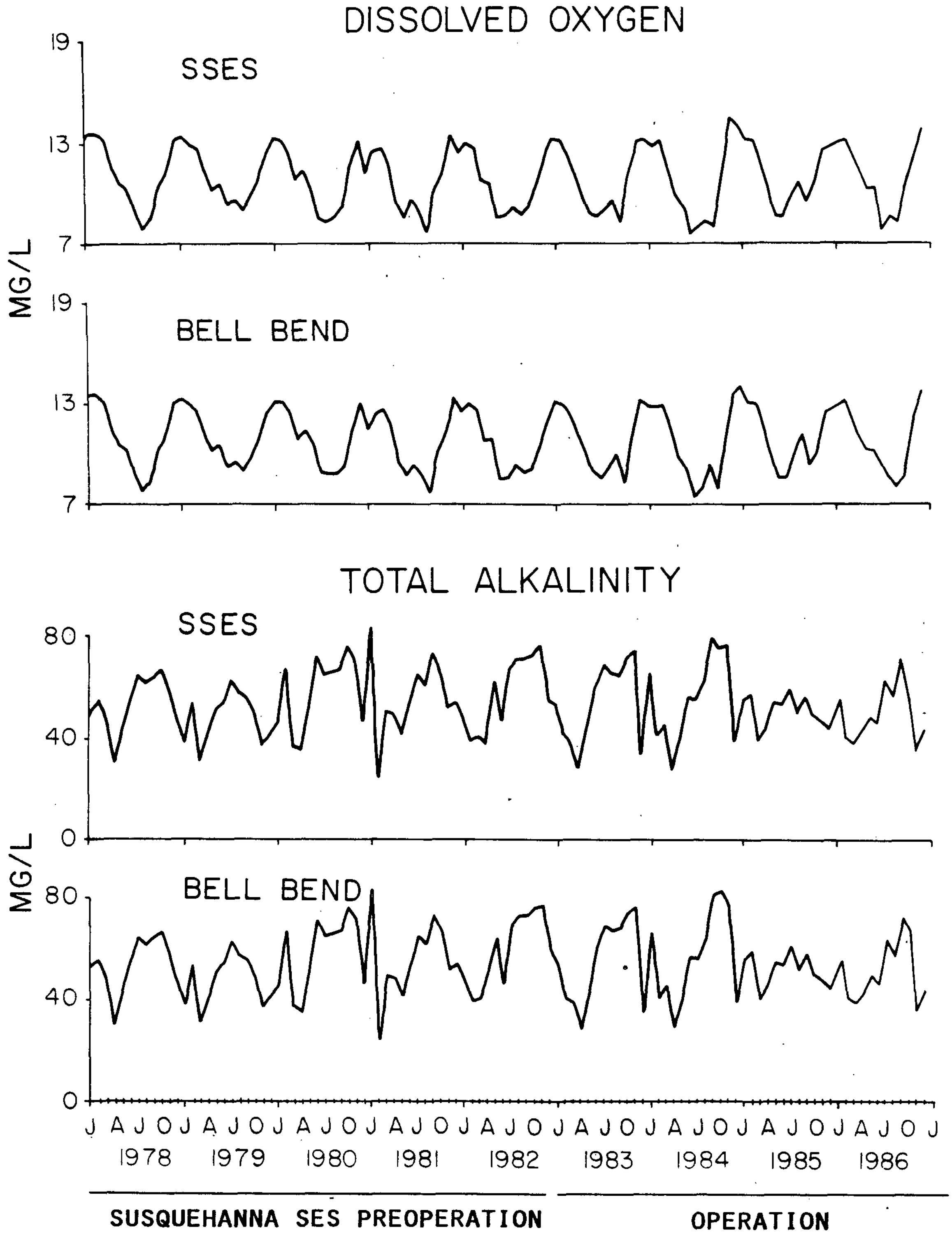

Fig. A-3

Monthly mean dissolved oxygen and total alkalinity of the Susquehanna River at the SSES and Bell Bend sampling sites, 1978-86.

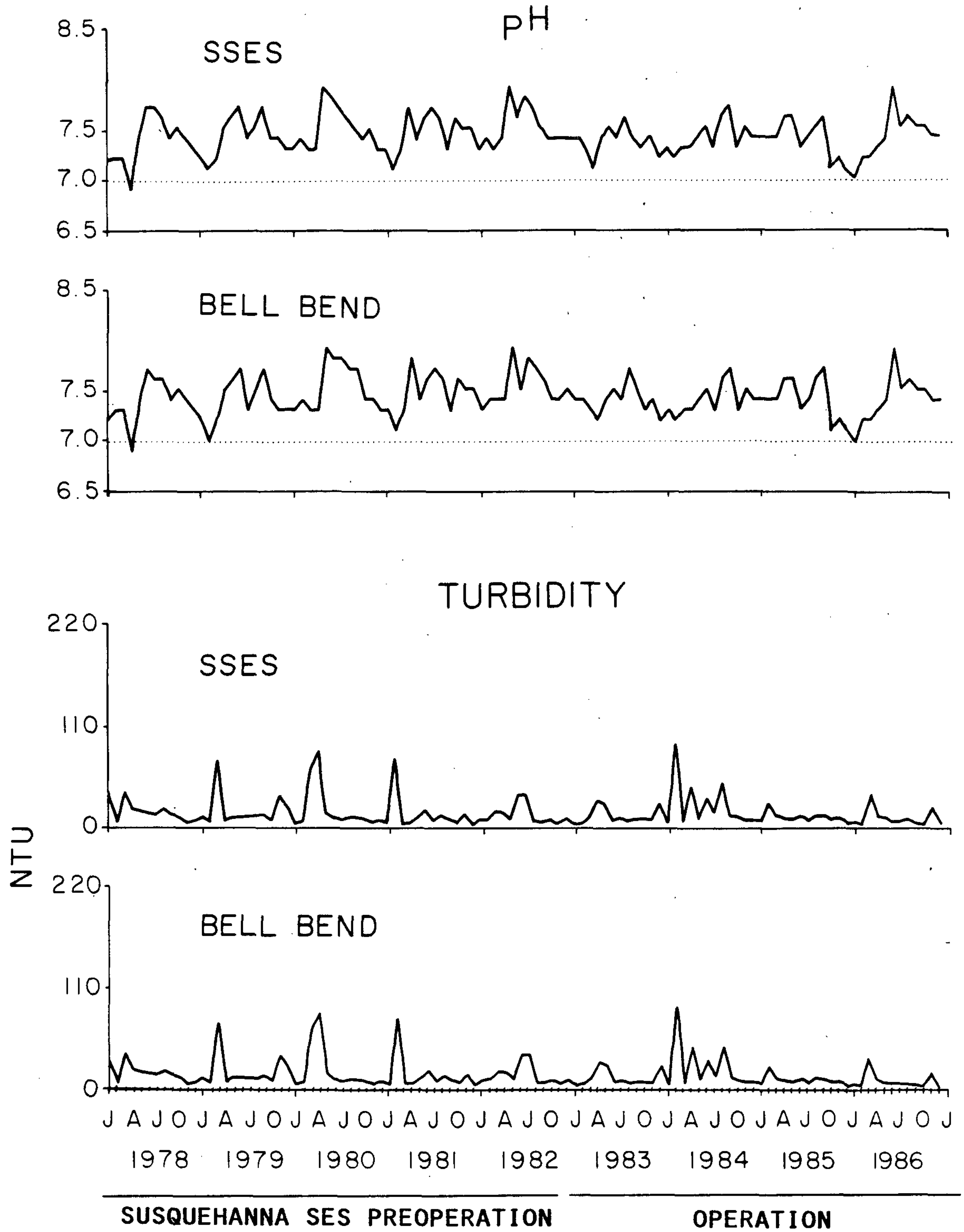

Fig. A-4

Monthly mean pH and turbidity of the Susquehanna River at the SSES and Bell Bend sampling sites, 1978-86.

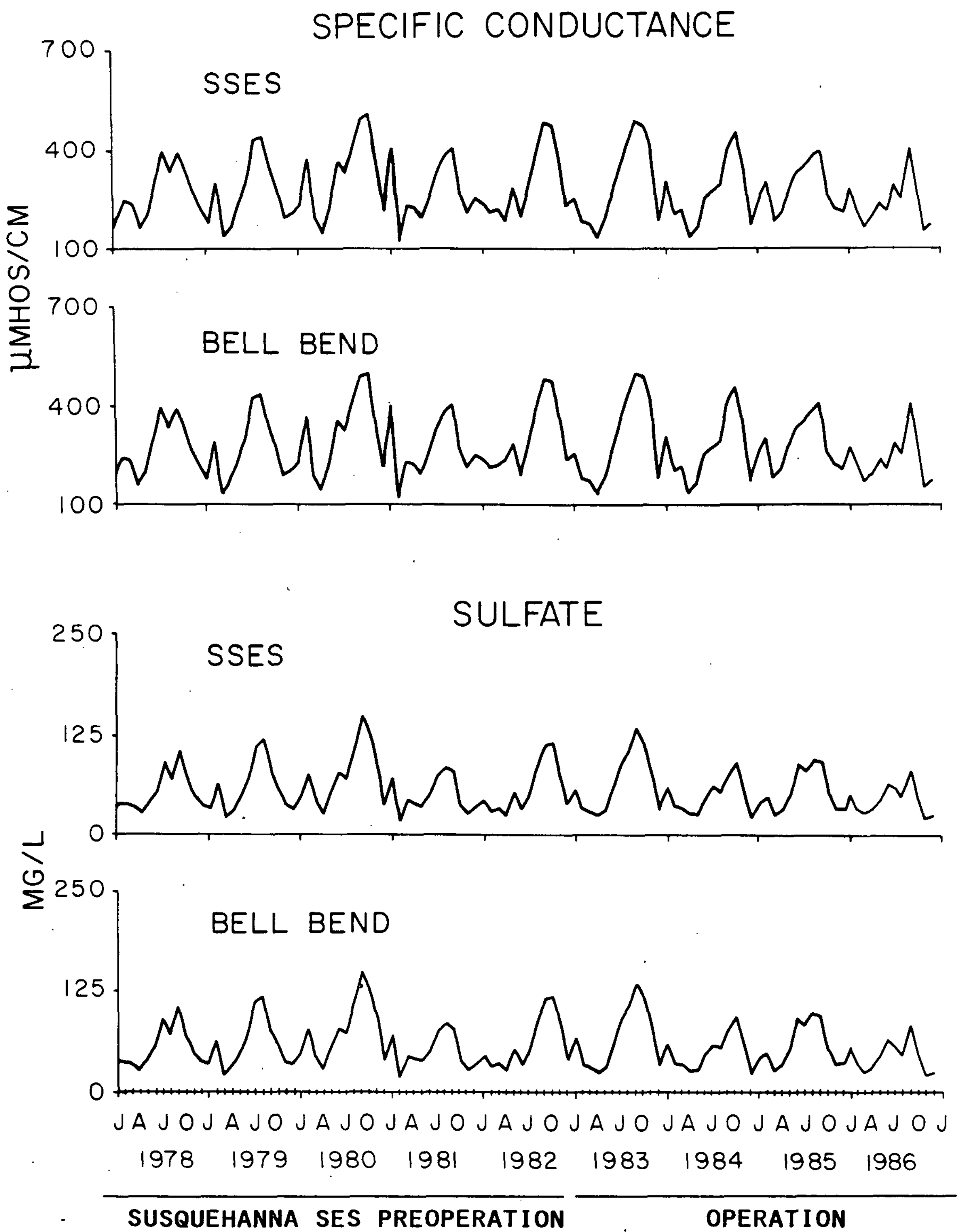

Fig. A-5

Monthly mean specific conductance and sulfate of the Susquehanna River at the SSES and Bell Bend sampling sites, 1978-86.

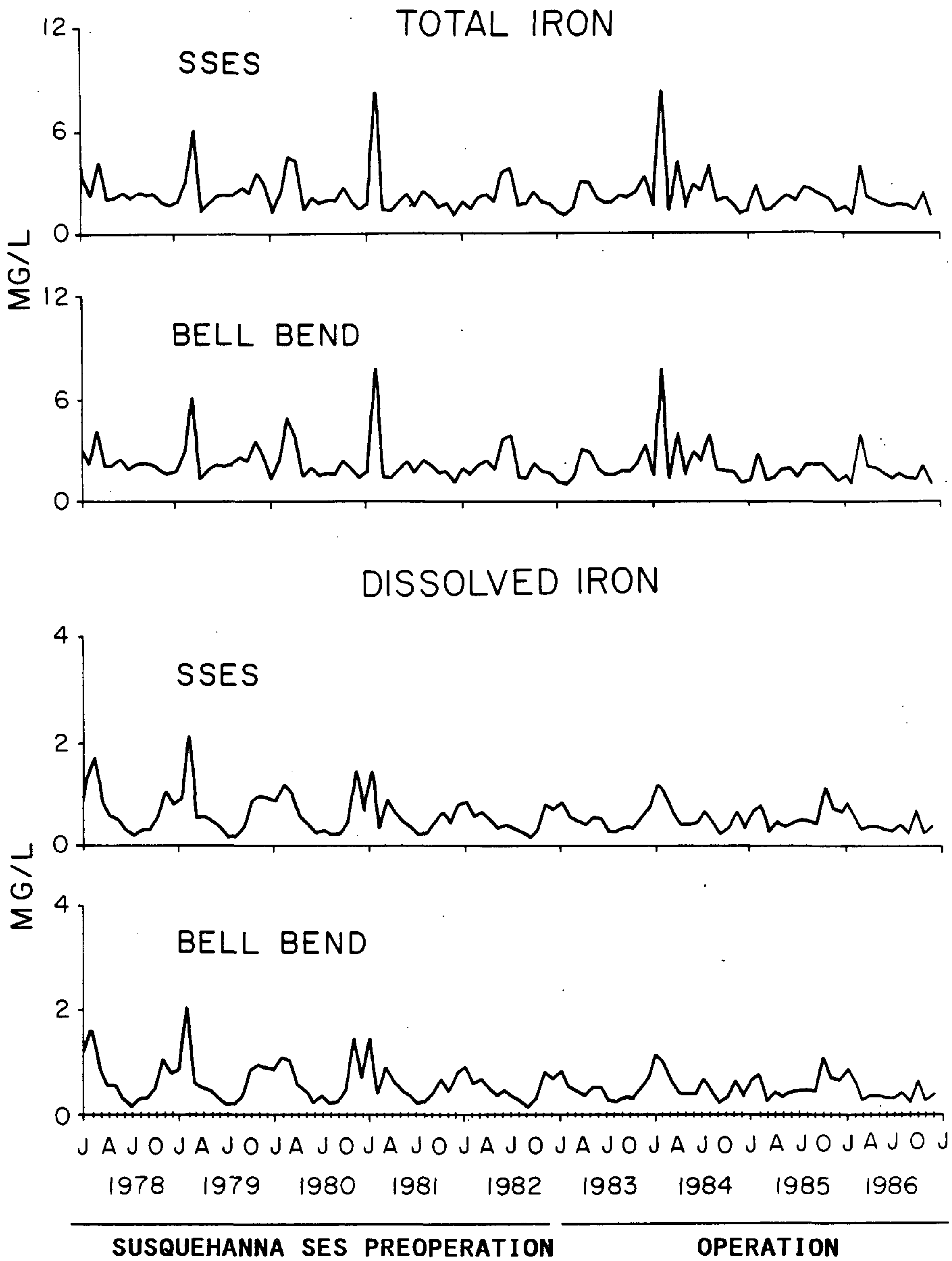

Fig. A-6

Monthly mean total and dissolved iron of the Susquehanna River at the SSES and Bell Bend sampling sites, 1978-86.

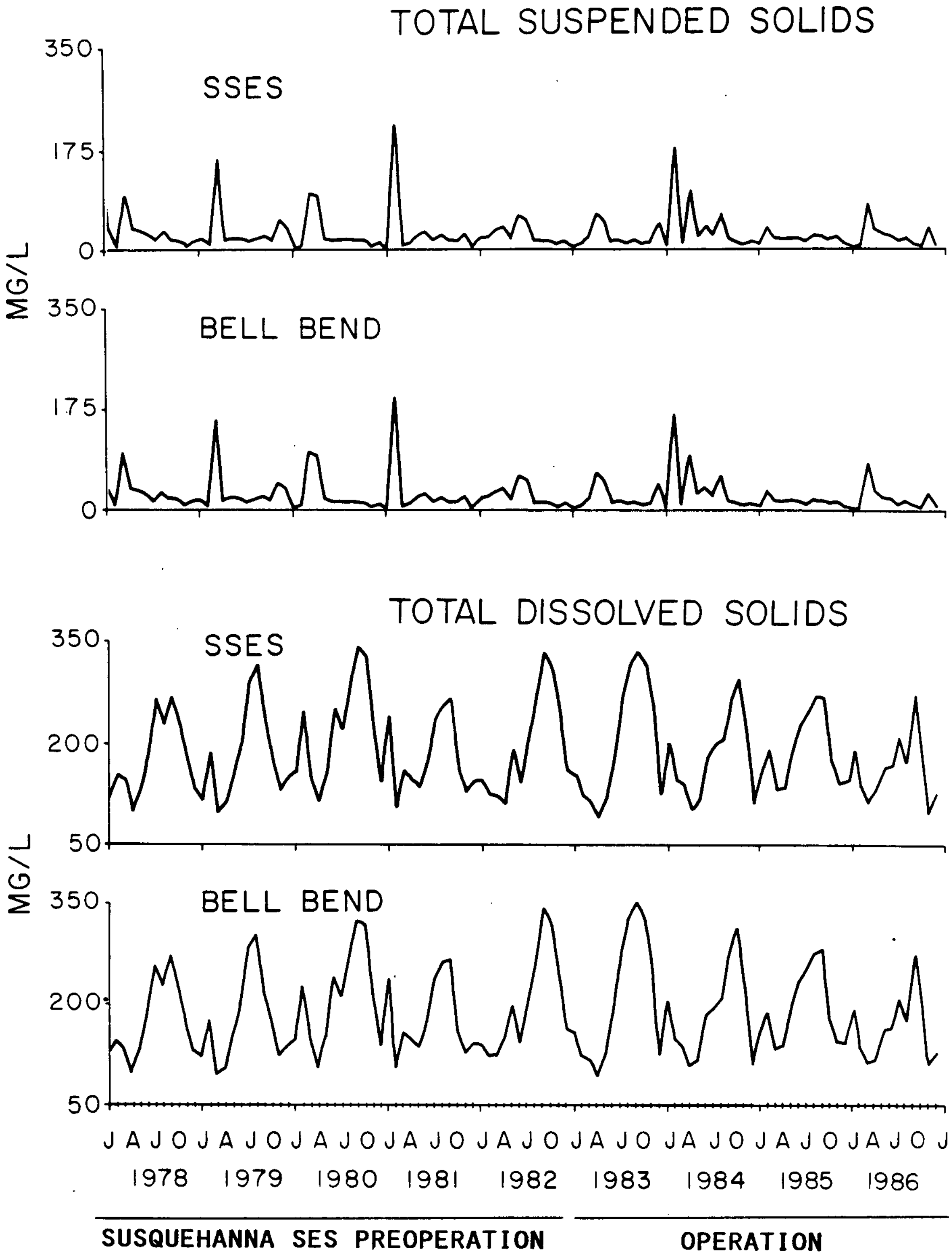

Fig. A-7

Monthly mean total suspended and dissolved solids of the Susquehanna River at the SSES and Bell Bend sampling sites, 1978-86.

ALGAE

by

Andrew J. Gurzynski and Rex. L. Lowe

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Samples of algae (periphyton and phytoplankton) were collected upriver from the Susquehanna SES intake structure (SSES) and downriver from the discharge diffuser (Bell Bend and Bell Bend I) in June, August, and October 1986. Overall, the mean periphyton density was greatest at Bell Bend (685 units/mm^2), followed by Bell Bend I (670 units/mm^2), and SSES (450 units/mm^2). Diatoms were the most abundant forms (67-71%) at all three sites. Green algae were the second most abundant (16-19%) and blue-green algae, the least (8-14%). Mean phytoplankton density was about equal at Bell Bend and Bell Bend I (12,100 units/ml) and somewhat less at SSES (10,800 units/ml). Diatoms were also the major component of the phytoplankton composing 67% of the total standing crop at the three sites. Green algae were less abundant (30%) and blue-green algae composed only 3% of the total standing crop.

Comparison of preoperational (1977-82) and operational (1983-86) data has not revealed any adverse effects from operation of the Susquehanna SES on either the periphyton or phytoplankton communities in the Susquehanna River. Differences in density and similarities in composition of algae between sites in operational years were also found during preoperational years. Decreases in density at both the SSES (control) and Bell Bend (indicator) sites during operational years were significantly correlated to natural changes in river level prior to sampling.

INTRODUCTION

The basic objective in 1986 was to evaluate effects of the Susquehanna SES on periphyton and phytoplankton communities in the Susquehanna River (Fig.

A-1). A control sampling site (SSES) was located 460 m upriver from the Susquehanna SES intake structure, 135 m from the west bank. An indicator site (Bell Bend) was located 400 m downriver from the discharge diffuser, 30 m from the west bank. Results of a dye study done at the diffuser (Sutron Corp. 1985) revealed that the Bell Bend site was in the discharge plume, but the center of the plume was located about 55 m from the west bank. In order to obtain samples near the center of the plume, a third site (Bell Bend I) was established next to the Bell Bend site, 55 m from the west bank.

PROCEDURES

Periphyton samples were collected from artificial substrates which consisted of six sandblasted plates of clear acrylic (22 x 30 cm) in "detritus-free" holders similar to those of Gale et al. (1976). Two holders with four plates each were placed on the river bottom at each site near the main channel, where depths ranged at SSES in 1986 from 1.0 to 7.3 m. At each site, two plates were sampled in June, August, and October. Plates were exposed to colonization for 12 months, except at Bell Bend I where they were first placed in May 1986. Three subsamples were taken from each plate by a scuba diver using a bar-clamp sampler (Gale 1975). Sampled plates were replaced with clean plates to be sampled later. The schedule for plate removal was a continuation of a plan established in 1977 by random selection.

The 415 mm^2 area of the plate delimited by each bar-clamp sampler was cleaned by scraping and vibration (Gale 1975) with an ultrasonic dental cleaning probe for 10 minutes. Dislodged cells were carried to a collection jar by water sprayed inside the collecting cup through the cleaning probe. As a result, loosened cells were not subjected to unnecessary vibration. Vibration may have destroyed some cells, but Gale (1975) reported that more cells per unit area were obtained by scraping and vibration than by scraping and brushing. Samples (250 ml) were preserved with formalin and, after settling 10 days, were concentrated to 50 ml by siphoning. One half of the concentrate was sent to Dr. Rex L. Lowe, Department of Biology, Bowling Green State University, Bowling Green, Ohio, for identification and enumeration of algae. The other half of the concentrate was placed in our reference collection to be retained for at least 12 months.

A 1-liter phytoplankton sample was collected near the river surface at each periphyton sampling site on the same days that periphyton samples were collected. After the samples were preserved and allowed to settle for 10 days, the algae in them was concentrated in a similar manner to that used for periphyton samples. The main difference in procedures was that phytoplankton samples, because of their greater initial volume, were siphoned three times instead of once (10 days settling time was allowed between each siphoning).

Algal cells in periphyton and phytoplankton samples that contained chloroplasts were enumerated as "units" (Gale and Lowe 1971). In most instances, at least 1,500 units were enumerated and identified in each subsample (about 500 per each of 3 analyses). Extremely low algal densities in some subsamples made it impractical to count 500 units and fewer were counted. Counts were made using a microscope (430X) and a Palmer counting cell. Higher magnification, including oil immersion, was used for some identifications. Algae were identified by Dr. Lowe to genus and the more abundant forms to species using keys by Hustedt (1930) and Prescott (1962).

RESULTS AND DISCUSSION

In 1986, 18 samples were collected at each site and a total of 40, 43, and 43 genera of periphytic algae were found at SSES (control), Bell Bend (indicator), and Bell Bend I (indicator), respectively. None of the genera that occurred at only one site composed more than 1% of the total units counted in any replicate. These data are summarized in Tables B-1 through B-3. Raw data are presented in Tables B-4 through B-12.

The mean periphyton density was greatest at Bell Bend (685 units/mm^2), followed by Bell Bend I (670 units/mm^2), and SSES (450 units/mm^2); diatoms (Bacillariophyta) were the most abundant forms and composed 71%, 76%, and 67% of the total units at the three sites, respectively. Green algae (Chlorophyta) composed 19% of the total at SSES and about 16% each at Bell Bend and Bell Bend I. Blue-green algae (Cyanophyta) composed about 14% of the total at SSES and Bell Bend and about 8% at Bell Bend I.

At the three sites, 14 species of periphytic algae were identified that composed 5% or more of the total units counted in at least one replicate sample (Table B-13). Most of the species of abundant diatoms were rated as "alkaliphilous" by Lowe (1974); three were rated "indifferent", and two were "unknown" with respect to pH preference.

The average density of periphyton in June, August, and October was always greater at Bell Bend than at SSES throughout each preoperational year (1977-82); this also occurred in three of the four operational years (1983-86) (Table B-14; Fig. B-1). The preoperational mean density at SSES was about 1,400 units/mm^2 while at Bell Bend, it averaged about 3,200 units/mm^2. However, the relative abundance of greens, diatoms, and blue-greens changed little between sites. Green algae composed about 54% and 47% of the total units at SSES and Bell Bend, respectively; diatoms composed 44% and 50%, and blue-green algae composed about 2% at both sites. From 1983, mean operational density at SSES averaged about 1,000 units/mm^2 while at Bell Bend, the mean density was about 1,700 units/mm^2. Green algae composed about 28% and 32% of the total units at SSES and Bell Bend, respectively; diatoms composed 68% and 61%; and blue-green algae composed about 4% and 7% of the total.

The greater abundance of periphytic algae at Bell Bend was probably due to low river levels, generally found throughout summer and early fall. When the river became low, shoals were exposed near each shore at SSES reducing the width of the river creating a swift current which may have swept periphyton away from the substrate. At Bell Bend, however, there were no such shoals and the current during low river level was reduced. As a result, periphyton were probably not scoured at this site and phytoplankton from the water column may have settled to the substrate and were included in the periphyton counts.

Three phytoplankton samples were collected at each site in 1986 for totals of 31, 37, and 35 genera at SSES (control), Bell Bend (indicator), and Bell Bend I (indicator), respectively (Tables B-15 through B-17). None of the genera that occurred at only one site composed more than 1% of the total units counted. Phytoplankton was slightly less abundant at SSES (10,800 units/ml) than at Bell Bend and Bell Bend I (12,100 units/ml) (Table B-18; Fig. B-2). Diatoms were the major component of the phytoplankton composing 67% of the total standing crop at the three sites. Green algae were less abundant and composed 30% of the total standing crop at the three sites; blue-green algae composed only 3% of the total standing crop.

Nine species of phytoplankton composed 5% or more of the total units counted in at least one sample from the three sites (Table B-19). Most of the phytoplankton found were "clean water" forms and four of the abundant species (*S. quadricauda, A. falcatus, C. meneghiniana,* and *N. acicularis*) were among the top 20 species listed by Palmer (1969) as being most tolerant of heavy organic pollution. Most abundant species of diatoms were rated as "alkaliphilous" by Lowe (1974), one was rated "indifferent", and another as "unknown" with respect to pH preference.

Similar phytoplankton densities and phytoplankton species were found in preoperational (1977-82) and operational (1983-86) samples collected at SSES and Bell Bend. The preoperational mean density at SSES averaged about 20,500 units/ml and about 20,000 units/ml at Bell Bend (Table B-18). Green algae were the most abundant forms of phytoplankton composing about 57% and 53% of the total units at SSES and Bell Bend, respectively. Diatoms composed 39% and 42%, and blue-green algae composed about 4% of the total at both sites. Operational densities averaged about 11,800 units/ml at SSES and about 12,500 units/ml at Bell Bend. Green algae were the major component of the phytoplankton community composing 54% and 51% of the total units found at SSES and Bell Bend, respectively. Diatoms composed 34% and 36% and blue-green algae composed about 12% of the total at both sites.

Overall, mean densities of periphyton and phytoplankton decreased at SSES and Bell Bend in operational years compared to preoperational years (Tables B-14 and B-18). Operation of the the Susquehanna SES did not cause these decreases because they occurred at both the control (SSES) and indicator (Bell Bend) sites. A probable explanation for this change was revealed by evaluation of the relationship between algae densities and natural river level using Spearman's nonparametric rank correlation. The average annual densities of periphyton and phytoplankton were ranked (highest to lowest) with the mean daily river level (lowest to highest) for each 30-day period prior to the sample collection date in June, August, and October from 1977 through 1986 at both SSES and Bell Bend. In all four pairs of rankings, densities of periphyton and phytoplankton at SSES and Bell Bend were significantly correlated ($P<0.05$) to the mean river level prior to sampling. That is, densities were highest when river levels were lowest. Periphyton which accumulated on acrylic plates during periods of low river level probably were scoured away during high flows and any phytoplankton increases that occurred in the water column during low river levels were diluted by these same high flows.

Large differences in periphytic densities occurred at Bell Bend and Bell Bend I in June and August, even though both sites are the same distance downriver from the discharge diffuser (Fig. B-1). Several factors probably account for these differences. First, the colonization period of the acrylic plates sampled in June at Bell Bend I was short (about 4 weeks). Elwood and Nelson (1972) found that at least 6 weeks were required to attain a "constant standing crop" on substrates in an artifical stream. Secondly, in August, colonization of acrylic plates at Bell Bend may have been inhibited by dead or living cells colonizing the plate prior to sampling, whereas colonization of the clean plates at Bell Bend I was uninhibited and took place rapidly. Thirdly, acrylic plates at Bell Bend may have become coated with silt and detritus which deterred colonization. Patrick et al. (1954) indicated that such accumulations made a surface "less favorable habitat for diatoms."

By October, acrylic plates at Bell Bend I, after a 5-month colonization period, had densities similar to those found at Bell Bend (Fig. B-1). Comparisons in 1987, after acrylic plates at both sites have been exposed to a one-year colonization period, may justify deletion of the Bell Bend site with continued sampling at Bell Bend I, which is located closer to the center of the discharge plume. In addition, phytoplankton samples will also be collected at both sites in 1987.

REFERENCES CITED

Elwood, J. W. and D. J. Nelson. 1972. Periphyton production and grazing rates in a stream measured with a ^{32}P material balance method. Oikos 22: 295-303.

Gale, W. F. 1975. Ultrasonic removal of epilithic algae in a bar-clamp sampler. J. Phycol. 11: 472-473.

________ and R. L. Lowe. 1971. Phytoplankton ingestion by the fingernail clam, *Sphaerium transversum* (Say), in Pool 19, Mississippi River. Ecology 52: 507-513.

________, T. V. Jacobsen, and K. M. Smith. 1976. Iron, and its role in a river polluted by mine effluents. Proc. Pa. Acad. Sci. 50: 182-195.

Hustedt, F. 1930. Bacillariophyta (Diatomeae). In A. Pascher (ed.), Die Susswasser - Flora Mitteleuropas. Heft 10. Gustav Fisher Verlag, Jena. viii. 466 pp.

Lowe, R. L. 1974. Environmental requirements and pollution tolerance of freshwater diatoms. Nat. Environ. Res. Cent., EPA-670/4-74-005. U.S. Environmental Protection Agency, Cincinnati, OH. 334 pp.

Palmer, C. M. 1969. A composite rating of algae tolerating organic pollution. J. Phycol. 5: 78-82.

Patrick, R., M. Hohn, and J. Wallace. 1954. A new method for determining the patterns of the diatom flora. Notulae Naturae, Acad. Nat. Sci. Phila. 259: 1-12.

Prescott, G. W. 1962. Algae of the western Great Lakes area. William C. Brown Co., Dubuque, IA. 977 pp.

Sutron Corporation. 1985. Study of travel time and mixing characteristics for the Susquehanna River below the Susquehanna Steam Electric Station. Sutron Report No. SCR85-0007. Sutron Corp., Herndon, VA.

Table B-1

Mean density (units/mm²) of periphytic algae on two acrylic plates submerged for 12 months at SSES on the Susquehanna River, 1986.

TAXON	25 JUNE	18 AUGUST	14 OCTOBER	% TOTAL
CHLOROPHYTA				
ACTINASTRUM	3.7	3.7	0.9	0.6
ANKISTRODESMUS	11.7	29.0	20.0	4.5
CERASTERIAS	0.0	0.3	0.0	<0.1
CHLAMYDOMONAS	0.3	1.5	0.0	0.1
CLOSTERIUM	0.0	0.0	1.2	0.1
COELASTRUM	0.0	1.2	0.0	0.1
COSMARIUM	0.0	1.2	4.6	0.4
CRUCIGENIA	0.9	0.6	0.0	0.1
DICTYOSPHAERIUM	0.0	1.9	0.0	0.1
GOLENKINIA	0.0	0.3	0.0	<0.1
KIRCHNERIELLA	0.3	3.7	3.1	0.5
OEDOGONIUM	0.0	0.3	0.0	<0.1
OOCYSTIS	1.5	7.1	0.3	0.7
PEDIASTRUM	0.3	0.0	0.0	<0.1
POLYEDRIOPSIS	0.3	1.2	0.0	0.1
SCENEDESMUS	9.6	22.5	25.0	4.2
TETRAEDRON	0.3	0.3	0.0	<0.1
TETRASTRUM	0.6	0.9	0.0	0.1
UNIDENTIFIED	22.8	52.1	17.6	6.8
BACILLARIOPHYTA				
ACHNANTHES	0.9	0.9	1.2	0.2
AMPHORA	0.0	0.0	0.3	<0.1
COCCONEIS	0.3	6.5	32.4	2.9
CYCLOTELLA	21.3	90.3	23.4	10.0
CYMBELLA	0.3	0.9	3.1	0.3
FRAGILARIA	0.0	0.6	0.0	<0.1
GOMPHONEMA	4.6	3.7	21.9	2.2
GYROSIGMA	0.0	0.0	1.5	0.1
MELOSIRA	0.9	4.9	25.9	2.3
MERIDION	0.0	0.0	0.3	<0.1
NAVICULA	29.0	15.1	173.0	16.0
NITZSCHIA	43.5	51.5	80.5	13.0
SKELETONEMA	4.3	10.5	0.0	1.1
RHOICOSPHENIA	0.0	0.0	0.9	0.1
STAURONEIS	0.0	0.0	16.0	1.2
STEPHANODISCUS	15.1	136.6	78.3	17.0
SURIRELLA	0.0	0.0	0.3	<0.1
SYNEDRA	5.2	0.9	4.6	0.8
CYANOPHYTA				
CHROOCOCCUS	1.2	2.2	0.0	0.3
OSCILLATORIA	0.0	0.3	0.9	0.1
SCHIZOTHRIX	125.2	7.7	51.5	13.6
RHODOPHYTA				
RHODOCHORTON	0.0	0.3	1.2	0.1
TOTAL	304.1	460.7	589.9	

Table B-2

Mean density (units/mm²) of periphytic algae on two acrylic plates submerged for 12 months at Bell Bend on the Susquehanna River, 1986.

TAXON	26 JUNE	19 AUGUST	14 OCTOBER	% TOTAL
CHLOROPHYTA				
ACTINASTRUM	6.0	1.0	0.0	0.3
ANKISTRODESMUS	13.7	34.2	24.1	3.5
CHLAMYDOMONAS	2.0	0.3	0.0	0.1
CHODATELLA	0.0	1.2	0.0	0.1
CLOSTERIUM	0.0	0.3	0.0	<0.1
COELASTRUM	0.0	1.5	0.9	0.1
COSMARIUM	0.0	0.3	0.0	<0.1
CRUCIGENIA	0.4	1.1	0.3	0.1
DICTYOSPHAERIUM	0.0	6.1	0.3	0.3
KIRCHNERIELLA	2.0	1.9	8.9	0.6
OOCYSTIS	5.2	7.4	0.3	0.6
PEDIASTRUM	0.0	0.3	0.3	<0.1
SCENEDESMUS	19.7	40.0	31.1	4.4
SELENASTRUM	0.4	0.3	0.0	<0.1
TETRAEDRON	0.0	0.4	0.0	<0.1
TETRASTRUM	0.4	1.9	0.3	0.1
UNIDENTIFIED	58.6	50.5	11.4	5.9
BACILLARIOPHYTA				
ACHNANTHES	0.8	0.3	0.3	0.1
AMPHORA	0.0	0.0	0.3	<0.1
ASTERIONELLA	4.0	0.0	1.2	0.3
COCCONEIS	4.8	5.9	54.9	3.2
CYCLOTELLA	172.7	149.4	28.7	17.1
CYMATOPLEURA	0.0	0.0	0.3	<0.1
CYMBELLA	5.2	1.5	4.6	0.6
DIATOMA	0.4	0.0	1.2	0.1
FRAGILARIA	0.0	0.0	4.0	0.2
FRUSTULIA	0.0	0.0	0.3	<0.1
GOMPHONEMA	4.0	3.5	9.6	0.8
GYROSIGMA	0.0	0.3	10.8	0.5
MELOSIRA	5.2	15.8	45.0	3.2
MERIDION	3.2	0.4	0.0	0.2
NAVICULA	33.3	18.3	88.5	6.8
NITZSCHIA	46.6	71.5	95.9	10.4
SKELETONEMA	12.5	14.2	0.3	1.3
RHOICOSPHENIA	0.0	0.3	4.3	0.2
STEPHANODISCUS	143.0	223.6	112.5	23.3
SYNEDRA	15.3	0.3	2.2	0.9
THALASSIOSIRA	41.0	0.0	0.0	2.0
CYANOPHYTA				
CHROOCOCCUS	0.8	5.2	0.0	0.3
COELOSPHAERIUM	0.0	0.0	0.3	<0.1
CYANARCUS	0.0	0.3	0.0	<0.1
OSCILLATORIA	0.0	0.0	1.2	0.1
SCHIZOTHRIX	99.2	106.3	42.9	12.1
EUGLENOPHYTA				
TRACHELOMONAS	0.0	0.0	0.6	<0.1
TOTAL	700.4	765.8	587.8	

Table B-3

Mean density (units/mm²) of periphytic algae on two acrylic plates submerged since 30 May at Bell Bend I on the Susquehanna River, 1986.

TAXON	27 JUNE	19 AUGUST	14 OCTOBER	% TOTAL
CHLOROPHYTA				
ACTINASTRUM	1.8	2.2	0.0	0.2
ANKISTRODESMUS	0.7	51.5	23.1	3.8
CERASTERIAS	0.0	0.6	0.0	<0.1
CHLAMYDOMONAS	0.1	0.7	0.3	0.1
CHODATELLA	0.0	0.6	0.0	<0.1
COELASTRUM	0.1	1.5	1.2	0.1
COSMARIUM	0.1	1.1	0.0	0.1
CRUCIGENIA	0.0	2.4	0.3	0.1
DICTYOSPHAERIUM	0.1	2.6	0.6	0.2
GOLENKINIA	0.0	0.6	0.0	<0.1
KIRCHNERIELLA	0.0	7.8	6.5	0.7
OEDOGONIUM	0.0	3.4	0.0	0.2
OOCYSTIS	0.0	14.0	0.9	0.7
PEDIASTRUM	0.0	0.0	0.3	<0.1
SCENEDESMUS	0.6	56.7	34.2	4.6
TETRAEDRON	0.0	1.0	0.0	0.1
TETRASTRUM	0.0	1.8	0.0	0.1
UNIDENTIFIED	3.5	89.0	9.9	5.1
BACILLARIOPHYTA				
ACHNANTHES	0.0	0.4	2.2	0.1
AMPHORA	0.0	0.0	0.3	<0.1
ASTERIONELLA	0.0	0.0	1.2	0.1
COCCONEIS	0.2	10.1	60.1	3.5
CYCLOTELLA	8.7	293.1	29.6	16.6
CYMBELLA	0.1	5.4	6.2	0.6
DIATOMA	0.0	0.0	0.6	<0.1
FRUSTULIA	0.0	0.3	0.9	0.1
GOMPHONEMA	0.3	8.1	9.3	0.9
GYROSIGMA	0.0	0.0	12.0	0.6
HANTZSCHIA	0.1	0.0	0.0	<0.1
MELOSIRA	0.3	8.2	37.9	2.3
MERIDION	0.0	0.0	0.3	<0.1
NAVICULA	2.9	9.4	121.2	6.7
NITZSCHIA	5.5	122.5	121.2	12.5
PINNULARIA	0.0	0.0	0.3	<0.1
SKELETONEMA	0.5	40.0	0.0	2.0
RHOICOSPHENIA	0.0	1.9	3.4	0.3
STEPHANODISCUS	20.4	442.3	117.8	29.1
SYNEDRA	2.9	0.6	1.5	0.3
CYANOPHYTA				
CHROOCOCCUS	0.5	1.1	0.0	0.1
MERISMOPEDIA	0.0	0.0	0.3	<0.1
OSCILLATORIA	0.1	0.0	0.9	0.1
SCHIZOTHRIX	1.4	73.2	86.6	8.1
EUGLENOPHYTA				
TRACHELOMONAS	0.0	1.7	0.0	0.1
RHODOPHYTA				
RHODOCHORTON	0.0	0.0	0.3	<0.1
TOTAL	50.9	1255.8	691.4	

Table B-4

Density (units/mm²) of periphytic algae on two acrylic plates submerged for 12 months at SSES on the Susquehanna River, 25 June 1986.

ACRYLIC PLATE	1			2				
SUBSAMPLE	1	2	3	1	2	3	MEAN	% TOTAL
TAXON								
CHLOROPHYTA								
ACTINASTRUM	0.0	5.6	1.9	5.6	9.3	0.0	3.7	1.2
ANKISTRODESMUS	7.4	13.0	13.0	3.7	13.0	20.4	11.7	3.9
CHLAMYDOMONAS	0.0	0.0	0.0	0.0	0.0	1.9	0.3	0.1
CRUCIGENIA	0.0	5.6	0.0	0.0	0.0	0.0	0.9	0.3
KIRCHNERIELLA	0.0	0.0	0.0	0.0	1.9	0.0	0.3	0.1
OOCYSTIS	0.0	0.0	3.7	1.9	3.7	0.0	1.5	0.5
PEDIASTRUM	0.0	0.0	0.0	1.9	0.0	0.0	0.3	0.1
POLYEDRIOPSIS	1.9	0.0	0.0	0.0	0.0	0.0	0.3	0.1
SCENEDESMUS	3.7	3.7	16.7	11.1	7.4	14.8	9.6	3.1
TETRAEDRON	1.9	0.0	0.0	0.0	0.0	0.0	0.3	0.1
TETRASTRUM	0.0	1.9	0.0	0.0	0.0	1.9	0.6	0.2
UNIDENTIFIED	27.8	9.3	25.9	20.4	11.1	42.6	22.8	7.5
BACILLARIOPHYTA								
ACHNANTHES	0.0	3.7	0.0	0.0	0.0	1.9	0.9	0.3
COCCONEIS	0.0	1.9	0.0	0.0	0.0	0.0	0.3	0.1
CYCLOTELLA	29.6	20.4	29.6	20.4	11.1	16.7	21.3	7.0
CYMBELLA	0.0	0.0	0.0	1.9	0.0	0.0	0.3	0.1
GOMPHONEMA	7.4	3.7	5.6	5.6	3.7	1.9	4.6	1.5
MELOSIRA	0.0	0.0	0.0	5.6	0.0	0.0	0.9	0.3
NAVICULA	18.5	20.4	46.3	38.9	33.3	16.7	29.0	9.5
NITZSCHIA	38.9	42.6	37.0	53.7	37.0	51.8	43.5	14.3
SKELETONEMA	0.0	7.4	0.0	14.8	0.0	3.7	4.3	1.4
STEPHANODISCUS	22.2	16.7	18.5	13.0	11.1	9.3	15.1	5.0
SYNEDRA	3.7	0.0	0.0	9.3	13.0	5.6	5.2	1.7
CYANOPHYTA								
CHROOCOCCUS	0.0	5.6	1.9	0.0	0.0	0.0	1.2	0.4
SCHIZOTHRIX	87.0	72.2	177.6	155.4	157.3	101.8	125.2	41.1
TOTAL	249.8	233.1	377.4	362.6	312.7	290.5	304.3	

Table B-5

Density (units/mm²) of periphytic algae on two acrylic plates submerged for 12 months at SSES on the Susquehanna River, 18 August 1986.

ACRYLIC PLATE	1			2				
SUBSAMPLE	1	2	3	1	2	3	MEAN	% TOTAL
TAXON								
CHLOROPHYTA								
ACTINASTRUM	0.0	3.7	5.6	7.4	5.6	0.0	3.7	0.8
ANKISTRODESMUS	16.7	35.2	33.3	27.8	27.8	33.3	29.0	6.3
CERASTERIAS	1.9	0.0	0.0	0.0	0.0	0.0	0.3	0.1
CHLAMYDOMONAS	1.9	0.0	0.0	1.9	0.0	5.6	1.5	0.3
COELASTRUM	0.0	0.0	1.9	0.0	0.0	5.6	1.2	0.3
COSMARIUM	0.0	0.0	0.0	0.0	0.0	7.4	1.2	0.3
CRUCIGENIA	0.0	3.7	0.0	0.0	0.0	0.0	0.6	0.1
DICTYOSPHAERIUM	0.0	0.0	1.9	0.0	0.0	9.3	1.9	0.4
GOLENKINIA	1.9	0.0	0.0	0.0	0.0	0.0	0.3	0.1
KIRCHNERIELLA	3.7	5.6	3.7	3.7	1.9	3.7	3.7	0.8
OEDOGONIUM	0.0	0.0	0.0	0.0	0.0	1.9	0.3	0.1
OOCYSTIS	3.7	11.1	3.7	3.7	9.3	11.1	7.1	1.5
POLYEDRIOPSIS	0.0	0.0	1.9	0.0	1.9	3.7	1.2	0.3
SCENEDESMUS	11.1	33.3	22.2	18.5	24.1	25.9	22.5	4.9
TETRAEDRON	0.0	0.0	1.9	0.0	0.0	0.0	0.3	0.1
TETRASTRUM	0.0	1.9	1.9	0.0	1.9	0.0	0.9	0.2
UNIDENTIFIED	22.2	68.5	44.4	42.6	75.9	59.2	52.1	11.3
BACILLARIOPHYTA								
ACHNANTHES	0.0	1.9	3.7	0.0	0.0	0.0	0.9	0.2
COCCONEIS	3.7	7.4	11.1	1.9	9.3	5.6	6.5	1.4
CYCLOTELLA	48.1	120.3	94.4	99.9	87.0	92.5	90.3	19.6
CYMBELLA	1.9	0.0	1.9	0.0	1.9	0.0	0.9	0.2
FRAGILARIA	0.0	3.7	0.0	0.0	0.0	0.0	0.6	0.1
GOMPHONEMA	5.6	3.7	0.0	7.4	5.6	0.0	3.7	0.8
MELOSIRA	0.0	1.9	3.7	14.8	7.4	1.9	4.9	1.1
NAVICULA	14.8	13.0	16.7	20.4	5.6	20.4	15.1	3.3
NITZSCHIA	37.0	66.6	81.4	31.5	53.7	38.9	51.5	11.2
SKELETONEMA	0.0	7.4	22.2	3.7	16.7	13.0	10.5	2.3
STEPHANODISCUS	74.0	181.3	142.5	151.7	131.4	138.8	136.6	29.6
SYNEDRA	0.0	3.7	0.0	1.9	0.0	0.0	0.9	0.2
CYANOPHYTA								
CHROOCOCCUS	0.0	1.9	1.9	0.0	1.9	7.4	2.2	0.5
OSCILLATORIA	0.0	0.0	1.9	0.0	0.0	0.0	0.3	0.1
SCHIZOTHRIX	3.7	5.6	16.7	3.7	5.6	11.1	7.7	1.7
RHODOPHYTA								
RHODOCHORTON	0.0	0.0	0.0	0.0	0.0	1.9	0.3	0.1
TOTAL	251.6	580.9	519.9	442.2	473.6	497.7	461.0	

Table B-6

Density (units/mm²) of periphytic algae on two acrylic plates submerged for 12 months at SSES on the Susquehanna River, 14 October 1986.

ACRYLIC PLATE	1			2				
SUBSAMPLE	1	2	3	1	2	3	MEAN	% TOTAL
TAXON								
CHLOROPHYTA								
ACTINASTRUM	3.7	0.0	0.0	1.9	0.0	0.0	0.9	0.2
ANKISTRODESMUS	37.0	9.3	20.4	14.8	24.1	14.8	20.0	3.4
CLOSTERIUM	1.9	5.6	0.0	0.0	0.0	0.0	1.2	0.2
COSMARIUM	3.7	7.4	5.6	1.9	7.4	1.9	4.6	0.8
KIRCHNERIELLA	0.0	1.9	0.0	1.9	13.0	1.9	3.1	0.5
OOCYSTIS	0.0	0.0	0.0	0.0	0.0	1.9	0.3	0.1
SCENEDESMUS	14.8	40.7	25.9	31.5	27.8	9.3	25.0	4.2
UNIDENTIFIED	22.2	9.3	14.8	16.7	22.2	20.4	17.6	3.0
BACILLARIOPHYTA								
ACHNANTHES	1.9	0.0	0.0	5.6	0.0	0.0	1.2	0.2
AMPHORA	0.0	1.9	0.0	0.0	0.0	0.0	0.3	0.1
COCCONEIS	33.3	55.5	25.9	14.8	35.2	29.6	32.4	5.5
CYCLOTELLA	27.8	31.5	22.2	24.1	24.1	11.1	23.4	4.0
CYMBELLA	9.3	5.6	0.0	3.7	0.0	0.0	3.1	0.5
GOMPHONEMA	25.9	25.9	20.4	13.0	18.5	27.8	21.9	3.7
GYROSIGMA	1.9	1.9	0.0	0.0	5.6	0.0	1.5	0.3
MELOSIRA	22.2	31.5	27.8	22.2	40.7	11.1	25.9	4.4
MERIDION	1.9	0.0	0.0	0.0	0.0	0.0	0.3	0.1
NAVICULA	140.6	173.9	205.4	205.4	209.1	103.6	173.0	29.3
NITZSCHIA	90.7	74.0	83.3	79.6	83.3	72.2	80.5	13.6
RHOICOSPHENIA	0.0	1.9	1.9	0.0	1.9	0.0	0.9	0.2
STAURONEIS	0.0	0.0	0.0	96.2	0.0	0.0	16.0	2.7
STEPHANODISCUS	111.0	131.4	87.0	0.0	96.2	44.4	78.3	13.3
SURIRELLA	1.9	0.0	0.0	0.0	0.0	0.0	0.3	0.1
SYNEDRA	11.1	7.4	3.7	0.0	0.0	5.6	4.6	0.8
CYANOPHYTA								
OSCILLATORIA	0.0	0.0	0.0	0.0	5.6	0.0	0.9	0.2
SCHIZOTHRIX	35.2	55.5	50.0	51.8	55.5	61.1	51.5	8.7
RHODOPHYTA								
RHODOCHORTON	0.0	0.0	1.9	0.0	3.7	1.9	1.2	0.2
TOTAL	597.6	671.6	595.7	584.6	673.4	418.1	590.2	

Table B-7

Density (units/mm²) of periphytic algae on two acrylic plates submerged for 12 months at Bell Bend on the Susquehanna River, 26 June 1986.

ACRYLIC PLATE	1			2				
SUBSAMPLE	1	2	3	1	2	3	MEAN	% TOTAL
TAXON								
CHLOROPHYTA								
ACTINASTRUM	9.6	9.6	4.8	0.0	7.2	4.8	6.0	0.9
ANKISTRODESMUS	28.9	12.1	9.6	4.8	24.1	2.4	13.7	1.9
CHLAMYDOMONAS	0.0	0.0	0.0	2.4	0.0	9.6	2.0	0.3
CRUCIGENIA	0.0	0.0	0.0	0.0	2.4	0.0	0.4	0.1
KIRCHNERIELLA	2.4	0.0	7.2	2.4	0.0	0.0	2.0	0.3
OOCYSTIS	7.2	9.6	7.2	7.2	0.0	0.0	5.2	0.7
SCENEDESMUS	19.3	16.9	12.1	16.9	21.7	31.3	19.7	2.8
SELENASTRUM	0.0	0.0	0.0	0.0	2.4	0.0	0.4	0.1
TETRASTRUM	0.0	0.0	0.0	2.4	0.0	0.0	0.4	0.1
UNIDENTIFIED	55.4	74.7	50.6	65.1	69.9	36.2	58.6	8.4
BACILLARIOPHYTA								
ACHNANTHES	0.0	2.4	0.0	0.0	0.0	2.4	0.8	0.1
ASTERIONELLA	4.8	7.2	0.0	9.6	2.4	0.0	4.0	0.6
COCCONEIS	2.4	9.6	4.8	7.2	4.8	0.0	4.8	0.7
CYCLOTELLA	272.3	202.4	147.0	149.4	151.8	113.3	172.7	24.7
CYMBELLA	12.1	4.8	0.0	4.8	9.6	0.0	5.2	0.7
DIATOMA	0.0	0.0	0.0	0.0	0.0	2.4	0.4	0.1
GOMPHONEMA	0.0	12.1	0.0	12.1	0.0	0.0	4.0	0.6
MELOSIRA	0.0	7.2	14.5	9.6	0.0	0.0	5.2	0.7
MERIDION	0.0	19.3	0.0	0.0	0.0	0.0	3.2	0.5
NAVICULA	33.7	28.9	31.3	38.6	55.4	12.1	33.3	4.8
NITZSCHIA	57.8	45.8	53.0	28.9	57.8	36.2	46.6	6.7
SKELETONEMA	28.9	12.1	19.3	14.5	0.0	0.0	12.5	1.8
STEPHANODISCUS	226.5	166.3	120.5	125.3	127.7	91.6	143.0	20.4
SYNEDRA	14.5	16.9	19.3	14.5	9.6	16.9	15.3	2.2
THALASSIOSIRA	67.5	48.2	31.3	36.2	36.2	26.5	41.0	5.8
CYANOPHYTA								
CHROOCOCCUS	0.0	0.0	2.4	0.0	0.0	2.4	0.8	0.1
SCHIZOTHRIX	14.5	69.9	151.8	113.3	94.0	151.8	99.2	14.2
TOTAL	858.0	776.0	686.9	665.2	677.2	539.8	700.5	

Table B-8

Density (units/mm²) of periphytic algae on two acrylic plates submerged for 12 months at Bell Bend on the Susquehanna River, 19 August 1986.

ACRYLIC PLATE	1			2				
SUBSAMPLE	1	2	3	1	2	3	MEAN	% TOTAL
TAXON								
CHLOROPHYTA								
ACTINASTRUM	0.0	3.7	0.0	0.0	2.4	0.0	1.0	0.1
ANKISTRODESMUS	5.6	14.8	24.1	18.5	55.4	87.1	34.2	4.5
CHLAMYDOMONAS	0.0	0.0	1.9	0.0	0.0	0.0	0.3	<0.1
CHODATELLA	1.9	0.0	1.9	0.0	0.0	3.4	1.2	0.2
CLOSTERIUM	0.0	1.9	0.0	0.0	0.0	0.0	0.3	<0.1
COELASTRUM	0.0	0.0	1.9	0.0	7.2	0.0	1.5	0.2
COSMARIUM	0.0	1.9	0.0	0.0	0.0	0.0	0.3	<0.1
CRUCIGENIA	0.0	0.0	0.0	1.9	4.8	0.0	1.1	0.1
DICTYOSPHAEPIUM	3.7	7.4	7.4	7.4	7.2	3.4	6.1	0.8
KIRCHNERIELLA	1.9	0.0	3.7	0.0	2.4	3.4	1.9	0.2
OOCYSTIS	3.7	3.7	5.6	0.0	14.5	16.8	7.4	1.0
PEDIASTRUM	0.0	0.0	0.0	1.9	0.0	0.0	0.3	<0.1
SCENEDESMUS	9.3	25.9	42.6	18.5	60.3	83.8	40.0	5.2
SELENASTRUM	0.0	0.0	1.9	0.0	0.0	0.0	0.3	<0.1
TETRAEDRON	0.0	0.0	0.0	0.0	2.4	0.0	0.4	0.1
TETRASTRUM	0.0	0.0	7.4	1.9	2.4	0.0	1.9	0.3
UNIDENTIFIED	53.7	27.8	51.8	22.2	50.6	97.2	50.5	6.6
BACILLARIOPHYTA								
ACHNANTHES	0.0	0.0	1.9	0.0	0.0	0.0	0.3	<0.1
COCCONEIS	1.9	9.3	11.1	7.4	2.4	3.4	5.9	0.8
CYCLOTELLA	42.6	118.4	122.1	72.2	219.3	321.6	149.4	19.5
CYMBELLA	1.9	5.6	1.9	0.0	0.0	0.0	1.5	0.2
GOMPHONEMA	1.9	11.1	5.6	0.0	2.4	0.0	3.5	0.5
GYROSIGMA	0.0	1.9	0.0	0.0	0.0	0.0	0.3	<0.1
MELOSIRA	9.3	13.0	14.8	0.0	14.5	43.6	15.8	2.1
MERIDION	0.0	0.0	0.0	0.0	2.4	0.0	0.4	0.1
NAVICULA	14.8	11.1	9.3	13.0	48.2	13.4	18.3	2.4
NITZSCHIA	42.6	61.1	70.3	20.4	94.0	140.7	71.5	9.3
SKELETONEMA	3.7	25.9	14.8	11.1	9.6	20.1	14.2	1.9
RHOICOSPHENIA	0.0	0.0	1.9	0.0	0.0	0.0	0.3	<0.1
STEPHANODISCUS	61.1	175.8	183.2	109.2	330.2	482.4	223.6	29.2
SYNEDRA	0.0	0.0	1.9	0.0	0.0	0.0	0.3	<0.1
CYANOHPYTA								
CHROOCOCCUS	5.6	1.9	5.6	5.6	2.4	10.1	5.2	0.7
CYANARCUS	0.0	0.0	1.9	0.0	0.0	0.0	0.3	<0.1
SCHIZOTHRIX	68.5	68.5	122.1	68.5	89.2	221.1	106.3	13.9
TOTAL	333.0	590.2	717.8	379.3	1024.3	1551.1	765.9	

Table B-9

Density (units/mm²) of periphytic algae on two acrylic plates submerged for 12 months at Bell Bend on the Susquehanna River, 14 October 1986.

ACRYLIC PLATE	1			2				
SUBSAMPLE	1	2	3	1	2	3	MEAN	% TOTAL
TAXON								
CHLOROPHYTA								
ANKISTRODESMUS	7.4	13.0	13.0	22.2	44.4	44.4	24.1	4.1
COELASTRUM	0.0	0.0	0.0	1.9	3.7	0.0	0.9	0.2
CRUCIGENIA	0.0	0.0	1.9	0.0	0.0	0.0	0.3	0.1
DICTYOSPHAERIUM	0.0	0.0	0.0	1.9	0.0	0.0	0.3	0.1
KIRCHNERIELLA	5.6	1.9	7.4	11.1	7.4	20.4	8.9	1.5
OOCYSTIS	0.0	1.9	0.0	0.0	0.0	0.0	0.3	0.1
PEDIASTRUM	1.9	0.0	0.0	0.0	0.0	0.0	0.3	0.1
SCENEDESMUS	14.8	14.8	33.3	29.6	61.1	33.3	31.1	5.3
TETRASTRUM	0.0	0.0	0.0	0.0	0.0	1.9	0.3	0.1
UNIDENTIFIED	1.9	14.8	11.1	5.6	20.4	14.8	11.4	1.9
BACILLARIOPHYTA								
ACHNANTHES	0.0	0.0	1.9	0.0	0.0	0.0	0.3	0.1
AMPHORA	0.0	0.0	0.0	1.9	0.0	0.0	0.3	0.1
ASTERIONELLA	0.0	0.0	7.4	0.0	0.0	0.0	1.2	0.2
COCCONEIS	27.8	38.9	94.4	46.3	59.2	62.9	54.9	9.3
CYCLOTELLA	14.8	20.4	31.5	35.2	31.5	38.9	28.7	4.9
CYMATOPLEURA	0.0	0.0	0.0	0.0	0.0	1.9	0.3	0.1
CYMBELLA	3.7	3.7	7.4	5.6	3.7	3.7	4.6	0.8
DIATOMA	0.0	0.0	5.6	1.9	0.0	0.0	1.2	0.2
FRAGILARIA	16.7	0.0	0.0	0.0	7.4	0.0	4.0	0.7
FRUSTULIA	0.0	0.0	1.9	0.0	0.0	0.0	0.3	0.1
GOMPHONEMA	3.7	3.7	14.8	13.0	18.5	3.7	9.6	1.6
GYROSIGMA	5.6	7.4	5.6	9.3	11.1	25.9	10.8	1.8
MELOSIRA	9.3	25.9	92.5	50.0	68.5	24.1	45.0	7.7
NAVICULA	66.6	99.9	88.8	81.4	105.5	88.8	88.5	15.0
NITZSCHIA	59.2	75.9	116.6	94.4	120.3	109.2	95.9	16.3
SKELETONEMA	0.0	0.0	0.0	0.0	0.0	1.9	0.3	0.1
RHOICOSPHENIA	1.9	7.4	0.0	9.3	5.6	1.9	4.3	0.7
STEPHANODISCUS	55.5	79.6	124.0	135.1	125.8	155.4	112.5	19.1
SYNEDRA	5.6	1.9	0.0	0.0	3.7	1.9	2.2	0.4
CYANOPHYTA								
COELOSPHAERIUM	0.0	0.0	0.0	1.9	0.0	0.0	0.3	0.1
OSCILLATORIA	0.0	0.0	0.0	3.7	3.7	0.0	1.2	0.2
SCHIZOTHRIX	22.2	38.9	27.8	61.1	70.3	37.0	42.9	7.3
EUGLENOPHYTA								
TRACHELOMONAS	1.9	0.0	0.0	0.0	0.0	1.9	0.6	0.1
TOTAL	325.6	449.6	686.4	621.6	771.5	673.4	588.0	

Table B-10

Density (units/mm²) of periphytic algae on two acrylic plates submerged since 30 May at Bell Bend I on the Susquehanna River, 27 June 1986.

ACRYLIC PLATE	1			2				
SUBSAMPLE	1	2	3	1	2	3	MEAN	% TOTAL
TAXON								
CHLOROPHYTA								
ACTINASTRUM	1.6	2.0	3.2	2.8	0.8	0.4	1.8	3.5
ANKISTRODESMUS	0.4	0.8	1.6	0.8	0.4	0.4	0.7	1.4
CHLAMYDOMONAS	0.0	0.0	0.0	0.0	0.4	0.0	0.1	0.1
COELASTRUM	0.0	0.0	0.0	0.4	0.0	0.0	0.1	0.1
COSMARIUM	0.0	0.4	0.0	0.0	0.0	0.0	0.1	0.1
DICTYOSPHAERIUM	0.0	0.8	0.0	0.0	0.0	0.0	0.1	0.3
SCENEDESMUS	0.0	0.4	0.4	0.8	1.2	0.8	0.6	1.2
UNIDENTIFIED	1.6	4.0	7.2	3.2	2.8	2.4	3.5	7.0
BACILLARIOPHYTA								
COCCONEIS	0.4	0.4	0.0	0.4	0.0	0.0	0.2	0.4
CYCLOTELLA	4.0	7.6	19.6	14.4	2.8	4.0	8.7	17.2
CYMBELLA	0.0	0.0	0.0	0.4	0.4	0.0	0.1	0.3
GOMPHONEMA	0.0	0.0	0.4	0.8	0.0	0.4	0.3	0.5
HANTZSCHIA	0.0	0.4	0.0	0.0	0.0	0.0	0.1	0.1
MELOSIRA	0.0	0.0	0.8	0.0	0.0	0.0	0.1	0.3
NAVICULA	3.2	1.6	3.2	7.6	1.2	0.4	2.9	5.7
NITZSCHIA	4.8	4.4	6.4	7.6	3.6	6.0	5.5	10.8
SKELETONEMA	0.0	0.0	2.4	0.0	0.0	0.8	0.5	1.1
STEPHANODISCUS	9.2	18.0	45.2	34.4	6.4	9.2	20.4	40.2
SYNEDRA	2.8	2.4	0.4	4.8	3.6	3.6	2.9	5.8
CYANOPHYTA								
CHROOCOCCUS	0.0	1.6	1.2	0.0	0.0	0.0	0.5	0.9
OSCILLATORIA	0.4	0.0	0.4	0.0	0.0	0.0	0.1	0.3
SCHIZOTHRIX	1.2	0.0	2.4	1.2	2.4	1.2	1.4	2.8
TOTAL	29.6	44.8	94.8	79.6	26.0	29.6	50.7	

Table B-11

Density (units/mm²) of periphytic algae on two acrylic plates submerged since 30 May at Bell Bend I on the Susquehanna River, 19 August 1986.

ACRYLIC PLATE	1			2				
SUBSAMPLE	1	2	3	1	2	3	MEAN	% TOTAL
TAXON								
CHLOROPHYTA								
ACTINASTRUM	0.0	0.0	0.0	4.8	3.4	4.8	2.2	0.2
ANKISTRODESMUS	25.9	73.7	63.7	45.8	63.7	36.2	51.5	4.1
CERASTERIAS	0.0	0.0	0.0	0.0	3.4	0.0	0.6	<0.1
CHLAMYDOMONAS	1.9	0.0	0.0	0.0	0.0	2.4	0.7	0.1
CHODATELLA	0.0	0.0	0.0	0.0	3.4	0.0	0.6	<0.1
COELASTRUM	0.0	3.4	3.4	0.0	0.0	2.4	1.5	0.1
COSMARIUM	0.0	0.0	3.4	0.0	3.4	0.0	1.1	0.1
CRUCIGENIA	3.7	0.0	0.0	0.0	3.4	7.2	2.4	0.2
DICTYOSPHAERIUM	7.4	3.4	0.0	4.8	0.0	0.0	2.6	0.2
GOLENKINIA	0.0	0.0	0.0	0.0	3.4	0.0	0.6	<0.1
KIRCHNERIELLA	0.0	10.1	3.4	12.1	6.7	14.5	7.8	0.6
OEDOGONIUM	0.0	20.1	0.0	0.0	0.0	0.0	3.4	0.3
OOCYSTIS	11.1	0.0	33.5	7.2	20.1	12.1	14.0	1.1
SCENEDESMUS	27.8	57.0	90.5	48.2	90.5	26.5	56.7	4.5
TETRAEDRON	0.0	0.0	3.4	0.0	0.0	2.4	1.0	0.1
TETRASTRUM	1.9	0.0	3.4	0.0	3.4	2.4	1.8	0.1
UNIDENTIFIED	70.3	70.4	150.8	48.2	117.3	77.1	89.0	7.1
BACILLARIOPHYTA								
ACHNANTHES	0.0	0.0	0.0	0.0	0.0	2.4	0.4	<0.1
COCCONEIS	7.4	20.1	10.1	2.4	13.4	7.2	10.1	0.8
CYCLOTELLA	192.4	361.8	331.7	253.1	405.4	214.5	293.1	23.3
CYMBELLA	1.9	13.4	3.4	4.8	6.7	2.4	5.4	0.4
FRUSTULIA	1.9	0.0	0.0	0.0	0.0	0.0	0.3	<0.1
GOMPHONEMA	1.9	0.0	13.4	2.4	16.8	14.5	8.1	0.6
MELOSIRA	9.3	20.1	20.1	0.0	0.0	0.0	8.2	0.7
NAVICULA	9.3	10.1	16.8	4.8	13.4	2.4	9.4	0.8
NITZSCHIA	68.5	197.7	87.1	108.5	157.5	115.7	122.5	9.8
SKELETONEMA	22.2	20.1	57.0	36.2	63.7	41.0	40.0	3.2
RHOICOSPHENIA	0.0	0.0	3.4	4.8	3.4	0.0	1.9	0.2
STEPHANODISCUS	288.6	546.1	499.2	380.8	616.4	322.9	442.3	35.2
SYNEDRA	0.0	3.4	0.0	0.0	0.0	0.0	0.6	<0.1
CYANOPHYTA								
CHROOCOCCUS	0.0	0.0	0.0	0.0	6.7	0.0	1.1	0.1
SCHIZOTHRIX	64.8	57.0	97.2	81.9	63.7	74.7	73.2	5.8
EUGLENOPHYTA								
TRACHELOMONAS	0.0	0.0	0.0	0.0	10.1	0.0	1.7	0.1
TOTAL	817.7	1487.4	1494.1	1050.8	1698.5	985.7	1255.7	

Table B-12

Density (units/mm²) of periphytic algae on two acrylic plates submerged since 30 May at Bell Bend I on the Susquehanna River, 14 October 1986.

ACRYLIC PLATE	1			2				
SUBSAMPLE	1	2	3	1	2	3	MEAN	% TOTAL
TAXON								
CHLOROPHYTA								
ANKISTRODESMUS	27.8	14.8	37.0	22.2	16.7	20.4	23.1	3.3
CHLAMYDOMONAS	0.0	1.9	0.0	0.0	0.0	0.0	0.3	<0.1
COELASTRUM	0.0	1.9	1.9	0.0	1.9	1.9	1.2	0.2
CRUCIGENIA	1.9	0.0	0.0	0.0	0.0	0.0	0.3	<0.1
DICTYOSPHAERIUM	1.9	1.9	0.0	0.0	0.0	0.0	0.6	0.1
KIRCHNERIELLA	11.1	3.7	9.3	0.0	3.7	11.1	6.5	0.9
OOCYSTIS	3.7	1.9	0.0	0.0	0.0	0.0	0.9	0.1
PEDIASTRUM	0.0	1.9	0.0	0.0	0.0	0.0	0.3	<0.1
SCENEDESMUS	40.7	27.8	61.1	16.7	33.3	25.9	34.2	4.9
UNIDENTIFIED	18.5	9.3	7.4	9.3	3.7	11.1	9.9	1.4
BACILLARIOPHYTA								
ACHNANTHES	3.7	0.0	1.9	1.9	3.7	1.9	2.2	0.3
AMPHORA	0.0	0.0	0.0	1.9	0.0	0.0	0.3	<0.1
ASTERIONELLA	0.0	0.0	7.4	0.0	0.0	0.0	1.2	0.2
COCCONEIS	38.9	61.1	51.8	64.8	66.6	77.7	60.1	8.7
CYCLOTELLA	35.2	33.3	16.7	27.8	27.8	37.0	29.6	4.3
CYMBELLA	0.0	11.1	5.6	9.3	5.6	5.6	6.2	0.9
DIATOMA	1.9	1.9	0.0	0.0	0.0	0.0	0.6	0.1
FRUSTULIA	1.9	3.7	0.0	0.0	0.0	0.0	0.9	0.1
GOMPHONEMA	0.0	13.0	9.3	5.6	9.3	18.5	9.3	1.3
GYROSIGMA	7.4	7.4	1.9	5.6	27.8	22.2	12.0	1.7
MELOSIRA	81.4	48.1	55.5	9.3	16.7	16.7	37.9	5.5
MERIDION	0.0	1.9	0.0	0.0	0.0	0.0	0.3	<0.1
NAVICULA	148.0	85.1	112.9	99.9	127.7	153.6	121.2	17.5
NITZSCHIA	83.3	105.5	127.7	112.9	142.5	155.4	121.2	17.5
PINNULARIA	0.0	0.0	0.0	0.0	1.9	0.0	0.3	<0.1
RHOICOSPHENIA	5.6	3.7	5.6	0.0	0.0	5.6	3.4	0.5
STEPHANODISCUS	136.9	125.8	70.3	114.7	111.0	148.0	117.8	17.0
SYNEDRA	9.3	0.0	0.0	0.0	0.0	0.0	1.5	0.2
CYANOPHYTA								
MERISMOPEDIA	0.0	0.0	0.0	0.0	0.0	1.9	0.3	<0.1
OSCILLATORIA	1.9	1.9	1.9	0.0	0.0	0.0	0.9	0.1
SCHIZOTHRIX	57.4	68.5	66.6	109.2	94.4	124.0	86.6	12.5
RHODOPHYTA								
RHODOCHORTON	0.0	0.0	0.0	1.9	0.0	0.0	0.3	<0.1
TOTAL	717.8	636.4	651.2	612.4	693.8	838.1	691.6	

Table B-13

Species of periphytic algae composing 5% or more of the total units counted in at least one replicate sample from SSES, Bell Bend, or Bell Bend I on the Susquehanna River, 1986. pH affinity as rated by Lowe (1974): 1 = alkaliphilous, 2 = acidophilous, 3 = indifferent, and 4 = unknown.

Species	pH Affinity	SSES	Bell Bend	Bell Bend I
CHLOROPHYTA				
Ankistrodesmus falcatus		Jun, Aug, Oct	Aug, Oct	
Scenedesmus quadricauda		Oct	Oct	Oct
BACILLARIOPHYTA				
Cocconeis placentula	(1)	Oct	Oct	Oct
Cyclotella meneghiniana	(1)	Jun	Jun	Jun
C. pseudostelligera	(3)	Aug	Aug	Aug
Melosira granulata	(1)		Oct	Oct
Navicula cryptocephala var. *veneta*	(1)	Oct	Oct	
N. salinarum var. *intermedia*	(4)	Oct	Oct	Oct
Nitzschia acicularis	(1)	Aug	Aug	Jun, Aug
N. dissipata	(1)	Jun		
N. palea	(3)	Aug, Oct	Aug, Oct	Aug, Oct
Stephanodiscus invisitatus	(4)	Jun, Aug, Oct	Jun, Aug, Oct	Jun, Aug, Oct
Thalassiosira pseudonana	(3)		Jun	
CYANOPHYTA				
Schizothrix calcicola		Jun, Oct	Jun, Aug, Oct	Jun, Aug, Oct

Table B-14

Average density (units/mm^2) and relative abundance (% total) of periphytic algae on two acrylic plates at SSES, Bell Bend, and Bell Bend I on the Susquehanna River collected in June, August, and October, 1977-86.

YEAR	GREENS		DIATOMS		BLUE GREENS		OTHER		TOTAL	
	UNITS/MM^2	% TOTAL	UNITS/MM^2	% TOTAL	UNITS/MM^2	% TOTAL	UNITS/MM^2	% TOTAL	UNITS/MM^2	% TOTAL
SSES										
PREOPERATION OF THE SUSQUEHANNA SES										
1977	372	55.0	228	33.7	74	10.9	2	0.3	676	99.9
1978	233	24.3	718	74.8	9	0.9	0	0.0	960	100.0
1979	563	40.8	784	56.8	32	2.3	0	0.0	1379	99.9
1980	707	40.8	998	57.6	27	1.6	0	0.0	1732	100.0
1981	1840	78.4	491	20.9	16	0.7	0	0.0	2347	100.0
1982	808	61.1	505	38.2	9	0.7	0	0.0	1322	100.0
MEAN	754	53.7	621	44.2	28	2.0	<1	<0.1	1403	99.9
OPERATION OF THE SUSQUEHANNA SES										
1983	336	46.4	338	46.6	50	6.9	0	0.0	724	99.9
1984	169	13.2	1100	85.8	13	1.0	0	0.0	1282	100.0
1985	484	34.1	909	64.1	22	1.6	3	0.2	1418	100.0
1986	84	18.6	304	67.4	63	14.0	0	0.0	451	100.0
MEAN	268	27.7	663	68.4	37	3.8	<1	<0.1	969	99.9
BELL BEND										
PREOPERATION OF THE SUSQUEHANNA SES										
1977	988	37.3	1473	55.7	181	6.8	4	0.2	2646	100.0
1978	293	16.7	1437	81.7	29	1.6	1	<0.1	1760	100.0
1979	1124	48.5	1092	47.1	101	4.4	0	0.0	2317	100.0
1980	2626	39.6	3929	59.3	69	1.0	0	0.0	6624	99.9
1981	2880	75.4	915	24.0	23	0.6	1	<0.1	3819	100.0
1982	1169	58.0	818	40.6	29	1.4	0	0.0	2016	100.0
MEAN	1513	47.3	1611	50.4	72	2.3	1	<0.1	3197	100.0
OPERATION OF THE SUSQUEHANNA SES										
1983	1565	56.9	904	32.8	285	10.3	1	<0.1	2755	100.0
1984	119	14.5	626	76.4	74	9.0	0	0.0	819	99.9
1985	342	14.2	2040	84.7	26	1.1	0	0.0	2408	100.0
1986	112	16.4	487	71.1	86	12.6	0	0.0	685	100.1
MEAN	535	32.1	1014	60.9	118	7.1	<1	<0.1	1667	100.1
BELL BEND I										
OPERATION OF THE SUSQUEHANNA SES										
1986	107	16.0	504	75.6	55	8.2	1	0.1	667	99.9

Table B-15

Density (units/ml) of phytoplankton in samples collected at SSES on the Susquehanna River, 1986.

TAXON	25 JUNE	18 AUGUST	14 OCTOBER	MEAN	% TOTAL
CHLOROPHYTA					
ACTINASTRUM	222	150	0	124.1	1.2
ANKISTRODESMUS	333	500	86	306.3	2.8
CHLAMYDOMONAS	22	1517	0	513.0	4.8
COELASTRUM	111	117	0	75.9	0.7
CRUCIGENIA	22	167	0	63.0	0.6
DICTYOSPHAERIUM	67	533	11	203.6	1.9
KIRCHNERIELLA	178	267	64	169.6	1.6
MICRACTINIUM	44	0	0	14.8	0.1
OOCYSTIS	311	100	0	137.0	1.3
PEDIASTRUM	0	17	7	7.9	0.1
SCENEDESMUS	444	1017	143	534.7	5.0
SELENASTRUM	0	17	0	5.6	0.1
TETRAEDRON	22	0	0	7.4	0.1
TETRASTRUM	67	83	7	52.4	0.5
UNIDENTIFIED	1889	1083	111	1027.6	9.5
BACILLARIOPHYTA					
ASTERIONELLA	133	0	14	49.2	0.5
COCCONEIS	0	0	11	3.6	<0.1
CYCLOTELLA	5222	3200	411	2944.3	27.3
GOMPHONEMA	0	0	11	3.6	<0.1
MELOSIRA	0	83	86	56.3	0.5
NAVICULA	22	0	61	27.6	0.3
NITZSCHIA	889	1483	132	834.8	7.8
SKELETONEMA	133	467	7	202.4	1.9
RHOICOSPHENIA	0	0	4	1.2	<0.1
STEPHANODISCUS	3533	4800	521	2951.6	27.4
SYNEDRA	333	0	0	111.1	1.0
CYANOPHYTA					
ANABAENA	0	0	4	1.2	<0.1
CHROOCOCCUS	778	150	4	310.4	2.9
MERISMOPEDIA	0	17	0	5.6	0.1
SCHIZOTHRIX	0	0	25	8.3	0.1
EUGLENOPHYTA					
TRACHELOMONAS	0	17	11	9.1	0.1
PYRRHOPHYTA					
PERIDINIUM	22	0	0	7.4	0.1
TOTAL	14800	15784	1728	10770.6	

Table B-16

Density (units/ml) of phytoplankton in samples collected at Bell Bend on the Susquehanna River, 1986.

TAXON	26 JUNE	19 AUGUST	14 OCTOBER	MEAN	% TOTAL
CHLOROPHYTA					
ACTINASTRUM	533	83	0	205.6	1.[illegible]
ANKISTRODESMUS	422	483	107	337.6	2.8
CHLAMYDOMONAS	67	1350	0	472.2	3.9
CLOSTERIUM	0	17	0	5.6	<0.1
COELASTRUM	0	0	4	1.2	<0.1
CRUCIGENIA	133	17	11	53.6	0.4
DICTYOSPHAERIUM	156	983	7	382.0	3.2
ELAKATOTHRIX	22	0	0	7.4	0.1
GOLENKINIA	0	17	0	5.6	<0.1
KIRCHNERIELLA	22	350	71	147.9	1.2
MICRACTINIUM	67	0	0	22.2	0.2
OOCYSTIS	356	117	0	157.4	1.3
PEDIASTRUM	22	0	7	9.8	0.1
POLYEDRIOPSIS	89	0	0	29.6	0.2
SCENEDESMUS	711	717	232	553.3	4.6
SELENASTRUM	0	17	0	5.6	<0.1
TETRAEDRON	0	67	0	22.2	0.2
TETRASTRUM	89	133	4	75.3	0.6
UNIDENTIFIED	1844	1183	86	1037.8	8.6
BACILLARIOPHYTA					
COCCONEIS	0	0	11	3.6	<0.1
CYCLOTELLA	6978	3083	514	3525.1	29.1
CYMATOPLEURA	0	0	4	1.2	<0.1
CYMBELLA	44	0	0	14.8	0.1
FRAGILARIA	0	0	43	14.3	0.1
GOMPHONEMA	0	17	0	5.6	<0.1
GYROSIGMA	0	0	7	2.4	<0.1
MELOSIRA	0	83	304	129.0	1.1
NAVICULA	0	0	71	23.8	0.2
NITZSCHIA	822	1367	214	801.1	6.6
SKELETONEMA	311	383	14	236.2	2.0
RHOICOSPHENIA	0	17	7	7.9	0.1
STEPHANODISCUS	4689	4683	653	3341.9	27.6
SYNEDRA	400	17	11	142.5	1.2
CYANOPHYTA					
CHROOCOCCUS	711	83	29	274.3	2.3
COELOSPHAERIUM	0	17	0	5.6	<0.1
MERISMOPEDIA	0	67	4	23.4	0.2
SCHIZOTHRIX	0	0	25	8.3	0.1
EUGLENOPHYTA					
TRACHELOMONAS	0	0	4	1.2	<0.1
TOTAL	18489	15350	2443	12094	

Table B-17

Density (units/ml) of phytoplankton in samples collected at Bell Bend I on the Susquehanna River, 1986.

TAXON	27 JUNE	19 AUGUST	14 OCTOBER	MEAN	% TOTAL
CHLOROPHYTA					
ACTINASTRUM	1000	133	0	377.8	3.1
ANKISTRODESMUS	356	817	157	443.1	3.7
CHLAMYDOMONAS	89	1267	0	451.9	3.7
CHODATELLA	0	0	4	1.2	<0.1
COELASTRUM	133	67	0	66.7	0.6
COSMARIUM	44	17	0	20.4	0.2
CRUCIGENIA	22	17	0	13.0	0.1
DICTYOSPHAERIUM	200	617	21	279.4	2.3
GOLENKINIA	22	17	0	13.0	0.1
KIRCHNERIELLA	111	633	143	295.8	2.4
MICRACTINIUM	67	17	0	27.8	0.2
OEDOGONIUM	0	0	7	2.4	<0.1
OOCYSTIS	289	83	11	127.6	1.1
POLYEDRIOPSIS	133	0	0	44.4	0.4
SCENEDESMUS	511	1117	232	620.0	5.1
SELENASTRUM	44	0	7	17.2	0.1
TETRAEDRON	22	67	0	29.6	0.2
TETRASTRUM	44	83	4	43.8	0.4
UNIDENTIFIED	1222	1067	214	834.4	6.9
BACILLARIOPHYTA					
ACHNANTHES	0	0	11	3.6	<0.1
ASTERIONELLA	0	0	14	4.8	<0.1
COCCONEIS	0	0	39	13.1	0.1
CYCLOTELLA	8155	2433	536	3708.2	30.6
CYMBELLA	0	0	7	2.4	<0.1
GOMPHONEMA	0	0	7	2.4	<0.1
MELOSIRA	0	33	118	50.4	0.4
NAVICULA	22	17	50	29.6	0.2
NITZSCHIA	867	917	204	662.3	5.5
SKELETONEMA	422	167	0	196.3	1.6
RHOICOSPHENIA	0	0	4	1.2	<0.1
STEPHANODISCUS	4978	3667	682	3108.8	25.7
SYNEDRA	400	33	4	145.6	1.2
CYANOPHYTA					
CHROOCOCCUS	1267	83	11	453.6	3.7
MERISMOPEDIA	0	17	4	6.7	0.1
SCHIZOTHRIX	0	0	36	11.9	0.1
EUGLENOPHYTA					
TRACHELOMONAS	0	0	4	1.2	<0.1
TOTAL	20422	13384	2528	12111.3	

Table B-18

Average density (units/ml) and relative abundance (% total) of phytoplankton at SSES, Bell Bend, and Bell Bend I on the Susquehanna River collected in June, August, and October 1977-86.

YEAR	GREENS		DIATOMS		BLUE GREENS		OTHER		TOTAL	
	UNITS/ML	% TOTAL	UNITS/ML	% TOTAL	UNITS/ML	% TOTAL	UNITS/ML	% TOTAL	UNITS/ML	% TOTAL
SSES										
PREOPERATION OF THE SUSQUEHANNA SES										
1977	4137	63.6	2068	31.8	298	4.6	6	<0.1	6509	100.0
1978	8492	35.4	15375	64.1	119	0.5	12	<0.1	23998	100.0
1979	11375	64.2	5496	31.0	823	4.6	20	0.1	17714	99.9
1980	14944	63.2	7213	30.5	1483	6.3	0	0.0	23640	100.0
1981	23979	61.8	12799	33.0	1995	5.1	23	<0.1	38796	99.9
1982	7224	57.5	5118	40.8	207	1.6	7	<0.1	12556	99.9
MEAN	11692	56.9	8012	39.0	821	4.0	11	<0.1	20536	99.9
OPERATION OF THE SUSQUEHANNA SES										
1983	12839	69.1	1979	10.6	3774	20.3	0	0.0	18592	100.0
1984	2876	66.3	1265	29.2	191	4.4	4	<0.1	4336	99.9
1985	6597	49.4	5572	41.7	1181	8.8	2	<0.1	13352	99.9
1986	3243	30.1	7186	66.7	326	3.0	17	0.2	10772	100.0
MEAN	6389	54.3	4001	34.0	1368	11.6	6	<0.1	11764	99.9
BELL BEND										
PREOPERATION OF THE SUSQUEHANNA SES										
1977	4074	57.8	2821	40.0	143	2.0	11	0.2	7049	100.0
1978	7435	32.4	15239	66.5	244	1.1	12	<0.1	22930	100.0
1979	11252	65.1	5632	32.6	369	2.1	41	0.2	17294	100.0
1980	15724	60.9	8136	31.5	1963	7.6	0	0.0	25823	100.0
1981	18987	52.2	15150	41.7	2226	6.1	1	<0.1	36364	100.0
1982	6503	60.8	3915	36.6	268	2.5	7	<0.1	10693	99.9
MEAN	10663	53.2	8482	42.4	869	4.3	12	<0.1	20026	99.9
OPERATION OF THE SUSQUEHANNA SES										
1983	12324	64.1	2116	11.0	4774	24.8	0	0.0	19214	99.9
1984	3114	66.3	1389	29.6	187	4.0	5	0.1	4695	100.0
1985	6648	48.0	6151	44.4	1050	7.6	2	<0.1	13851	100.0
1986	3532	29.2	8249	68.2	312	2.6	1	<0.1	12094	100.0
MEAN	6405	51.4	4476	35.9	1581	12.7	2	<0.1	12464	100.0
BELL BEND I										
OPERATION OF THE SUSQUEHANNA SES										
1986	3709	30.6	7929	65.5	472	3.9	1	<0.1	12111	100.0

Table B-19

Species of phytoplankton composing 5% or more of the total units counted in at least one sample from SSES, Bell Bend, or Bell Bend I on the Susquehanna River, 1986. pH affinity as rated by Lowe (1974): 1 = alkaliphilous, 2 = acidophilous, 3 = indifferent, and 4 = unknown.

Species	pH Affinity	SSES	Bell Bend	Bell Bend I
CHLOROPHYTA				
Ankistrodesmus falcatus				Oct
Chlamydomonas globosa		Aug	Aug	Aug
Dictyosphaerium pulchellum			Aug	Aug
Scenedesmus quadricauda		Oct	Oct	Aug, Oct
BACILLARIOPHYTA				
Cyclotella meneghiniana	(1)	Jun, Oct	Jun, Oct	Jun, Oct
C. pseudostelligera	(3)	Aug, Oct	Aug, Oct	Aug, Oct
Melosira granulata	(1)		Oct	
Nitzschia acicularis	(1)	Aug	Aug, Oct	Aug
Stephanodiscus invisitatus	(4)	Jun, Aug, Oct	Jun, Aug, Oct	Jun, Aug, Oct

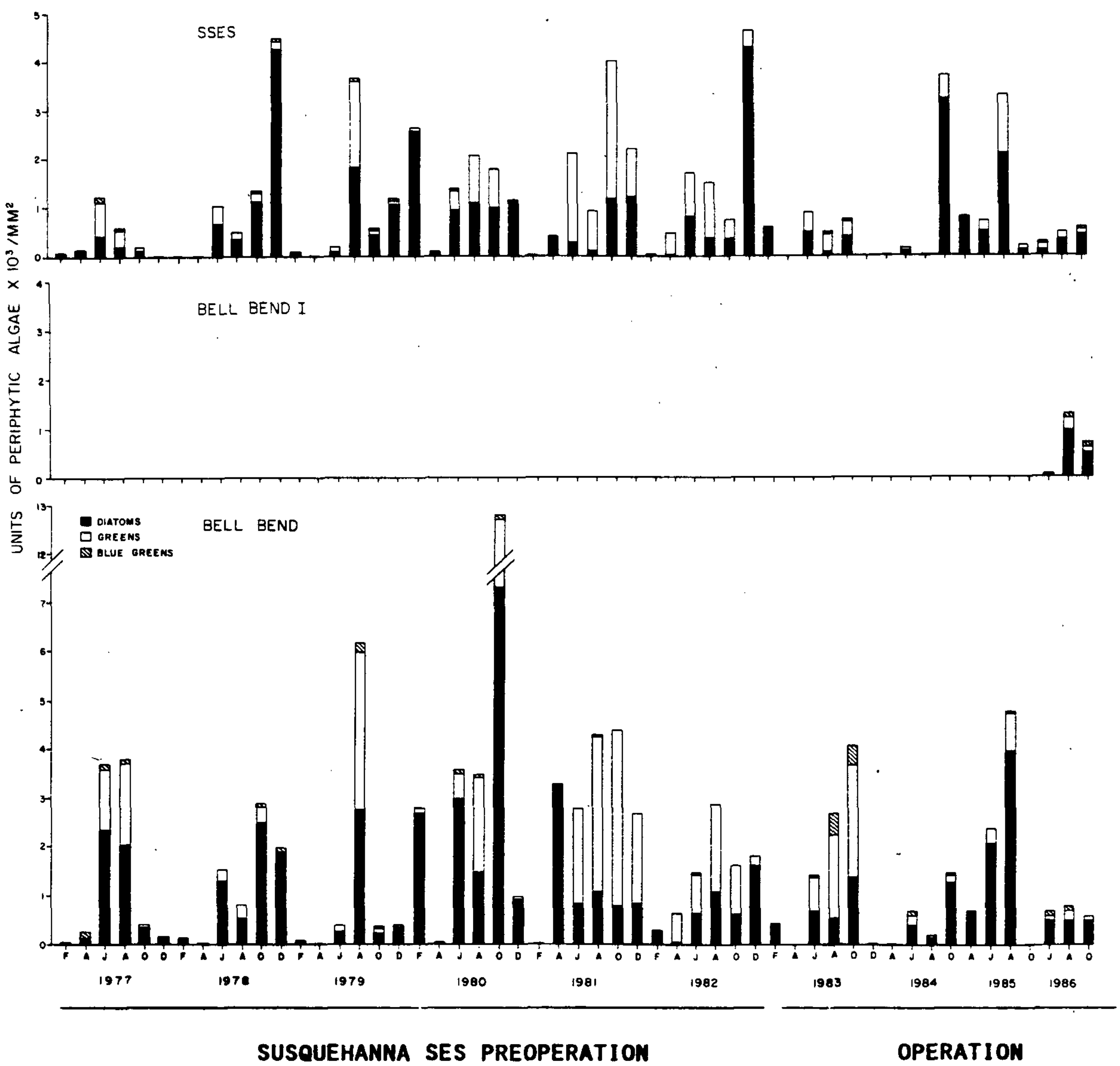

Fig. B-1

Standing crop of periphytic algae (units/mm²) on cumulative acrylic plates at SSES, Bell Bend I, and Bell Bend on the Susquehanna River, 1977-86.

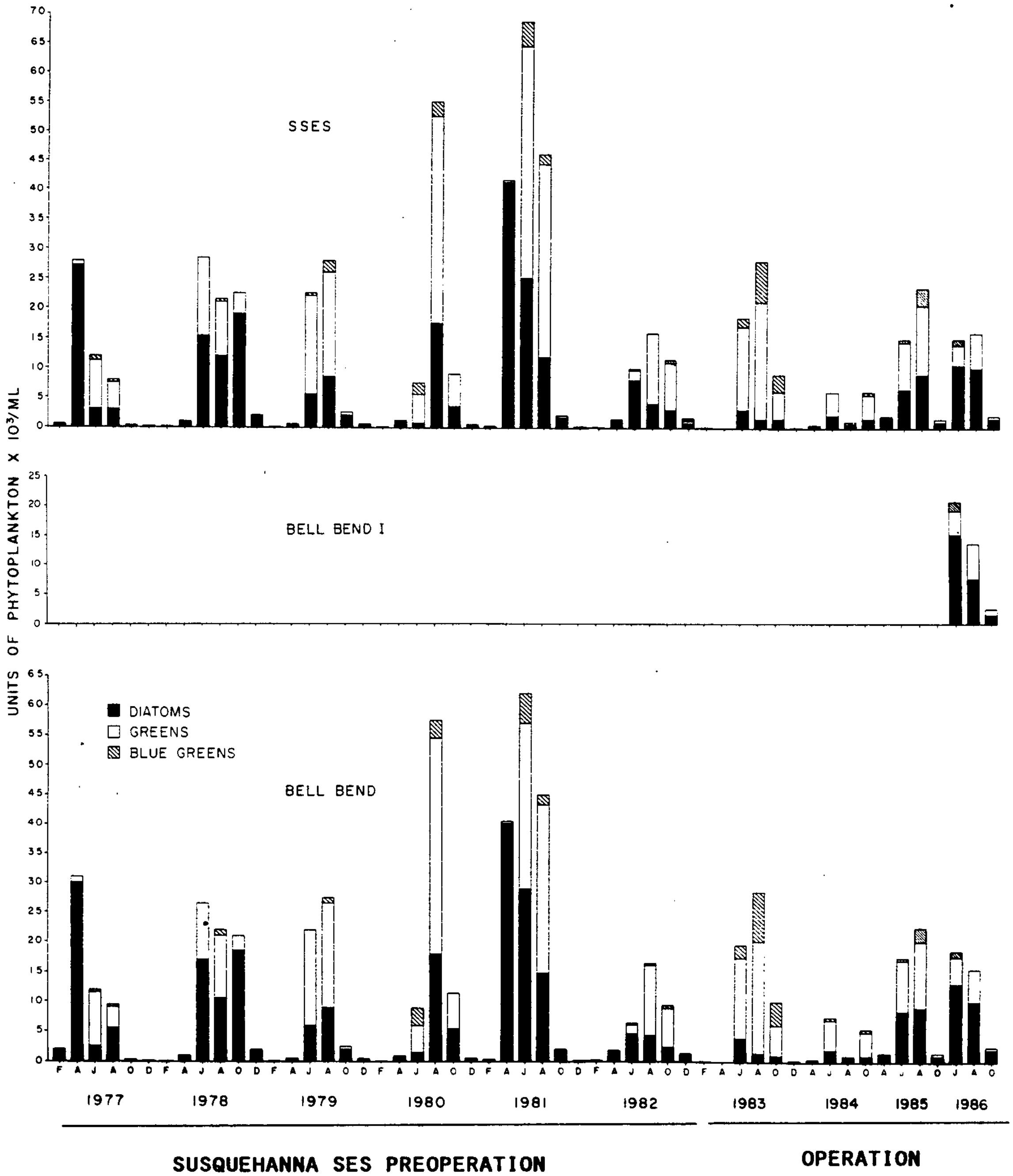

Fig. B-2

Standing crop of phytoplankton (units/ml) at SSES, Bell Bend I, and Bell Bend on the Susquehanna River, 1977-86.

BENTHIC MACROINVERTEBRATES

by

Lynn S. Zelenak

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Benthic macroinvertebrate samples were collected from the Susquehanna River at a control site (SSES I) and two indicator sites (Bell Bend III, Bell Bend IV) in June, August, and October 1986. Two samples were collected at each site from acrylic plates, using a bar-clamp sampler, to determine species composition and density of macroinvertebrates. A dome suction sampler was also used to collect a biomass sample at each site. Overall, density at both Bell Bend sites (III and IV) was consistently higher than at SSES I in each sampling period. Total mean density was greatest at Bell Bend IV (107,300 organisms/m^2) and was composed primarily of chironomids and naidids. Chironomids and naidids were also the dominant macroinvertebrates at Bell Bend III, but total mean density was only 59,700 org/m^2. At SSES I, total mean density (51,400 org/m^2) was less than half of that collected at Bell Bend IV. Total mean biomass at SSES I was 2.8 g/m^2; trichopterans composed 61% of the total. At both Bell Bend III and Bell Bend IV, total mean biomass was 1.9 g/m^2 and was composed of about 50% ephemeropterans. Total biomass was greatest at all sites in October. Biomass at Bell Bend has shown little variability in the operational years (1983-86).

INTRODUCTION

Benthic macroinvertebrates have been monitored in the Susquehanna River near the Susquehanna SES since 1975 to establish a baseline of preoperational conditions (Deutsch 1976-78, Sabin et al. 1979-80, Deutsch et al. 1981-83). In September 1982, Unit 1 of the Susquehanna SES became operational and, beginning in 1983, all data collected were considered operational (Deutsch et al. 1984, Zelenak et al. 1985-86). The objective in 1986, as it has been since 1983, was to evaluate effects of the Susquehanna SES on the benthic macroinvertebrate community by monitoring benthos upriver from the intake structure (SSES) and downriver from the discharge diffuser (Bell Bend).

Density and biomass of macroinvertebrates have increased several fold at both SSES and Bell Bend since 1975. Even before the start of the operational phase of these studies in 1983, macroinvertebrate densities had reached a level where biologists had difficulty sorting and identifying the high number of organisms in a timely manner. Use of the dome suction sampler, developed specifically by Gale and Thompson (1975) for river sampling, remained suitable for biomass estimates because organisms were only sorted into major groups and a 841-micron mesh sieve was used. This size mesh allowed the loss of early instar organisms and most naidids and small chironomids. The dome sampler, however, was no longer appropriate for density estimates since all of the organisms in each sample that were sieved in a 250-micron mesh sieve had to be sorted and identified. Although improved subsampling techniques may have sufficiently reduced the density samples to a more manageable size, it was also evident from benthic data collected in previous years, that two groups of macroinvertebrates seemed to closely reflect changes in river water quality with changes in their species representation. These groups are the midges (Diptera: Chironomidae) and the hydropsychid caddisflies (Trichoptera: Hydropsychidae). Studies done in the Susquehanna River with artificial substrates (acrylic plates) by Deutsch (1980) and a similar unpublished work showed that these two groups also predominated on the plates. Concerning the use of artificial substrates, Rosenberg and Resh (1982) listed several advantages (standardization of microhabitat, increased sampling precision, and reduced variability) and disadvantages (selectivity of substrates, lack of information about colonization dynamics, and inconvenience of use). In our situation, however, it was felt that the advantages of using plates outweighed the disadvantages. Therefore, beginning in 1986, acrylic plates were used rather than the dome suction sampler for collection of density samples.

PROCEDURES

Three sites were sampled in 1986 (Table C-1; Fig. A-1). SSES I was retained as a control site and Bell Bend III as an indicator site. Although Bell Bend III was located directly downriver from the Susquehanna SES discharge diffuser pipe, results of a dye study done in 1985 (Sutron 1985), revealed that it was not in the center of the discharge plume. Therefore, an additional indicator site (Bell Bend IV) was established in 1986 closer to the center of the plume.

Two density samples were collected from acrylic plates using a bar-clamp sampler (Deutsch 1980) at SSES I on 30 June, 21 August, and 15 October, and at Bell Bend III and IV on 27 June, 21 August, and 16 October. Prior to sampling, scuba divers placed eight acrylic plates, 20 x 30 cm and 13-mm thick, into two detritus-free acrylic holders, similar to those of Gale et al. (1976), at Bell Bend III and IV on 30 May and at SSES I on 2 June. At each site, divers securely fastened a bar-clamp sampler on each of two randomly selected plates. The sampler cup enclosed a 56.75 cm^2 area on the plate's upper surface. A foam rubber ring around the cup sealed it to the plate and a removable screened insert (250-micron in June; 180-micron in August and October) inside the cup retained the sample. Samples were collected on the downriver half of the plate, at least 2 cm from any edge. As each plate was sampled and removed, replacement plates were installed for future sampling.

In the laboratory, screens were removed from the sampler cups and washed. Organisms were removed from the plate surface by brushing and/or scraping. Sample material was pipetted from the cup, concentrated by sieving (180-micron mesh), and preserved in 10% buffered formalin. Later, upon examination of the residue with a dissecting microscope (10-70X), organisms were sorted, identified, and counted. Invertebrates were identified (usually to genus or species) using taxonomic keys cited in Zelenak et al. (1986). Some chironomids had to be mounted on microscope slides and examined with a compound microscope (400-1000X) for identification. The number of organisms per square meter was determined by multiplying the number found in each sample by 176.2.

One biomass sample was collected from natural river substrate with a dome suction sampler at SSES I on 26 June, 20 August, and 15 October and at Bell Bend III and IV on 27 June, 21 August, and 16 October. The dome sampler was lowered from a boat to the river bottom; a scuba diver moved it upriver to the first undisturbed area where an adequate seal between the sampler band and the substrate could be established. The diver then vacuumed the substrate inside the sampler (0.163 m^2) for five minutes with a screened intake nozzle leading to the sampler's pump. Sediments (silt, sand, and fine gravel) and organisms were pumped into a nylon net (216-micron mesh). The diver carefully vacuumed large stones within the dome sampler and then discarded them.

In the laboratory, this sample was washed and sieved (841-micron mesh). It was then refrigerated (or kept in ice water) until organisms were sorted. By chilling the sample, it was possible to avoid the use of preservatives which distort organism weight (Howmiller 1972, Wiederholm and Eriksson 1977). Before molluscs were weighed, their shells were decalcified in 5% HCl. Processing was always completed within 12 hours of collection. Organisms were sorted into major groups and then dried in aluminum foil containers at 100±3 C for at least 12 hours, cooled to room temperature, and weighed on a Mettler H10W balance. The mass of organisms per square meter was determined by multiplying the weight of each group by 6.1.

RESULTS AND DISCUSSION

Density

In 1986, density at both Bell Bend sites (III and IV) was consistently higher than at SSES I in each sampling period (Table C-2). Total mean density was greatest at Bell Bend IV (107,300 organisms/m^2). It was composed primarily of chironomids (54%) and naidids (38%). Hydropsychids composed only 7% of the total density. At Bell Bend III, total mean density was 59,700 org/m^2 and was also primarily composed of chironomids (69%) and naidids (19%). At SSES I, total mean density (51,400 org/m^2) was less than half of that collected at Bell Bend IV. It was composed mostly of chironomids (56%) and hydropsychids (27%); naidids composed 12% of the total density. A listing of benthic macroinvertebrates found at all three sites in 1986 is in Table C-3.

In June at SSES I, total mean density was 1,000 org/m^2 (Table C-4) and was composed mostly of *Rheotanytarsus* spp. (73%). At Bell Bend III, total mean density was 5,500 org/m^2 and was composed mostly of chironomids (61%), hydropsychids (18%), and naidids (13%). Two species of midges, *Rheotanytarsus* spp. and *Nanocladius* spp., were the most abundant. Total mean density at Bell Bend IV was 7,100 org/m^2. It was composed mostly of chironomids (58%) and naidids (24%). Again, *Rheotanytarsus* spp. and *Nanocladius* spp. were the most abundant.

In August, total mean density at SSES I (72,400 org/m^2) was again lower than at the Bell Bend sites (Table C-5). *Rheotanytarsus* spp. predominated (53%) and the next most abundant species was *Hydropsyche phalerata* (32%). Total mean density at Bell Bend III was 74,400 org/m^2 and was composed primarily of *Rheotanytarsus* spp. (67%) and naidids (14%). Hydropsychids composed 7% of the total density; most of these were very young first instar larvae. Total mean density at Bell Bend IV was 97,400 org/m^2; 74% of this were *Rheotanytarsus* spp. and 12% were naidids. A previous study to determine colonization rates of acrylic plates (Deutsch 1980) showed that trichopteran reproduction was an important means of colonizing plates; most rapid colonization of the year occurred in August, due to the expanding populations of this group. Also, fewer numbers of hydropsychids, particularly *Hydropsyche phalerata*, were observed at Bell Bend sites in late summer and fall in 1980-81 (unpublished study). Therefore, fewer numbers of hydropsychids found at Bell Bend in 1986 were almost certainly due to different microhabitat conditions rather than due to the effect of the Susquehanna SES.

In October at SSES I, total mean density was 80,700 org/m^2 (Table C-6) and was composed mostly of *Rheotanytarsus* spp. (41%), naidids (20%), and *Hydropsyche phalerata* (17%). At Bell Bend III, the total mean density (99,400 org/m^2) was composed mostly of *Rheotanytarsus* spp. (44%) and naidids (24%). The primary difference between Bell Bend III and IV in October was the decrease in naidids. At Bell Bend IV, there were 108,600 naidids/m^2, while at Bell Bend III there were only 23,400 naidids/m^2. Total mean density at Bell Bend IV was 217,500 org/m^2 and was composed mostly of naidids (50%) and *Rheotanytarsus* spp. (26%). *Cheumatopsyche* spp. and *Hydropsyche phalerata* composed 5% and 2% of the total density, respectively.

Although density at Bell Bend IV was consistently greater than at Bell Bend III in 1986, insufficient data have been collected to determine whether this is a persistent trend. Both Bell Bend sites will be retained in 1987 and work will continue in an effort to explain the differences between them. It is possible that in the future, sampling at Bell Bend III may be eliminated.

Biomass

Total mean biomass at SSES I was 2.8 g/m^2; trichopterans (1.7 g/m^2) composed 61% of the total (Table C-7). Ephemeropterans (0.9 g/m^2) composed 32% of the biomass. Total mean biomass at Bell Bend III was 1.9 g/m^2 and was composed primarily of ephemeropterans (0.9 g/m^2) and trichopterans (0.5 g/m^2). Biomass at Bell Bend IV was 1.9 g/m^2 and was composed mostly of ephemeropterans (0.9 g/m^2), trichopterans (0.7 g/m^2), and molluscs (0.2 g/m^2). Biomass at Bell Bend has remained relatively stable during the past eight years (Fig. C-1). Since 1978, biomass at SSES had been between 2- and 5-fold greater than at Bell Bend. This year, although still greatest at SSES, it declined from previous years. Differences in macroinvertebrate biomass at the two stations are largely attributed to differences in substrate and river current. For example, SSES is located in a riffle area, more suitable for rheophilic organisms like hydropsychids than Bell Bend.

In June at SSES I, total organism weight was 2.2 g/m^2 and was composed mostly of trichopterans (58%) and ephemeropterans (33%). At Bell Bend III, total biomass was 1.6 g/m^2 and was composed mostly of ephemeropterans (86%). At Bell Bend IV, total biomass was 1.3 g/m^2 and again was mostly ephemeropterans (82%). Trichopterans composed 7% of the biomass.

In August, total biomass at SSES I was 2.8 g/m^2 and was composed mostly of trichopterans (56%) and ephemeropterans (35%). At Bell Bend III, it was 1.4 g/m^2 and its major components were trichopterans (39%), ephemeropterans (31%), and coleopterans (11%). At Bell Bend IV, total biomass was 1.5 g/m^2, composed mostly of trichopterans (45%), ephemeropterans (27%), and molluscs (18%).

Total biomass was greatest at all sites in October. At SSES I, it was 3.6 g/m^2 and was composed mostly of trichopterans (66%) and ephemeropterans (29%). At Bell Bend III, the total biomass (2.7 g/m^2) was composed mostly of ephemeropterans (38%), trichopterans (36%), and molluscs (18%). Total biomass at Bell Bend IV was 2.8 g/m^2 with trichopterans (43%) and ephemeropterans (41%) comprising most of the mass.

Biomass at Bell Bend has shown little variability in the operational years, or, in fact, since 1981 (Fig. C-1). The increase between 1977 and 1979 was probably due to improved water quality. Biomass at SSES has shown much more variability. The increased biomass at SSES is due primarily to the increased numbers of hydropsychids. It seems that this group is more susceptible to variations in river temperature and flow than the ephemeropterans and the chironomids, which often form a large portion of the biomass at Bell Bend.

Trends

Macroinvertebrate density and biomass steadily increased at both stations between 1977 and 1980 (Fig. C-1). This followed a six-year period of significant ($P<0.05$) improvement in Susquehanna River water quality (Soya and Jacobsen 1979). In particular, there was a decrease in acid mine drainage, which was found to suppress the macroinvertebrate community in the study area (Deutsch 1981). Since 1978, no significant trends in water quality improvement have been observed at either SSES or Bell Bend (Soya and Jacobsen 1985). In the months preceding sampling river temperature and flow seem to be the determining factors which control macroinvertebrate density and biomass. Increasing trends in density and biomass, established during preoperational years of the Susquehanna SES, leveled off at both the control and indicator stations after 1983 when the Susquehanna SES became operational (Fig. C-1). The Susquehanna SES has had no detectable impact on the macroinvertebrate community downriver from the discharge diffuser.

REFERENCES CITED

Cummins, K. W. 1962. An evaluation of some techniques for the collection and analysis of benthic samples with special emphasis on lotic waters. Am. Midl. Nat. 67(2): 477-504.

Deutsch, W. G. 1976. Macroinvertebrates. Pages 123-161 *in* T. V. Jacobsen (ed.), Ecological studies of the North Branch Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1975). Ichthyological Associates, Inc., Berwick, PA.

________. 1977. Benthic macroinvertebrates. Pages 36-69 *in* T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1976). Ichthyological Associates, Inc., Berwick, PA.

________. 1978. Benthic macroinvertebrates. Pages 68-119 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1977). Ichthyological Associates, Inc., Berwick, PA.

________. 1980. Macroinvertebrate colonization of acrylic plates in a large river. Hydrobiologia 75: 65-72.

________. 1981. Suppression of macrobenthos in an iron-polluted stretch of the Susquehanna River (Pennsylvania). Proc. Pa. Acad. Sci. 55: 37-42.

________, W. F. Gale, and L. Sabin-Zelenak. 1981. Benthic macroinvertebrates. Pages 80-120 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1980). Ichthyological Associates, Inc., Berwick, PA.

________, L. S. Imes, and W. F. Gale. 1982. Benthic macroinvertebrates. Pages 83-123 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1981 annual report). Ichthyological Associates, Inc., Berwick, PA.

________, J. L. Meyer, and W. F. Gale. 1983. Benthic macroinvertebrates. Pages 83-120 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1982 annual report). Ichthyological Associates, Inc., Berwick, PA.

________, J. L. Meyer, L. S. Zelenak, and W. F. Gale. 1984. Benthic macroinvertebrates. Pages 83-114 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1983 annual report). Ichthyological Associates, Inc., Berwick, PA.

Gale, W. F. and J. D. Thompson. 1975. A suction sampler for quantitatively sampling benthos on rocky substrates in rivers. Trans. Am. Fish. Soc. 104(2): 398-405.

________, T. V. Jacobsen, and K. M. Smith. 1976. Iron, and its role in a river polluted by mine effluents. Proc. Pa. Acad. Sci. 50: 182-195.

Howmiller, R. P. 1972. Effects of preservatives on weights of some common macrobenthic invertebrates. Trans. Am. Fish. Soc. 101(4): 743-746.

Rosenberg, D. M. and V. H. Resh. 1982. The use of artificial substrates in the study of freshwater benthic macroinvertebrates. Pages 175-236 in J. Cairns, Jr. (ed.), Artificial substrates. Ann Arbor Science Publ., Inc., Ann Arbor, MI.

Sabin, L., W. G. Deutsch, and W. F. Gale. 1979. Benthic macroinvertebrates. Pages 86-119 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1978). Ichthyological Associates, Inc., Berwick, PA.

Sabin-Zelenak, L., W. G. Deutsch, and W. F. Gale. 1980. Benthic macroinvertebrates. Pages 79-115 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1979). Ichthyological Associates, Inc., Berwick, PA.

Soya, W. J. and T. V. Jacobsen. 1979. Physicochemical analyses. Pages 3-42 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1978). Ichthyological Associates, Inc., Berwick, PA.

________ and ________. 1985. Physicochemical analyses. Pages 7-53 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1984 annual report). Ichthyological Associates, Inc., Berwick, PA.

Sutron Corporation. 1985. Study of travel time and mixing characteristics for the Susquehanna River below the Susquehanna Steam Electric Station. Sutron Report No. SCR-85-0007. Sutron Corp., Herndon, VA.

Wiederholm, T. and L. Eriksson. 1977. Effects of alcohol-preservation on the weight of some benthic invertebrates. Zoon 5: 29-31.

Zelenak, L. S., W. G. Deutsch, and W. F. Gale. 1985. Benthic macroinvertebrates. Pages 77-111 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1984 annual report). Ichthyological Associates, Inc., Berwick, PA.

________, ________, and T. V. Jacobsen. 1986. Benthic macroinvertebrates. Pages 75-110 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1985 annual report). Ecology III, Inc., Berwick, PA.

Table C-1

Description and location of benthic macroinvertebrate sampling sites on the Susquehanna River, 1986.

Station	SSES	BELL BEND	
Site	I	III	IV
Depth[a]	0.6	1.3	1.3
Substrate Type[b]	gravel-pebble	gravel-pebble with boulders[c]	gravel-pebble with boulders[c]
Location	850 m upriver from the center of the intake structure; 30 m from the west bank	710 m downriver from the center of the discharge diffuser; 70 m from the west bank	710 m downriver from the center of the discharge diffuser; 55 m from the west bank

[a]Site depth (m) when river surface elevation is 148.6 m above mean sea level (river discharge about 120 m^3/s) at the Susquehanna SES Biological Laboratory.

[b]Based on predominant particle size (Cummins 1962).

[c]There tended to be accumulations of soft sediments downstream from boulders.

Table C-2

Density (org/m²) and percent total of major groups of benthic macroinvertebrates collected with a bar-clamp sampler at SSES I, Bell Bend III, and Bell Bend IV on the Susquehanna River, 1986.

SAMPLING SITE	JUN		AUG		OCT		MEAN	
TAXA	ORG/M²	% TOTAL	ORG/M²	% TOTAL	ORG/M²	% TOTAL	ORG/M²	% TOTAL
SSES I								
NAIDIDAE	88	9.1	2,732	3.8	16,125	20.0	6,315	12.3
HYDROPSYCHIDAE	88	9.1	24,848	34.3	17,006	21.1	13,981	27.2
CHIRONOMIDAE	793	81.8	41,501	57.3	43,792	54.3	28,696	55.9
OTHER	0	0.0	3,348	4.6	3,789	4.7	2,379	4.6
TOTAL	969	100.0	72,429	100.0	80,712	100.0	51,370	100.0
BELL BEND III								
NAIDIDAE	705	12.9	10,486	14.1	23,350	23.5	11,513	19.3
HYDROPSYCHIDAE	969	17.7	4,846	6.5	9,076	9.1	4,964	8.3
CHIRONOMIDAE	3,348	61.3	56,216	75.6	64,235	64.6	41,266	69.1
OTHER	441	8.1	2,820	3.8	2,732	2.7	1,997	3.3
TOTAL	5,463	100.0	74,368	100.0	99,392	100.0	59,741	100.0
BELL BEND IV								
NAIDIDAE	1,674	23.5	11,367	11.7	108,644	50.0	40,562	37.8
HYDROPSYCHIDAE	1,322	18.5	3,260	3.3	16,742	7.7	7,108	6.6
CHIRONOMIDAE	4,141	58.0	80,095	82.3	89,083	41.0	57,773	53.8
OTHER	0	0.0	2,643	2.7	2,996	1.4	1,880	1.8
TOTAL	7,137	100.0	97,365	100.0	217,464	100.0	107,322	100.0

Table C-3

Benthic macroinvertebrates collected with a bar-clamp sampler at SSES I, Bell Bend III, and Bell Bend IV on the Susquehanna River, 1986.

	SS I	BB III	BB IV
Platyhelminthes			
Turbellaria			
Alloeocoela		X	
Tricladida		X	X
Nemertinea			
Tetrastemmatidae			
Prostoma sp.	X	X	
Nematoda	X	X	X
Annelida			
Oligochaeta			
Naididae	X	X	X
Arthropoda			
Insecta			
Plecoptera			X
Ephemeroptera		X	
Ephemerellidae			X
Baetidae	X		
Heptageniidae			
Stenonema pulchellum		X	
Trichoptera			
Hydropsychidae			
Cheumatopsyche spp.	X	X	X
Hydropsyche morosa	X	X	X
H. phalerata	X	X	X
Macrostemum spp.		X	
Leptoceridae			
Nectopsyche sp.		X	
Oecetis avara		X	
Diptera			
Tipulidae	X		
Simuliidae	X	X	X
Empididae			
Hemerodromia sp.	X	X	X
Ceratopogonidae		X	X
Chironomidae	X	X	X
Tanypodinae		X	X
Thienemannimyia gr.	X	X	X
Chironominae		X	X
Dicrotendipes spp.	X	X	X
Glyptotendipes sp.		X	X
Parachironomus spp.		X	X
Polypedilum convictum	X	X	X
P. nr. *scalaenum*		X	
Rheotanytarsus spp.	X	X	X
Tanytarsus spp.		X	X
Orthocladiinae	X	X	X
Cricotopus bicinctus		X	
Cricotopus spp.	X	X	X
Nanocladius spp.	X	X	X
Thienemanniella spp.		X	X
Tvetenia discoloripes gr.	X	X	X
Mollusca			
Gastropoda			
Ancylidae			
Ferrissia sp.	X	X	X

Table C-4

Density (org/m^2) and percent total of benthic macroinvertebrates collected from two acrylic plates with a bar-clamp sampler at SSES I (30 June) and Bell Bend III and IV (27 June) on the Susquehanna River, 1986.

ACRYLIC PLATE	1	2	MEAN	% TOTAL
TAXON	SSES I			
NAIDIDAE	0.0	176.2	88.1	9.1
HYDROPSYCHE PHALERATA	176.2	0.0	88.1	9.1
RHEOTANYTARSUS SPP.	1409.8	0.0	704.9	72.7
NANOCLADIUS SPP.	0.0	176.2	88.1	9.1
TOTAL	1586.0	352.5	969.2	100.0
	BELL BEND III			
ALLOEOCOELA	0.0	176.2	88.1	1.6
NAIDIDAE	881.1	528.7	704.9	12.9
EPHEMEROPTERA	352.5	0.0	176.2	3.2
CHEUMATOPSYCHE SPP.	176.2	352.5	264.3	4.8
HYDROPSYCHE PHALERATA	1233.6	0.0	616.8	11.3
MACROSTEMUM SPP.	176.2	0.0	88.1	1.6
SIMULIIDAE	176.2	0.0	88.1	1.6
EMPIDIDAE	176.2	0.0	88.1	1.6
CHIRONOMIDAE (PUPAE)	528.7	0.0	264.3	4.8
POLYPEDILUM CONVICTUM	176.2	0.0	88.1	1.6
RHEOTANYTARSUS SPP.	2291.0	881.1	1586.0	29.0
CRICOTOPUS SPP.	176.2	352.5	264.3	4.8
NANOCLADIUS SPP.	1057.4	1057.4	1057.4	19.4
TVETENIA DISCOLORIPES GR.	176.2	0.0	88.1	1.6
TOTAL	7577.8	3348.3	5463.0	100.0
	BELL BEND IV			
NAIDIDAE	881.1	2467.2	1674.2	23.5
CHEUMATOPSYCHE SPP.	0.0	352.5	176.2	2.5
HYDROPSYCHE PHALERATA	1938.5	352.5	1145.5	16.0
CHIRONOMIDAE (PUPAE)	704.9	0.0	352.5	4.9
THIENEMANNIMYIA GR.	176.2	0.0	88.1	1.2
DICROTENDIPES SPP.	176.2	176.2	176.2	2.5
POLYPEDILUM CONVICTUM	176.2	176.2	176.2	2.5
RHEOTANYTARSUS SPP.	1233.6	1762.3	1497.9	21.0
CRICOTOPUS SPP.	176.2	352.5	264.3	3.7
NANOCLADIUS SPP.	2467.2	704.9	1586.0	22.2
TOTAL	7930.2	6344.2	7137.2	100.0

Table C-5

Density (org/m^2) and percent total of benthic macroinvertebrates collected on two acrylic plates with a bar-clamp sampler at SSES I, Bell Bend III, and Bell Bend IV on the Susquehanna River, 21 August 1986.

ACRYLIC PLATE	1	2	MEAN	% TOTAL
TAXON	SSES I			
NEMATODA	0.0	176.2	88.1	0.1
NAIDIDAE	2643.4	2819.6	2731.5	3.8
BAETIDAE	528.7	176.2	352.5	0.5
CHEUMATOPSYCHE SPP.	352.5	881.1	616.8	0.9
HYDROPSYCHE MOROSA	528.7	352.5	440.6	0.6
HYDROPSYCHE PHALERATA	24319.3	22380.8	23350.1	32.2
HYDROPSYCHE SPP.	0.0	881.1	440.6	0.6
SIMULIIDAE	0.0	528.7	264.3	0.4
HEMERODROMIA SP.	1762.3	1057.4	1409.8	1.9
CHIRONOMIDAE	352.5	0.0	176.2	0.2
CHIRONOMIDAE (PUPAE)	1586.0	1233.6	1409.8	1.9
THIENEMANNIMYIA GR.	176.2	0.0	88.1	0.1
POLYPEDILUM CONVICTUM	352.5	704.9	528.7	0.7
RHEOTANYTARSUS SPP.	33483.1	42823.2	38153.1	52.7
CRICOTOPUS SPP.	176.2	352.5	264.3	0.4
NANOCLADIUS SPP.	176.2	0.0	88.1	0.1
TVETENIA DISCOLORIPES GR.	176.2	1409.8	793.0	1.1
FERRISSIA SP.	1409.8	1057.4	1233.6	1.7
TOTAL	68023.6	76835.0	72429.3	100.0
	BELL BEND III			
TRICLADIDA	0.0	176.2	88.1	0.1
NEMATODA	704.9	176.2	440.6	0.6
NAIDIDAE	7225.3	13745.7	10485.5	14.1
HYDROPSYCHIDAE	4758.1	0.0	2379.1	3.2
CHEUMATOPSYCHE SPP.	0.0	1586.0	793.0	1.1
HYDROPSYCHE MOROSA	0.0	176.2	88.1	0.1
HYDROPSYCHE PHALERATA	704.9	2467.2	1586.0	2.1
NECTOPSYCHE SP.	0.0	176.2	88.1	0.1
HEMERODROMIA SP.	352.5	1233.6	793.0	1.1
CHIRONOMIDAE (PUPAE)	1586.0	3524.5	2555.3	3.4
TANYPODINAE	352.5	176.2	264.3	0.4
THIENEMANNIMYIA GR.	352.5	0.0	176.2	0.2
DICROTENDIPES SPP.	0.0	176.2	88.1	0.1
POLYPEDILUM CONVICTUM	176.2	176.2	176.2	0.2
RHEOTANYTARSUS SPP.	46523.9	53573.0	50048.5	67.3
ORTHOCLADIINAE	352.5	0.0	176.2	0.2
CRICOTOPUS BICINCTUS	176.2	0.0	88.1	0.1
CRICOTOPUS SPP.	1409.8	528.7	969.2	1.3
NANOCLADIUS SPP.	1233.6	704.9	969.2	1.3
THIENEMANNIELLA SPP.	0.0	1409.8	704.9	0.9
FERRISSIA SP.	1762.3	1057.4	1409.8	1.9
TOTAL	67671.2	81064.4	74367.8	100.0
	BELL BEND IV			
TRICLADIDA	0.0	176.2	88.1	0.1
NEMATODA	0.0	176.2	88.1	0.1
NAIDIDAE	4053.2	18680.1	11366.6	11.7
EPHEMERELLIDAE	176.2	0.0	88.1	0.1
HYDROPSYCHIDAE	352.5	176.2	264.3	0.3
CHEUMATOPSYCHE SPP.	528.7	1057.4	793.0	0.8
HYDROPSYCHE MOROSA	0.0	352.5	176.2	0.2
HYDROPSYCHE PHALERATA	1409.8	2643.4	2026.6	2.1
SIMULIIDAE	0.0	352.5	176.2	0.2
HEMERODROMIA SP.	1057.4	881.1	969.2	1.0
CHIRONOMIDAE (PUPAE)	2819.6	3524.5	3172.1	3.3
TANYPODINAE	0.0	176.2	88.1	0.1
THIENEMANNIMYIA GR.	0.0	1409.8	704.9	0.7
POLYPEDILUM CONVICTUM	528.7	704.9	616.8	0.6
RHEOTANYTARSUS SPP.	50929.6	92871.6	71900.6	73.8
TANYTARSUS SPP.	0.0	176.2	88.1	0.1
ORTHOCLADIINAE	0.0	176.2	88.1	0.1
CRICOTOPUS SPP.	1057.4	1586.0	1321.7	1.4
NANOCLADIUS SPP.	1233.6	2467.2	1850.4	1.9
THIENEMANNIELLA SPP.	352.5	0.0	176.2	0.2
TVETENIA DISCOLORIPES GR.	0.0	176.2	88.1	0.1
FERRISSIA SP.	2291.0	176.2	1233.6	1.3
TOTAL	66790.0	127940.8	97365.4	100.0

Table C-6

Density (org/m²) and percent total of benthic macroinvertebrates collected from two acrylic plates with a bar-clamp sampler at SSES I (15 October) and Bell Bend III and IV (16 October) on the Susquehanna River, 1986.

ACRYLIC PLATE	1	2	MEAN	% TOTAL
TAXON	SSES I			
PROSTOMA SP.	0.0	176.2	88.1	0.1
NAIDIDAE	352.5	31897.1	16124.8	20.0
TRICHOPTERA	176.2	0.0	88.1	0.1
CHEUMATOPSYCHE SPP.	3172.1	2291.0	2731.5	3.4
HYDROPSYCHE MOROSA	352.5	1233.6	793.0	1.0
HYDROPSYCHE PHALERATA	15508.0	11454.8	13481.4	16.7
TIPULIDAE	1057.4	0.0	528.7	0.7
HEMERODROMIA SP.	3172.1	1586.0	2379.1	2.9
CHIRONOMIDAE (PUPAE)	1762.3	0.0	881.1	1.1
THIENEMANNIMYIA GR.	176.2	352.5	264.3	0.3
DICROTENDIPES SPP.	0.0	176.2	88.1	0.1
POLYPEDILUM CONVICTUM	1762.3	1586.0	1674.2	2.1
RHEOTANYTARSUS SPP.	37536.4	29253.7	33395.0	41.4
ORTHOCLADIINAE	1762.3	881.1	1321.7	1.6
CRICOTOPUS SPP.	4758.1	3172.1	3965.1	4.9
NANOCLADIUS SPP.	352.5	528.7	440.6	0.5
TVETENIA DISCOLORIPES GR.	1762.3	1762.3	1762.3	2.2
FERRISSIA SP.	176.2	1233.6	704.9	0.9
TOTAL	73839.1	87584.8	80712.0	100.0
	BELL BEND III			
PROSTOMA SP.	881.1	352.5	616.8	0.6
NEMATODA	176.2	0.0	88.1	0.1
NAIDIDAE	28196.3	18503.8	23350.1	23.5
STENONEMA PULCHELLUM	352.5	0.0	176.2	0.2
CHEUMATOPSYCHE SPP.	9516.3	5815.5	7665.9	7.7
HYDROPSYCHE MOROSA	352.5	176.2	264.3	0.3
HYDROPSYCHE PHALERATA	1409.8	881.1	1145.5	1.2
OECETIS AVARA	0.0	704.9	352.5	0.4
HEMERODROMIA SP.	881.1	1762.3	1321.7	1.3
CERATOPOGONIDAE	0.0	176.2	88.1	0.1
CHIRONOMIDAE (PUPAE)	6696.6	2114.7	4405.7	4.4
TANYPODINAE	704.9	352.5	528.7	0.5
THIENEMANNIMYIA GR.	3700.8	3524.5	3612.7	3.6
CHIRONOMINAE	352.5	176.2	264.3	0.3
DICROTENDIPES SPP.	1057.4	2467.2	1762.3	1.8
GLYPTOTENDIPES SP.	881.1	352.5	616.8	0.6
PARACHIRONOMUS SPP.	1409.8	704.9	1057.4	1.1
POLYPEDILUM CONVICTUM	2291.0	1233.6	1762.3	1.8
POLYPEDILUM NR. SCALAENUM	176.2	176.2	176.2	0.2
RHEOTANYTARSUS SPP.	51810.7	34716.7	43263.7	43.5
TANYTARSUS SPP.	176.2	352.5	264.3	0.3
ORTHOCLADIINAE	1233.6	881.1	1057.4	1.1
CRICOTOPUS SPP.	2995.9	3524.5	3260.2	3.3
NANOCLADIUS SPP.	2995.9	881.1	1938.5	2.0
TVETENIA DISCOLORIPES GR.	176.2	352.5	264.3	0.3
FERRISSIA SP.	176.2	0.0	88.1	0.1
TOTAL	118600.8	80183.3	99392.0	100.0
	BELL BEND IV			
TRICLADIDA	176.2	176.2	176.2	0.1
NEMATODA	0.0	176.2	88.1	0.0
NAIDIDAE	104678.8	112609.1	108643.9	50.0
PLECOPTERA	0.0	176.2	88.1	0.0
EPHEMERELLIDAE	352.5	176.2	264.3	0.1
CHEUMATOPSYCHE SPP.	13745.7	9340.0	11542.9	5.3
HYDROPSYCHE PHALERATA	6696.6	3700.8	5198.7	2.4
HEMERODROMIA SP.	2114.7	2291.0	2202.8	1.0
CERATOPOGONIDAE	0.0	176.2	88.1	0.0
CHIRONOMIDAE	0.0	21675.9	10838.0	5.0
CHIRONOMIDAE (PUPAE)	176.2	176.2	176.2	0.1
TANYPODINAE	0.0	176.2	88.1	0.0
THIENEMANNIMYIA GR.	3877.0	3524.5	3700.8	1.7
CHIRONOMINAE	0.0	1057.4	528.7	0.2
DICROTENDIPES SPP.	1233.6	704.9	969.2	0.4
GLYPTOTENDIPES SP.	528.7	176.2	352.5	0.2
PARACHIRONOMUS SPP.	1233.6	1586.0	1409.8	0.6
POLYPEDILUM CONVICTUM	4229.4	2114.7	3172.1	1.5
RHEOTANYTARSUS SPP.	66261.4	47757.5	57009.4	26.2
ORTHOCLADIINAE	1233.6	704.9	969.2	0.4
CRICOTOPUS SPP.	5110.6	6344.2	5727.4	2.6
NANOCLADIUS SPP.	4229.4	2995.9	3612.7	1.7
TVETENIA DISCOLORIPES GR.	704.9	352.5	528.7	0.2
FERRISSIA SP.	0.0	176.2	88.1	0.0
TOTAL	216583.0	218345.3	217464.1	100.0

Table C-7

Dry weight (g/m²) and percent total of major groups of benthic macroinvertebrates collected with a dome sampler at SSES I, Bell Bend III, and Bell Bend IV on the Susquehanna River, 1986.

SAMPLING SITE	JUN		AUG		OCT		MEAN	
TAXA	G/M²	% TOTAL	G/M²	% TOTAL	G/M²	% TOTAL	G/M²	% TOTAL
SSES I								
OLIGOCHAETA	0.1	4.0	< 0.1	0.2	< 0.1	0.1	< 0.1	1.1
PLECOPTERA	< 0.1	1.3	0.0	0.0	< 0.1	0.1	< 0.1	0.4
EPHEMEROPTERA	0.7	33.1	1.0	35.0	1.0	28.9	0.9	32.0
TRICHOPTERA	1.3	57.7	1.6	56.2	2.4	66.1	1.7	60.7
COLEOPTERA	0.1	2.5	0.2	5.8	0.1	3.5	0.1	4.0
DIPTERA	< 0.1	0.7	< 0.1	1.1	< 0.1	0.1	< 0.1	0.6
MOLLUSCA	< 0.1	0.6	< 0.1	1.0	< 0.1	1.4	< 0.1	1.0
OTHER	0.0	0.0	< 0.1	0.8	0.0	0.0	< 0.1	0.2
TOTAL	2.2	100.0	2.8	100.0	3.6	100.0	2.8	100.0
BELL BEND III								
OLIGOCHAETA	< 0.1	0.4	< 0.1	0.5	< 0.1	0.6	< 0.1	0.5
CRUSTACEA	0.0	0.0	0.0	0.0	< 0.1	0.4	< 0.1	0.2
PLECOPTERA	< 0.1	0.1	0.0	0.0	0.0	0.0	< 0.1	0.0
EPHEMEROPTERA	1.4	86.4	0.4	31.0	1.0	37.7	0.9	50.1
TRICHOPTERA	0.1	4.1	0.5	39.4	1.0	35.9	0.5	27.6
COLEOPTERA	0.1	3.5	0.2	11.1	0.1	4.3	0.1	5.7
DIPTERA	< 0.1	1.4	< 0.1	1.3	< 0.1	0.5	< 0.1	1.0
MOLLUSCA	0.1	3.4	0.1	8.2	0.5	18.3	0.2	11.6
OTHER	< 0.1	0.7	0.1	8.6	0.1	2.3	0.1	3.3
TOTAL	1.6	100.0	1.4	100.0	2.7	100.0	1.9	100.0
BELL BEND IV								
OLIGOCHAETA	< 0.1	1.2	0.0	0.0	< 0.1	0.2	< 0.1	0.4
CRUSTACEA	< 0.1	0.2	0.0	0.0	0.0	0.0	< 0.1	0.1
PLECOPTERA	< 0.1	0.9	0.0	0.0	0.0	0.0	< 0.1	0.2
EPHEMEROPTERA	1.1	81.6	0.4	27.2	1.1	41.3	0.9	46.7
TRICHOPTERA	0.1	7.2	0.7	45.1	1.2	42.9	0.7	35.3
COLEOPTERA	< 0.1	3.4	0.1	7.5	0.1	2.1	0.1	3.9
DIPTERA	< 0.1	2.2	< 0.1	1.5	< 0.1	0.4	< 0.1	1.1
MOLLUSCA	< 0.1	1.6	0.3	18.5	0.2	6.8	0.2	8.8
OTHER	< 0.1	1.8	0.0	0.0	0.2	6.4	0.1	3.6
TOTAL	1.3	100.0	1.5	100.0	2.8	100.0	1.9	100.0

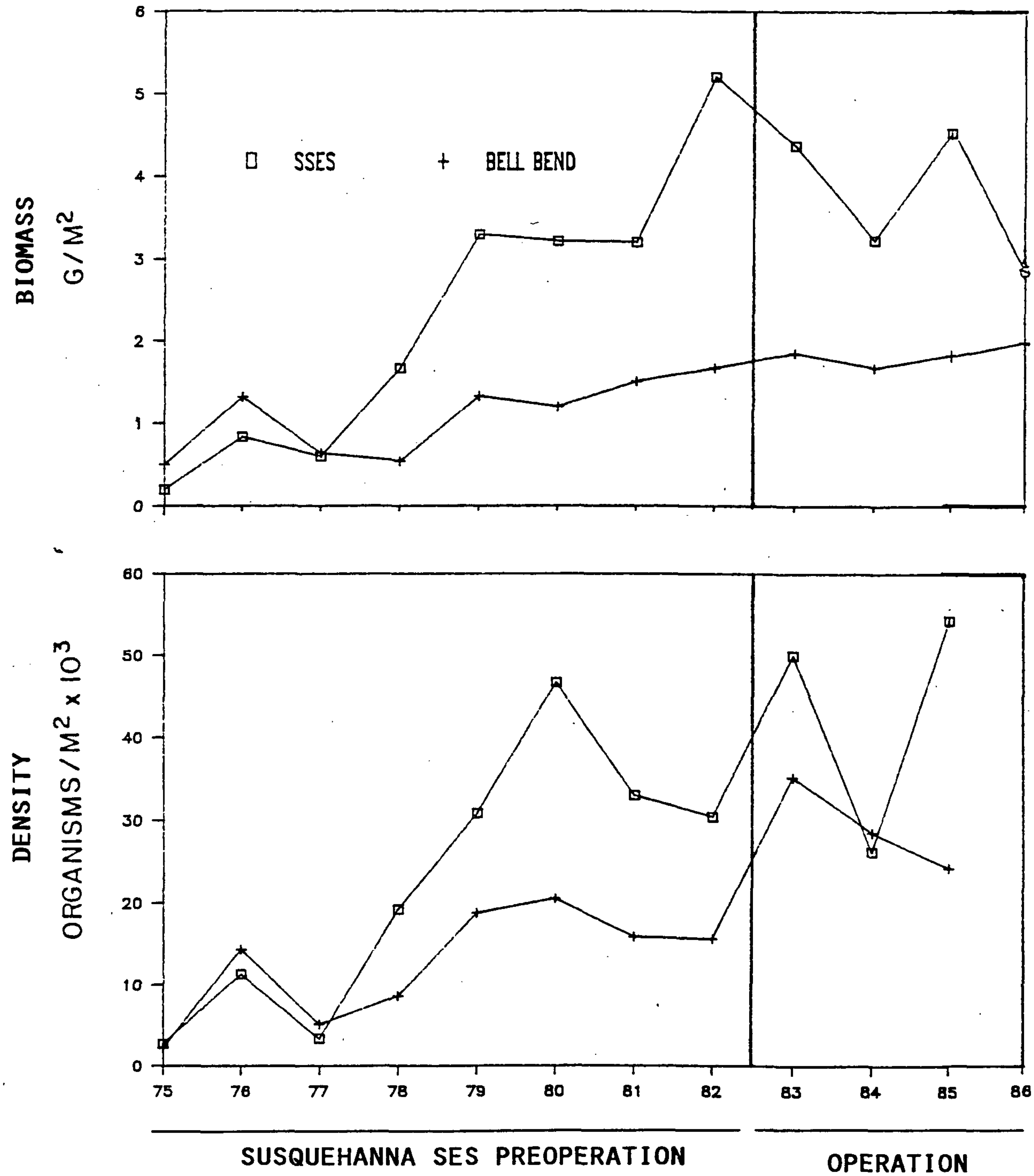

Fig. C-1

Annual mean biomass (g/m²) and density (org/m²) of benthic macroinvertebrates collected with a dome sampler at SSES and Bell Bend on the Susquehanna River, 1975-86. In 1986, only biomass data were included because density samples were collected with a bar-clamp sampler.

FISHES

by

Brian P. Mangan

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Fish were sampled near the Susquehanna SES with an electrofisher and seine at SSES and Bell Bend in June, August, and October. While electrofishing, 895 specimens of 23 species were observed, and walleye was the most abundant species at both stations. A total of 1,136 specimens (20 species) was captured by seine at SSES and Bell Bend. Spotfin shiner was the most abundant species captured at both stations. No significant differences ($P<0.05$) were found in the number of species present at the collection sites in either electrofishing or seining samples.

Preoperational electrofishing and seining data, collected in June, August, and October, 1976-82, were compared with data collected in the same months during operational years, 1983-86. These comparisons revealed no impact upon the fish community from operation of the Susquehanna SES.

INTRODUCTION

Species composition and relative abundance of fishes in the vicinity of the Susquehanna SES were monitored from July 1971 through September 1982, to establish a baseline of preoperational fisheries data (Ichthyological Associates 1972; Ichthyological Associates, Inc. 1973-74; Buynak and Gurzynski 1976a-b, 1977a-b; Buynak et al. 1978a-b, 1979-82; Deutsch et al. 1983). Before 1976, fish were sampled at several locations on the Susquehanna River, from Falls to Danville, Pennsylvania. Since 1976, studies were confined to one station upriver from the intake structure (SSES) and one station downriver from the discharge diffuser (Bell Bend; Fig. D-1). Preoperational monitoring ended when Susquehanna SES Unit 1 began operation in September 1982. Since then, operational studies have been conducted to determine if the power plant has had an impact on the fish community (Deutsch et al. 1984-86).

PROCEDURES

Electrofishing

Electrofishing was conducted at four 1000-m long sites; two sites were located at the SSES sampling station, as were two sites at Bell Bend (Table D-1; Fig. D-1). Sampling was usually done within 50 m of the river bank, unless low water conditions made sampling near the shore impossible. In past years during summer months at the SSES east site, shallow water forced the electrofishing boat far enough from shore to overlap the SSES west site, therefore the same area was sampled twice. This did not occur in 1986.

Fish were sampled during the months of June, August, and October when river levels did not exceed 150.3 m above mean sea level (msl). At levels greater than this, electrofishing proved ineffective due to increased turbidity and current velocity. Sampling began approximately one hour after sunset, and the sequences of sites sampled were randomly determined.

The electrofisher was similar to that described by Novotny and Priegel (1974), and consisted of a 4-KV generator (direct current) and a variable voltage pulsator mounted in a 6-m flat-bottomed boat, which was powered by an outboard motor. Long-handled nets were used by two observers in the bow and by the boat operator to collect fish for closer examination. Identifications and counts were recorded on a cassette tape recorder or in a field notebook during the progression of each 1000-m run. At each site, the first 20 fish of each species were weighed and measured. Scale samples were also collected from the fishes. These data will be retained for future age and growth studies of selected species. Cochran's Q-statistic (Hendrickson 1978) was used to determine any significant differences in the total number of species observed between the sites, at the 5% probability level.

Seining

Fish were collected with a 7.6-m bag seine (6-mm mesh) at four sites; two sites were located at the SSES sampling station and two sites were at Bell Bend (Table D-1; Fig. D-1). Samples were collected during the months of June, August, and October when river levels were less than 149.4 m above msl. Sampling sequences were randomly determined. Seining began approximately one hour after sunset.

To sample, one seine brail was kept stationary on the river bank as the seine was taken into the river to a distance of about 6 m, if not limited by depth. The seine was then pulled upriver and into shore. Two replicate hauls were made at each site; catches from both hauls were combined and considered one unit of effort which took about 15 minutes. Fishes were immediately placed in 10% formalin in the field. Samples were stored in the laboratory for at least two weeks. The fish were then washed and soaked in water for two more days before each one was identified, counted, weighed, and measured. Final preservation was in 40% isopropyl alcohol. Cochran's Q-statistic (Hendrickson 1978) was used to determine if sites differed in the total number of species present at the 5% probability level.

RESULTS AND DISCUSSION

Electrofishing

A total of 895 specimens of 23 species was observed during electrofishing at SSES and Bell Bend (Tables D-2 through D-5). At SSES, 18 species were observed (Table D-6), and five of these species composed 70% of the total. Walleye was the most abundant (21%), followed by smallmouth bass (18%), rock bass (16%), quillback (8%), and shorthead redhorse (7%). Twenty-one species were observed at Bell Bend (Table D-7); again the most abundant was walleye (19%), followed by smallmouth bass (19%), rock bass (12%), shorthead redhorse (8%), and white sucker (8%). These five fishes composed 66% of the total number observed at Bell Bend. About 10% of the fish at both stations could not be identified because turbid water limited visibility.

In June at SSES, smallmouth bass dominated the sample of 10 species (22%), while at Bell Bend, white sucker was the most abundant species of 16 observed (19%). Walleye was second in abundance at SSES and Bell Bend and composed 18% of the totals at each station. The total mean number of fish observed per unit effort at both stations was smaller in June than in either August or October.

Smallmouth bass was the dominant species at both SSES (23%) and Bell Bend (31%) in August. At SSES, rock bass was the next most abundant species (21%), while at Bell Bend, walleye was second in abundance (17%). The total mean number of fish observed per unit effort was greater in August (98) than in June or October at SSES. Thirteen species were counted at SSES and twelve were seen at Bell Bend.

In October, walleye was the most observed fish at both stations (26% at SSES; 22% at Bell Bend). Rock bass was the next most abundant at SSES (18%), while at Bell Bend, shorthead redhorse was second in abundance (15%). The total mean observations per unit effort during October was the second greatest at SSES in 1986, and at Bell Bend, it was the greatest for both stations throughout the entire year. At SSES, 15 species were observed, and 16 species were seen at Bell Bend.

No significant difference was found in the number of species present at the four sites (Q = 4.317; DF = 3). The number of species observed at the SSES sites ranged from 7 to 13 (mean = 10), and those observed at Bell Bend ranged from 6 to 15 (mean = 10). At SSES, more specimens were observed at the east bank site than at the west bank in all months sampled. This also occurred at Bell Bend in June and August. The number of specimens observed at the SSES sites ranged from 44 to 119 (mean = 78; SD = 27.3), while at Bell Bend, this ranged from 41 to 102 (mean = 70; SD = 21.9). Overall, more fish were observed at SSES (N = 471) than at Bell Bend (N = 424) in 1986.

When comparisons were made from data collected in June, August, and October evening samples since 1976, it was found that more fish were observed per unit effort at Bell Bend in 7 out of the 11 years compared (Fig. D-2). Six of these were preoperational years and one was an operational year. The largest difference in the number of specimens observed between stations occurred in 1980. The SSES station in this year had only 49% (N = 230) of the number of fish observed at Bell Bend. However, the 1980 sample represented only an October collection, since June and August samples were missed in that year. Those years similar to 1986 in the mean number of fish per unit effort (stations combined) include two preoperational years, 1976 (mean = 66) and 1978 (mean = 77) and 1983 (mean = 80), an operational year.

During the 11-year period since 1976, the number of walleye observed per unit effort fluctuated dramatically between years (Figs. D-3 and D-4). Yet within any given year, the percent composition of walleye observed between stations was similar. Observations in preoperational years from 1979 to 1981 revealed an abundance of walleye at both SSES and Bell Bend. Counts in operational years of 1985 and 1986 were similar. In 1986, as in 1985, the majority of these walleye were young-of-the year. This continues to suggest favorable reproductive conditions in this area of the river (Gale and Mohr 1976).

The 1986 electrofishing data revealed no impact of the Susquehanna SES on the fish community at the stations sampled. Since 1983, suckers observed per unit effort have decreased at SSES, but remained consistent at Bell Bend. Smallmouth bass observations increased at least 3-fold since 1985 at both stations. In general, decreases in the numbers of species and specimens compared to 1985 probably occurred because of decreased sampling effort in 1986. Six species observed in 1985, were not seen in 1986 (stations combined). At SSES, eight fewer species were observed in 1986, while at Bell Bend, four fewer were observed.

Seining

A total of 1,136 specimens of 20 species was captured by seining at SSES and Bell Bend (Tables D-2 and D-8 through D-10). At SSES, 15 species were captured (Table D-11), three of which composed 85% of the total annual catch.

Spotfin shiner was the most abundant (54%), followed by bluntnose minnow (21%) and tessellated darter (10%). Sixteen species were captured at Bell bend (Table D-12); three species composed 86% of the total annual catch. Spotfin shiner was the most abundant (75%), followed by white sucker (6%) and bluntnose minnow (5%).

In June, spotfin shiner dominated the catch at both SSES (81%) and Bell Bend (81%). White sucker was the second most abundant species captured at both stations and composed 7% and 10% of the totals at SSES and Bell Bend, respectively. The total mean number of fish captured per unit effort was greater in June than in any other month sampled at both stations. At SSES, 11 species of fish were captured, while at Bell Bend, 9 species were captured.

Four young-of-the-year muskellunge were collected with the seine on 23 June 1986. One fish was captured at the SSES west bank site and the other three were taken at the Bell Bend west bank site. These fish represent the first evidence of muskellunge natural reproduction in this area of the river (Mangan 1986).

Spotfin shiner was the most abundant fish captured in August at SSES (46%) and Bell Bend (64%). At SSES, spottail shiner was the second most abundant (20%), while at Bell Bend tessellated darter was more abundant (16%). The total mean number of fish captured per unit effort was lower in August at both stations than in any other month in 1986. Eleven species were collected at SSES, and twelve species were collected at Bell Bend.

In October, bluntnose minnow was the predominant fish captured (48%) at SSES, followed by tessellated darter (24%). At Bell Bend, spotfin shiner was most abundant (68%), followed by bluntnose minnow (16%). The total mean number of fish captured per unit effort in October at both sites was the second largest of the months sampled in 1986. At SSES, five species of fish were captured, whereas six species were found at Bell Bend.

No significant difference was found in the number of species present at the four sites sampled (Q = 3.00; DF = 3). Numbers of species at the SSES sites ranged from 3 to 10 (mean = 7; SD = 2.3), and those found at Bell Bend ranged from 5 to 9 (mean = 7; SD = 1.5). More species were found at the SSES east bank sites in August and October; at Bell Bend, more were collected at the east bank site in August.

Differences in the numbers of fish captured between Bell Bend sites were not as pronounced as those at SSES. For example, at Bell Bend approximately twice as many specimens were collected at the west bank site in June and October, and in August, about 2-fold more were captured at the east bank site. At SSES, however, the number of fish collected at the west bank site was 4-fold greater than at the east bank site in June, and 32-fold more fish were collected at the east bank site in October. These greater differences at SSES are probably the result of increasing dissimilarity of the collection sites at this station. The SSES east bank site had a muddy substrate without emergent vegetation, while the west bank site was composed of gravel with emergent vegetation. Also, an eddy occurred at the SSES east bank site in the months of August and October. The SSES west bank site was not subject to such a current.

Data comparisons of seine collections during the months of June, August, and October since 1976 revealed that more fish were captured at SSES sites (verses Bell Bend sites) in four out of seven preoperational years. However, in three out of four operational years, more fish were captured at the Bell

Bend sites (Fig. D-5). Large differences in mean capture per unit effort between the stations occurred during the preoperational years of 1977 (SSES was 30% of the Bell Bend catch), 1978 (Bell Bend was 26% of SSES), 1980 (Bell Bend was 40% of SSES), and 1981 (SSES was 41% of Bell Bend). Such differences are accounted for by habitat variation between stations.

Spotfin shiner dominated the catches during the preoperational years of 1976, 1978, 1981, 1982, and during the operational years of 1984 through 1986 at SSES (Fig. D-6); spotfin shiner was also the most abundant fish in Bell Bend collections during 1976, 1978, 1981, and 1984 through 1986 (Fig. D-7). The smallest number of fish captured per unit effort at SSES during preoperational years occurred in 1976, while during the operational period this occurred in 1985. At Bell Bend, the smallest preoperational catch occurred in 1978; the smallest operational catch was in 1984. Throughout the 11-year period when both stations were compared, the smallest mean catch per unit effort occurred at Bell Bend in 1978.

The percent composition of the samples revealed the presence of spottail shiner, tessellated darter, and bluntnose minnow (except at Bell Bend in 1976), in each year from the three months compared. Also common to these collections were fallfish, white sucker, rock bass, bluegill, and walleye. Comparison of data collected at SSES and Bell Bend seining sites revealed no impact from operation of the Susquehanna SES at the stations sampled.

The total number of specimens collected in 1986 was 40% of the 1985 catch. Two species collected in 1985 were not collected in 1986 (stations combined). Five fewer species were captured at SSES as was one less species at Bell Bend. Analogous to electrofishing data, both the decreases in specimens and species can be attributed to decreased sampling effort in 1986.

REFERENCES CITED

Buynak, G. L. and A. J. Gurzynski. 1976a. Fishes. Pages 231-279 in T. V. Jacobsen (ed.), Ecological studies of the North Branch Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Progress report for the period January-December 1974). Ichthyological Associates, Inc., Berwick, PA.

________ and ________. 1976b. Fishes. Pages 175-236 in T. V. Jacobsen (ed.), Ecological studies of the North Branch Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1975). Ichthyological Associates, Inc., Berwick, PA.

________ and ________. 1977a. Electrofishing of fishes. Pages 167-188 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1976). Ichthyological Associates, Inc., Berwick, PA.

________ and ________. 1977b. Seining of fishes. Pages 189-203 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1976). Ichthyological Associates, Inc., Berwick, PA.

Buynak, G. L., A. J. Gurzynski, and H. W. Mohr, Jr. 1978a. Electrofishing of fishes. Pages 220-242 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1977). Ichthyological Associates, Inc., Berwick, PA.

________, ________, and ________. 1978b. Seining of fishes. Pages 243-257 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1977). Ichthyological Associates, Inc., Berwick, PA.

Buynak, G. L., A. J. Gurzynski, H. W. Mohr, Jr., and T. V. Jacobsen. 1979. Fishes. Pages 158-195 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1978). Ichthyological Associates, Inc., Berwick, PA.

________, ________, ________, and ________. 1980. Fishes. Pages 158-185 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1979). Ichthyological Associates, Inc., Berwick, PA.

________, ________, ________, and ________. 1981. Fishes. Pages 163-196 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1980). Ichthyological Associates, Inc., Berwick, PA.

________, ________, ________, and ________. 1982. Fishes. Pages 170-208 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1981 annual report). Ichthyological Associates, Inc., Berwick, PA.

Deutsch, W. G., A. J. Gurzynski, and W. F. Gale. 1983. Fishes. Pages 163-189 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1982 annual report). Ichthyological Associates, Inc., Berwick, PA.

________, ________, and ________. 1984. Fishes. Pages 154-176 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1983 annual report). Ichthyological Associates, Inc., Berwick, PA.

Deutsch, W. G., A. J. Gurzynski, B. P. Mangan, and W. F. Gale. 1985. Fishes. Pages 150-173 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1984 annual report). Ichthyological Associates, Inc., Berwick, PA.

________, ________, ________, and ________. 1986. Fishes. Pages 111-139 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1985 annual report). Ecology III, Inc., Berwick, PA.

Gale, W. F. and H. W. Mohr, Jr. 1976. Fish spawning in a large Pennsylvania river receiving mine effluents. Proc. Pa. Acad. Sci. 50: 160-162.

Hendrickson, J. A., Jr. 1978. Statistical analysis of the presence-absence component of species composition data. Pages 113-124 in K. L. Dickson, J. Cairns, Jr., and R. J. Livingston (eds.), Biological data in water pollution assessment: quantitative and statistical analyses. ASTM STP 642. American Society for Testing and Materials, Philadelphia, PA.

Ichthyological Associates. 1972. An ecological study of the North Branch Susquehanna River in the vicinity of Berwick, Pennsylvania (Progress report for the period January-December 1971). Pennsylvania Power and Light Co., Allentown, PA. 232 pp.

Ichthyological Associates, Inc. 1973. An ecological study of the North Branch Susquehanna River in the vicinity of Berwick, Pennsylvania (Progress report for the period January-December 1972). Pennsylvania Power and Light Co., Allentown, PA. 658 pp.

________. 1974. An ecological study of the North Branch Susquehanna River in the vicinity of Berwick, Pennsylvania (Progress report for the period January-December 1973). Pennsylvania Power and Light Co., Allentown, PA. 838 pp.

Mangan, B. P. 1986. Natural reproduction of the muskellunge (*Esox masquinongy*) in the Susquehanna River near Berwick, Pennsylvania. Proc. Pa. Acad. Sci. 60(2): 200.

Novotny, D. W. and G. R. Priegel. 1974. Electrofishing boats. Improved designs and operational guidelines to increase the effectiveness of boom shockers. Tech. Bull. No. 73. Dept. Nat. Resour., Madison, WI. 48 pp.

Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea, and W. B. Scott. 1980. A list of common and scientific names of fishes from the United States and Canada. Am. Fish. Soc. Spec. Publ. No. 12. 174 pp.

Table D-1

Descriptions of electrofishing (EL) and seining (SN) sites at SSES and Bell Bend on the Susquehanna River, 1986.

Site	Location
	SSES
EL-1	East bank, 130 m upriver from gas-line crossing to 330 m upriver from a point opposite the center of the Susquehanna SES intake structure
EL-2	West bank from gas-line crossing to a point 250 m upriver from the center of the Susquehanna SES intake structure
SN-1	East bank, 560 m upriver from a point opposite the center of the Susquehanna SES intake structure (10 m upriver from the mouth of Little Wapwallopen Creek)
SN-2	West bank, 400 m upriver from the center of the Susquehanna SES intake structure (100 m downriver from the boat dock at the Susquehanna SES Biological Laboratory)
	BELL BEND
EL-3	East bank, 390 m downriver from a point opposite the Susquehanna SES intake structure to a point 500 m upriver from the mouth of Wapwallopen Creek
EL-4	West bank, 380 m downriver from the Susquehanna SES intake structure (170 m downriver from the discharge diffuser) to a point near the southeastern boundary of PP&L's Wetlands Nature Area
SN-3	East bank, 2.6 km downriver from a point opposite the Susquehanna SES intake structure, at the launching ramp of the Berwick Boat Club
SN-4	West bank, 1.3 km downriver from the Susquehanna SES intake structure, near the southeastern boundary of PP&L's Wetlands Nature Area

Table D-2

Fishes that were observed or collected while electrofishing and seining at SSES and Bell Bend on the Susquehanna River, 1971-86. An asterisk (*) denotes fishes taken in 1986. Names of fishes and the order of listing conform to Robins et al. (1980).

Anguillidae - Freshwater Eels
- * *Anguilla rostrata* - American eel

Clupeidae - Herrings
- *Alosa sapidissima* - American shad
- * *Dorosoma cepedianum* - gizzard shad

Salmonidae - Trouts
- *Coregonus artedii* - cisco
- *Salmo gairdneri* - rainbow trout
- *S. trutta* - brown trout

Esocidae - Pikes
- * *Esox lucius* - northern pike
- * *E. masquinongy* - muskellunge
- * *E. niger* - chain pickerel
- *E. lucius x E. masquinongy* - tiger muskellunge

Cyprinidae - Carps and Minnows
- *Campostoma anomalum* - central stoneroller
- * *Cyprinus carpio* - common carp
- *Exoglossum maxillingua* - cutlips minnow
- * *Nocomis micropogon* - river chub
- *Notemigonus crysoleucas* - golden shiner
- *Notropis amoenus* - comely shiner
- *N. cornutus* - common shiner
- * *N. hudsonius* - spottail shiner
- * *N. procne* - swallowtail shiner
- *N. rubellus* - rosyface shiner
- *N. spilopterus* - spotfin shiner
- * *Pimephales notatus* - bluntnose minnow
- *Rhinichthys atratulus* - blacknose dace
- *R. cataractae* - longnose dace
- *Semotilus atromaculatus* - creek chub
- * *S. corporalis* - fallfish

Catostomidae - Suckers
- * *Carpiodes cyprinus* - quillback
- * *Catostomus commersoni* - white sucker
- * *Hypentelium nigricans* - northern hog sucker
- * *Moxostoma macrolepidotum* - shorthead redhorse

Ictaluridae - Bullhead Catfishes
- *Ictalurus catus* - white catfish
- *I. natalis* - yellow bullhead
- * *I. nebulosus* - brown bullhead
- * *I. punctatus* - channel catfish
- *Noturus insignis* - margined madtom

Cyprinodontidae - Killifishes
- *Fundulus diaphanus* - banded killifish

Percichthyidae - Temperate Basses
- *Morone saxatilis x M. chrysops* - striped bass-white bass hybrid

Centrarchidae - Sunfishes
- * *Ambloplites rupestris* - rock bass
- * *Lepomis auritus* - redbreast sunfish
- * *L. cyanellus* - green sunfish
- * *L. gibbosus* - pumpkinseed
- * *L. macrochirus* - bluegill
- * *Micropterus dolomieui* - smallmouth bass
- * *M. salmoides* - largemouth bass
- * *Pomoxis annularis* - white crappie
- * *P. nigromaculatus* - black crappie

Percidae - Perches
- * *Etheostoma olmstedi* - tessellated darter
- *E. zonale* - banded darter
- * *Perca flavescens* - yellow perch
- *Percina peltata* - shield darter
- * *Stizostedion vitreum vitreum* - walleye

Cottidae - Sculpins
- *Cottus bairdi* - mottled sculpin

Table D-3

Number of fish observed while electrofishing at SSES and Bell Bend on the Susquehanna River, 18 June 1986.

Station	SSES			BELL BEND		
Site	East	West	Total	East	West	Total
Time	2305-2323	2233-2249		2138-2159	2054-2116	
American eel	0	0	0	1	0	1
Muskellunge	0	0	0	1	0	1
Common carp	1	0	1	0	0	0
Fallfish	0	0	0	0	7	7
Quillback	2	1	3	1	0	1
White sucker	3	7	10	12	7	19
Northern hog sucker	1	0	1	1	0	1
Shorthead redhorse	5	10	15	3	0	3
Sucker spp.	2	0	2	0	0	0
Brown bullhead	0	0	0	2	0	2
Channel catfish	0	0	0	1	0	1
Catfish spp.	0	1	1	0	0	0
Rock bass	3	0	3	6	5	11
Green sunfish	0	1	1	0	0	0
Bluegill	0	1	1	1	2	3
Smallmouth bass	11	9	20	11	4	15
Largemouth bass	0	0	0	2	0	2
Black crappie	0	0	0	1	0	1
Sunfish spp.	2	3	5	2	2	4
Yellow perch	0	0	0	1	0	1
Walleye	12	5	17	9	9	18
Fish (unidentified)	7	6	13	5	5	10
Total	49	44	93	60	41	101

Table D-4

Number of fish observed while electrofishing at SSES and Bell Bend on the Susquehanna River, 13 August 1986.

Station	SSES			BELL BEND		
Site	East	West	Total	East	West	Total
Time	2116-2139	2158-2215		2313-2331	2229-2250	
Common carp	4	0	4	3	1	4
Quillback	7	5	12	4	5	9
White sucker	3	7	10	1	0	1
Northern hog sucker	2	3	5	0	1	1
Shorthead redhorse	3	2	5	4	0	4
Sucker spp.	3	0	3	1	0	1
Brown bullhead	0	0	0	0	1	1
Channel catfish	3	3	6	1	0	1
Rock bass	27	14	41	6	12	18
Redbreast sunfish	1	0	1	0	0	0
Green sunfish	3	0	3	0	0	0
Pumpkinseed	2	0	2	1	0	1
Bluegill	0	0	0	2	3	5
Smallmouth bass	22	23	45	19	20	39
Sunfish spp.	6	2	8	6	4	10
Yellow perch	1	0	1	0	0	0
Walleye	21	11	32	12	9	21
Fish (unidentified)	11	6	17	7	1	8
Total	119	76	195	67	57	124

Table D-5

Number of fish observed while electrofishing at SSES and Bell Bend on the Susquehanna River, 13 October 1986.

Station	SSES			BELL BEND		
Site	East	West	Total	East	West	Total
Time	2207-2231	2132-2153		1954-2014	2035-2057	
Gizzard shad	1	0	1	0	0	0
Muskellunge	0	1	1	0	1	1
Chain pickerel	0	0	0	1	0	1
Pike spp.	0	1	1	1	1	2
Common carp	3	1	4	1	0	1
Fallfish	1	0	1	0	2	2
Quillback	16	7	23	7	8	15
White sucker	4	3	7	6	7	13
Northern hog sucker	0	1	1	2	0	2
Shorthead redhorse	8	6	14	22	7	29
Sucker spp.	1	0	1	2	0	2
Channel catfish	0	1	1	0	1	1
Rock bass	15	18	33	3	19	22
Green sunfish	0	1	1	0	1	1
Bluegill	1	0	1	4	0	4
Smallmouth bass	8	11	19	15	11	26
Largemouth bass	0	1	1	1	0	1
White crappie	0	0	0	0	2	2
Sunfish spp.	3	0	3	1	4	5
Walleye	35	13	48	16	27	43
Fish (unidentified)	10	12	22	15	11	26
Total	106	77	183	97	102	199

Table D-6

Mean number of fish observed per unit effort while electrofishing at SSES on the Susquehanna River, 1986.

Species	Jun	Aug	Oct	Mean	% Total
Gizzard shad	0.0	0.0	0.5	0.17	0.22
Muskellunge	0.0	0.0	0.5	0.17	0.22
Pike spp.	0.0	0.0	0.5	0.17	0.22
Common carp	0.5	2.0	2.0	1.50	1.91
Fallfish	0.0	0.0	0.5	0.17	0.22
Quillback	1.5	6.0	11.5	6.33	8.06
White sucker	5.0	5.0	3.5	4.50	5.73
Northern hog sucker	0.5	2.5	0.5	1.17	1.49
Shorthead redhorse	7.5	2.5	7.0	5.67	7.22
Sucker spp.	1.0	1.5	0.5	1.00	1.27
Channel catfish	0.0	3.0	0.5	1.17	1.49
Catfish spp.	0.5	0.0	0.0	0.17	0.22
Rock bass	1.5	20.5	16.5	12.83	16.34
Redbreast sunfish	0.0	0.5	0.0	0.17	0.22
Green sunfish	0.5	1.5	0.5	0.83	1.06
Pumpkinseed	0.0	1.0	0.0	0.33	0.42
Bluegill	0.5	0.0	0.5	0.33	0.42
Smallmouth bass	10.0	22.5	9.5	14.00	17.83
Largemouth bass	0.0	0.0	0.5	0.17	0.22
Sunfish spp.	2.5	4.0	1.5	2.67	3.40
Yellow perch	0.0	0.5	0.0	0.17	0.22
Walleye	8.5	16.0	24.0	16.17	20.59
Fish (unidentified)	6.5	8.5	11.0	8.67	11.04
Total	46.5	97.5	91.5	78.53	

Table D-7

Mean number of fish observed per unit effort while electrofishing at Bell Bend on the Susquehanna River, 1986.

Species	Jun	Aug	Oct	Mean	% Total
American eel	0.5	0.0	0.0	0.17	0.24
Muskellunge	0.5	0.0	0.5	0.33	0.47
Chain pickerel	0.0	0.0	0.5	0.17	0.24
Pike spp.	0.0	0.0	1.0	0.33	0.46
Common carp	0.0	2.0	0.5	0.83	1.17
Fallfish	3.5	0.0	1.0	1.50	2.12
Quillback	0.5	4.5	7.5	4.17	5.90
White sucker	9.5	0.5	6.5	5.50	7.78
Northern hog sucker	0.5	0.5	1.0	0.67	0.95
Shorthead redhorse	1.5	2.0	14.5	6.00	8.49
Sucker spp.	0.0	0.5	1.0	0.50	0.71
Brown bullhead	1.0	0.5	0.0	0.50	0.71
Channel catfish	0.5	0.5	0.5	0.50	0.71
Rock bass	5.5	9.0	11.0	8.50	12.03
Green sunfish	0.0	0.0	0.5	0.17	0.24
Pumpkinseed	0.0	0.5	0.0	0.17	0.24
Bluegill	1.5	2.5	2.0	2.00	2.83
Smallmouth bass	7.5	19.5	13.0	13.33	18.86
Largemouth bass	1.0	0.0	0.5	0.50	0.71
White crappie	0.0	0.0	1.0	0.33	0.47
Black crappie	0.5	0.0	0.0	0.17	0.24
Sunfish spp.	2.0	5.0	2.5	3.17	4.48
Yellow perch	0.5	0.0	0.0	0.17	0.24
Walleye	9.0	10.5	21.5	13.67	19.34
Fish (unidentified)	5.0	4.0	13.0	7.33	10.37
Total	50.5	62.0	99.5	70.68	

Table D-8

Number of fish captured by seining at SSES and Bell Bend on the Susquehanna River, 23 June 1986.

Station	SSES			BELL BEND		
Site	East	West	Total	East	West	Total
Time	2235-2249	2217-2232		2136-2146	2153-2208	
Species						
Northern pike	0	1	1	0	0	0
Muskellunge	0	1	1	0	3	3
Spottail shiner	1	0	1	4	1	5
Spotfin shiner	34	158	192	114	184	298
Bluntnose minnow	2	11	13	2	6	8
White sucker	1	15	16	4	31	35
Rock bass	2	2	4	5	2	7
Green sunfish	0	1	1	0	0	0
Pumpkinseed	0	3	3	1	1	2
Tessellated darter	0	3	3	1	1	2
Walleye	1	1	2	6	2	8
Total	41	196	237	137	231	368

Table D-9

Number of fish captured by seining at SSES and Bell Bend on the Susquehanna River, 12 August 1986.

Station	SSES			BELL BEND		
Site	East	West		East	West	Total
Time	2200-2217	2143-2157	Total	2103-2114	2123-2134	
Species						
Chain pickerel	0	1	1	0	0	0
River chub	0	0	0	1	2	3
Spottail shiner	8	11	19	3	4	7
Swallowtail shiner	0	0	0	1	0	1
Spotfin shiner	28	16	44	49	17	66
Bluntnose minnow	1	0	1	4	0	4
Fallfish	0	1	1	1	0	1
Northern hogsucker	0	0	0	0	1	1
Rock bass	4	6	10	0	1	1
Redbreast sunfish	0	0	0	0	1	1
Pumpkinseed	2	1	3	1	0	1
Bluegill	6	3	9	0	0	0
Smallmouth bass	0	0	0	1	0	1
White crappie	2	0	2	0	0	0
Tessellated darter	0	4	4	10	7	17
Walleye	1	0	1	0	0	0
Total	52	43	95	71	33	104

Table D-10

Number of fish captured by seining at SSES and Bell Bend on the Susquehanna River, 16 October 1986.

Station	SSES			BELL BEND		
Site	East	West	Total	East	West	Total
Time	2049-2105	2034-2045		1948-2008	2013-2028	
Species						
Spottail shiner	5	0	5	7	1	8
Spotfin shiner	45	2	47	34	58	92
Bluntnose minnow	92	3	95	0	21	21
Rock bass	2	0	2	1	1	2
Bluegill	0	0	0	1	2	3
Tessellated darter	47	1	48	2	7	9
Total	191	6	197	45	90	135

Table D-11

Mean number of fish captured per unit effort in seining hauls at SSES on the Susquehanna River, 1986.

Species	Jun	Aug	Oct	Mean	% Total
Northern pike	0.5	0.0	0.0	0.17	0.19
Muskellunge	0.5	0.0	0.0	0.17	0.19
Chain pickerel	0.0	0.5	0.0	0.17	0.19
Spottail shiner	0.5	9.5	2.5	4.17	4.73
Spotfin shiner	96.0	22.0	23.5	47.17	53.48
Bluntnose minnow	6.5	0.5	47.5	18.17	20.60
Fallfish	0.0	0.5	0.0	0.17	0.19
White sucker	8.0	0.0	0.0	2.67	3.03
Rock bass	2.0	5.0	1.0	2.67	3.03
Green sunfish	0.5	0.0	0.0	0.17	0.19
Pumpkinseed	1.5	1.5	0.0	1.00	1.13
Bluegill	0.0	4.5	0.0	1.50	1.70
White crappie	0.0	1.0	0.0	0.33	0.37
Tessellated darter	1.5	2.0	24.0	9.17	10.40
Walleye	1.0	0.5	0.0	0.50	0.57
Total	118.5	47.5	98.5	88.20	

Table D-12

Mean number of fish captured per unit effort in seining hauls at Bell Bend on the Susquehanna River, 1986.

Species	Jun	Aug	Oct	Mean	% Total
Muskellunge	1.5	0.0	0.0	0.50	0.49
River chub	0.0	1.5	0.0	0.50	0.49
Spottail shiner	2.5	3.5	4.0	3.33	3.29
Swallowtail shiner	0.0	0.5	0.0	0.17	0.17
Spotfin shiner	149.0	33.0	46.0	76.00	75.11
Bluntnose minnow	4.0	2.0	10.5	5.50	5.44
Fallfish	0.0	0.5	0.0	0.17	0.17
White sucker	17.5	0.0	0.0	5.83	5.76
Northern hogsucker	0.0	0.5	0.0	0.17	0.17
Rock bass	3.5	0.5	1.0	1.67	1.65
Redbreast sunfish	0.0	0.5	0.0	0.17	0.17
Pumpkinseed	1.0	0.5	0.0	0.50	0.49
Bluegill	0.0	0.0	1.5	0.50	0.49
Smallmouth bass	0.0	0.5	0.0	0.17	0.17
Tessellated darter	1.0	8.5	4.5	4.67	4.62
Walleye	4.0	0.0	0.0	1.33	1.31
Total	184.0	52.0	67.5	101.18	

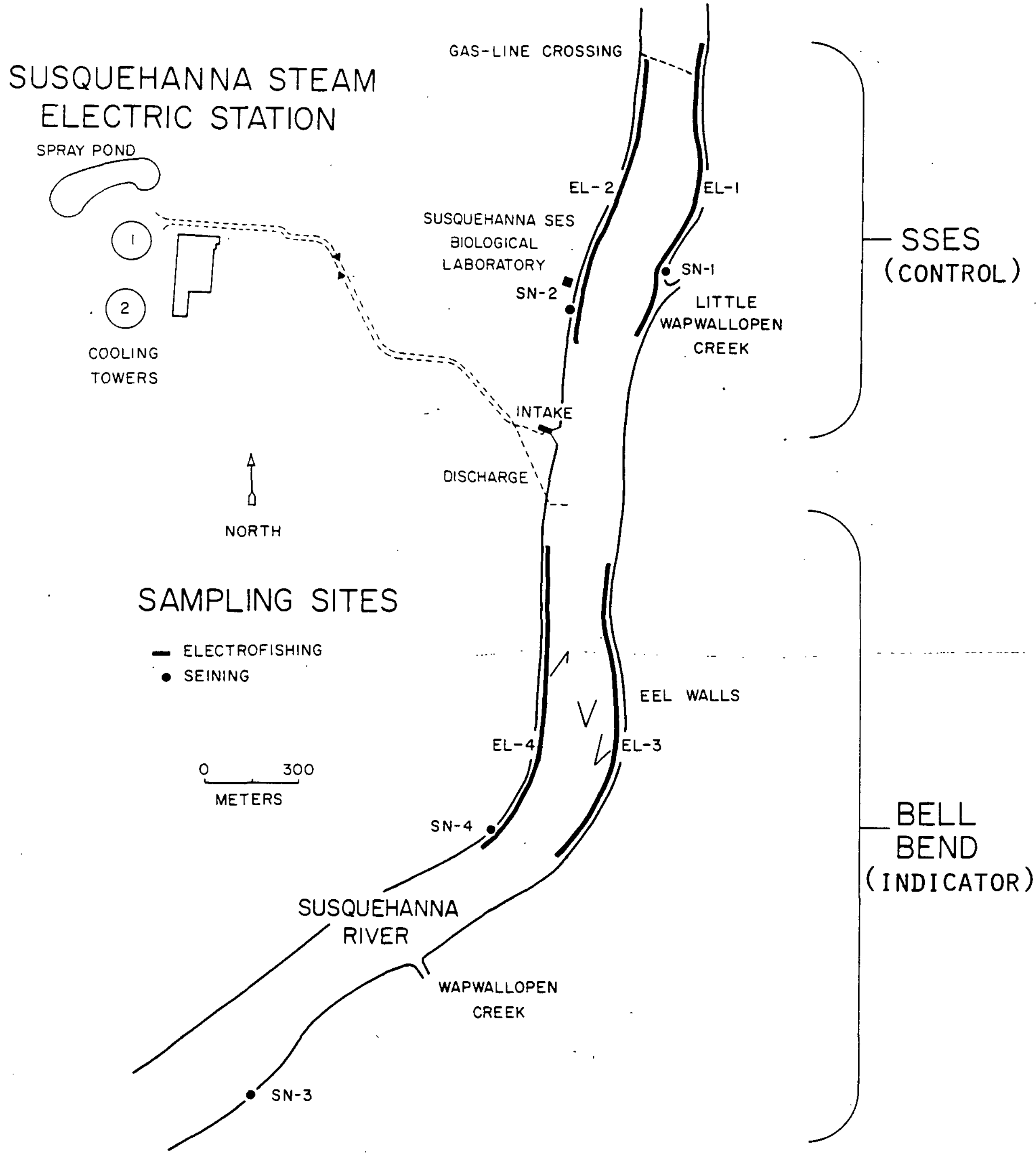

Fig. D-1

Sampling sites for electrofishing (EL) and seining (SN) at SSES and Bell Bend on the Susquehanna River, 1986.

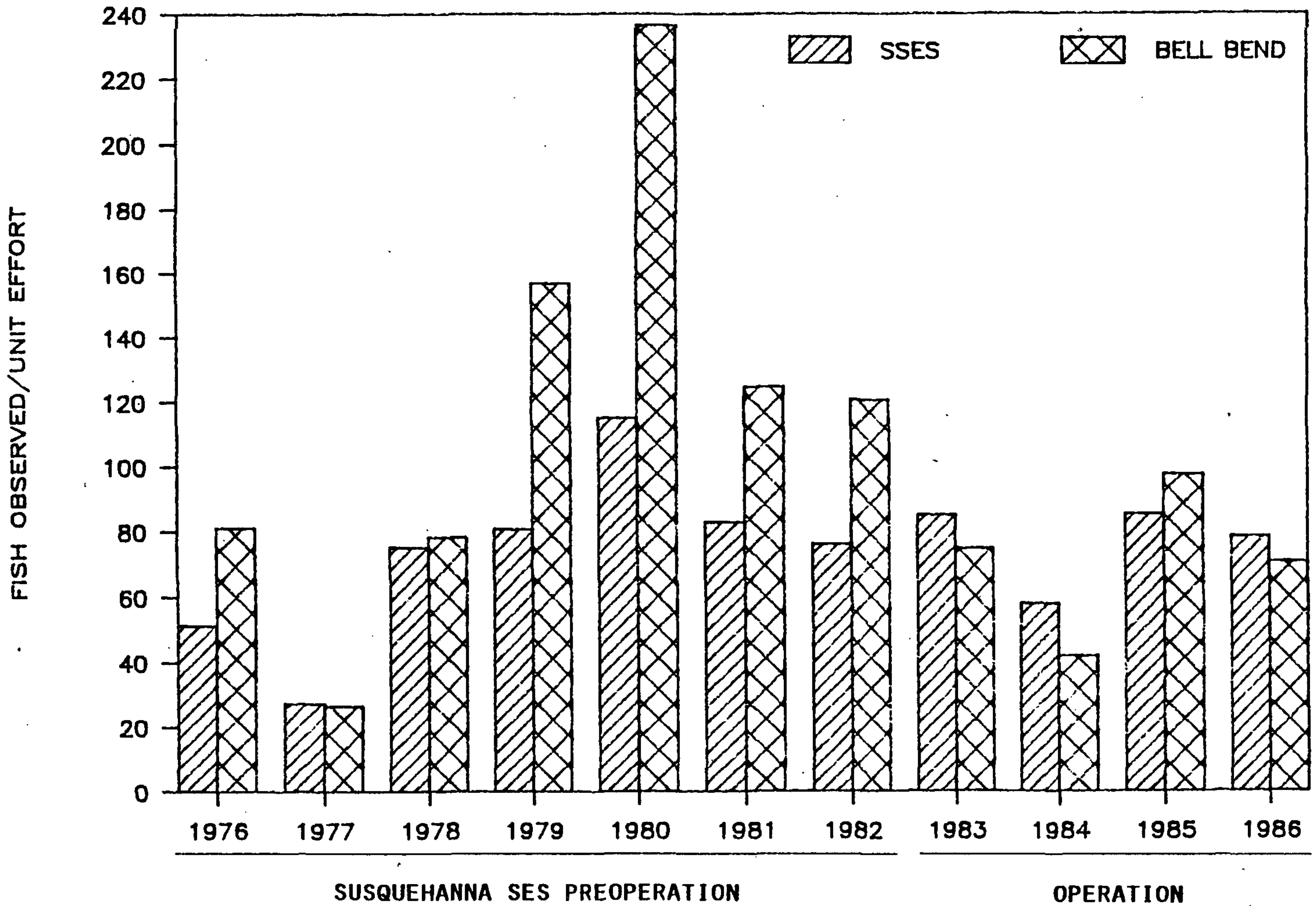

Fig. D-2

Annual mean number of fish observed per unit effort during evening electrofishing at SSES and Bell Bend on the Susquehanna River in June, August, and October, 1976-86.

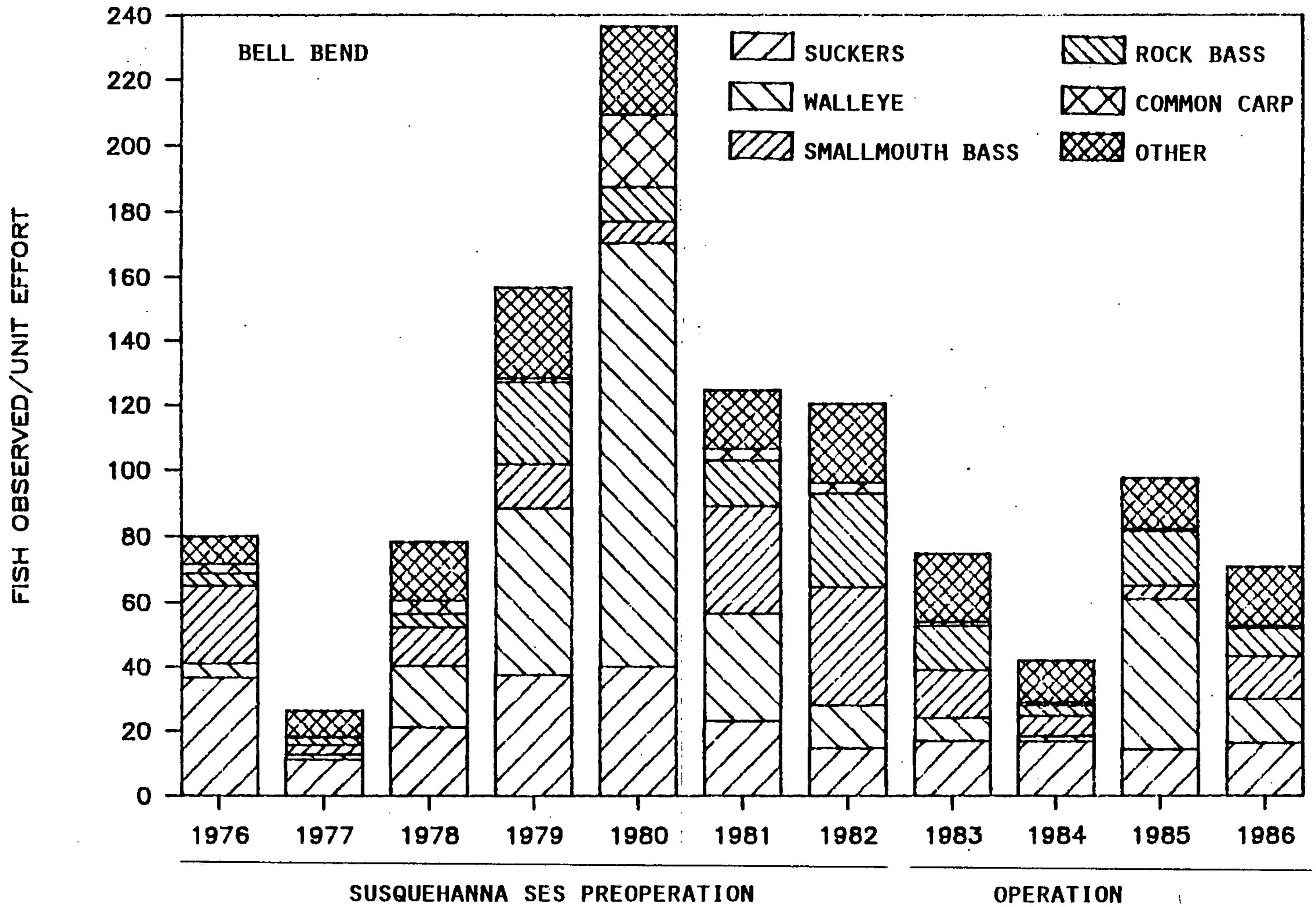

Fig. D-3

Annual mean number of fish observed per unit effort during evening electrofishing at SSES on the Susquehanna River in June, August, and October, 1976-86.

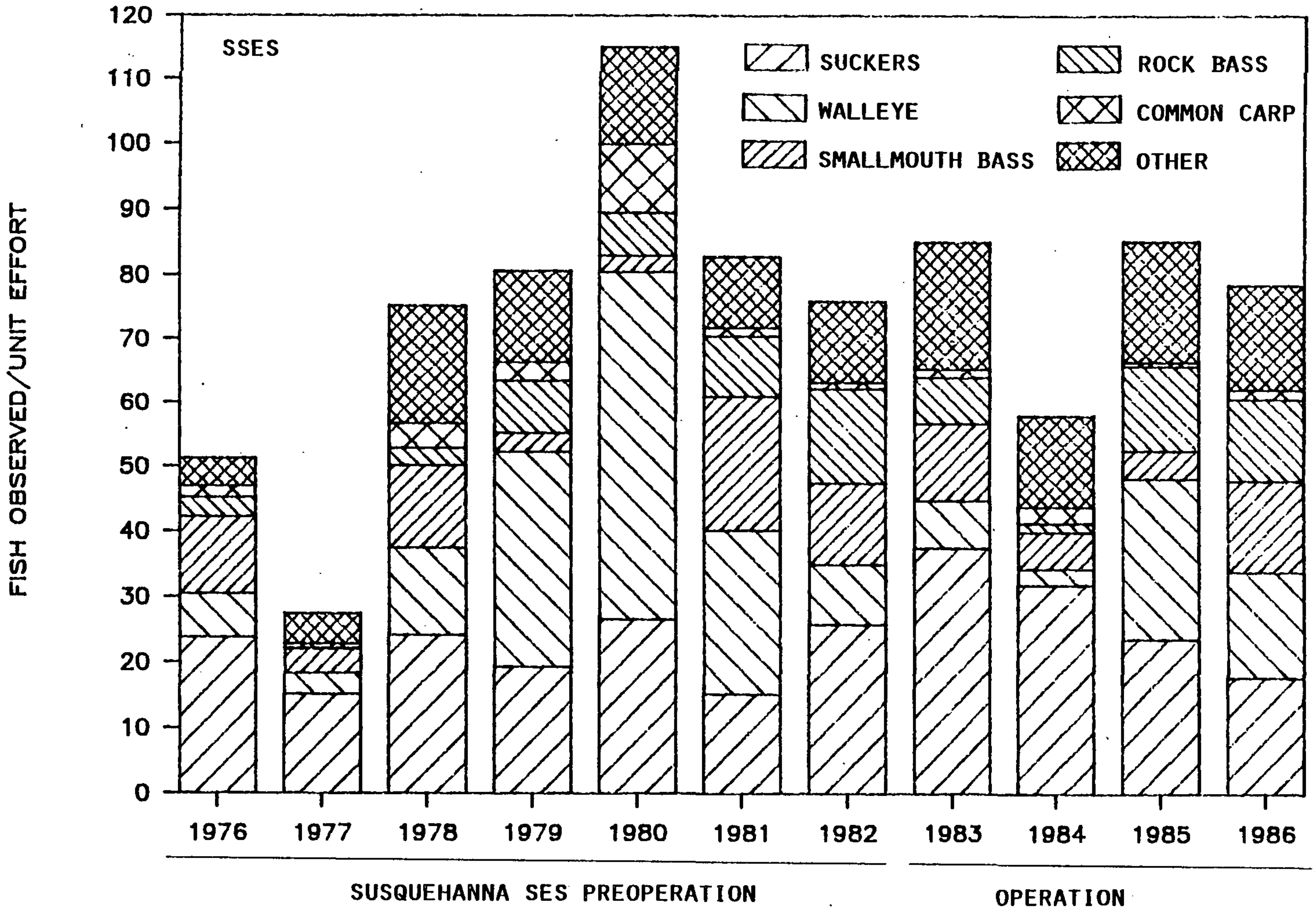

Fig. D-4

Annual mean number of fish observed per unit effort during evening electrofishing at Bell Bend on the Susquehanna River in June, August, and October, 1976-86.

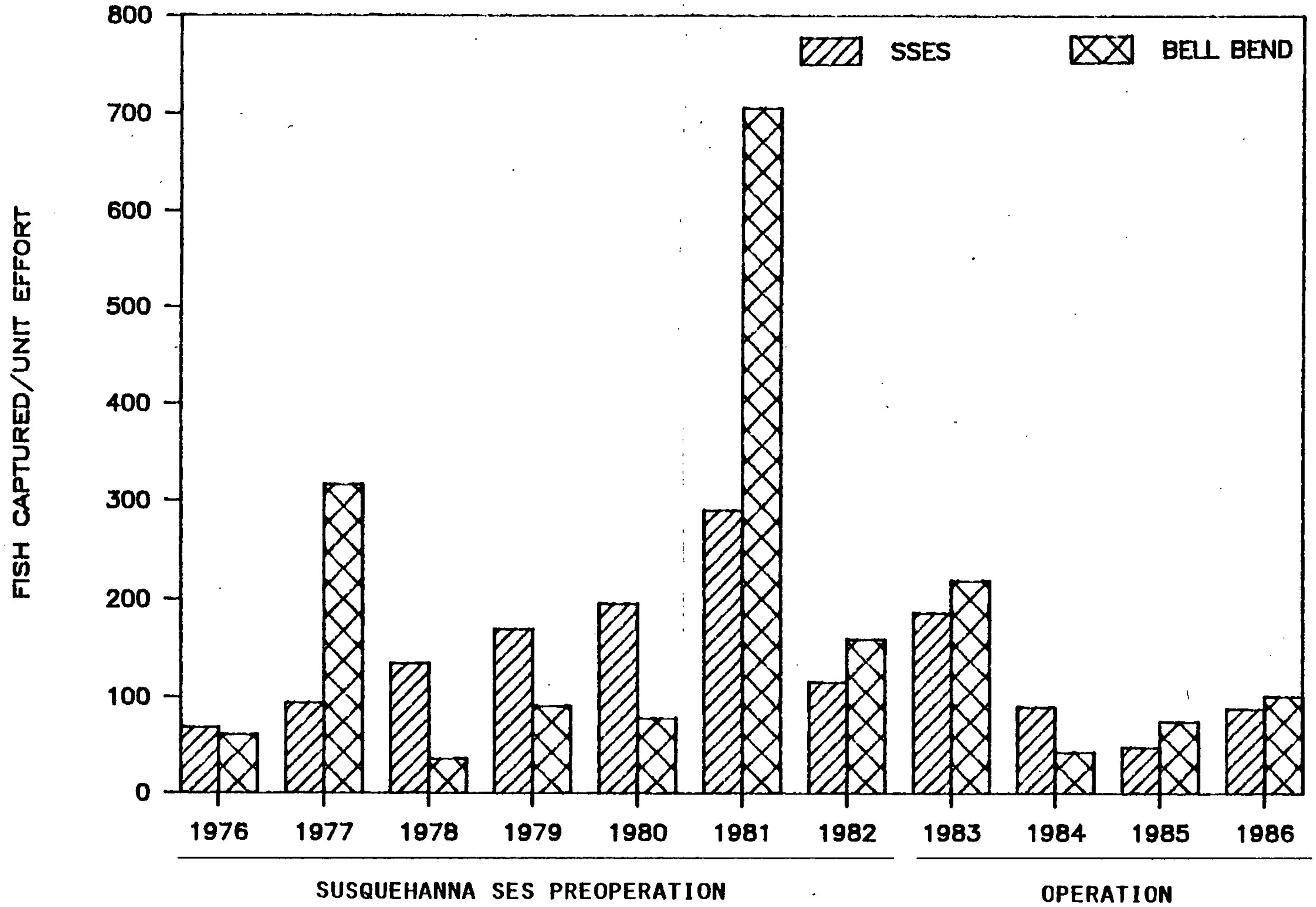

Fig. D-5

Annual mean number of fish captured by seining at SSES and Bell Bend on the Susquehanna River in June, August, and October, 1976-86.

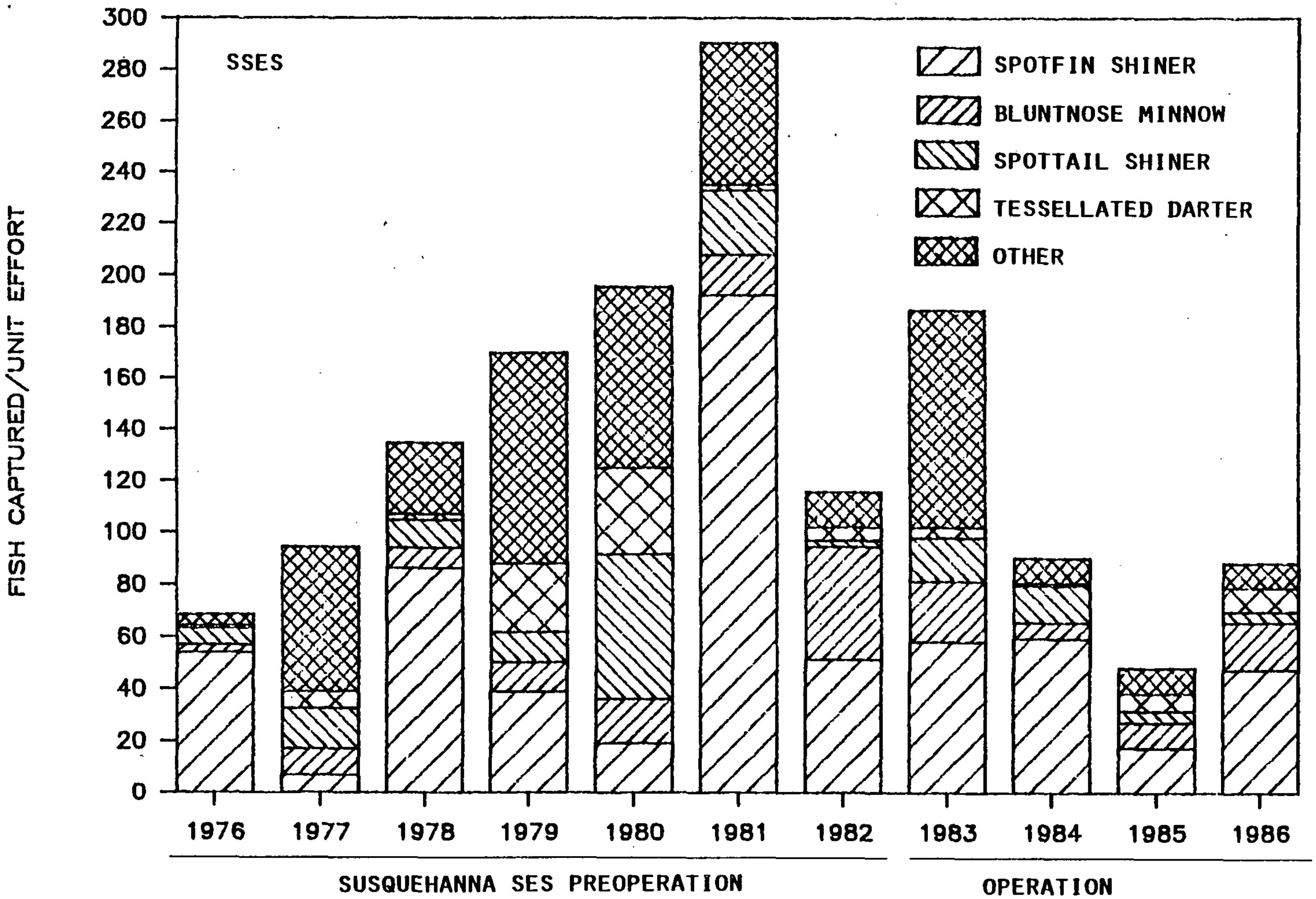

Fig. D-6

Annual mean number of fish captured per unit effort by seining at SSES on the Susquehanna River in June, August, and October, 1976-86.

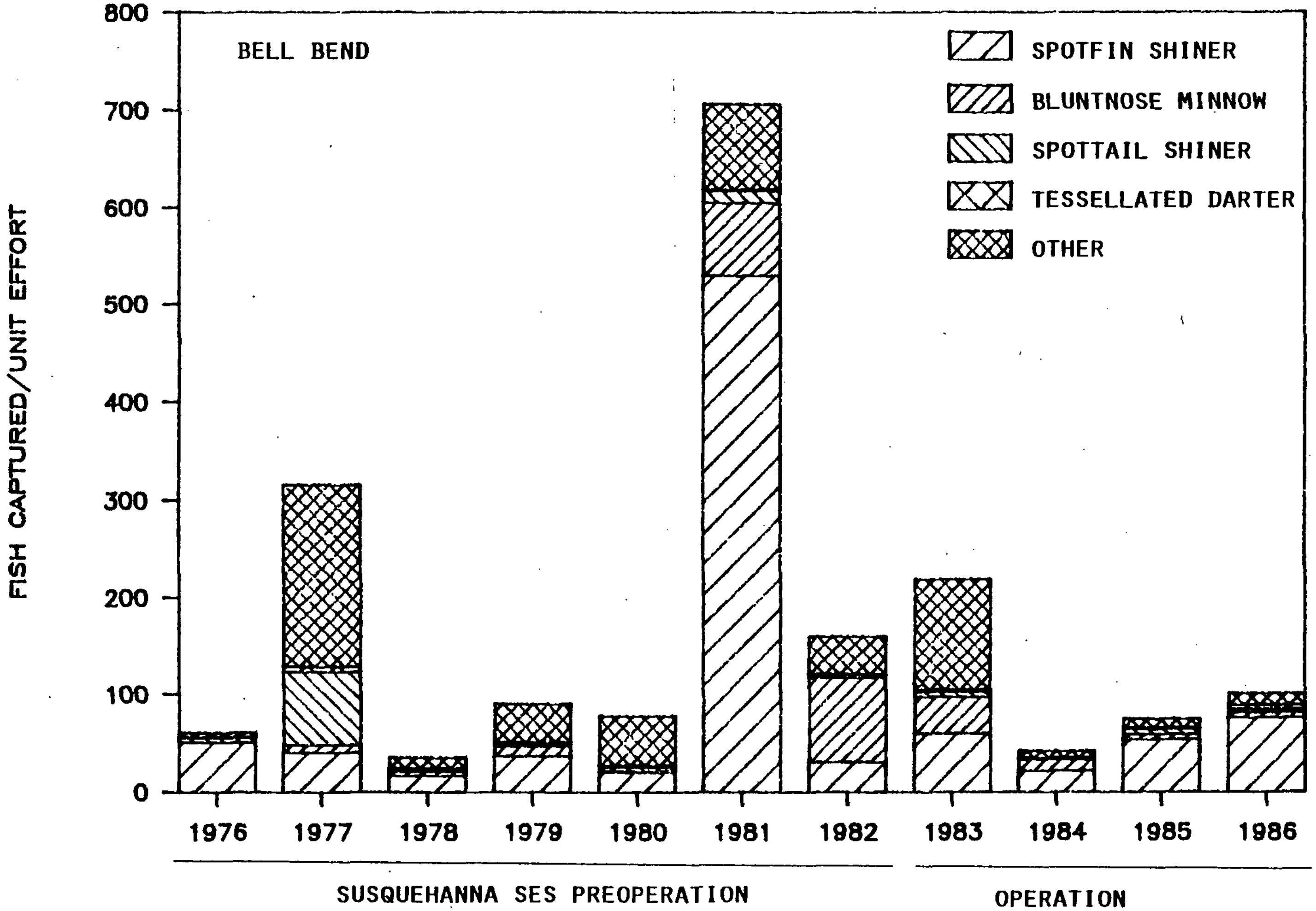

Fig. D-7

Annual mean number of fish captured per unit effort by seining at Bell Bend on the Susquehanna River in June, August, and October, 1976-86.

ANGLER SURVEY

by

Walter J. Soya and Andrew J. Gurzynski

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Four hundred and ten anglers were interviewed during 24 weekend and holiday surveys on a 6.0-km section of the Susquehanna River near the Susquehanna SES throughout 1986. These anglers fished for 1,189.6 hours, caught 347 fish of at least 15 species, and harvested 104 fish of at least 11 species. Walleye was the most frequently caught fish (36.3% of the total catch), followed by channel catfish (24.5%), smallmouth bass (19.9%), common carp (5.8%), rock bass (3.7%), and white sucker (2.9%). Of these, walleye was most frequently harvested. Projected for 1986, an estimated 1,930 anglers fished 7,337 hours, caught 2,092 fish, and harvested 627. Operation of the Susquehanna SES had no observable impact on angler use of the Susquehanna River in the study area.

INTRODUCTION

The relative abundance of fishes has been monitored in the Susquehanna River near the Susquehanna SES since 1971. Although this stretch is degraded by acid mine drainages and sewage, the water quality has improved in recent years (Soya et al. 1984b) and interest in river fishing has increased. Angler surveys were conducted in the vicinity of the Susquehanna SES in 1981 (Buynak et al. 1982) and 1982 (Soya et al. 1983) to document use of the river by anglers prior to operation. After operation began, surveys were conducted in 1983 and 1984 (Soya et al. 1984a-85) and 1986. The objective of these three surveys was to evaluate the impact of Susquehanna SES operation on river angling. These evaluations and data from the 1986 angler survey are presented in this report.

PROCEDURES

Angler surveys were conducted on the Susquehanna River from the southern tip of Gould Island to Hess Sand and Stone, Inc. in 1986 (Fig. E-1). This included a survey area of 1.9 km upriver from the Susquehanna SES intake structure and 4.1 km downriver. Survey dates included two randomly-selected weekend days or holidays in each month. Weekdays were not included because results from the four previous surveys showed that over 70% of the river anglers interviewed fished on weekends or holidays. On each date, day length (sunrise to sunset) was divided into three equal time periods and one survey was conducted within each of these periods. The start time for each period was determined by dividing the first time period into equal intervals of no less than 45 minutes and no more than 60 minutes. There were from four to six intervals per time period depending upon day length. One of the intervals was randomly selected, and the first minute of that interval was the start time. The same interval was used to select start times in the other two periods. Surveys were conducted by a biologist for at least one hour during each time period.

The following information was obtained from anglers: 1) time fishing began; 2) species fished for; 3) number and species of fish caught, released, and harvested; 4) use of catch; 5) bait used; and 6) county or state of residence. The interviewer also recorded the time of the interview and the location of each angler (east bank, west bank, or boat). At the conclusion of an interview, each angler was given a questionnaire (stamped postcard preaddressed to the Susquehanna SES Biological Laboratory) to obtain the time fishing ended and final catch and harvest data. Anglers were requested to return their cards even if they did not catch any fish. As an incentive to return the questionnaire, anglers were informed that each completed questionnaire was eligible for three cash prizes in an annual drawing.

Data from both complete and incomplete fishing trips were used to estimate the number of anglers in each month. A fishing trip, defined as time spent fishing on the river, was considered complete when an angler or group of anglers was either interviewed at the end of fishing or when fishing continued after the interview and their completed questionnaire was returned. An incomplete trip occurred when an angler or group of anglers did not return their questionnaire. Data from complete and incomplete fishing trips were grouped to obtain angler estimates (*EA*) for each month using the formula:

$$EA = (Mwe)\ (Twe)$$

where *Mwe* = mean number of anglers (complete and incomplete trips) interviewed per weekend day or holiday each month and *Twe* = total number of weekend days and holidays each month. The annual estimate was then obtained by summing the monthly estimates.

Complete and incomplete fishing trips were also used to estimate the total number of hours fished (*EH*) using the formula:

$$EH = \sum_{i=1}^{12} \left[\frac{[H(C)_i]\ [EA(C)_i]}{A(C)_i} + \frac{2[H(I)_i]\ [EA(I)_i]}{A(I)_i} \right]$$

where $H(C)_i$ = total number of hours fished by complete trip anglers in month "i", $A(C)_i$ = total number of complete trip anglers in month "i", $H(I)_i$ = total number of hours fished by incomplete trip anglers in month "i", $A(I)_i$ = total number of incomplete trip anglers in month "i", while $EA(C)_i$ and $EA(I)_i$ represent estimated anglers for complete and incomplete trips, respectively, in month "i". Total fishing time for incomplete trips (time from start of fishing to time of interview) was doubled with the assumption that anglers were contacted during the midpoint of their fishing trip. We found, as did DiCostanzo (1956) and Groen and Schmulbach (1978), that doubling incomplete trip time produced satisfactory estimates of complete fishing trips.

The monthly estimated number of fish caught and harvested was determined by multiplying mean monthly survey values by the estimated number of hours fished (*EH*). The annual estimate was the sum of monthly estimates. These estimates are conservative because interviews were only conducted from sunrise to sunset on each survey date, and, therefore, night anglers were not included. Survey data were analyzed using Friedman's two-way analysis of variance (Hollander and Wolfe 1973) to determine if the variation in numbers of anglers, hours fished, fish caught, and fish harvested over time (months and time periods) and location (east bank, west bank, or boat) was significant.

RESULTS AND DISCUSSION

There were 410 anglers interviewed (197 complete trips and 213 incomplete trips) during 24 surveys throughout 1986 (Table E-1). These anglers fished for 1,189.6 hours, caught 347 fish of at least 15 species, and harvested 104 fish of at least 11 species (Table E-2). Mean survey values in 1986 were 0.8 fish caught per angler, 0.3 fish harvested per angler, 2.9 hours fished per angler, 0.3 fish caught per hour, and 0.1 fish harvested per hour.

Significantly more anglers ($P<0.05$) were interviewed in the third time period (48.5%) than in the first (24.9%) or second (26.6%) period (Table E-1). More fish were caught (151) in the third time period, but the catch rate was greatest in the first period (1.0 fish per angler). Anglers fished longer (3.3 h/angler) in the first time period than the second (3.2 h/angler) or third period (2.5 h/angler). In all previous surveys, significantly more anglers were also interviewed in the third time period.

Six species composed over 91% of the total catch and harvest (Table E-2). Walleye was the most frequently caught fish (36.3% of the total catch), followed by channel catfish (24.5%), smallmouth bass (19.9%), common carp (5.8%), rock bass (3.7%), and white sucker (2.9%). More walleyes were harvested (47) than any other species. They were followed in abundance by channel catfish (33), smallmouth bass (7), white sucker (5), and common carp (3). No rock bass were kept. Walleye, smallmouth bass, and channel catfish were the most commonly caught fish in preoperational and operational surveys. They composed from 49 to 80% of the total catch in these surveys.

The number of anglers that stated they would eat at least a portion of their catch has remained consistent (from 56% to 67% of the total) throughout preoperational and operational surveys. In 1986, 62.0% of the anglers stated they would eat at least a portion of their catch (Table E-3), even though only 30.0% of the fish caught in 1986 were harvested. The rate of harvest is affected by the catch of undesirable species and minimum size limits for gamefishes. Smallmouth bass must be larger than 254 mm and walleyes larger than 381 mm to be harvested; 24 of the 69 smallmouth bass and 75 of the 126 walleye caught in 1986 were smaller than these limits. Only 28.3% of the fish caught in the surveys since 1981 were kept.

More anglers fished for gamefishes (muskellunge, smallmouth bass, and walleye) than for catfishes, common carp, or suckers (Table E-3). Gamefish anglers also outnumbered anglers with no preference of catch. As in previous surveys, the vast majority of anglers (95.6%) resided in the neighboring Luzerne, Columbia, and Schuylkill counties. Four out-of-state anglers were interviewed in 1986.

More anglers (57.3%) fished from the river banks than from boats (Table E-4). Comparison of angling data from the east bank, west bank, and boats revealed significant differences ($P<0.01$) in the number of anglers, hours fished, fish caught, and fish harvested. Over 95% of the river bank anglers were interviewed on the east bank, probably because of easier access from PA Route 239 and Legislative Route 665 (Fig. E-1). Whereas, along the entire west bank, access is limited by either private property or a 300-700 m walk to the river. Bank anglers on both sides of the river are also hindered by steep and sometimes slippery banks, overhanging trees and brush, and poison ivy.

Even though boat angling is limited by the lack of a public launch site, there was a substantial increase in the number of boat anglers. In the four previous surveys, the percent of boat interviews ranged from 12.0% to 29.8% of the total. In 1986, 175 anglers (42.7%) were interviewed in boats (Table E-4). They caught 85 more fish than bank anglers, harvested 34 more fish, and generally fished longer. This increase was probably due to above average river flow throughout the summer months in 1986 (Fig. A-2). In most years, low summer flow hinders boat angling because of shallow water conditions.

Angling occurred throughout the year in preoperational and operational surveys (Table E-5). In all surveys, there usually were less than 20 anglers interviewed in the months of January, October, November, and December, and more than 30 surveyed monthly from February through September. Most effort generally occurred from May through September, however, many anglers continued to fish throughout the winter months.

The total number of anglers interviewed on weekends and holidays in 1986 was similar to totals recorded in previous surveys (Table E-5). From 415 to 427 anglers were interviewed in each year, except 1984 when only 378 were contacted because of generally poor angling conditions on the river throughout much of this year (Soya et al. 1985). Even though there was no substantial change in the number of anglers interviewed in all five surveys, the hours fished increased by about 30% from preoperational to operational surveys. The increase in hours fished, however, did not result in a greater number of fish caught per angler. Comparison of completed trip data revealed that anglers in preoperational years had a higher catch and harvest per effort than anglers in operational years (Table E-6). These results show that anglers were willing to increase their fishing time in an attempt to improve their success.

Projected for 1986, an estimated 1,930 anglers fished the Susquehanna River in the study area on weekends and holidays (Table E-7). It was also estimated that these anglers fished 7,337 hours, caught 2,092 fish, and harvested 627. When compared to weekend and holiday estimates from the previous surveys, the estimated hours fished were the greatest and the estimated fish caught were the lowest.

Operation of the Susquehanna SES had no observable impact on angler use of the Susquehanna River in the study area. A comparison of preoperational to operational surveys showed that similar numbers of anglers were interviewed in: 1) daily time periods, 2) months throughout the year, and 3) annual surveys. Walleye, smallmouth bass, and channel catfish were the most commonly caught fish in all surveys. The ratio of anglers which stated they would eat at least a portion of their catch remained consistent from preoperational through operational surveys. Based on completed trip data, anglers fished longer in operational surveys, but caught fewer fish. The increase in effort may be indicative of improved water quality near the Susquehanna SES.

REFERENCES CITED

Buynak, G. L., W. J. Soya, and T. V. Jacobsen. 1982. Creel Survey. Pages 326-352 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1981 annual report). Ichthyological Associates, Inc., Berwick, PA.

DiCostanzo, C. 1956. Clear Lake creel census and evaluation of sampling techniques. Pages 17-29 in Symposium on sampling problems in creel census, 1956. Iowa Coop. Fish. Res. Unit, Iowa State College Press, Ames, IA.

Groen, C. L. and J. C. Schmulbach. 1978. The sport fishery of the unchannelized and channelized Middle Missouri River. Trans. Am. Fish. Soc. 107(3): 412-418.

Hollander, M. and D. A. Wolfe. 1973. Nonparametric statistical methods. John Wiley and Sons, Inc., New York, NY. 503 pp.

Soya, W. J., A. J. Gurzynski, and T. V. Jacobsen. 1983. Angler survey. Pages 190-211 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1982 annual report). Ichthyological Associates, Inc., Berwick, PA.

________, ________, and ________. 1984a. Angler survey. Pages 177-198 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1983 annual report). Ichthyological Associates, Inc., Berwick, PA.

________, B. P. Mangan, and T. V. Jacobsen. 1984b. Physicochemical analyses. Pages 7-57 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1983 annual report). Ichthyological Associates, Inc., Berwick, PA.

________, A. J. Gurzynski, and T. V. Jacobsen. 1985. Angler Survey. Pages 174-197 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1984 annual report). Ichthyological Associates, Inc., Berwick, PA.

Table E-1

Angler survey data collected on the Susquehanna River, January through December 1986.

Date	4 JAN			19 JAN		
Time Period	1st	2nd	3rd	1st	2nd	3rd
Start Time	0950	1256	1602	0725	1039	1352
River Level	148.88	148.88	148.88	148.55	148.55	148.58
Water Temp (C)	0.7	1.0	0.9	1.0	1.0	1.0
Air Temp (C)	0.0	1.0	2.0	10.0	13.5	15.0
Anglers	7	4	2	4	3	6
Fish Caught	11	4	5	0	15	4
Fish Harvested	8	4	0	0	2	3
Hours Fished	47.0	19.5	3.0	7.5	7.5	18.2
Catch/Angler	1.6	1.0	2.5	0.0	5.0	0.7
Harvest/Angler	1.1	1.0	0.0	0.0	0.7	0.5
Hours/Angler	6.7	4.9	1.5	1.9	2.5	3.0
Catch/Effort (h)	0.2	0.2	1.7	0.0	2.0	0.2
Harvest/Effort (h)	0.2	0.2	0.0	0.0	0.3	0.2
Species						
Walleye	8H 3R	4H	5R		2H 13R	3H 1R

Date	9 FEB			23 FEB		
Time Period	1st	2nd	3rd	1st	2nd	3rd
Start Time	0941	1310	1638	0744	1124	1503
River Level	149.40	149.34	149.34	151.87	151.72	151.63
Water Temp (C)	0.0	0.2	0.0	0.8	0.9	1.1
Air Temp (C)	3.5	4.0	4.5	4.0	10.0	9.0
Anglers	7	3	3	7	1	13
Fish Caught	1	0	0	12	0	8
Fish Harvested	0	0	0	1	0	2
Hours Fished	16.0	6.3	4.5	36.0	0.9	26.8
Catch/Angler	0.1	0.0	0.0	1.7	0.0	0.6
Harvest/Angler	0.0	0.0	0.0	0.1	0.0	0.2
Hours/Angler	2.3	2.1	1.5	5.1	0.9	2.1
Catch/Effort (h)	0.1	0.0	0.0	0.3	0.0	0.3
Harvest/Effort (h)	0.0	0.0	0.0	<0.1	0.0	0.1
Species						
Common carp	1R					
Quillback						1R
White sucker				3R		
Shorthead redhorse				1R		1R
Sucker sp.						1R
Channel catfish				7R		3R
Walleye				1H		2H

Table E-1 (cont.)

Date	8 MAR			22 MAR		
Time Period	1st	2nd	3rd	1st	2nd	3rd
Start Time	0822	1213	1605	0653	1058	1503
River Level	149.31	149.31	149.25	151.63	151.53	151.44
Water Temp (C)	1.1	1.6	1.7	3.5	3.5	4.0
Air Temp (C)	-8.0	-3.0	-2.0	-11.5	3.0	6.5
Anglers	2	9	8	0	1	1
Fish Caught	0	0	1		1	0
Fish Kept	0	0	1		0	0
Hours Fished	0.5	23.8	6.8		2.5	2.5
Catch/Angler	0.0	0.0	0.1		1.0	0.0
Harvest/Angler	0.0	0.0	0.1		0.0	0.0
Hours/Angler	0.3	2.6	0.9		2.5	2.5
Catch/Effort (h)	0.0	0.0	0.1		0.4	0.0
Harvest/Effort (h)	0.0	0.0	0.1		0.0	0.0
Species						
Smallmouth bass					1R	
Walleye			1H			

Date	13 APR			20 APR		
Time Period	1st	2nd	3rd	1st	2nd	3rd
Start Time	0620	1045	1510	0612	1043	1514
River Level	149.49	149.49	149.49	150.92	150.77	150.68
Water Temp (C)	7.5	8.0	8.5	9.6	10.0	10.6
Air Temp (C)	-5.0	11.5	14.0	6.0	18.5	19.5
Anglers	0	5	20	0	0	17
Fish Caught		3	13			30
Fish Harvested		0	1			16
Hours Fished		14.2	59.1			39.3
Catch/Anglers		0.6	0.7			1.8
Harvest/Angler		0.0	0.1			0.9
Hours/Angler		2.8	3.0			2.3
Catch/Effort (h)		0.2	0.2			0.8
Harvest/Effort (h)		0.0	<0.1			0.4
Species						
Common carp			1R			
Fallfish		2R				
White sucker			1H 2R			4H
Shorthead redhorse						1H
Brown bullhead						1H
Channel catfish			9R			10H 13R
Rock bass						1R
Walleye		1R				

Table E-1 (cont.)

Date	11 MAY			17 MAY		
Time Period	1st	2nd	3rd	1st	2nd	3rd
Start Time	0648	1136	1624	0543	1035	1527
River Level	148.76	148.76	148.76	148.58	148.58	148.58
Water Temp (C)	16.6	17.6	18.5	17.2	17.9	19.2
Air Temp (C)	8.0	24.5	26.0	16.0	26.0	28.5
Anglers	0	10	21	3	4	14
Fish Caught		6	14	1	1	11
Fish Harvested		5	1	1	0	1
Hours Fished		15.0	65.8	9.7	23.0	27.8
Catch/Angler		0.6	0.7	0.3	0.3	0.8
Harvest/Angler		0.5	<0.1	0.3	0.0	0.1
Hours/Angler		1.5	3.1	3.2	5.8	2.0
Catch/Effort (h)		0.4	0.2	0.1	<0.1	0.4
Harvest/Effort (h)		0.3	<0.1	0.1	0.0	<0.1
<u>Species</u>						
Brown bullhead		1H	1R			
Channel catfish		3H	3R	1H		
Smallmouth bass		1R	5R		1R	3R
Crappie sp.			1R			
Walleye		1H				7R

Date	7 JUN			29 JUN		
Time Period	1st	2nd	3rd	1st	2nd	3rd
Start Time	0531	1032	1534	0855	1358	1901
River Level	150.10	150.04	150.01	148.85	148.82	148.79
Water Temp (C)	20.5	20.0	20.0	22.4	24.1	23.9
Air Temp (C)	12.5	24.0	27.0	23.5	29.0	27.0
Anglers	0	3	9	10	9	22
Fish Caught		12	7	3	8	11
Fish Harvested		12	0	0	1	0
Hours Fished		10.7	35.0	31.4	33.5	58.8
Catch/Angler		4.0	0.8	0.3	0.9	0.5
Harvest/Angler		4.0	0.0	0.0	0.1	0.0
Hours/Angler		3.6	3.9	3.1	3.7	2.7
Catch/Effort (h)		1.1	0.2	0.1	0.2	0.2
Harvest/Effort (h)		1.1	0.0	0.0	<0.1	0.0
<u>Species</u>						
Common carp			2R			
Fallfish			2R			
Shorthead redhorse						1R
Channel catfish		12H		2R		
Rock bass				1R	3R	2R
Smallmouth bass			2R		1R	7R
Largemouth bass			1R			
Crappie sp.					1H	
Walleye					3R	1R

Table E-1 (cont.)

Date	13 JUL			20 JUL		
Time Period	1st	2nd	3rd	1st	2nd	3rd
Start Time	0940	1438	1937	0746	1241	1736
River Level	148.64	148.64	148.64	149.19	149.19	149.16
Water Temp (C)	22.0	23.5	23.5	23.5	23.5	23.6
Air Temp (C)	22.5	30.5	28.0	22.5	25.0	25.5
Anglers	15	6	7	10	12	0
Fish Caught	7	0	2	3	7	
Fish Harvested	2	0	0	0	3	
Hours Fished	25.9	8.7	10.0	26.5	58.3	
Catch/Angler	0.5	0.0	0.3	0.3	0.6	
Harvest/Angler	0.1	0.0	0.0	0.0	0.3	
Hours/Angler	1.7	1.5	1.4	2.7	4.9	
Catch/Effort (h)	0.3	0.0	0.2	0.1	0.1	
Harvest/Effort (h)	0.1	0.0	0.0	0.0	0.1	
Species						
Common carp	1R				1H 1R	
Channel catfish			1R			
Rock bass	1R		1R			
Bluegill					2H	
Smallmouth bass				3R	3R	
Walleye	2H 3R					

Date	16 AUG			17 AUG		
Time Period	1st	2nd	3rd	1st	2nd	3rd
Start Time	0613	1050	1527	0710	1146	1621
River Level	148.73	148.73	148.73	148.64	148.61	148.61
Water Temp (C)	23.1	23.3	23.8	23.5	24.0	24.0
Air Temp (C)	19.0	22.5	26.0	20.0	24.5	26.5
Anglers	4	5	8	5	6	5
Fish Caught	2	3	11	9	3	2
Fish Harvested	0	1	1	0	0	0
Hours Fished	6.3	35.5	35.2	25.0	14.5	11.6
Catch/Angler	0.5	0.6	1.4	1.8	0.5	0.4
Harvest/Angler	0.0	0.2	0.1	0.0	0.0	0.0
Hours/Angler	1.6	7.1	4.4	5.0	2.4	2.3
Catch/Effort (h)	0.3	0.1	0.3	0.4	0.2	0.2
Harvest/Effort (h)	0.0	<0.1	<0.1	0.0	0.0	0.0
Species						
Channel catfish	1R	1H		6R	1R	
Rock bass		2R				
Smallmouth bass	1R		1H 10R	3R	2R	2R

Table E-1 (cont.)

Date	14 SEP			20 SEP		
Time Period	1st	2nd	3rd	1st	2nd	3rd
Start Time	0943	1324	1735	0828	1224	1640
River Level	148.27	148.27	148.27	148.24	148.24	148.24
Water Temp (C)	20.0	21.6	22.0	17.0	18.0	18.5
Air Temp (C)	14.5	19.5	19.0	12.0	17.0	19.0
Anglers	8	2	14	0	8	7
Fish Caught	4	3	3		5	21
Fish Harvested	2	1	0		2	11
Hours Fished	37.2	4.0	29.3		12.3	23.0
Catch/Angler	0.5	1.5	0.2		0.6	3.0
Harvest/Angler	0.3	0.5	0.0		0.3	1.6
Hours/Angler	4.7	2.0	2.1		1.5	3.3
Catch/Effort (h)	0.1	0.8	0.1		0.4	0.9
Harvest/Effort (h)	0.1	0.3	0.0		0.2	0.5
Species						
Muskellunge					1H	
Common carp			1R			6R
Brown bullhead						1H
Channel catfish						5H 2R
Smallmouth bass	2H 2R		2R		3R	4H 2R
Sunfish sp.		2R				
Yellow perch		1H				
Walleye					1H	1H

Date	4 OCT			12 OCT		
Time Period	1st	2nd	3rd	1st	2nd	3rd
Start Time	0703	1056	1449	1013	1359	1744
River Level	148.70	148.73	148.85	148.82	148.82	148.82
Water Temp (C)	19.9	19.8	20.0	13.0	14.0	14.0
Air Temp (C)	18.0	21.0	23.0	13.0	21.0	18.0
Anglers	0	2	4	5	3	6
Fish Caught		1	5	4	1	1
Fish Harvested		0	0	0	0	1
Hours Fished		5.0	8.5	19.3	9.3	8.0
Catch/Angler		0.5	1.3	0.8	0.3	0.2
Harvest/Angler		0.0	0.0	0.0	0.0	0.2
Hours/Angler		2.5	2.1	3.9	3.1	1.3
Catch/Effort (h)		0.2	0.6	0.2	0.1	0.1
Harvest/Effort (h)		0.0	0.0	0.0	0.0	0.1
Species						
Brown bullhead			1R			
Channel catfish					1R	1H
Smallmouth bass		1R	4R	3R		
Walleye				1R		

Table E-1 (cont.)

Date	11 NOV			16 NOV		
Time Period	1st	2nd	3rd	1st	2nd	3rd
Start Time	0916	1238	1602	0831	1141	1507
River Level	150.13	150.13	150.13	149.40	149.37	149.34
Water Temp (C)	8.0	7.5	7.5	4.2	4.4	4.4
Air Temp (C)	2.0	3.0	3.5	4.3	8.0	8.5
Anglers	0	2	0	4	7	8
Fish Caught		0		5	12	2
Fish Harvested		0		3	2	1
Hours Fished		6.0		21.5	19.9	18.7
Catch/Angler		0.0		1.3	1.7	0.3
Harvest/Angler		0.0		0.8	0.3	0.1
Hours/Angler		3.0		5.4	2.8	2.3
Catch/Effort (h)		0.0		0.2	0.6	0.1
Harvest/Effort (h)		0.0		0.1	0.1	0.1
Species						
Channel catfish					3R	
Rock bass					2R	
Walleye				3H 2R	2H 5R	1H 1R

Date	13 DEC			21 DEC		
Time Period	1st	2nd	3rd	1st	2nd	3rd
Start Time	0720	1025	1330	0900	1201	1504
River Level	149.98	149.95	149.92	149.58	149.52	149.52
Water Temp (C)	2.5	2.3	2.3	2.6	2.9	2.9
Air Temp (C)	-3.0	-2.0	-1.0	0.0	1.0	1.5
Anglers	4	0	0	7	4	4
Fish Caught	1			38	10	0
Fish Harvested	1			4	10	0
Hours Fished	12.2			16.8	23.0	5.5
Catch/Angler	0.3			5.4	2.5	0.0
Harvest/Angler	0.3			0.6	2.5	0.0
Hours/Angler	3.1			2.4	5.8	1.4
Catch/Effort (h)	0.1			2.3	0.4	0.0
Harvest/Effort (h)	0.1			0.2	0.4	0.0
Species						
Common carp				1R		
Walleye	1H			4H 33R	10H	

H = Harvested
R = Released

Table E-2

Summary of angler data collected on the Susquehanna River, 1986.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	% TOTAL NUMBER
Anglers	26	34	21	42	52	53	50	33	39	20	21	19	410	
Fish Caught	39	21	2	46	33	41	19	30	36	12	19	49	347	
Fish Harvested	17	3	1	17	8	13	5	2	16	1	6	15	104	
Hours Fished	102.7	90.5	36.1	112.6	141.3	169.4	129.4	128.1	105.8	50.1	66.1	57.5	1189.6	
Catch/Angler	1.5	0.6	0.1	1.1	0.6	0.8	0.4	0.9	0.9	0.6	0.9	2.6	0.8	
Harvest/Angler	0.7	0.1	<0.1	0.4	0.2	0.2	0.1	0.1	0.4	0.1	0.3	0.8	0.3	
Hours/Angler	4.0	2.7	1.7	2.7	2.7	3.2	2.6	3.9	2.7	2.5	3.1	3.0	2.9	
Catch/Effort(h)	0.4	0.2	0.1	0.4	0.2	0.3	0.1	0.2	0.2	0.2	0.3	0.9	0.3	
Harvest/Effort(h)	0.2	<0.1	<0.1	0.2	0.1	0.1	<0.1	<0.1	0.2	<0.1	0.1	0.3	0.1	
<u>Species</u>														
Muskellunge									1H				1H	0.3
Common carp		1R		1R	2H-3R	2R	1H-2R		7R			1R	3H-17R	5.8
Fallfish				2R		2R							4R	1.2
Quillback		1R											1R	0.3
White sucker		3R		5H-2R									5H- 5R	2.9
Shorthead redhorse		2R		1H		1R							1H- 3R	1.2
Sucker sp.		1R											1R	0.3
Brown bullhead				1H	1H-1R				1H	1R			3H- 2R	1.4
Channel catfish		10R		10H-22R	4H-3R	12H-2R	1R	1H-8R	5H-2R	1H-1R	3R		33H-52R	24.5
Rock bass				1R		6R	2R	2R			2R		13R	3.7
Bluegill							2H						2H	0.6
Smallmouth bass			1R		10R	10R	6R	1H-18R	6H-9R	8R			7H-62R	19.9
Largemouth bass						1R							1R	0.3
Sunfish sp.									2R				2R	0.6
Crappie sp.					1R	1H							1H- 1R	0.6
Yellow perch									1H				1H	0.3
Walleye	17H-22R	3H	1H	1R	1H-7R	4R	2H-3R		2H	1R	6H-8R	15H-33R	47H-79R	36.3

H = Harvested
R = Released

Table E-3

Use of catch, residence, times interviewed, bait used, and preference of catch obtained during angler surveys on the Susquehanna River, 1986.

	NUMBER OF ANGLERS													
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	% TOTAL
Use of Catch														
Eat	17	20	12	25	20	45	29	15	26	10	19	16	254	62.0
Release	9	8	6	17	32	8	21	17	12	9	2	2	143	34.9
Other	0	6	3	0	0	0	0	1	1	1	0	1	13	3.2
Residence														
PA County														
Carbon	1	0	0	0	1	1	0	0	4	4	0	0	11	2.7
Columbia	9	11	8	7	14	17	18	3	6	0	6	9	108	26.3
Luzerne	10	23	10	31	35	27	27	25	26	14	12	4	244	59.5
Montgomery	0	0	0	0	0	0	3	0	0	0	0	0	3	0.7
Schuylkill	6	0	3	4	1	7	2	5	3	0	3	6	40	9.8
Out of State														
Florida	0	0	0	0	0	1	0	0	0	0	0	0	1	0.2
New Jersey	0	0	0	0	1	0	0	0	0	0	0	0	1	0.2
Virginia	0	0	0	0	0	0	0	0	0	2	0	0	2	0.5
Times Interviewed														
1	20	33	12	40	39	45	38	25	26	14	11	9	312	76.1
2	6	1	8	2	13	8	5	6	6	3	3	4	65	15.9
3	0	0	1	0	0	0	7	2	6	1	2	3	22	5.4
4-9	0	0	0	0	0	0	0	0	1	2	5	3	11	2.7
Bait Used														
Natural	18	0	1	31	19	26	16	11	8	10	7	4	151	36.8
Artificial	0	24	8	0	6	11	21	7	9	4	3	15	108	26.3
Both	8	10	12	11	27	16	13	15	22	6	11	0	151	36.8
Preference of Catch														
Any Fish	5	2	5	20	25	29	21	23	25	6	2	0	162	39.5
Gamefishes[a]	19	32	16	0	18	20	23	9	13	8	19	19	194	47.3
Catfishes	2	0	0	22	17	4	6	1	1	6	0	0	52	12.7
Carp/suckers	0	0	0	0	2	0	0	0	0	0	0	0	2	0.5

[a]Muskellunge, smallmouth bass, walleye

Table E-4

Summary of angler data from east and west banks and boats on the Susquehanna River, 1986.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
E A S T B A N K													
Anglers	7	32	15	28	26	30	20	14	24	11	9	8	224
Fish Caught	0	21	1	22	20	12	6	10	7	4	1	0	104
Fish Harvested	0	3	0	8	6	1	3	0	2	1	1	0	25
Hours Fished	28.5	89.8	21.8	64.1	95.4	94.8	52.0	40.6	65.8	18.3	22.7	7.2	601.0
Catch/Angler	0.0	0.7	0.1	0.8	0.8	0.4	0.3	0.7	0.3	0.4	0.1	0.0	0.5
Harvest/Angler	0.0	0.1	0.0	0.3	0.2	<0.1	0.2	0.0	0.1	0.1	0.1	0.0	0.1
Hours/Angler	4.1	2.8	1.5	2.3	3.7	3.2	2.6	2.9	2.7	1.7	2.5	0.9	2.7
Catch/Effort (h)	0.0	0.2	<0.1	0.3	0.2	0.1	0.1	0.2	0.1	0.2	<0.1	0.0	0.2
Harvest/Effort (h)	0.0	<0.1	<0.1	0.1	0.1	<0.1	0.1	0.0	<0.1	0.1	<0.1	0.0	<0.1
W E S T B A N K													
Anglers	2	0	0	6	0	0	0	0	3	0	0	0	11
Fish Caught	5			2					20				27
Fish Harvested	0			0					10				10
Hours Fished	3.0			12.5					8.0				23.5
Catch/Angler	2.5			0.3					6.7				2.5
Harvest/Angler	0.0			0.0					3.3				0.9
Hours/Angler	1.5			2.1					2.7				2.1
Catch/Effort (h)	1.7			0.2					2.5				1.1
Harvest/Effort (h)	0.0			0.0					1.3				0.4
B O A T													
Anglers	17	2	6	8	26	23	30	19	12	9	12	11	175
Fish Caught	34	0	1	22	13	29	13	20	9	8	18	49	216
Fish Harvested	17	0	1	9	2	12	2	2	4	0	5	15	69
Hours Fished	71.2	0.7	14.3	36.0	45.9	74.6	77.4	87.5	32.0	31.8	43.4	50.3	565.1
Catch/Angler	2.0	0.0	0.2	2.8	0.5	1.3	0.4	1.1	0.8	0.9	1.5	4.5	1.2
Harvest/Angler	1.0	0.0	0.2	1.1	0.1	0.5	0.1	0.1	0.3	0.0	0.4	1.4	0.4
Hours/Angler	4.2	0.4	2.4	4.5	1.8	3.2	2.6	4.6	2.7	3.5	3.6	4.6	3.2
Catch/Effort (h)	0.5	0.0	0.1	0.6	0.3	0.4	0.2	0.2	0.3	0.3	0.4	1.0	0.4
Harvest/Effort (h)	0.2	0.0	0.1	0.3	<0.1	0.2	<0.1	<0.1	0.1	0.0	0.1	0.3	0.1

Table E-5

Summary of anglers, hours fished, fish caught, and fish harvested during weekend and holiday angler surveys on the Susquehanna River throughout preoperation and operation of the Susquehanna SES, 1981-86.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Anglers													
Preoperation													
1981	2	58	52	50	26	32	71	26	62	14	25	2	420
1982	0	13	22	18	88	31	74	75	59	23	7	17	427
Operation													
1983	24	64	30	48	34	57	38	47	67	5	1	0	415
1984	0	51	18	21	72	45	22	50	37	18	14	30	378
1986	26	34	21	42	52	53	50	33	39	20	21	19	410
												MEAN	410
Hours Fished													
Preoperation													
1981	5.5	91.8	71.4	62.6	49.2	82.2	169.1	46.1	172.0	38.1	51.0	6.0	844.9
1982	0.0	49.8	42.7	30.2	200.4	40.9	167.1	148.2	151.8	75.7	19.7	28.2	954.9
Operation													
1983	58.3	211.3	69.9	123.0	101.6	159.2	96.7	132.2	185.9	16.8	0.3	0.0	1,155.0
1984	0.0	189.8	44.3	33.1	188.2	218.4	82.8	160.6	114.2	40.6	34.1	44.3	1,150.3
1986	102.7	90.5	36.1	112.6	141.3	169.4	129.4	128.1	105.8	50.1	66.1	57.5	1,189.6
												MEAN	1,058.9
Fish Caught													
Preoperation													
1981	32	31	14	9	5	54	59	14	83	30	42	1	374
1982	0	43	39	2	57	25	113	25	37	43	38	10	432
Operation													
1983	4	133	18	9	15	94	23	26	67	6	0	0	395
1984	0	61	34	57	49	59	49	66	30	10	8	21	444
1986	39	21	2	46	33	41	19	30	36	12	19	49	347
												MEAN	398
Fish Harvested													
Preoperation													
1981	1	15	8	0	0	16	16	0	15	18	6	0	95
1982	0	3	11	0	14	6	25	6	8	1	12	0	86
Operation													
1983	1	9	2	6	2	36	4	5	9	4	0	0	78
1984	0	28	27	14	11	18	13	17	1	7	3	10	149
1986	17	3	1	17	8	13	5	2	16	1	6	15	104
												MEAN	102

Table E-6

Summary of completed fishing trip data for weekend and holiday anglers on the Susquehanna River, 1981-86.

	1981	1982	1983	1984	1986
Anglers	126	167	225	215	197
Hours Fished	425.6	386.0	825.7	922.2	824.7
Fish Caught	262	290	352	341	263
Fish Harvested	65	52	62	130	80
Catch/Angler	2.1	1.7	1.6	1.6	1.3
Harvest/Angler	0.5	0.3	0.3	0.6	0.4
Hours/Angler	3.4	3.5	3.7	4.3	4.2
Catch/Effort (h)	0.6	0.5	0.4	0.4	0.3
Harvest/Effort (h)	0.2	0.1	0.1	0.1	0.1

Table E-7

Summary of estimated anglers, hours fished, fish caught, and fish harvested during weekend and holiday angler surveys on the Susquehanna River throughout preoperation and operation of the Susquehanna SES, 1981-86.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Anglers													
Preoperation													
1981	10	261	234	225	143	128	320	130	279	70	138	9	1,947
1982	0	58	88	81	484	124	370	338	266	126	35	85	2,055
Operation													
1983	120	288	120	240	170	228	209	188	302	28	5	0	1,898
1984	0	230	81	105	324	202	110	200	204	81	63	165	1,765
1986	117	153	105	189	260	238	225	165	176	90	126	86	1,930
Hours Fished													
Preoperation													
1981	27.5	687.2	626.8	464.0	491.7	446.8	1,199.7	316.0	962.1	249.5	346.5	27.0	5,844.8
1982	0.0	226.8	202.0	208.8	1,544.4	296.0	1,284.5	1,016.1	860.8	496.1	98.5	187.0	6,421.0
Operation													
1983	495.5	989.1	346.0	1,031.0	637.0	900.4	621.0	620.4	1,053.0	97.9	3.0	0.0	6,794.3
1984	0.0	892.8	241.2	292.0	1,145.7	1,015.6	443.0	773.2	886.0	221.4	180.9	305.8	6,397.6
1986	562.0	508.5	288.5	664.6	1,031.5	1,031.8	885.6	682.5	575.6	276.3	486.0	344.2	7,337.1
Fish Caught													
Preoperation													
1981	160	232	123	55	50	294	419	96	464	196	285	4	2,378
1982	0	196	184	14	439	181	869	171	210	282	190	66	2,802
Operation													
1983	34	623	89	75	94	532	148	122	380	35	0	0	2,132
1984	0	287	185	503	298	274	262	318	233	54	42	145	2,601
1986	213	118	16	272	238	250	130	160	196	66	140	293	2,092
Fish Harvested													
Preoperation													
1981	5	112	70	0	0	87	114	0	84	118	41	0	631
1982	0	14	52	0	108	43	192	41	45	7	60	0	562
Operation													
1983	8	42	10	50	12	204	26	23	51	23	0	0	449
1984	0	132	147	124	67	84	70	82	8	38	16	69	837
1986	93	17	8	100	58	79	34	11	87	6	44	90	627

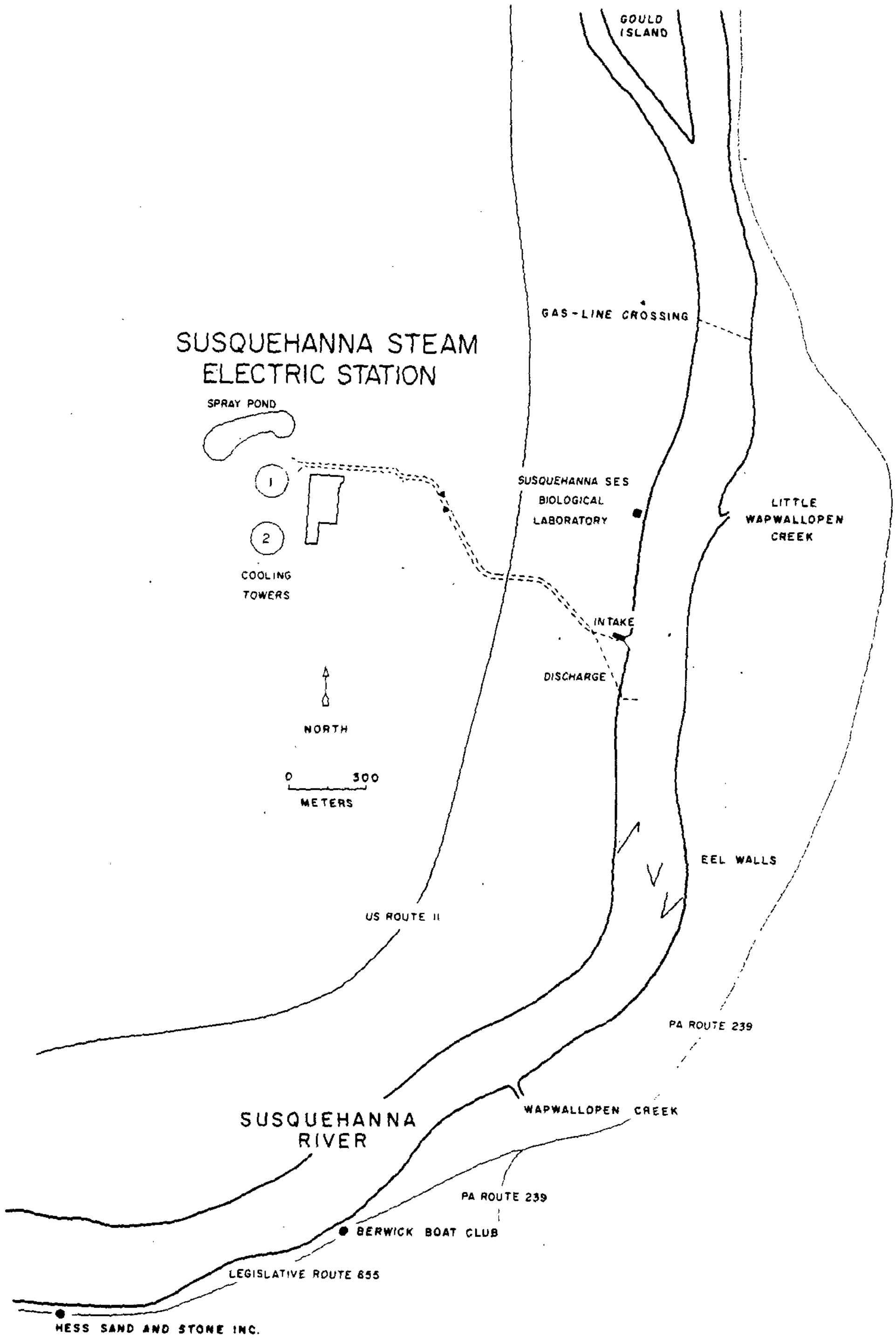

Fig. E-1

Angler survey area on the Susquehanna River near the Susquehanna SES, 1986.

FLORA, VEGETATION, AND METEOROLOGY

by

James D. Montgomery

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

From 1972 through 1974 and 1977 through 1986, 708 species of vascular plants have been observed in the vicinity of the Susquehanna SES. In 1986, 388 taxa were found on six forest salt drift transects. Thirty-six plant parasitic diseases were observed on 49 host species. Disease frequency ranged from rare to abundant. Disease effect ranged from discoloration to minor leaf necrosis for most diseases. Leaf spot anthracnose of *Cornus florida* continued to cause serious damage including host death.

Quantitative vegetation studies were conducted in three upland forests at the Susquehanna SES and at an upland forest near Elimsport, Pennsylvania, which served as a control site. In the upland forest plots, increases in tree density and decreases in sapling density were normal successional changes. Other changes were due to natural forest dynamics (tree diseases, insect damage, etc.). None of the changes in the forest plots could be attributed to the operation of the Susquehanna SES.

Meteorological records for air temperature, barometric pressure, precipitation, fog, and cloud cover were made from January through December 1986. Mean temperature was lowest in January, highest in July; rainfall was least in September and greatest in July. Fog occurred on 50 of 251 days of observation.

INTRODUCTION

Terrestrial ecological studies were conducted in the vicinity of the Susquehanna SES from 1972 through 1974 (Ichthyological Associates, Inc. 1973-74, Burton 1976) and from 1977 through 1986 (Montgomery 1978-86). The flora and vegetation studies conducted from 1977 through 1982 gathered baseline information for comparison with data collected after the Susquehanna SES began operation in September 1982. In 1986, systematic information was collected on the phenology of flowering plants and ferns and on the incidence of parasitic plant diseases (flora), and quantitative information was obtained on selected plant communities (vegetation). The purpose of the flora and vegetation studies in 1986 was to monitor changes, if any, during Susquehanna SES operation in comparison to preoperational studies of 1977-82. Both units were operating during the summer of 1986.

PROCEDURES

Flora

Floristic studies were conducted from March through October 1986. As from 1977 through 1985 (Montgomery 1978-86), observations were made on both sides of the Susquehanna River in the vicinity of the Susquehanna SES (Fig. F-1). In addition to general observations, transects for systematic observations were established. Nine transects were originally selected for observing possible effects of moisture and salt drift from the Susquehanna SES cooling towers during operation, and are referred to as salt drift transects. Five of these transects were utilized in 1986; the following transects were omitted: Gould Island Forest, North Field, Switchyard Field, and Transmission Corridor Field. These transects were at varying distances and directions from the Susquehanna SES in mainly forested areas (Table F-1; Fig. F-1).

In 1982, an off-site control transect was established near the Elimsport Substation of PP&L. This area was selected primarily for vegetation studies; however, it was considered useful to have a salt drift transect at this site for comparison with the Susquehanna SES transects.

On each salt drift transect, the following data were recorded: all plant taxa in flower (shedding spores for ferns), all parasitic plant diseases observed according to host species, and frequency and relative effect of the disease on the host.

Each transect was surveyed once a month from March through October. Identifications of vascular plants were made using Fernald (1950), Gleason and Cronquist (1963), Peterson and McKenny (1968); Wherry (1961) and Mickel (1979) for ferns; and Hitchcock (1950) for grasses. Nomenclature follows Gleason and Cronquist (1963), except for ferns and fern allies, for which Mickel (1979) is used. Parasitic plant diseases were identified using U.S. Department of Agriculture (1960), Hepting (1971), Westcott (1971), and Pennsylvania Department of Environmental Resources (1975). Scientific names are used because of the confusion of some common names of plants. Common and scientific names are given in Tables F-2 and F-3. Species not observed prior to 1986 were collected and added to the reference herbarium.

Vegetation

Quantitative vegetation studies at the Susquehanna SES were conducted in three upland forests: Council Cup Forest, Township Road 419 (TR419) Forest, and Quarry Hillside Forest (Fig. F-1), and a control upland forest at Elimsport Substation. The Gould Island Forest was not sampled in 1986. The two upland fields, sampled 1978-85, were also not done in 1986.

The upland forest plots were sampled in July. Council Cup Forest is located on a gently east-facing slope east of the Council Cup Overlook, in Conyngham and Hollenback Townships, Luzerne County, 3 km southeast of the Susquehanna SES. TR419 Forest is located on a steep south-facing hillside above a road (Township Road 419) just north of the Susquehanna SES fence, in Salem Township, Luzerne County. Quarry Hillside Forest is located on a steep south-facing hillside east of an abandoned quarry above PA Route 239, in Conyngham Township, Luzerne County. The Elimsport Substation Forest was established in 1982 as a control forest plot, so that changes that might occur during operation of the Susquehanna SES could be compared with a remote plot unlikely to be affected by operation of the Susquehanna SES (Montgomery 1983). The Elimsport Substation Forest is located 5.4 km NNE of Elimsport, in Washington Township, Lycoming County, 72 km N84°W of the Susquehanna SES.

The forest plots were sampled for trees and saplings using 10x10-m quadrats, and for seedlings using nested 1x1-m quadrats (Cain and Castro 1959). Details of this sampling procedure are discussed in Montgomery (1985), and earlier annual reports from 1978 through 1984. Frequency, relative frequency, density, relative density, dominance, and relative dominance were calculated (Cain and Castro 1959, Montgomery 1985). Importance value was found as the sum of relative frequency + relative density + relative dominance. Density was not used for shrubs, herbs, and ground cover.

Meteorology

Meteorological records of air temperature, barometric pressure, precipitation, fog, and cloud cover were made as a supplement to flora, vegetation, and bird studies. Temperature and barometric pressure were continuously recorded at the Susquehanna SES Biological Laboratory using a Taylor Weather-Hawk Recording Thermometer and Barometer, respectively. Both instruments were calibrated at least monthly. Minimum and maximum temperatures, with times of occurrence, were tabulated daily, and daily barometric pressure readings were tabulated at 1200 and 2400 hours. Precipitation was collected in a U.S. Weather Bureau Rain Gauge at the Biological Laboratory. The amount was recorded daily except on weekends; precipitation that accumulated on weekends was measured on Monday morning. Fog observations were made at the Biological Laboratory and at Transmission Corridor Field just north of U.S. Route 11 (Fig. F-1) between 0700 and 0800 hours each day except on weekends. Fog was categorized as "light" (visibility one-fourth mile or more) or "dense" (visibility less than one-fourth mile) as done by the U.S. Weather Service. Photographs of the cooling towers were taken at each location to document the presence or absence of fog using a 35-mm Minolta XF-M camera with a macrozoom lens set at 70 mm. Slides were stored at the Biological Laboratory. Weather conditions, including cloud cover and type of precipitation if any, were recorded at the same time as fog observations. Since conditions differed little at the Biological Laboratory and Transmission Corridor Field, data were combined for reporting purposes. Fog was reported if it occurred at either site. Presence or absence of a plume from the cooling towers was determined from the photographs. In cases ot dense fog where plume presence could not be determined, no report of plume was made.

RESULTS AND DISCUSSION

Flora

From 1972 through 1974 and 1977 through 1986, 708 species of vascular plants have been observed in the vicinity of the Susquehanna SES. This total includes 132 woody plants (Table F-2) and 576 herbaceous plants (Table F-3). Two species were observed for the first time on the site in 1986. None of these plants is currently listed or under review as threatened or endangered by the U.S. Department of the Interior (1982, 1983).

Although a complete survey of flora was not made at the Elimsport Substation in 1982-86, 13 species were found on the salt drift transect or in vegetation studies that did not occur at the Susquehanna SES site (Table F-4).

There were 388 plant taxa observed in flower or shedding spores on the forest salt drift transects (Table F-5). QSH (abbreviations are defined in Table F-1) had the greatest number of taxa (217), followed by TR438 (169), TR419 (155), CC (120), RF (117), and ELIM (103). The highest number of taxa in flower or shedding spores on the transects occurred in May. On individual transects, highest numbers occurred in August on RF, TR438, QSH, and ELIM, and in May on TR419 and CC. These are typical patterns that have occurred both before and during Susquehanna SES operation.

Comparison of 1986 forest transect phenology data with 1978 through 1985 data indicated that 175 taxa (45%) occurred on the same transects in 1986 as in 1985, including 110 taxa (28%) which occurred on the same transect for three or more consecutive years (at least 1984-86); 85 taxa (22%) occurred on one additional transect or one fewer transect in 1986 than 1985; and 74 taxa (19%) were more variable in occurrence. In addition, 54 taxa (14%) occurred in 1986, but not in 1985. These data are similar (within 7%) to 1985 figures, and also to preoperational data (within 10%). Changes are due in part to variability to spring flowering plants (discussed in Montgomery 1985, 1986).

Thirty-six parasitic diseases were observed on 49 host species (Table F-7). Three diseases were observed for the first time in 1986. As in 1977-85, leaf spots were the most frequent diseases encountered, accounting for 17 of the 36 diseases (47%) on 21 host species (43%). Powdery mildew occurred on 13 species (27%); eight rust diseases occurred on 15 species (31%).

Disease frequency ranged from rare to abundant (Table F-7) for all kinds of diseases and no pattern was evident. Disease effect ranged from discoloration only for powdery mildews, to minor leaf necrosis for most other diseases. Leaf spot anthracnose (dieback) of *Cornus florida* caused serious effects, including host death, although the effects were not as widespread as in 1984-85. Dr. Barry Towers, Bureau of Forestry, Pennsylvania Department of Agriculture (personal communication, December 1986), indicated that this disease continued to be widespread in Pennsylvania, causing serious losses of trees in many areas.

Numbers of diseases and hosts, and disease frequency were within ranges from previous years for forest transects. No effects were observed that could be attributed to operation of the Susquehanna SES, and no effects of salt drift were observed.

Vegetation

In the Council Cup Forest in 1986, *Betula lenta* was the most important (highest importance value) tree (Table F-7), *Acer rubrum* was the most important sapling (Table F-8) and seedling (Table F-9). These two species have been the most important in the three classes since the study began in 1977, including preoperational (1977-82) and operational (1983-86) periods. Tree density was 640 trees/ha (Table F-7), a slight increase from 1985 but within the range of previous years (Fig. F-2). Sapling density was 1,940/ha (Table F-8), a slight decrease from 1985 (Fig. F-2), and continuing a decline in sapling density recorded since 1977; this is a successional change as the forest matures and saplings are crowded out or recruited into tree size class. Seedling density was 22,500/ha (Table F-9), representing the lowest value since studies began, although seedling density has varied over the years (Fig. F-2). *Vaccinium vacillans* was the most important shrub, and *Lycopodium flabelliforme* the most important herb (Table F-10); litter was the most important ground cover. Each of these has also been the most important since 1977.

In the TR419 Forest, *Quercus velutina* was the most important tree (Table F-11), *Cornus florida* was the most important sapling (Table F-12), and *Sassafras albidum*, the most important seedling (Table F-13). In the tree and sapling classes, these species have been the most important in previous years. Among tree seedlings, *Sassafras albidum*, *Acer rubrum*, and *Fraxinus americana* have been important in different years. Tree density was 524/ha (Table F-11), a slight decrease from 1985 (Fig. F-2). Sapling density was 824/ha (Table F-12); sapling density has exhibited an irregular decline from 1977-86 (Fig.

F-2). Seedling density was 48,333/ha (Table F-13), the lowest recorded from 1978-86 (Fig. F-2). Decreases in saplings and seedlings are probably successional changes as the forest matures. *Rubus allegheniensis* was the most important shrub, *Carex swannii* was the most important herb, and litter was the predominate ground cover (Table F-14). *Rubus allegheniensis* and litter have been most important since 1978. *Dennstaedtia punctilobula* (second in 1986) was the most important herb in earlier years (1978-81); *Carex swannii* has been most important since 1982.

In the Quarry Hillside Forest, *Quercus borealis* was the most important tree (Table F-15) and sapling (Table F-16); *Acer rubrum* was the most important seedling (Table F-17). *Quercus velutina* was the most important tree from 1978-82; *Quercus borealis* was most important from 1983-86. This change may be caused by problems in identification as discussed by Montgomery (1986), *Cornus florida* was the most important sapling from 1978-84; its decrease has been caused by spot anthracnose. Many dead stems in the plot indicate the former abundance of this species. *Acer rubrum* and *Fraxinus americana* have been the most important seedlings from 1978-86. Tree density was 647/ha in 1986 (Fig. F-2), and has remained nearly constant from 1978-86. Sapling density was 842/ha (Fig. F-2). Decreases from *Cornus florida* death have been noted previously. Seedling density was 52,333/ha and has fluctuated between 50,000 and 70,000 since 1978 (Fig. F-2). *Lindera benzoin* was the most important shrub, *Aster divaricatus* was the most important herb, and litter was the predominate ground cover (Table F-18). *Parthenocissus quinquefolia* was the most important shrub from 1978-83 (second in 1986), *Lindera benzoin*, the most important from 1984-86. *Aster divaricatus* and litter have been the most important herb and ground cover, respectively, since 1978.

In the Elimsport Substation Forest, *Acer rubrum* was the most important tree (Table F-19), *Betula lenta* the most important sapling (Table F-20), and *Acer rubrum* the most important seedling (Table F-21). Each of these has been most important in its class since studies at Elimsport were begun in 1982. Tree density was 690/ha, continuing an increase observed each year, 1982-85 (Fig. F-2). Sapling density was 4,875/ha, continuing a decrease from 1978-85 (Fig. F-2). Both of these changes are, like the similar changes in the Council Cup Forest, successional. Seedling density was 57,500/ha, a decrease from 1985, but within the range of earlier years (Fig. F-2). *Smilax rotundifolia* was the most important shrub, *Dennstaedtia punctilobula* was the most important herb, and litter was the most important ground cover (Table F-22). Each has been the most important also in previous years.

Successional changes, including increases in tree density and decreases in sapling density have been observed, especially in the Council Cup and Elimsport Forests. Decreases in *Cornus florida* in all plots is due to death of plants from spot anthracnose. This has been observed at Elimsport Forest as well as the forest plots near the Susquehanna SES. Other changes have been few and can be attributed to natural forest dynamics. No changes have been observed in the Susquehanna SES forests that could be related to the operation of the Susquehanna SES.

Meteorology

Meteorological data are presented in Table F-23. January was the coldest month (mean temperature, 0.3 C), and July was the warmest month (mean temperature, 22.5 C). Lowest temperature was recorded on 29 January (-14.0 C), and maximum temperature on 7 July (35.5 C). Barometric pressure is also reported in Table F-23. Rainfall was least in September and greatest in July. Fog occurred on 50 days of 251 days of observation (20%). Light fog occurred on 29 days, dense fog on 21 days. September had 13 days of fog, October 9, and August 7; no fog was observed in May or December. Fog occurred on 25 days with a plume present from one tower, 10 days with plumes from both towers, and 7 days when no plume was present from either tower. On 8 days, a plume could not be determined. As indicated above, fog was most prevalent in autumn 1986, when Unit 2 was being refueled. There was no evidence of a relationship between the plume from the Susquehanna SES cooling towers and fog, since fog was either widespread in the valley or local along the Susquehanna River, but not related to the distance and direction of the plume.

REFERENCES CITED

Burton, J. R. 1976. Terrestrial ecology. Pages 280-314 in T. V. Jacobsen (ed.), Ecological studies of the North Branch Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Progress report for the period January-December 1974). Ichthyological Associates. Inc., Berwick, PA.

Cain, S. A. and G. M. O. Castro. 1959. Manual of vegetation analysis. Harper and Brothers, New York, NY. 325 pp.

Fernald, M. L. 1950. Gray's new manual of botany. 8th ed. American Book Co., New York, NY. 1632 pp.

Gleason, H. A. and A. Cronquist. 1963. Manual of vascular plants of northeastern United States and adjacent Canada. D. Van Nostrand Co., New York, NY. 810 pp.

Hepting, G. H. 1971. Diseases of forest and shade trees of the United States. U.S. Dept. Agric. Handbook No. 386. U.S. Govt. Printing Office, Washington, DC. 658 pp.

Hitchcock, A. S. 1950. Manual of the grasses of the United States. 2nd ed. Revised by A. Chase. U.S. Govt. Printing Office, Washington, DC. 1051 pp.

Ichthyological Associates, Inc. 1973. An ecological study of the North Branch Susquehanna River in the vicinity of Berwick, Pennsylvania (Progress report for the period January-December 1972). Pa. Power and Light Co., Allentown, PA. 658 pp.

________. 1974. An ecological study of the North Branch Susquehanna River in the vicinity of Berwick, Pennsylvania (Progress report for the period January-December 1973). Pa. Power and Light Co., Allentown, PA. 838 pp.

Mickel, J. T. 1979. How to know the ferns and fern allies. William C. Brown Co., Dubuque, IA. 229 pp.

Montgomery, J. D. 1978. Flora and vegetation. Pages 279-310 _in_ T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1977). Ichthyological Associates, Inc., Berwick, PA.

________. 1979. Flora and vegetation. Pages 196-249 _in_ T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1978). Ichthyological Associates, Inc., Berwick, PA.

________. 1980. Flora and vegetation. Pages 196-249 _in_ T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1979). Ichthyological Associates, Inc., Berwick, PA.

________. 1981. Flora and vegetation. Pages 197-254 _in_ T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1980). Ichthyological Associates, Inc., Berwick, PA.

________. 1982. Flora and vegetation. Pages 209-278 _in_ T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1981 annual report). Ichthyological Associates, Inc., Berwick, PA.

________. 1983. Flora and vegetation. Pages 212-285 _in_ T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1982 annual report). Ichthyological Associates, Inc., Berwick, PA.

________. 1984. Flora, vegetation, and meteorology. Pages 199 to 282 _in_ T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1983 annual report). Ichthyological Associates, Inc., Berwick, PA.

________. 1985. Flora, vegetation, and meteorology. Pages 198-285 _in_ T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1984 annual report). Ichthyological Associates, Inc., Berwick, PA.

________. 1986. Flora, vegetation, and meteorology. Pages 140-222 _in_ T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1985 annual report). Ecology III, Inc., Berwick, PA.

Pennsylvania Department of Environmental Resources. 1975. Forest insect and disease management manual. Bureau of Forestry, Harrisburg, PA. 184 pp.

Peterson, R. T. and M. McKenny. 1968. A field guide to wildflowers of northeastern and north-central North America. Houghton Mifflin Co., Boston, MA. 420 pp.

U. S. Department of Agriculture. 1960. Index of plant diseases in the United States. Agric. Handbook No. 165. U.S. Govt. Printing Office, Washington, DC.

U. S. Department of the Interior. 1982. Endangered and threatened wildlife and plants. 50 CFR 17.11 and 17.12.

________. 1983. Endangered and threatened wildlife and plants; supplement to review of plant taxa for listing; proposed rule. Federal Register 48(229): 53640-53670.

Westcott, C. 1971. Plant disease handbook. 2nd ed. D. Van Nostrand Co., New York, NY. 825 pp.

Wherry, E. T. 1961. The fern guide. Doubleday and Co., Inc., Garden City, NY. 318 pp.

Table F-1

Location of salt drift transects in the vicinity of the Susquehanna SES and at the Elimsport Substation, 1986.

Transect (Abbreviation)	Direction from SSES	Distance from SSES (km)	Habitat Type	Transect Length (km)	Location of Transect
River Forest (RF)	E-NE	1.5-2.0	River bottom hardwood forest	1.2	Adjacent to the Susquehanna River, north from Susquehanna SES Biological Laboratory to southern tip of Gould Island
TR 419 (TR419)	N	0.5-1.2	Upland hardwood-pine forest	1.5	Along Township Road 419, from U.S. 11 to T.R. 438
TR 438 (TR438)	W-SW	0.4-1.9	Upland forest, open field, marsh	2.3	Along Township Road 438, from T.R. 419 to the entrance of abandoned race track
Quarry-Spring House Trail (QSH)	ENE	2.2-3.2	Upland hardwood-pine forest	2.3	Trail from PA. 239 (quarry trail) to the transmission line along ridge top to the transmission line down the slope of Little Wapwallopen Valley to a trail past an abandoned spring house, ending on PA. 239
Council Cup (CC)	ESE	2.8-3.3	Upland hardwood-pine forest	1.4	Council Cup Nature Trail and Overlook
Elimsport Substation (Elim)	WNW	72	Upland forest and transmission line	0.8	Adjacent to and east of Elimsport Substation, 5.4 km NNE of Elimsport, Lycoming County

Table F-2

Species of woody plants observed in the vicinity of the Susquehanna SES, 1972-74 and 1977-86. Taxa are arranged alphabetically within phyla.

PINOPHYTA
- Cupressaceae
  - *Juniperus virginiana* - red cedar
  - *Thuja occidentalis* - arbor vitae
- Pinaceae
  - *Picea glauca* - white spruce
  - *P. rubens* - red spruce
  - *Pinus rigida* - pitch pine
  - *P. strobus* - white pine
  - *P. sylvestris* - scotch pine
  - *P. virginiana* - Virginia pine
  - *Tsuga canadensis* - eastern hemlock

MAGNOLIOPHYTA-DICOTYLEDONEAE
- Aceraceae
  - *Acer negundo* - box-elder
  - *A. nigrum* - black maple
  - *A. pensylvanicum* - striped maple
  - *A. platanoides* - Norway maple
  - *A. rubrum* - red maple
  - *A. saccharinum* - silver maple
  - *A. saccharum* - sugar maple
  - *A. spicatum* - mountain maple
- Anacardiaceae
  - *Rhus copallina* - winged sumac
  - *R. glabra* - smooth sumac
  - *R. radicans* - poison ivy
  - *R. typhina* - staghorn sumac
  - *R. vernix* - poison sumac
- Aquifoliaceae
  - *Ilex verticellata* - winterberry
- Berberidaceae
  - *Berberis thunbergii* - Japanese barberry
- Betulaceae
  - *Alnus rugosa* - speckled alder
  - *Betula lenta* - sweet birch
  - *B. lutea* - yellow birch
  - *B. nigra* - river birch
  - *B. papyrifera* - paper birch
  - *B. populifolia* - gray birch
  - *Carpinus caroliniana* - American hornbeam
  - *Corylus americana* - hazel-nut
  - *Ostrya virginiana* - hop-hornbeam
- Bignoniaceae
  - *Campsis radicans* - trumpet-creeper
  - *Catalpa bignonioides* - catalpa
- Caprifoliaceae
  - *Diervilla lonicera* - bush-honeysuckle
  - *Lonicera tatarica* - tartarian honeysuckle
  - *Sambucus canadensis* - common elder
  - *S. pubens* - red-berried elder
  - *Viburnum acerifolium* - maple-leaf viburnum
  - *V. dentatum* - arrowwood
- Celastraceae
  - *Celastrus scandens* - bittersweet
- Cornaceae
  - *Cornus alternifolia* - alternate-leaf dogwood
  - *C. amomum* - silky dogwood
  - *C. florida* - flowering dogwood
  - *C. racemosa* - gray dogwood
  - *C. rugosa* - round-leaf dogwood
  - *Nyssa sylvatica* - black gum
- Elaeagnaceae
  - *Elaeagnus commutata* - silverberry
- Ericaceae
  - *Gaylussacia baccata* - black huckleberry
  - *Kalmia angustifolia* - sheep laurel
  - *K. latifolia* - mountain laurel
  - *Rhododendron maximum* - rhododendron
  - *R. nudiflorum* - pinxter-flower
  - *R. roseum* - mountain azalea
  - *Vaccinium corymbosum* - high-bush blueberry
  - *V. stamineum* - deerberry
  - *V. vacillans* - low-bush blueberry
- Fagaceae
  - *Castanea dentata* - American chestnut
  - *Fagus grandifolia* - American beech
  - *Quercus alba* - white oak
  - *Q. bicolor* - swamp white oak
  - *Q. borealis* - red oak
  - *Q. ilicifolia* - scrub oak
  - *Q. palustris* - pin oak
  - *Q. prinus* - chestnut oak
  - *Q. veluntina* - black oak
- Hamamelidaceae
  - *Hamamelis virginiana* - witch hazel
- Juglandaceae
  - *Carya cordiformis* - bitternut hickory
  - *C. glabra* - pignut hickory
  - *C. ovata* - shagbark hickory
  - *C. tomentosa* - mockernut hickory
  - *Juglans cinerea* - butternut
  - *J. nigra* - black walnut
- Lauraceae
  - *Lindera benzoin* - spicebush
  - *Sassafras albidum* - sassafras
- Leguminosae
  - *Gleditsia triacanthos* - honey locust
  - *Robinia pseudoacacia* - black locust
  - *Wisteria floribunda* - wisteria
- Magnoliaceae
  - *Liriodendron tulipifera* - tulip-tree
- Moraceae
  - *Morus rubra* - red mulberry
- Myricaceae
  - *Myrica asplenifolia* - sweet fern
- Oleaceae
  - *Forsythia* sp. - forsythia
  - *Fraxinus americana* - white ash
  - *F. pennsylvanica* - red ash
  - *Ligustrum vulgare* - common privet
  - *Syringa vulgaris* - lilac
- Platanaceae
  - *Platanus occidentalis* - sycamore
- Rhamnaceae
  - *Ceanothus americanus* - New Jersey tea
- Rosaceae
  - *Amelanchier arborea* - shad-bush
  - *A. stolonifera* - shad-bush
  - *Aronia melanocarpa* - chokeberry
  - *Crataegus pruinosa* - hawthorne
  - *Crataegus* sp. - hawthorne
  - *Physocarpus opulifolius* - ninebark
  - *Prunus avium* - sweet cherry
  - *P. pensylvanica* - pin cherry
  - *P. serotina* - black cherry
  - *P. virginiana* - choke cherry

Rosaceae (cont.)
- *Pyrus communis* - pear
- *P. malus* - apple
- *Pyrus* sp. - crabapple
- *Rosa canina* - dog-rose
- *R. multiflora* - multiflora rose
- *R. palustris* - swamp rose
- *R. virginiana* - wild rose
- *Rubus allegheniensis* - blackberry
- *R. flagellaris* - dewberry
- *R. hispidus* - dewberry
- *R. occidentalis* - black raspberry
- *Spiraea latifolia* - meadow-sweet
- *S. tomentosa* - steeplebush

Rubiaceae
- *Cephalanthus occidentalis* - buttonbush

Rutaceae
- *Zanthoxylum americanum* - prickly ash

Salicaceae
- *Populus grandidentata* - big-toothed aspen
- *P. tremuloides* - quaking aspen
- *Salix humilis* - prairie willow
- *S. nigra* - black willow
- *S. sericea* - silky willow
- *Salix* sp. - willow

Saxifragaceae
- *Hydrangea arborescens* - hydrangea
- *Ribes americanum* - wild black currant

Staphyleaceae
- *Staphylea trifolia* - bladder-nut

Tiliaceae
- *Tilia americana* - basswood

Ulmaceae
- *Celtis occidentalis* - hackberry
- *Ulmus americana* - American elm
- *U. rubra* - slippery elm

Vitaceae
- *Parthenocissus quinquefolia* - Virginia creeper
- *Vitis aestivalis* - summer grape
- *V. labrusca* - fox grape
- *V. riparia* - riverbank grape

MAGNOLIOPHYTA-MONOCOTYLEDONEAE

Liliaceae
- *Smilax rotundifolia* - greenbrier

Table F-3

Species of herbaceous plants observed in the vicinity of the Susquehanna SES, 1972-74 and 1977-86. Taxa are arranged alphabetically within phyla. An asterisk (*) indicates taxa observed for the first time in 1986.

EQUISETOPHYTA
Equisetaceae
Equisetum arvense - field horsetail
E. sylvaticum - woodland horsetail

LYCOPODIOPHYTA
Isoetaceae
Isoetes engelmannii - Englemann's quillwort

Lycopodiaceae
Lycopodium clavatum - staghorn clubmoss
L. flabelliforme - ground pine
L. inundatum - bog clubmoss
L. lucidulum - shining clubmoss
L. obscurum - tree clubmoss
L. tristachyum - ground cedar
Lycopodium X habereri - hybrid clubmoss

Selaginellaceae
Selaginella apoda - meadow spike-moss

POLYPODIOPHYTA
Ophioglossaceae
Botrychium dissectum - grape fern
B. lanceolatum - lanceolate
B. matricariifolium - daisy-leaf grape fern
B. virginianum - rattlesnake fern

Osmundaceae
Osmunda cinnamomea - cinnamon fern
O. claytoniana - interrupted fern

Polypodiaceae
Adiantum pedatum - maidenhair fern
Asplenium platyneuron - ebony spleenwort
Athyrium filix-femina - lady fern
A. thelypterioides - silvery spleenwort
Cystopteris fragilis - fragile fern
C. protrusa - lowland fragile fern
Dennstaedtia punctilobula - hay-scented fern
Dryopteris cristata - crested wood fern
D. intermedia - evergreen wood fern
D. marginalis - marginal wood fern
D. spinulosa - spinulose wood fern
Dryopteris X boottii - Boott's wood fern
Dryopteris X triploidea - hybrid wood fern
Dryopteris X uligonosa - hybrid wood fern
Gymnocarpium dryopteris - oak fern
Matteuccia struthiopteris - ostrich fern
Onoclea sensibilis - sensitive fern
Polypodium virginianum - common polypody
Polystichum acrostichoides - Christmas fern
Pteridium aquilinum - bracken
Thelypteris noveboracensis - New York fern
T. palustris - marsh fern
Woodsia ilvensis - rusty woodsia
W. obtusa - blunt-lobed woodsia

MAGNOLIOPHYTA-DICOTYLEDONEAE

Acanthaceae
Justicia americana - water-willow

Aizoaceae
Mollugo verticillata - carpet-weed

Apocynaceae
Apocynum androsaemifolium - dogbane
A. cannabinum - Indian hemp
Vinca minor - periwinkle

Araliaceae
Aralia nudicaulis - wild sarsaparilla
Panax trifolium - dwarf ginseng

Asclepiadaceae
Asclepias amplexicaulis - blunt-leaved milkweed
A. incarnata - swamp milkweed
A. quadrifolia - four-leaved milkweed
A. syriaca - common milkweed
A. tuberosa - butterfly-weed
A. viridiflora - green milkweed

Asteraceae
Achillea millefolium - yarrow
Ambrosia artemisiifolia - ragweed
A. trifida - giant ragweed
Anaphalis margaritacea - pearly everlasting
Antennaria neglecta - pussytoes
A. plantaginifolia - pussytoes
Anthemis cotula - mayweed
Arctium minus - burdock
Aster acuminatus - whorled wood aster
A. cordifolius - heart-leaved aster
A. divaricatus - white wood aster
A. dumosus - aster
A. laevis - smooth aster
A. lateriflorus - calico aster
A. novae-angliae - New England aster
A. patens - late purple aster
A. paternus - aster
A. pilosus - aster
A. prenanthoides - aster
A. puniceus - purple-stemmed aster
A. simplex - aster
A. umbellatus - flat-topped white aster
A. undulatus - aster
Bidens cernua - beggar-ticks
B. frondosa - beggar-ticks
B. tripartita - beggar-ticks
Cacalia suaveolens - Indian-plantain
Centaurea maculosa - spotted knapweed
Chrysanthemum leucanthemum - ox-eye daisy
Cichorium intybus - chicory
Cirsium arvense - Canada thistle
C. pumilum - pasture thistle
C. vulgare - bull thistle
Conyza canadensis - horseweed
Erechtites hieracifolia - fireweed
Erigeron annus - daisy fleabane
E. philadelphicus - dairy fleabane
Eupatorium fistulosum - Joe-Pye-weed
E. maculatum - spotted Joe-Pye-weed
E. perfoliatum - boneset
E. rugosum - white snakeroot
Galinsoga ciliata - galinsoga
Gnaphalium obtusifolium - cudweed
G. uliginosum - cudweed
Helenium autumnale - sneezeweed
Helianthus decapetalus - thin-leaf sunflower
H. divaricatus - woodland sunflower
H. tuberosus - Jerusalem artichoke
Heliopsis helianthoides - ox-eye
Hieracium aurantiacum - king-devil
H. paniculatum - hawkweed
H. pilosella - mouse-ear hawkweed
H. pratense - hawkweed
H. scabrum - hawkweed
H. venosum - rattlesnake-weed
Krigia virginica - dwarf dandelion
Lactuca canadensis - wild lettuce
Matricaria matricarioides - pineapple-weed
Prenanthes alba - tall white lettuce
Rudbeckia hirta - black-eyed susan
R. laciniata - coneflower
Senecio aureus - golden ragwort
S. obovatus - roundleaf ragwort
Solidago arguta - sharp-leaved goldenrod
S. bicolor - silverrod
S. caesia - blue-stemmed goldenrod
S. canadensis - Canada goldenrod
S. flexicaulis - zigzag goldenrod
S. gigantea - late goldenrod
S. graminifolia - flat-topped goldenrod
S. juncea - early goldenrod
S. nemoralis - little gray goldenrod
S. rugosa - rough goldenrod
Taraxacum officinale - dandelion
Tragopogon dubius - goat's beard
Tussilago farfara - coltsfoot
Vernonia noveboracensis - ironweed
Xanthium strumarium - cocklebur

Table F-3 (cont.)

Balsaminaceae
Impatiens biflora - jewelweed
I. pallida - pale jewelweed

Berberidaceae
Caulophyllum thalictroides - blue cohosh
Podophyllum peltatum - may apple

Boraginaceae
Hackelia virginiana - beggar's lice
Mertensia virginica - Virginia bluebells
Myosotis laxa - forget-me-not
M. scorpioides - forget-me-not
M. verna - forget-me-not

Callitrichaceae
Callitriche heterophylla - water starwort

Campanulaceae
Campanula aparinoides - marsh bellflower
Triodanis perfoliata - Venus' looking-glass

Cannabinaceae
Cannabis sativa - marijuana

Caprifoliacea
Lonicera japonica - Japanese honeysuckle

Caryophyllaceae
Agrostemma githago - corn-cockle
Arenaria serpyllifolia - sandwort
Cerastium arvense - field chickweed
C. vulgatum - mouse-ear chickweed
Dianthus armeria - deptford pink
Lychnis alba - white campion
Paronychia canadensis - whitlow-wort
Saponaria officinalis - bouncing bet
Silene stellata - starry campion
Stellaria aquatica - chickweed
S. graminea - common stitchwort
S. longifolia - chickweed
S. media - common chickweed

Ceratophyllaceae
Ceratophyllum demersum - hornwort

Chenopodiaceae
Chenopodium album - lamb's quarters
C. ambrosioides - Mexican tea

Cistaceae
Helianthemum canadense - frostweed
**Lechea racemulosa* - pinweed

Convolvulaceae
Convolvulus sepium - hedge bindweed
Cuscuta gronovii - dodder

Crassulaceae
Penthorum sedoides - ditch stonecrop
Sedum telephium - orpine

Cruciferae
Alliaria officinalis - garlic mustard
Arabidopsis thalliana - mouse-ear cress
Arabis canadensis - rock cress
A. glabra - rock cress
A. laevigata - rock cress
A. lyrata - rock cress
A. shortii - rock cress

Cruciferae (cont.)
Barbarea vulgaris - wintercress
Brassica campestris - field mustard
B. kaber - charlock
B. nigra - black mustard
Capsella bursa-pastoris - shepherd's purse
Cardamine bulbosa - bitter cress
C. parviflora - bitter cress
C. pensylvanica - bitter cress
C. pratensis - cuckoo-flower
Dentaria diphylla - pepperwort
D. laciniata - cut-leaf toothwort
Draba verna - whitlow-grass
Erysinum cheiranthoides - wormseed mustard
Hesperis matronalis - dame's rocket
Lepidium campestre - field cress
L. virginicum - pepper-grass
Nasturtium officinale - water-cress
Rorippa islandica - marsh cress
R. sylvestris - yellow cress
Sisymbrium altissimum - tumble mustard
S. officinale - water-cress
Thlaspi arvense - field pennycress

Cucurbitaceae
Echinocystis lobata - wild cucumber
Sicyos angulatus - bur-cucumber

Ericaceae
Chimaphila maculata - spotted wintergreen
C. umbellata - pipsissewa
Epigaea repens - trailing arbutus
Gaultheria procumbens - wintergreen
Monotropa uniflora - Indian pipe
Pyrola elliptica - shinleaf

Euphorbiaceae
Acalypha rhomboidea - three-seeded mercury
Euphorbia maculata - spurge
E. preslii - spurge

Fumariaceae
Corydalis flavula - corydalis
C. sempervirens - corydalis
Dicentra cucullaria - Dutchman's breeches

Gentianaceae
Gentiana andrewsii - bottle gentian
G. crinita - fringed gentian

Geraniaceae
Geranium carolinianum - Carolina cranesbill
G. maculatum - wild geranium

Hydrophyllaceae
Hydrophyllum virginianum - waterleaf

Hypericaceae
Hypericum gentianoides - St. John's wort
H. mutilum - St. John's wort
H. perforatum - common St. John's wort
H. punctatum - spotted St. John's wort
H. pyramidatum - great St. John's wort
Triadenum virginicum - marsh St. John's wort

Labiatae
Collinsonia canadensis - horse-balm
Cunila origanoides - dittany
Galeopsis tetrahit - hemp-nettle
Glecoma hederacea - gill-over-the-ground
Hedeoma pulegioides - American pennyroyal
Lamium amplexicaule - dead nettle
L. purpureum - dead nettle
Leonurus cardiaca - motherwort
Lycopus americanus - water horehound
L. virginicus - water horehound

Table F-3 (cont.)

Labiatae (cont.)
- *Monarda clinopodia* - wild bergamot
- *M. fistulosa* - wild bergamot
- *Nepeta cataria* - catnip
- *Prunella vulgaris* - self-heal
- *Pycnanthemum incanum* - mountain-mint
- *P. virginianum* - mountain-mint
- *Satureja vulgaris* - wild basil
- *Scutellaria galericulata* - skullcap
- *S. lateriflora* - skullcap
- *Stachys hispida* - rough hedge-nettle
- *Teucrium canadense* - woodsage
- *Trichostema dichotomum* - blue curls

Leguminosae
- *Amphicarpa bracteata* - hog peanut
- *Apios americana* - groundnut
- *Baptisia tinctoria* - wild indigo
- *Cassia nictitans* - wild sensitive plant
- *Coronilla varia* - crown vetch
- *Desmodium canescens* - tick-trefoil
- *D. dillenii* - tick-trefoil
- *D. glutinosum* - tick-trefoil
- *D. lineatum* - tick-trefoil
- *D. nudiflorum* - tick-trefoil
- *D. paniculatum* - tick-trefoil
- *Lathyrus latifolius* - everlasting pea
- *Lespedeza hirta* - bush-clover
- *L. intermedia* - bush-clover
- *L. violacea* - bush-clover
- *L. virginica* - bush-clover
- *Lotus corniculatus* - bird's-foot trefoil
- *Medicago lupulina* - black medick
- *Melilotus alba* - white sweet clover
- *M. officinalis* - yellow sweet clover
- *Trifolium agrarium* - hop-clover
- *T. arvense* - rabbit-foot clover
- *T. hybridum* - alsike clover
- *T. pratense* - red clover
- *T. repens* - white clover
- *Vicia cracca* - cow vetch

Lentibulariaceae
- *Utricularia vulgaris* - bladderwort

Limnanthaceae
- *Floerkia proserpinacoides* - false mermaid

Linaceae
- *Linum virginianum* - wild flax

Lobeliaceae
- *Lobelia cardinalis* - cardinal-flower
- *L. inflata* - Indian-tobacco
- *L. siphilitica* - great lobelia
- *L. spicata* - lobelia

Lythraceae
- *Lythrum salicaria* - purple loosestrife

Malvaceae
- *Abutilon theophrasti* - velvet-leaf
- *Malva neglecta* - cheeses

Onograceae
- *Circaea quadrisulcata* - enchanter's nightshade
- *Epilobium coloratum* - willow-herb
- *Gaura biennis* - biennial gaura
- *Ludwigia alternifolia* - seed-box
- *L. palustris* - seed-box
- *Oenothera biennis* - evening-primrose
- *O. perennis* - sundrops

Orobanchaceae
- *Orobanche uniflora* - cancer-root

Oxalidaceae
- *Oxalis dillenii* - yellow wood sorrel
- *O. stricta* - yellow wood sorrel
- *O. violacea* - violet wood sorrel

Papaveraceae
- *Chelidonium majus* - celandine
- *Sanguinaria canadensis* - bloodroot

Phytolaccaceae
- *Phytolacca americana* - pokeweed

Plantaginaceae
- *Plantago aristata* - buckhorn
- *P. lanceolata* - English plantain
- *P. major* - common plantain

Polemoniaceae
- *Phlox paniculata* - phlox
- *P. subulata* - moss-pink
- *Polemonium reptans* - Jacob's ladder

Polygalaceae
- *Polygala paucifolia* - fringed polygala
- *P. sanguinea* - cross-leaved milkwort
- *P. verticillata* - whorled milkwort

Polygonaceae
- *Polygonum arifolium* - halberd-leaved tearthumb
- *P. aviculare* - knotweed
- *P. caespitosum* - long-bristled smartweed
- *P. cilinode* - bindweed
- *P. convolvulus* - black bindweed
- *P. cuspidatum* - Mexican bamboo
- *P. hydropiperoides* - mild water pepper
- *P. natans* - water smartweed
- *P. pensylvanicum* - smartweed
- *P. persicaria* - smartweed
- *P. punctatum* - smartweed
- *P. sagittatum* - arrow-leaved tearthumb
- *P. scandens* - false buckwheat
- *P. virginanum* - Virginia knotweed
- *Rumex acetosella* - sheep sorrel
- *R. crispus* - curly dock
- *R. obtusifolius* - bitter dock
- *R. patientia* - patience dock

Portulacaceae
- *Claytonia virginica* - spring beauty

Primulaceae
- *Lysimachia ciliata* - fringed loosestrife
- *L. quadrifolia* - whorled loosestrife
- *L. terrestris* - yellow loosestrife
- *L. vulgaris* - garden loosestrife
- *Trientalis borealis* - starflower

Ranunculaceae
- *Anemone canadensis* - Canada anemone
- *A. quinquefolia* - wood anemone
- *A. virginiana* - thimbleweed
- *Anemonella thalictroides* - rue anemone
- *Aquilegia canadensis* - columbine
- *Cimicifuga racemosa* - bugbane
- *Clematis virginiana* - virgin's bower
- *Coptis trifolia* - goldthread
- *Hepatica americana* - hepatica
- *Ranunculus abortivus* - kidneyleaf buttercup
- *R. acris* - common buttercup

Table F-3 (cont.)

Ranunculaceae (cont.)
- *Ranunculus bulbosus* - buttercup
- *R. pensylvanicus* - buttercup
- *R. recurvatus* - buttercup
- *R. repens* - creeping buttercup
- *R. septentrionalis* - buttercup
- *Thalictrum dioicum* - early meadow rue
- *T. polygamum* - tall meadow rue

Rosaceae
- *Agrimonia grypsosepala* - agrimony
- *Fragaria virginiana* - wild strawberry
- *Geum canadense* - avens
- *G. laciniatum* - avens
- *Gillenia trifoliata* - bowman's root
- *Potentilla canadensis* - dwarf cinquefoil
- *P. norvegica* - rough cinquefoil
- *P. recta* - rough-fruited cinquefoil
- *P. simplex* - cinquefoil

Rubiaceae
- *Galium aparine* - cleavers
- *G. asprellum* - bedstraw
- *G. boreale* - bedstraw
- *G. circaezans* - bedstraw
- *G. mollugo* - cleavers
- *G. palustre*- bedstraw
- *G. trifidum* - bedstraw
- *G. triflorum* - bedstraw
- *Houstonia caerulea* - bluets
- *Mitchella repens* - partridge-berry

Santalaceae
- *Comandra umbellata* - bastard toad-flax

Saxigragaceae
- *Chrysosplenum americanum* - golden saxifrage
- *Mitella diphylla* - miterwort
- *Saxifraga virginiensis* - early saxifrage

Scrophylariaceae
- *Aureolaria virginica* - downy false foxglove
- *Chelone glabra* - turtle-head
- *Gerardia tenuifolia* - slender gerardia
- *Linaria vulgaris* - butter-and-eggs
- *Lindernia dubia* - false pumpernel
- *Melamphrym lineare* - cow-wheat
- *Mimulus ringens* - monkey-flower
- *Pedicularis canadensis* - lousewort
- *Penstemon digitalis* - beard-tongue
- *P. hirsutis* - hairy beard-tongue
- *Scrophylaria lanceolata* - figwort
- *Verbascum blattaria* - moth mullein
- *V. thapsus* - common mullein
- *Veronica americana* - American brooklime
- *V. arvensis* - speedwell
- *V. officinalis* - common speedwell
- *V. peregrina* - speedwell
- *V. serpyllifolia* - speedwell
- *Veronicastrum virginicum* - culver's root

Solanaceae
- *Physalis heterophylla* - ground cherry
- *Solanum carolinense* - horse-nettle
- *S. dulcamara* - nightshade
- *S. nigrum* - black nightshade

Umbelliferae
- *Cicuta bulbifera* - water hemlock
- *C. maculata* - water hemlock
- * *Conium maculatum* - poison hemlock
- *Cryptotaenia canadensis* - honewort
- *Daucus carota* - Queen Anne's lace
- *Osmorhiza claytoni* - sweet cicely
- *O. longistylis* - sweet cicely

Umbelliferae (cont.)
- *Pastinaca sativa* - wild parsnip
- *Sanicula marilandica* - black snakeroot
- *Zizea aptera* - golden alexanders
- *Z. aurea* - golden alexanders

Urticaceae
- *Boehmeria cylindrica* - false nettle
- *Parietaria pensylvanica* - pellitory
- *Pilea pumila* - clearweed
- *Urtica dioica* - stinging nettle

Valerianaceae
- *Valerianella locusta* - corn-salad

Verbenaceae
- *Verbena hastata* - blue vervain
- *V. urticifolia* - white vervain
- *V.* x *engelmannii* - hybrid vervain

Violaceae
- *Viola blanda* - sweet white violet
- *V. conspersa* - American dog-violet
- *V. cucullata* - blue marsh violet
- *V. eriocarpa* - smooth yellow violet
- *V. fimbriatula* - northern downy violet
- *V. palmata* - wood-violet
- *V. papilionacea* - common blue violet
- *V. pubescens* - downy yellow violet
- *V. sororia* - woolly blue violet
- *V. striata* - pale violet

MAGNOLIOPHYTA-MONOCOTYLEDONEAE

Alismaceae
- *Alisma subcordatum* - water-plantain
- *Sagittaria latifolia* - arrow-head

Amaryllidaceae
- *Hypoxis hirsuta* - stargrass

Araceae
- *Acorus calamus* - sweet flag
- *Arisaema dracontium* - green dragon
- *A. triphyllum* - jack-in-the-pulpit
- *Symplocarpus foetidus* - skunk cabbage

Commelinaceae
- *Commelina communis* - day-flower

Cyperaceae
- *Bulbostylis capillaris* - sedge
- *Carex annectens* - sedge
- *C. bromoides* - sedge
- *C. comosa* - sedge
- *C. crinita* - sedge
- *C. debilis* - sedge
- *C. intumescens* - sedge
- *C. lacustris* - sedge
- *C. laevivaginata* - sedge
- *C. laxiflora* - sedge
- *C. lurida* - sedge
- *C. muhlenbergii* - sedge
- *C. pensylvanica* - sedge
- *C. rosea* - sedge
- *C. scoparia* - sedge
- *C. stipata* - sedge
- *C. stricta* - sedge
- *C. swannii* - sedge
- *C. tribuloides* - sedge
- *C. vulpinoidea* - sedge
- *Carex* sp. (unidentified) - sedge
- *Cyperus esculentus* - yellow nut-grass
- *C. filiculmis* - galingale
- *C. odoratus* - galingale
- *C. strigosus* - galingale
- *Dulichium arundinaceum* - three-way sedge

Table F-3 (cont.)

Cyperaceae (cont.)
- *Eleocharis acicularis* - spike-rush
- *E. intermedia* - spike-rush
- *E. obtusa* - spike-rush
- *E. tenuis* - spike-rush
- *Scirpus americanus* - three-sqaure
- *S. atrovirens* - bulrush
- *S. cyperinus* - woolgrass
- *S. validus* - great bulrush

Dioscoreaceae
- *Dioscorea villosa* - wild yam

Gramineae
- *Agropyron repens* - quack grass
- *Agrostis hyemalis* - bentgrass
- *A. perennans* - autumn bent
- *A. stolonifera* - bentgrass
- *Alopecurus aequalis* - foxtail
- *Andropogon gerardi* - big bluestem
- *A. scoparius* - little bluestem
- *A. virginicus* - broom sedge
- *Anthoxanthum odoratum* - sweet vernal grass
- *Aristida dichotoma* - three-awn
- *Arrhenantherum elatius* - oat-grass
- *Bromus inermis* - smooth brome
- *B. japonicus* - Japanese chess
- *B. latiglumis* - bromegrass
- *B. mollis* - soft chess
- *B. tectorum* - downy chess
- *Cinna arundinacea* - stout woodreed
- *Dactylis glomerata* - orchard grass
- *Danthonia spicata* - poverty oatgrass
- *Deschampsia flexuosa* - hairgrass
- *Digitaria ischaemum* - crabgrass
- *D. sanguinalis* - crabgrass
- *Echinochloa muricata* - barnyard grass
- *Elymus canadensis* - wild rye
- *E. riparius* - wild rye
- *E. villosus* - wild rye
- *E. virginicus* - wild rye
- *Eragrostis capillaris* - lovegrass
- *E. ciliansis* - lovegrass
- *E. frankii* - lovegrass
- *E. hypnoides* - lovegrass
- *E. pilosa* - lovegrass
- *E. spectabilis* - purple lovegrass
- *Eulalia viminea* - Japanese stilt-grass
- *Festuca elatior* - meadow fescue
- *F. obtusa* - nodding fescue
- *F. rubra* - red fescue
- *Glyceria canadensis* - rattlesnake mannagrass
- *G. striata* - fowl mannagrass
- *Holcus lanatus* - velvet grass
- *Hysterix patula* - bottlebrush
- *Leersia oryzoides* - rice cutgrass
- *L. virginica* - white grass
- *Lolium perenne* - perennial ryegrass
- *Muhlenbergia frondosa* - wirestem muhly
- *M. schreberi* - nimblewill
- *M. sobolifera* - muhly
- *Panicum boscii* - panic-grass
- *P. capillare* - witch grass
- *P. clandestinum* - panic-grass
- *P. commutatum* - panic-grass
- *P. depauperatum* - panic-grass
- *P. dichotomiflorum* - panic-grass
- *P. dichotomum* - panic-grass
- *P. lanuginosum* - panic-grass
- *P. nitidum* - panic-grass
- *P. virgatum* - switchgrass
- *Paspalum pubescens* - paspalum
- *Phalaris arundinacea* - reed canary grass
- *Phleum pratense* - timothy
- *Poa annua* - speargrass
- *P. compressa* - Canada bluegrass
- *P. palustris* - fowl bluegrass
- *P. pratensis* - Kentucky bluegrass
- *P. trivialis* - bluegrass
- *Setaria faberii* - nodding foxtail
- *S. glauca* - foxtail grass
- *S. italica* - foxtail millet

Gramineae (cont.)
- *Sorghastrum nutans* - Indian grass
- *Sphenopholis intermedia* - wedgegrass
- *Sporobolus vaginiflorus* - dropseed
- *Triodia flava* - purpletop

Hydrocharitaceae
- *Anacharis canadensis* - water-weed

Iridaceae
- *Iris versicolor* - blue flag
- *Sisyrinchium angustifolium* - blue-eyed grass

Juncaceae
- *Juncus acuminatus* - rush
- *J. effusus* - rush
- *J. tenuis* - path rush
- *Luzula campestris* - wood rush

Lemnaceae
- *Lemna minor* - duckweed
- *Wolffia punctata* - water meal

Liliaceae
- *Allium canadense* - wild garlic
- *A. vineale* - field garlic
- *Asparagus officinalis* - asparagus
- *Erythronium albidum* - white trout-lily
- *E. americanum* - trout-lily
- *Hemerocallus fulva* - day-lily
- *Lilium canadense* - Canada lily
- *L. superbum* - turk's-cap
- *Maianthemum canadense* - wild lily-of-the-valley
- *Medeola virginiana* - Indian cucumber
- *Ornithogalum umbellatum* - star of Bethlehem
- *Polygonatum biflorum* - Soloman's seal
- *P. pubsecens* - Soloman's seal
- *Smilacina racemosa* - false Soloman's seal
- *Trillum cernuum* - nodding trillium
- *T. erectum* - purple trillium
- *Uvularia perfoliata* - pe.[illegible]oliate bellwort
- *U. sessilifolia* - sessile-leaved bellwort
- *Veratrum veride* - false hellebore

Najadaceae
- *Potamogeton crispis* - pondweed
- *P. foliosus* - pondweed
- *P. spirillus* - pondweed

Orchidaceae
- *Cypripedium acaule* - pink lady's slipper
- *Epipactis helleborine* - helleborine
- *Goodyera pubescens* - rattlesnake plantain
- *Habenaria lacera* - ragged finged orchid
- *H. orbiculata* - round-leaved orchid
- *Spiranthes cernua* - ladies' tresses
- *S. gracilis* - ladies' tresses

Sparganiaceae
- *Sparganium eurycarpum* - bur-reed

Typhaceae
- *Typha angustifolia* - narrow-leaf cat-tail
- *T. latifolia* - cat-tail

Table F-4

Species of plants observed at Elimsport Substation and not found at Susquehanna SES, 1982-86. Arrangement as in Table F-3.

POLYPODIOPHYTA
- Osmundaceae
  - *Osmunda regalis* - royal fern

MAGNOLIOPHYTA-DICOTHYLEDONEAE
- Asteraceae
  - *Solidago odora* - sweet goldenrod
- Ericaceae
  - *Lyonia ligustrina* - male berry
  - *Vaccinium atrococcum* - black blueberry
- Gentianaceae
  - *Bartonia paniculata* - bartonia
- Leguminosae
  - *Desmodium marilandicum* - tick-trefoil
- Melastomataceae
  - *Rhexia virginica* - meadow-beauty
- Violaceae
  - *Viola sagittata* - arrow-leaved violet

MAGNOLIOPHYTA-MONOCOTYLEDONEAE
- Cyperaceae
  - *Rhynchospora capitellata* - beak-rush
- Gramineae
  - *Calamagrostis cinnoides* - reed grass
  - *Festuca ovina* - sheep fescue
- Junaceae
  - *Juncus marginatus* - rush
- Orchidaceae
  - *Habenaria clavellata* - green woodland orchid

Table F-5

Months when plants were observed in flower or shedding spores on forest salt drift transects in the vicinity of the Susquehanna SES and Elimsport Substation, 1986. Names, abbreviations, and locations of transects are given in Table F-1.

SPECIES	RF	TR419	TR438	QSH	CC	ELIM
ACALYPHA RHOMBOIDEA	0	AUG	0	0	0	0
ACER SACCHARINUM	MAR	0	0	MAR	0	0
ACHILLEA MILLEFOLIUM	JUN	JUN-OCT	JUL-SEP	JUN-SEP	JUL-SEP	JUL, AUG
AGRIMONIA GRYPSOSEPALA	0	0	0	JUL	JUL,AUG	0
AGROSTIS PERENNANS	AUG	0	AUG	AUG, SEP	AUG	AUG
A. STOLONIFERA	JUN	JUN	JUN,JUL	JUN	0	JUN
ALLIARIA OFFICINALIS	MAY-JUL	0	0	MAY	0	0
AMBROSIA ARTEMISIIFOLIA	0	0	AUG	AUG,SEP	AUG,SEP	AUG,SEP
A. TRIFIDA	AUG	0	0	0	0	0
AMELANCHIER ARBOREA	0	0	APR	APR	0	0
AMPHICARPA BRACTEATA	0	0	AUG	AUG	AUG	0
ANAPHALIS MARGARITACEA	0	0	0	0	0	AUG
ANDROPOGON SCOPARIUS	0	0	0	AUG,SEP	0	AUG,SEP
A. VIRGINICUS	0	0	0	SEP	AUG,SEP	AUG,SEP
ANEMONE VIRGINIANA	0	0	0	JUN	JUL	0
ANEMONELLA THALICTROIDES	0	0	0	APR,MAY	0	0
ANTENNARIA NEGLECTA	0	APR,MAY	MAY	APR,MAY	APR,MAY	0
A. PLANTAGINIFOLIA	0	MAY	0	APR,MAY	0	0
ANTHOXANTHUM ODORATUM	0	MAY	MAY	MAY,JUN	MAY	0
APIOS AMERICANA	0	0	AUG	0	0	0
APOCYNUM ANDROSAEMIFOLIUM	0	0	0	JUN	0	0
A. CANNABINUM	0	JUN,JUL	JUN	JUN,JUL	0	JUN
AQUILEGIA CANADENSIS	0	0	0	0	APR,MAY	0
ARABIDOPSIS THALLIANA	0	APR,MAY	MAY	APR,MAY	0	0
ARABIS LAEVIGATA	0	MAY	0	MAY	0	0
A. LYRATA	0	0	MAY	0	0	0
ARALIA NUDICAULIS	0	0	0	0	MAY	0
ARCTIUM MINUS	JUL,AUG	JUL-SEP	0	0	0	0
ARENARIA SERPYLLIFOLIA	0	MAY,JUN	MAY,JUN	0	0	0
ARISAEMA TRIPHYLLUM	MAY	MAY	0	0	0	0
ARISTIDA DICHOTOMA	0	0	0	AUG,SEP	0	0
ARONIA MELANOCARPA	0	0	MAY	0	0	0
ASCLEPIAS INCARNATA	JUN	0	JUL	0	0	0
A. SYRIACA	0	JUN,JUL	JUN, JUL	0	0	0
ASPLENIUM PLATYNEURON	0	JUL,AUG	0	JUN-AUG	JUN-AUG	0
ASTER CORDIFOLIUS	SEP	SEP,OCT	0	SEP,OCT	0	0
A. DIVARICATUS	AUG-OCT	0	0	AUG-OCT	SEP	0
A. LAEVIS	0	0	0	0	SEP	0
A. LATERIFLORUS	0	SEP	SEP	SEP	0	SEP
A. NOVAE-ANGLIAE	0	0	SEP,OCT	SEP	0	0
A. PATENS	0	0	0	SEP	0	0
A. PATERNUS	0	0	0	JUL	0	0
A. PILOSUS	SEP,OCT	SEP,OCT	SEP,OCT	SEP,OCT	0	SEP,OCT
A. PUNICEUS	0	0	SEP	0	0	0
A. SIMPLEX	0	SEP,OCT	SEP	0	0	0
A. UNDULATUS	0	0	0	0	SEP	0
ATHYRIUM FILIX-FEMINA	0	JUL,AUG	AUG	AUG	0	0
AUREOLARIA VIRGINICA	0	0	0	0	JUL	0
BAPTISIA TINCTORIA	0	0	0	JUN,JUL	0	JUN,JUL
BARBAREA VULGARIS	MAY	MAY	MAY	MAY	MAY	MAY
BARTONIA VIRGINICA	0	0	0	0	0	JUL,AUG
BERBERIS THUNBERGII	0	APR,MAY	0	APR	0	0
BETULA LENTA	0	0	0	0	MAY	0
B. NIGRA	MAY	0	0	0	0	0
B. POPULIFOLIA	0	0	0	APR	0	0
BIDENS FRONDOSA	AUG,SEP	0	0	0	0	SEP
BOTRYCHIUM DISSECTUM	0	0	0	AUG,SEP	0	0
BRASSICA KABER	0	MAY-AUG	MAY-AUG	0	0	0
B. NIGRA	JUN,JUL	0	0	0	0	0
BROMUS INERMIS	MAY	MAY,JUN,AUG	MAY,JUN,AUG	0	0	0
B. JAPONICUS	0	0	JUL	0	0	0

Table F-5 (cont.)

SPECIES	RF	TR419	TR438	QSH	CC	ELIM
CALAMAGROSTIS CINNOIDES	0	0	0	0	0	AUG
CAMPANULA APARINOIDES	0	0	0	0	JUN	0
CARDAMINE PENSYLVANICA	0	APR,MAY	MAY	APR	0	0
CAREX PENSYLVANICA	0	0	0	APR	APR	0
CAREX SP.	MAY	MAY	MAY	MAY	MAY	MAY
CARYA CORDIFORMIS	MAY	0	0	0	0	0
C. GLABRA	0	0	0	MAY	0	0
C. TOMENTOSA	0	0	MAY	MAY	MAY	MAY
CASSIA NICTITANS	0	0	JUL,AUG	0	0	0
CATALPA BIGNONIOIDES	0	JUN	0	0	0	0
CEANOTHUS AMERICANUS	0	0	0	JUN,JUL	JUN	0
CELTIS OCCIDENTALIS	APR	0	0	APR	0	0
CENTAUREA MACULOSA	0	0	JUN-OCT	0	0	JUL-OCT
CERASTIUM ARVENSE	0	0	0	0	MAY	0
C. VULGATUM	0	MAY-JUL	MAY	MAY	MAY	JUN
CHELIDONIUM MAJUS	MAY,JUN	MAY-AUG	0	0	0	0
CHENOPODIUM AMBROSIOIDES	0	0	0	0	AUG	0
CHIMAPHILA MACULATA	0	0	0	0	JUL	0
CHRYSANTHEMUM LEUCANTHEMUM	0	MAY-AUG	MAY-AUG	MAY-AUG	JUN	JUN,JUL
CICUTA MACULATA	0	0	JUL	0	0	0
CINNA ARUNDINACEA	JUL,AUG	AUG	0	0	0	0
CIRCAEA QUADRISULCATA	0	JUL	0	JUL	JUL,AUG	0
CIRSIUM ARVENSE	0	JUL	0	JUL	0	0
C. VULGARE	JUL,AUG	JUN,JUL	JUL-SEP	AUG	0	AUG
CLAYTONIA VIRGINICA	APR,MAY	0	0	0	0	0
CLEMATIS VIRGINIANA	0	0	AUG	0	0	0
COLLINSONIA CANADENSIS	0	0	AUG	0	0	0
COMMANDRA UMBELLATA	0	0	0	MAY	0	0
COMMELINA COMMUNIS	AUG,SEP	JUN-SEP	AUG,SEP	JUN-SEP	0	0
CONIUM MACULATUM	0	MAY,JUN	0	0	0	0
CONVOLVULUS SEPIUM	JUN	JUL,AUG	AUG	0	0	0
CONYZA CANADENSIS	AUG	AUG	AUG	0	AUG	0
CORNUS AMOMUM	0	0	JUN	0	0	0
C. FLORIDA	0	MAY	MAY	MAY	MAY	APR,MAY
CORONILLA VARIA	0	JUN-SEP	JUN-SEP	0	0	JUN-SEP
CORYDALIS FLAVULA	0	0	0	APR	0	0
CORYLUS AMERICANA	0	MAR	MAR	0	0	0
CRATAEGUS SP.	0	0	MAY	MAY	MAY	0
CRYPTOTAENIA CANADENSIS	MAY,JUN	0	0	0	0	0
CUNILA ORIGANOIDES	0	0	0	AUG	0	0
CYPREPEDIUM ACAULE	0	0	0	MAY	MAY	0
CYSTOPTERIS FRAGILIS	0	0	0	MAY,JUN	0	0
DACTYLIS GLOMERATA	MAY	MAY	MAY	MAY	0	0
DANTHONIA SPICATA	0	0	0	JUN	MAY,JUN	JUN
DAUCUS CAROTA	0	JUL,AUG	JUN-OCT	JUL-SEP	JUL,AUG	JUL-SEP
DENNSTAEDTIA PUNCTILOBULA	0	JUN-AUG	JUN-AUG	JUN-AUG	JUL,AUG	JUN-AUG
DENTARIA LACINIATA	APR	0	0	0	0	0
DESCHAMPSIA FLEXUOSA	0	0	0	JUN	0	0
DESMODIUM DILLENII	AUG	AUG,SEP	JUL,AUG	AUG	0	0
D. LINEATUM	0	0	0	AUG,SEP	0	0
D. MARILANDICUM	0	0	0	0	0	JUL,AUG
D. NUDIFLORUM	0	JUL,AUG	0	JUL	AUG	0
D. PANICULATUM	0	0	AUG	AUG	AUG	0
DIANTHUS ARMERIA	0	JUN,JUL	JUN,JUL	JUN-SEP	0	JUN
DICENTRA CUCULLARIA	APR	0	0	0	0	0
DIGITARIA SANGUINALIS	0	AUG,SEP	AUG	AUG,SEP	0	AUG
DRYOPTERIS INTERMEDIA	0	JUN	0	JUN	JUN	0
D. MARGINALIS	0	JUN,JUL	AUG	JUN-AUG	JUN,JUL	0
D. SPINULOSA	0	JUN	0	JUN	0	0
ECHINOCHLOA MURICATA	JUL	AUG	0	0	0	0
ECHINOCYSTIS LOBATA	AUG	0	0	0	0	0
ELAEAGNUS COMMUTATA	0	0	0	0	0	MAY
ELEOCHARIS TENUIS	0	0	0	0	0	MAY
ELEUSINE INDICA	0	AUG	0	JUN	0	0
ELYMUS RIPARIUS	JUN,JUL	0	0	0	0	0
E. VILLOSUS	JUN,JUL	0	0	0	0	0
E. VIRGINICUS	JUN,JUL	0	0	0	0	0

Table F-5 (cont.)

SPECIES	RF	TR419	TR438	QSH	CC	ELIM
EPIGAEA REPENS	0	0	0	APR	APR	0
EQUISETUM ARVENSE	0	0	APR	0	0	0
ERAGROSTIS CILIANENSIS	0	AUG	AUG	0	0	0
E. PILOSA	0	AUG	AUG	0	0	0
E. SPECTABILIS	0	0	0	AUG,SEP	0	0
ERECHTITES HIERACIFOLIA	0	AUG,SEP	SEP	AUG,SEP	0	AUG,SEP
ERIGERON ANNUUS	JUN-SEP	JUN-SEP	JUN-SEP	JUN-SEP	AUG,SEP	JUN-AUG
E. PHILADELPHICUS	MAY	MAY	MAY	MAY	0	0
ERYSIMUM CHIERANTHOIDES	0	JUN	JUN	0	0	0
ERYTHRONIUM ALBIDUM	APR	0	0	0	0	0
E. AMERICANUM	APR	0	0	0	0	0
EULALIA VIMINEA	0	0	0	SEP	0	0
EUPATORIUM FISTULOSUM	0	0	AUG,SEP	0	0	JUL-SEP
E. MACULATUM	JUL	AUG	0	0	0	0
E. PERFOLIATUM	0	0	AUG,SEP	AUG	0	AUG,SEP
E. RUGOSUM	JUL-SEP	JUL-OCT	SEP	AUG,SEP	SEP	0
FESTUCA OBTUSA	MAY,JUN	0	0	MAY	0	0
FLOERKIA PROSERPINACOIDES	MAY	0	0	0	0	0
FRAGARIA VIRGINIANA	0	MAY	APR,MAY	APR	MAY	APR,MAY
FRAXINUS AMERICANA	MAY	APR,MAY	0	APR,MAY	MAY	0
GALINSOGA CILIATA	0	JUL-OCT	OCT	JUL-OCT	0	0
GALIUM APARINE	0	MAY	MAY	MAY	MAY	0
GAYLUSSACIA BACCATA	0	0	0	MAY	MAY	MAY
GERANIUM CAROLINIANUM	0	0	0	MAY	0	0
G. MACULATUM	0	0	0	MAY	MAY	0
GERARDIA TENUIFOLIA	0	0	0	SEP	0	0
GEUM CANADENSE	JUN,JUL	JUN	0	JUN,JUL	JUN,JUL	0
GLECHOMA HEDERACEA	MAY	0	MAY	0	0	0
GNAPHALIUM OBTUSIFOLIUM	0	AUG	0	AUG,SEP	0	AUG,SEP
GOODYERA PUBESCENS	0	0	0	JUL	JUL,AUG	JUL
HABENARIA CLAVELLATA	0	0	0	0	0	JUL
H. LACERA	0	0	0	JUL	0	0
HAMAMELIS VIRGINIANA	0	0	0	OCT	0	0
HELENIUM AUTUMNALE	0	AUG	0	0	0	0
HELIANTHUS DIVARICATUS	0	0	0	JUL,AUG	JUL-SEP	0
HEMEROCALLUS FULVA	0	JUN	JUN,JUL	JUN	0	0
HESPERIS MATRONALIS	MAY,JUN	MAY	MAY	0	0	0
HIERACIUM PANICULATUM	0	AUG	0	0	0	0
H. PRATENSE	0	MAY,JUN	MAY-JUL	MAY,JUN	MAY,JUN	MAY
H. SCABRUM	0	0	AUG	AUG	0	AUG
H. VENOSUM	0	0	0	MAY	JUN	0
HOLCUS LANATUS	0	0	0	JUN,JUL	0	0
HOUSTONIA CAERULEA	0	0	0	APR,MAY	MAY	0
HYDRANGEA ARBORESCENS	JUN	0	0	JUN	0	0
HYDROPHYLLUM VIRGINIANUM	MAY	0	0	0	0	0
HYPERICUM PERFORATUM	JUN	JUL	JUL	JUL,AUG	JUL,AUG	JUL
H. PUNCTATUM	JUL	JUL	AUG	JUL,AUG	0	JUL
HYPOXIS HIRSUTA	0	0	0	0	MAY	MAY,JUL
ILEX VERTICELLATA	0	0	JUN	0	0	0
IMPATIENS BIFLORA	JUN-SEP	JUL,AUG	AUG,SEP	0	0	0
I. PALLIDA	JUN-SEP	JUL-SEP	0	AUG,SEP	0	0
JUGLANS NIGRA	0	0	0	MAY	0	0
JUNCUS EFFUSUS	0	0	JUN	0	0	0
J. TENUIS	0	0	0	JUN	JUN	JUN
KALMIA LATIFOLIA	0	0	0	0	MAY	0
KRIGIA VIRGINICA	0	0	0	MAY	0	0
LACTUCA CANADENSIS	0	0	JUL,AUG	JUL,AUG	JUL,AUG	JUL
LAMIUM PURPUREUM	0	APR	0	0	0	0
LECHIA RACEMULOSA	0	0	0	AUG	0	0
LEERSIA VIRGINICA	JUL-SEP	JUL,AUG	0	JUL,AUG	0	0
LEONURUS CARDIACA	JUN	JUN-AUG	0	0	0	0
LEPIDIUM CAMPESTRE	0	APR,MAY	MAY	MAY	0	0
L. VIRGINICUM	0	MAY	0	0	0	0
LESPEDIZA HIRTA	0	0	0	SEP	0	0
L. INTERMEDIA	0	0	0	AUG	AUG,SEP	0
L. VIRGINICA	0	0	0	AUG	0	0
LILIUM SUPERBUM	JUL	0	0	0	0	0
LINARIA VULGARIS	AUG	JUN-AUG	AUG	JUN-OCT	0	0

Table F-5 (cont.)

SPECIES	RF	TR419	TR438	QSH	CC	ELIM
LINDERA BENZOIN	APR	APR	0	APR	0	0
LIRIODENDRON TULIPIFERA	0	MAY	0	MAY	MAY	MAY
LOBELIA INFLATA	AUG	0	AUG	JUL,AUG	0	JUL
L. SIPHILITICA	SEP	0	0	SEP	0	0
LOLIUM PERENNE	0	JUN	JUN	MAY	0	0
LONICERA TATARICA	0	0	MAY	0	0	0
LOTUS CORNICULATUS	0	MAY-AUG	MAY-AUG	0	0	MAY-AUG
LUDWIGIA ALTERNIFOLIA	0	0	0	0	0	JUL
LUZULA CAMPESTRIS	0	0	0	APR,MAY	0	0
LYCHNIS ALBA	0	0	MAY	0	MAY,JUL	0
LYCOPODIUM FLABELLIFORME	0	0	OCT	0	OCT	0
L. INUNDATUM	0	0	0	0	0	AUG,SEP
L. OBSCURUM	0	0	OCT	0	OCT	0
LYCOPUS VIRGINICUS	AUG	0	0	AUG	0	AUG
LYSIMACHIA CILIATA	JUN,JUL	0	0	0	0	0
L. QUADRIFOLIA	0	0	0	JUN	0	JUN
MAIANTHEMUM CANADENSE	0	0	0	0	MAY	0
MATRICARIA MATRICARIOIDES	0	MAY	0	0	0	0
MATTEUCCIA STRUTHIOPTERIS	OCT	0	0	0	0	0
MEDICAGO LUPULINA	0	JUN	MAY-JUL	0	0	AUG
MELAMPYRUM LINEARE	0	0	0	0	JUL	0
MELILOTUS ALBA	0	0	JUL	JUL	0	0
M. OFFICINALIS	0	0	JUN,JUL	0	0	0
MERTENSIA VIRGINICA	APR,MAY	0	0	0	0	0
MITCHELLA REPENS	0	0	0	0	JUN	0
MONOTROPA UNIFLORA	0	0	0	0	JUL,AUG	JUN,JUL
MUHLENBERGIA FRONDOSA	AUG,SEP	0	0	AUG,SEP	0	0
M. SCHREBERI	0	0	AUG	0	0	0
M. SOBOLIFERA	0	0	0	SEP	0	0
MYRICA ASPLENIFOLIA	0	0	0	APR	0	0
NEPETA CATARIA	0	0	JUL	0	0	0
OENOTHERA BIENNIS	JUL-SEP	AUG,SEP	AUG,SEP	AUG	0	JUL
ONOCLEA SENSIBILIS	0	0	MAR	0	0	0
OSMUNDA CINNAMOMEA	0	0	0	0	0	MAY
O. CLAYTONIANA	0	MAY	0	0	0	MAY
OSTRYA VIRGINIANA	APR	0	0	0	0	0
OXALIS VIOLACEA	0	MAY	0	MAY	0	0
OXALIS SP.	JUN-AUG	MAY-AUG	MAY-SEP	MAY-AUG	MAY,JUL,AUG	MAY
PANICUM CAPILLARE	AUG	AUG	AUG	AUG,SEP	0	0
P. CLANDESTINUM	0	0	0	JUN	0	JUN
P. VIRGATUM	AUG	0	0	0	0	0
PANICUM SP.	0	JUN	JUN	MAY,JUN	0	JUN
PENSTEMON HIRSUTUS	0	0	0	MAY,JUN	JUN	0
PHALARIS ARUNDINACEA	MAY	0	0	0	0	0
PHLEUM PRATENSE	0	JUN	JUN	0	0	JUN
PHLOX PANICULATA	0	0	0	MAY,JUL,AUG	0	0
P. SUBULATA	0	0	0	0	APR,MAY	0
PHYTOLACCA AMERICANA	AUG,SEP	JUL-SEP	JUL	JUL,AUG	0	0
PILEA PUMILA	AUG	AUG	0	AUG	0	0
PLANTAGO ARISTATA	0	0	0	AUG	0	0
P. LANCEOLATA	0	MAY-AUG	MAY-AUG	MAY	0	JUN,JUL
P. MAJOR	0	JUN,AUG	JUL,AUG	0	0	0
POA ANNUA	MAY	MAY	0	MAY	MAY	0
P. COMPRESSA	0	MAY,JUN	0	JUN	JUN	JUN
P. PRATENSIS	MAY	MAY,JUN	MAY	MAY	MAY	MAY
PODOPHYLLUM PELTATUM	MAY	0	MAY	MAY	0	0
POLYGALA PAUCIFOLIA	0	0	0	0	MAY	APR,MAY
P. SANGUINEA	0	0	0	AUG,SEP	0	0
POLYGONATUM BIFLORUM	0	MAY	0	MAY	MAY	0
POLYGONUM ARIFOLIUM	0	0	0	0	0	AUG
P. AVICULARE	0	JUL,AUG	0	AUG	0	0
P. CILINODE	JUN-SEP	0	0	0	0	0
P. CUSPIDATUM	JUL-SEP	0	0	0	0	0
P. PENSYLVANICUM	AUG,SEP	JUL,AUG	AUG,SEP	JUL-SEP	0	JUL-SEP
P. PERSICARIA	JUL,SEP	JUN-OCT	0	JUN-SEP	0	0
P. PUNCTATUM	AUG,SEP	AUG	0	AUG	0	0
P. SAGITTATUM	AUG,SEP	0	AUG,SEP	0	0	0

Table F-5 (cont.)

SPECIES	RF	TR419	TR438	QSH	CC	ELIM
P. SCANDENS	SEP	0	0	AUG	JUL	0
P. VIRGINIANUM	JUL,AUG	AUG	AUG	JUL,AUG	AUG	0
POLYSTICHUM ACROSTICHOIDES	0	JUN	0	MAY,JUN	0	0
POTENTILLA NORVEGICA	JUN	0	JUL	AUG	0	0
P. RECTA	0	0	JUL	0	JUL	0
P. SIMPLEX	0	MAY	MAY	APR-JUN	MAY	APR,MAY
PRENANTHES ALBA	0	0	0	AUG,SEP	0	0
PRUNELLA VULGARIS	JUL,AUG	JUL-SEP	0	0	0	JUL-SEP
PRUNUS AVIUM	0	0	0	APR	0	0
P. PENSYLVANICA	0	0	0	APR	MAY	0
P. SEROTINA	0	MAY	MAY	MAY	0	0
P. VIRGINIANA	0	0	MAY	0	APR,MAY	0
PYCNANTHEMUM INCANUM	0	0	0	JUL-SEP	JUL-SEP	0
P. VIRGINIANUM	0	0	0	0	0	JUL
PYROLA ELLIPTICA	0	0	0	0	JUN	0
PYRUS COMMUNIS	0	0	0	APR	0	0
P. MALUS	0	0	0	APR,MAY	0	0
QUERCUS ALBA	0	0	0	MAY	MAY	0
Q. BICOLOR	0	0	MAY	0	0	0
Q. BOREALIS	MAY	MAY	MAY	0	MAY	0
Q. PALUSTRIS	0	0	MAY	0	0	0
Q. PRINUS	0	0	0	0	MAY	0
Q. VELUTINA	0	MAY	MAY	MAY	MAY	0
RANUNCULUS ABORTIVUS	APR,MAY	APR,MAY	APR,MAY	APR,MAY	MAY	0
R. ACRIS	0	0	MAY-JUL	MAY	0	0
R. RECURVATUS	0	MAY	0	MAY	0	0
RHEXIA VIRGINICA	0	0	0	0	0	JUL,AUG
RHODODENDRON NUDIFLORUM	0	0	MAY	0	MAY	MAY
R. ROSEUM	0	0	0	0	MAY	0
RHUS GLABRA	0	0	0	JUN	0	0
R. RADICANS	MAY	0	0	0	0	0
R. TYPHINA	0	JUN	0	0	0	0
RHYNCHOSPORA CAPITELLATA	0	0	0	0	0	JUL
RIBES ROTUNDIFOLIUM	0	0	0	APR	0	0
ROBINIA PSEUDOACACIA	MAY	0	MAY	0	0	0
ROSA MULTIFLORA	0	0	0	MAY	0	0
R. VIRGINIANA	0	JUN	0	JUN	JUN	0
RUBUS ALLEGHENIENSIS	0	MAY	MAY	MAY	MAY	MAY
R. FLAGELLARIS	MAY	MAY	MAY	MAY,JUN	MAY	MAY
R. HISPIDUS	0	0	0	0	0	JUN
R. OCCIDENTALIS	0	MAY	MAY	MAY	MAY	0
RUDBECKIA HIRTA	0	JUN-AUG	JUL-OCT	JUN,JUL	0	JUN-AUG
RUMEX ACETOSELLA	0	MAY-JUL	MAY-JUL	MAY-JUL	MAY,JUN	MAY,JUN
R. CRISPUS	MAY	MAY	MAY	JUN	0	0
R. OBTUSIFOLIUS	MAY	0	0	0	0	0
SALIX SERICEA	0	0	APR	0	0	0
SAMBUCUS CANADENSIS	JUN	0	JUN,JUL	JUN	0	JUN
SAPONARIA OFFICINALIS	0	0	JUL-SEP	0	0	0
SASSAFRAS ALBIDUM	0	APR,MAY	APR,MAY	APR,MAY	0	APR,MAY
SATUREJA VULGARIS	0	JUN	0	JUN,JUL	JUL,AUG	0
SAXIFRAGA VIRGINIENSIS	0	0	0	APR,MAY	APR,MAY	0
SCIRPUS CYPRINUS	0	0	0	0	0	JUL
SCROPHULARIA LANCEOLATA	JUL	JUN	JUN	MAY,JUN	JUN	0
SELAGINELLA APODA	JUL,SEP	0	0	0	0	0
SENECIO OBOVATUS	0	0	0	0	MAY	0
SETARIA FABERII	0	JUL,AUG	JUL,AUG	0	0	JUL
S. GLAUCA	0	JUL,AUG	AUG	JUL,AUG	0	0
S. ITALICA	0	0	0	AUG	0	0
SICYOS ANGULATUS	AUG	0	0	0	0	0
SILENE STELLATA	0	0	0	AUG	0	0
SISYRINCHIUM ANGUSTIFOLIUM	0	0	0	MAY,JUN	0	JUN
SMILACENA RACEMOSA	0	MAY	MAY	0	MAY	0
SMILAX ROTUNDIFOLIA	0	0	0	0	0	MAY
SOLANUM CAROLINENSE	0	0	JUL,AUG	JUL,AUG	0	0
SOLIDAGO ARGUTA	0	0	0	0	JUL-SEP	0
S. BICOLOR	0	0	0	AUG,SEP	SEP,OCT	0

Table F-5 (cont.)

SPECIES	RF	TR419	TR438	QSH	CC	ELIM
S. CAESIA	0	SEP	0	SEP	SEP,OCT	0
S. CANADENSIS	AUG,SEP	AUG,SEP	AUG,SEP	AUG,SEP	0	AUG,SEP
S. FLEXICAULIS	AUG-OCT	0	0	0	0	0
S. GIGANTEA	JUL-SEP	JUL,AUG	JUL,AUG	AUG	0	0
S. GRAMINIFOLIA	AUG	AUG,SEP	AUG,SEP	AUG,SEP	0	JUL-SEP
S. JUNCEA	JUL	AUG	JUL,AUG	JUN-SEP	0	JUL-SEP
S. NEMORALIS	0	0	AUG,SEP	AUG,SEP	0	AUG,SEP
S. ODORA	0	0	0	0	0	AUG
S. RUGOSA	SEP	SEP,OCT	SEP,OCT	AUG,SEP	SEP	AUG,SEP
SORGHASTRUM NUTANS	0	0	JUL	0	0	0
SPHENOPHOLIS INTERMEDIA	0	0	0	MAY	0	0
SPIRAEA LATIFOLIA	0	0	JUL,AUG	0	0	0
SPIRANTHES CERNUA	0	0	SEP	SEP	0	AUG,SEP
S. GRACILIS	0	0	AUG	0	0	AUG
SPOROBOLIS VAGINIFLORUS	0	0	AUG	0	0	0
STAPHYLEA TRIFOLIA	MAY	0	0	0	0	0
STELLARIA AQUATICA	MAY,JUN	0	0	0	MAY,SEP	0
S. LONGIFOLIA	0	0	0	MAY	0	0
S. MEDIA	0	APR,MAY	0	MAY	MAY	0
SYMPLOCARPUS FOETIDUS	0	0	MAR	0	0	0
TARAXACUM OFFICINALE	APR,MAY	APR-AUG,OCT	APR-AUG	APR,MAY	APR,MAY	APR,MAY
TEUCRIUM CANADENSE	JUL	JUL	JUL	JUL	0	0
THELYPTERIS NOVEBORACENSIS	0	0	0	JUL,AUG	0	JUL,AUG
TRAGOPOGON DUBIUS	0	0	MAY	0	0	0
TRIFOLIUM AGRARIUM	0	0	JUN	JUN	0	0
T. HYBRIDUM	0	0	JUN,JUL	0	0	JUN
T. PRATENSE	0	0	JUL-OCT	0	0	AUG
T. REPENS	JUN	MAY-AUG	MAY-AUG	0	JUN	0
TRILLIUM ERECTUM	APR	0	0	0	0	0
TRIODANIS PERFOLIATA	0	JUN	0	JUN	JUN	0
TRIODIA FLAVA	0	AUG	AUG,SEP	AUG,SEP	0	0
TUSSILAGO FARFARA	0	MAR,APR	MAR-MAY	0	0	0
URTICA DIOICA	JUL	0	0	0	0	0
UVULARIA PERFOLIATA	0	0	0	0	MAY	0
VACCINIUM ATROCOCCUM	0	0	0	0	0	APR,MAY
V. CORYMBOSUM	0	0	MAY	APR	0	APR,MAY
V. STAMINEUM	0	MAY	0	MAY	MAY	0
V. VACILLANS	0	MAY	MAY	APR,MAY	MAY	MAY
VERBASCUM BLATTARIA	0	0	JUN	0	0	0
V. THAPSIS	0	JUL,AUG	JUN,JUL	JUL,AUG	JUL	0
VERBENA HASTATA	0	0	JUL,AUG	JUL,AUG	0	0
V. URTICIFOLIA	JUL,AUG	JUL	0	JUL,AUG	JUL,AUG	0
VERNONIA NOVABORACENSIS	0	0	AUG	0	0	0
VERONICA ARVENSIS	0	APR,MAY	MAY	MAY	0	0
V. OFFICINALIS	0	MAY	0	MAY	0	0
V. PEREGRINA	0	MAY	0	0	0	0
V. SERPYLLIFOLIA	0	MAY	MAY	MAY	MAY	0
VIBURNUM ACERIFOLIUM	0	MAY	0	MAY	MAY	0
VINCA MINOR	0	APR,MAY	0	0	0	0
VIOLA BLANDA	0	0	0	0	MAY	APR,MAY
V. FIMBRIATULA	0	0	0	APR,MAY	0	APR,MAY
V. PALMATA	0	0	0	0	MAY	0
V. PENSYLVANICA	APR,MAY	APR,MAY	APR,MAY	APR,MAY	MAY	0
V. PUBESCENS	APR	0	0	APR	0	0
V. SORORIA	0	MAY	0	0	0	0
V. STRIATA	MAY	0	0	0	0	0
VITIS RIPARIA	0	MAY	0	0	0	0
WOODSIA OBTUSA	0	0	0	JUN,JUL	0	0
ZIZEA AUREA	MAY	0	0	0	0	0

Table F-6

Parasitic plant diseases observed on salt drift transects in the vicinity of the Susquehanna SES and at Elimsport, 1986. Names, abbreviations, and locations of transects are given in Table F-1.

Host Species	Disease	Transects	Disease Freq.*	Disease Effect**
Acer rubrum	Phyllosticta minima leaf spot	TR419, TR438, OSH, CC, Elim	2-4	1
Acer rubrum	Rhytisma acerinum tar spot	TR438, Elim	3-4	1
Acer saccharinum	Phyllosticta minima leaf spot	RF	3	1
Acer saccharinum	Rhytisma acerinum tar spot	RF	3	1
Ambrosia artemisiifolia	Erysiphe cichoracearum powdery mildew	TR438	2	0
Arisaema triphyllum	Uromyces ari-triphylli rust	TR419	4	1
Aster cordifolius	Coleosporium asterum pine-needle rust	TR419	3	1
Aster cordifolius	Erysiphe cichoracearum powdery mildew	TR419	3	0
Aster simplex	Erysiphe cichoracearum powdery mildew	TR419	3	0
Betula lenta	Gloeosporium betularum leaf spot	OSH	3	1
Carya cordiformis	Mycosphaerella caryigena* leaf spot	RF	2	1
Carya glabra	Gnomonia caryae anthracnose	OSH	2	1
Castanea dentata	Endothia parasitica chestnut blight	CC	3	5
Cornus amomum	Septoria cornicola leaf spot	TR438	4	1
Cornus florida	Discula corni leaf spot/dieback	TR419, OSH, CC, Elim	3-4	1-3
Crataegus sp.	Gymnosporangium globosum cedar-hawthorne rust	OSH	4	1
Desmodium dillenii	Erysiphe polygoni powdery mildew	TR419	3	0
Eupatorium rugosum	Erysiphe cichoracearum powdery mildew	RF, TR419	2	0
Fragaria virginiana	Cylindrosporium sp. leaf spot	TR438	2-5	1
Fraxinus americana	Gloeosporium aridum anthracnose	CC	3	1
Fraxinus americana	Mycosphaerella effigurata* leaf spot	OSH	2	1
Impatiens sp.	Puccinia recondita rust	RF, TR419, TR438	2-3	1
Kalmia latifolia	Phyllosticta sp. leaf spot	CC	4	1
Liriodendron tulipifera	Mycosphaerella liriodendri leaf spot	CC, Elim	1-3	1
Panicum lanuginosum	Balansia strangulans black ring	OSH	3	1
Parthenocissus quinquefolia	Guignardia bidwillii leaf spot	TR419, OSH, CC	2-4	1
Podophyllum peltatum	Puccinia podophylli rust	RF, TR438, OSH	2-4	1
Prunus virginiana	Coccomyces lutescens leaf spot	CC	4	1
Pycnanthemum incanum	Erysiphe cichoracearum powdery mildew	CC	4	0
Quercus bicolor	Gnomonia quercina anthracnose	TR438	4	1
Quercus borealis	Microsphaera alni powdery mildew	TR438, OSH	1	0-1
Quercus palustris	Actinopelte dryina leaf spot	TR438	4	1
Ranunculus abortivus	Puccinia eatoniae* rust	OSH	3	1

Table F-6 (cont.)

Rhus radicans	Cercospora sp.? leaf spot	QSH	3	1
Rubus allegheniensis	Gloeosporium rufomaculans leaf spot	QSH	2	1
Rubus flagellaris	Gymnoconia peckiana rust	QSH, Elim	2-3	1
Rubus hispidus	Gloeosporium rufomaculans leaf spot	Elim	3-5	1
Rubus occidentalis	Gymnoconia peckiana rust	TR419	3	1
Sassafras albidum	Actinopelte dryina leaf spot	TR419, TR438	3	1
Solidago arguta	Erysiphe cichoracearum powdery mildew	CC	3	0
Solidago caesia	Coleosporium asterum pine-needle rust	TR419	4	1
Solidago caesia	Erysiphe cichoracearum powdery mildew	TR419	3	0
Solidago canadensis	Coleosporium asterum pine-needle rust	RF, TR419, TR438, QSH Elim	3-5	1
Solidago canadensis	Erysiphe cichoracearum powdery mildew	TR419, TR438, QSH, Elim	3-4	0
Solidago flexicaulis	Coleosporium asterum pine-needle rust	RF	4	1
Solidago gigantea	Coleosporium asterum pine-needle rust	RF	3	1
Solidago gigantea	Erysiphe cichoracearum powdery mildew	TR419	4	0
Solidago graminifolia	Coleosporium delicatulum pine-needle rust	RF	4	1
Solidago graminifolia	Placosphaeria haydeni tar spot	RF, TR419, TR438, QSH, Elim	3-5	1
Solidago juncea	Coleosporium asterum pine-needle rust	QSH	3	1
Solidago rugosa	Coleosporium asterum pine-needle rust	TR438, QSH, Elim	3-4	1
Solidago rugosa	Erysiphe cichoracearum powdery mildew	TR419, TR438, QSH, CC	2-4	0
Tilia americana	Gnomonia tiliae anthracnose	RF	3	1
Verbena urticifolia	Erysiphe cichoracearum powdery mildew	RF, TR419, QSH, CC,	3-5	0-1
Viola blanda	Septoria verbenae? leaf spot	Elim	3	1
Viburnum acerifolium	Cercospora varia ?* leaf spot	QSH	3	1
Vitis aestivalis	Phyllosticta viticola leaf spot	TR419, CC	2-3	1
Vitis riparia	Phyllosticta viticola leaf spot	TR419	3	1

*Disease Frequency Code

1 = Rare - one or two plants only (estimated at less than 5% of population affected).
2 = Uncommon - a few plants, either scattered or clumped (estimated at less than 10% of population affected).
3 = Scattered - several plants at different localities (estimated at 10-25% of population affected).
4 = Common - many plants affected (estimated at 25-50% of population).
5 = Abundant - more than half affected (estimated at 50-100% of population).

**Disease Effect Code

0 = No effect except possibly discoloration.
1 = Local necrosis in small areas only.
2 = More important necrosis in larger area.
3 = Important necrosis and minor defoliation or twig death.
4 = Important necrosis and more important defoliation or twig death.
5 = Major necrosis and defoliation or host death.

Table F-7

Vegetation analysis for trees in the Council Cup Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DENSITY (NO./HA)	RELATIVE DENSITY	DOMINANCE (BA/HA)	RELATIVE DOMINANCE	IMPORT. VALUE
BETULA LENTA	SWEET BIRCH	0.75	25.4	230	35.9	61634	31.9	93.2
QUERCUS VELUTINA	BLACK OAK	0.40	13.6	85	13.3	22749	11.8	38.7
QUERCUS PRINUS	CHESTNUT OAK	0.30	10.2	75	11.7	14993	7.8	29.7
PINUS STROBUS	WHITE PINE	0.25	8.5	45	7.0	22996	11.9	27.4
ACER RUBRUM	RED MAPLE	0.30	10.2	50	7.8	12771	6.6	24.6
QUERCUS BOREALIS	RED OAK	0.30	10.2	50	7.8	11078	5.7	23.7
QUERCUS ALBA	WHITE OAK	0.15	5.1	20	3.1	24214	12.5	20.7
PINUS VIRGINIANA	VIRGINIA PINE	0.15	5.1	40	6.3	15516	8.0	19.4
TSUGA CANADENSIS	EASTERN HEMLOCK	0.05	1.7	15	2.3	2545	1.3	5.3
PYRUS MALUS	APPLE	0.05	1.7	5	0.8	1418	0.7	3.2
CARYA GLABRA	PIGNUT HICKORY	0.05	1.7	5	0.8	1135	0.6	3.1
POPULUS GRANDIDENTATA	BIG-TOOTHED ASPEN	0.05	1.7	5	0.8	770	0.4	2.9
SASSAFRAS ALBIDUM	SASSAFRAS	0.05	1.7	5	0.8	664	0.3	2.8
BETULA POPULIFOLIA	GRAY BIRCH	0.05	1.7	5	0.8	393	0.2	2.7
PRUNUS PENSYLVANICA	PIN CHERRY	0.05	1.7	5	0.8	475	0.2	2.7
TOTAL		-	100.0	640	100.0	93351	100.0	300.0

Table F-8

Vegetation analysis for saplings in the Council Cup Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DENSITY (NO./HA)	RELATIVE DENSITY	DOMINANCE (BA/HA)	RELATIVE DOMINANCE	IMPORT. VALUE
ACER RUBRUM	RED MAPLE	0.85	17.2	485	32.6	6397	23.6	73.4
BETULA LENTA	SWEET BIRCH	0.65	13.1	265	17.8	6374	23.5	54.4
QUERCUS BOREALIS	RED OAK	0.60	12.1	145	9.7	3523	13.0	34.8
PINUS STROBUS	WHITE PINE	0.55	11.1	125	8.4	1645	6.1	25.6
QUERCUS PRINUS	CHESTNUT OAK	0.35	7.1	125	8.4	2015	7.4	22.9
QUERCUS VELUTINA	BLACK OAK	0.35	7.1	50	3.4	1610	5.9	16.4
BETULA POPULIFOLIA	GRAY BIRCH	0.20	4.0	40	2.7	1162	4.3	11.0
CARYA TOMENTOSA	MOCKERNUT HICKORY	0.20	4.0	35	2.3	840	3.1	9.4
QUERCUS ALBA	WHITE OAK	0.15	3.0	40	2.7	664	2.4	8.1
CARYA GLABRA	PIGNUT HICKORY	0.20	4.0	25	1.7	585	2.2	7.9
FRAXINUS AMERICANA	WHITE ASH	0.20	4.0	20	1.3	240	0.9	6.2
TSUGA CANADENSIS	EASTERN HEMLOCK	0.05	1.0	30	2.0	836	3.1	6.1
CASTANEA DENTATA	AMERICAN CHESTNUT	0.15	3.0	35	2.3	106	0.4	5.7
SASSAFRAS ALBIDUM	SASSAFRAS	0.10	2.0	15	1.0	514	1.9	4.9
AMELANCHIER ARBOREA	SHAD-BUSH	0.10	2.0	20	1.3	137	0.5	3.8
PRUNUS SEROTINA	BLACK CHERRY	0.10	2.0	20	1.3	145	0.5	3.8
PRUNUS PENSYLVANICA	PIN CHERRY	0.05	1.0	5	0.3	318	1.2	2.5
ACER PENSYLVANICUM	STRIPED MAPLE	0.05	1.0	5	0.3	16	0.1	1.4
CORNUS FLORIDA	FLOWERING DOGWOOD	0.05	1.0	5	0.3	35	0.1	1.4
TOTAL		-	100.0	1490	100.0	27162	100.0	300.0

Table F-9

Vegetation analysis for tree seedlings in the Council Cup Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DENSITY (NO./HA)	RELATIVE DENSITY	DOMINANCE (% COVER)	RELATIVE DOMINANCE	IMPORT. VALUE
ACER RUBRUM	RED MAPLE	0.47	25.3	6500	28.9	1.70	17.8	72.0
PRUNUS SEROTINA	BLACK CHERRY	0.20	10.8	3000	13.3	1.12	11.7	35.8
QUERCUS ALBA	WHITE OAK	0.10	5.4	2750	12.2	1.48	15.5	33.1
SASSAFRAS ALBIDUM	SASSAFRAS	0.17	9.1	2000	8.9	0.95	9.9	27.9
QUERCUS BOREALIS	RED OAK	0.23	12.4	1500	6.7	0.78	8.2	27.3
QUERCUS VELUTINA	BLACK OAK	0.15	8.1	2000	8.9	0.72	7.5	24.5
CASTANEA DENTATA	AMERICAN CHESTNUT	0.07	3.8	250	1.1	1.73	18.1	23.0
QUERCUS PRINUS	CHESTNUT OAK	0.17	9.1	1500	6.7	0.38	4.0	19.8
BETULA LENTA	SWEET BIRCH	0.05	2.7	500	2.2	0.10	1.0	5.9
FRAXINUS AMERICANA	WHITE ASH	0.05	2.7	500	2.2	0.07	0.7	5.6
PRUNUS AVIUM	SWEET CHERRY	0.05	2.7	500	2.2	0.05	0.5	5.4
CARYA GLABRA	PIGNUT HICKORY	0.03	1.6	250	1.1	0.25	2.6	5.3
POPULUS TREMULOIDES	QUAKING ASPEN	0.03	1.6	500	2.2	0.05	0.5	4.3
AMELANCHIER ARBOREA	SHAD-BUSH	0.03	1.6	250	1.1	0.10	1.0	3.7
ACER PENSYLVANICUM	STRIPED MAPLE	0.03	1.6	250	1.1	0.05	0.5	3.2
CRATAEGUS SP.	HAWTHORNE	0.03	1.6	250	1.1	0.03	0.3	3.0
TOTAL		-	100.0	22500	100.0	9.56	100.0	300.0

Table F-10

Vegetation analysis for shrubs, herbs, and ground cover in the Council Cup Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE (% COVER)	RELATIVE DOMINANCE	IMPORTANCE VALUE
SHRUBS						
VACCINIUM VACILLANS	LOW-BUSH BLUEBERRY	0.42	30.2	4.47	17.6	47.8
KALMIA LATIFOLIA	MOUNTAIN LAUREL	0.23	16.5	5.33	21.0	37.5
VACCINIUM STAMINEUM	DEERBERRY	0.15	10.8	6.58	25.9	36.7
RHODODENDRON NUDIFLORUM	PINXTER-FLOWER	0.13	9.4	3.83	15.1	24.5
RHUS RADICANS	POISON IVY	0.15	10.8	1.80	7.1	17.9
RUBUS ALLEGHENIENSIS	BLACKBERRY	0.13	9.4	1.10	4.3	13.7
PARTHENOCISSUS QUINQUEFOLIA	VIRGINIA CREEPER	0.07	5.0	0.45	1.8	6.8
GAYLUSSACIA BACCATA	BLACK HUCKLEBERRY	0.05	3.6	0.65	2.6	6.2
KALMIA ANGUSTIFOLIA	SHEEP LAUREL	0.03	2.2	0.75	3.0	5.2
VIBURNUM ACERIFOLIUM	MAPLE-LEAF VIBURNUM	0.03	2.2	0.45	1.8	4.0
HERBS						
LYCOPODIUM FLABELLIFORME	GROUND PINE	0.30	22.7	7.60	36.4	59.1
DENNSTAEDTIA PUNCTILOBULA	HAY-SCENTED FERN	0.13	9.8	4.42	21.1	30.9
ARALIA NUDICAULIS	WILD SARSAPARILLA	0.17	12.9	3.67	17.6	30.5
MAIANTHEMUM CANADENSE	WILD LILY-OF-THE-VALLEY	0.15	11.4	3.05	14.6	26.0
LYSIMACHIA QUADRIFOLIA	WHORLED LOOSESTRIFE	0.17	12.9	0.38	1.8	14.7
MITCHELLA REPENS	PARTRIDGE-BERRY	0.03	2.3	0.75	3.6	5.9
POLYGALA PAUCIFOLIA	FRINGED POLYGALA	0.05	3.8	0.23	1.1	4.9
CHIMAPHILIA MACULATA	SPOTTED WINTERGREEN	0.05	3.8	0.05	0.2	4.0
DESCHAMPSIA FLEXUOSA	HAIRGRASS	0.03	2.3	0.30	1.4	3.7
MEDEOLA VIRGINIANA	INDIAN CUCUMBER	0.03	2.3	0.10	0.5	2.8
PRENANTHES ALBA	TALL WHITE LETTUCE	0.03	2.3	0.07	0.3	2.6
DANTHONIA SPICATA	POVERTY OATGRASS	0.03	2.3	0.05	0.2	2.5
GALIUM CIRCAEZANS	BEDSTRAW	0.03	2.3	0.05	0.2	2.5
GAULTHERIA PROCUMBENS	WINTERGREEN	0.03	2.3	0.05	0.2	2.5
MELAMPYRUM LINEARE	COW-WHEAT	0.03	2.3	0.05	0.2	2.5
PYROLA ELLIPTICA	SHINLEAF	0.03	2.3	0.05	0.2	2.5
VERONICA OFFICINALIS	COMMON SPEEDWELL	0.03	2.3	0.03	0.1	2.4
GROUND COVER						
LITTER	-	1.00	73.0	98.42	98.8	171.8
MOSS	-	0.20	14.6	0.40	0.4	15.0
ROCK	-	0.17	12.4	0.80	0.8	13.2

Table F-11

Vegetation analysis for trees in the TR419 Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DENSITY (NO./HA)	RELATIVE DENSITY	DOMINANCE (BA/HA)	RELATIVE DOMINANCE	IMPORT. VALUE
QUERCUS VELUTINA	BLACK OAK	0.58	18.9	133	25.4	81420	35.4	79.7
PINUS VIRGINIANA	VIRGINIA PINE	0.33	10.7	75	14.3	43603	19.0	44.0
CORNUS FLORIDA	FLOWERING DOGWOOD	0.54	17.6	79	15.1	9579	4.2	36.9
QUERCUS PRINUS	CHESTNUT OAK	0.29	9.4	42	8.0	13584	5.9	23.3
ACER RUBRUM	RED MAPLE	0.25	8.1	42	8.0	15715	6.8	22.9
PRUNUS SEROTINA	BLACK CHERRY	0.25	8.1	33	6.3	15037	6.5	20.9
PINUS STROBUS	WHITE PINE	0.13	4.2	38	7.3	13388	5.8	17.3
CARYA TOMENTOSA	MOCKERNUT HICKORY	0.25	8.1	29	5.5	5550	2.4	16.0
FRAXINUS AMERICANA	WHITE ASH	0.13	4.2	17	3.2	7730	3.4	10.8
QUERCUS ALBA	WHITE OAK	0.08	2.6	8	1.5	10138	4.4	8.5
PRUNUS AVIUM	SWEET CHERRY	0.08	2.6	8	1.5	4483	2.0	6.1
TSUGA CANADENSIS	EASTERN HEMLOCK	0.04	1.3	8	1.5	4637	2.0	4.8
LIRIODENDRON TULIPIFERA	TULIP-TREE	0.04	1.3	4	0.8	3564	1.6	3.7
QUERCUS BOREALIS	RED OAK	0.04	1.3	4	0.8	946	0.4	2.5
CARYA GLABRA	PIGNUT HICKORY	0.04	1.3	4	0.8	327	0.1	2.2
TOTAL		-	100.0	524	100.0	29701	100.0	300.0

Table F-12

Vegetation analysis for saplings in the TR419 Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DENSITY (NO./HA)	RELATIVE DENSITY	DOMINANCE (BA/HA)	RELATIVE DOMINANCE	IMPORT. VALUE
CORNUS FLORIDA	FLOWERING DOGWOOD	0.63	18.9	158	19.2	5328	32.2	70.3
ACER RUBRUM	RED MAPLE	0.67	20.1	175	21.2	1865	11.3	52.6
QUERCUS VELUTINA	BLACK OAK	0.33	9.9	179	21.7	3115	18.8	50.4
CARYA TOMENTOSA	MOCKERNUT HICKORY	0.33	9.9	58	7.0	2127	12.9	29.8
CARYA GLABRA	PIGNUT HICKORY	0.13	3.9	63	7.6	1361	8.2	19.7
QUERCUS BOREALIS	RED OAK	0.21	6.3	25	3.0	615	3.7	13.0
CRATAEGUS SP.	HAWTHORNE	0.17	5.1	29	3.5	275	1.7	10.3
QUERCUS PRINUS	CHESTNUT OAK	0.13	3.9	17	2.1	177	1.1	7.1
SASSAFRAS ALBIDUM	SASSAFRAS	0.13	3.9	17	2.1	147	0.9	6.9
FRAXINUS AMERICANA	WHITE ASH	0.13	3.9	21	2.5	62	0.4	6.8
BETULA LENTA	SWEET BIRCH	0.08	2.4	25	3.0	108	0.7	6.1
QUERCUS ALBA	WHITE OAK	0.08	2.4	8	1.0	268	1.6	5.0
AMELANCHIER ARBOREA	SHAD-BUSH	0.04	1.2	13	1.6	347	2.1	4.9
PRUNUS SEROTINA	BLACK CHERRY	0.08	2.4	8	1.0	190	1.1	4.5
BETULA POPULIFOLIA	GRAY BIRCH	0.08	2.4	8	1.0	134	0.8	4.2
QUERCUS PALUSTRIS	PIN OAK	0.04	1.2	8	1.0	213	1.3	3.5
FAGUS GRANDIFOLIA	AMERICAN BEECH	0.04	1.2	8	1.0	85	0.5	2.7
PINUS STROBUS	WHITE PINE	0.04	1.2	4	0.5	118	0.7	2.4
TOTAL		-	100.0	824	100.0	16535	100.0	300.0

Table F-13

Vegetation analysis for tree seedlings in the TR419 Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DENSITY (NO./HA)	RELATIVE DENSITY	DOMINANCE (% COVER)	RELATIVE DOMINANCE	IMPORT. VALUE
SASSAFRAS ALBIDUM	SASSAFRAS	0.40	15.4	12292	25.4	2.94	23.4	64.2
ACER RUBRUM	RED MAPLE	0.56	21.6	8958	18.5	2.56	20.4	60.5
FRAXINUS AMERICANA	WHITE ASH	0.42	16.2	7500	15.5	2.31	18.4	50.1
PRUNUS SEROTINA	BLACK CHERRY	0.31	12.0	6458	13.4	1.35	10.7	36.1
QUERCUS VELUTINA	BLACK OAK	0.33	12.7	4167	8.6	1.04	8.3	29.6
PRUNUS AVIUM	SWEET CHERRY	0.17	6.6	3125	6.5	0.27	2.1	15.2
QUERCUS PRINUS	CHESTNUT OAK	0.06	2.3	1250	2.6	1.10	8.8	13.7
QUERCUS BOREALIS	RED OAK	0.06	2.3	833	1.7	0.23	1.8	5.8
CRATAEGUS SP.	HAWTHORNE	0.04	1.5	625	1.3	0.21	1.7	4.5
CORNUS FLORIDA	FLOWERING DOGWOOD	0.06	2.3	625	1.3	0.06	0.5	4.1
CELTIS OCCIDENTALIS	HACKBERRY	0.02	0.8	417	0.9	0.19	1.5	3.2
CARYA GLABRA	PIGNUT HICKORY	0.04	1.5	417	0.9	0.08	0.6	3.0
BETULA LENTA	SWEET BIRCH	0.04	1.5	417	0.9	0.04	0.3	2.7
QUERCUS ALBA	WHITE OAK	0.02	0.8	625	1.3	0.06	0.5	2.6
POPULUS GRANDIDENTATA	BIG-TOOTHED ASPEN	0.02	0.8	208	0.4	0.06	0.5	1.7
AMELANCHIER ARBOREA	SHAD-BUSH	0.02	0.8	208	0.4	0.04	0.3	1.5
CARYA TOMENTOSA	MOCKERNUT HICKORY	0.02	0.8	208	0.4	0.02	0.2	1.4
TOTAL		-	100.0	48333	100.0	12.56	100.0	300.0

Table F-14

Vegetation analysis for shrubs, herbs, and ground cover in the TR419 Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE (% COVER)	RELATIVE DOMINANCE	IMPORTANCE VALUE
SHRUBS						
RUBUS ALLEGHENIENSIS	BLACKBERRY	0.35	20.6	5.23	25.0	45.6
LINDERA BENZOIN	SPICEBUSH	0.15	8.8	6.21	29.7	38.5
PARTHENOCISSUS QUINQUEFOLIA	VIRGINIA CREEPER	0.33	19.4	1.83	8.7	28.1
VITIS AESTIVALIS	SUMMER GRAPE	0.33	19.4	1.02	4.9	24.3
VACCINIUM VACILLANS	LOW-BUSH BLUEBERRY	0.21	12.4	1.29	6.2	18.6
VACCINIUM STAMINEUM	DEERBERRY	0.06	3.5	2.65	12.7	16.2
RHUS RADICANS	POISON IVY	0.13	7.6	1.21	5.8	13.4
VIBURNUM ACERIFOLIUM	MAPLE-LEAF VIBURNUM	0.06	3.5	1.27	6.1	9.6
RUBUS OCCIDENTALIS	BLACK RASBERRY	0.04	2.4	0.13	0.6	3.0
HAMAMELIS VIRGINIANA	WITCH HAZEL	0.02	1.2	0.04	0.2	1.4
RUBUS FLAGELLARIS	DEWBERRY	0.02	1.2	0.04	0.2	1.4
HERBS						
CAREX SWANNII	SEDGE	0.46	18.9	2.46	14.1	33.0
DENNSTAEDTIA PUNCTILOBULA	HAY-SCENTED FERN	0.13	5.3	2.96	16.9	22.2
POLYGONUM VIRGINIANUM	VIRGINIA KNOTWEED	0.10	4.1	1.06	6.1	10.2
VIOLA PUBESCENS	DOWNY YELLOW VIOLET	0.02	0.8	1.37	7.8	8.6
GEUM CANADENSE	AVENS	0.08	3.3	0.85	4.9	8.2
SOLIDAGO CAESIA	BLUE-STEMMED GOLDENROD	0.10	4.1	0.65	3.7	7.8
EUPATORIUM RUGOSUM	WHITE SNAKEROOT	0.06	2.5	0.81	4.6	7.1
UVULARIA PERFOLIATA	PERFOLIATE BELLWORT	0.10	4.1	0.46	2.6	6.7
ASTER DIVARICATUS	WHITE WOOD ASTER	0.08	3.3	0.42	2.4	5.7
ALLIARIA OFFICINALIS	GARLIC MUSTARD	0.02	0.8	0.83	4.7	5.5
POLYSTICHUM ACROSTICHOIDES	CHRISTMAS FERN	0.04	1.6	0.65	3.7	5.3
DANTHONIA SPICATA	POVERTY OATGRASS	0.08	3.3	0.35	2.0	5.3
CAREX ROSEA	SEDGE	0.06	2.5	0.46	2.6	5.1
GALIUM APARINE	CLEAVERS	0.06	2.5	0.44	2.5	5.0
PANICUM SPP.	PANIC-GRASS	0.08	3.3	0.27	1.5	4.8
CIRCAEA QUADRISULCATA	ENCHANTER NIGHTSHADE	0.08	3.3	0.23	1.3	4.6
DRYOPTERIS SPINULOSA	SPINULOSE WOOD FERN	0.04	1.6	0.48	2.7	4.3
MAIANTHEMUM CANADENSE	WILD LILY-OF-THE-VALLEY	0.04	1.6	0.46	2.6	4.2
VIOLA PAPILIONACEA	COMMON BLUE VIOLET	0.08	3.3	0.10	0.6	3.9
SOLIDAGO RUGOSA	ROUGH GOLDENROD	0.06	2.5	0.21	1.2	3.7
DESMODIUM NUDIFLORUM	TICK-TREFOIL	0.06	2.5	0.08	0.5	3.0
PILEA PUMILA	CLEARWEED	0.04	1.6	0.21	1.2	2.8
ATHYRIUM FILIX-FEMINA	LADY FERN	0.02	0.8	0.35	2.0	2.8
IMPATIENS BIFLORA	JEWELWEED	0.04	1.6	0.17	1.0	2.6
ASPLENIUM PLATYNEURON	EBONY SPLEENWORT	0.04	1.6	0.08	0.5	2.1
POLYGONUM PERSICARIA	SMARTWEED	0.04	1.6	0.06	0.3	1.9
ARISAEMA TRIPHYLLUM	JACK-IN-THE-PULPIT	0.02	0.8	0.17	1.0	1.8
LYCOPODIUM FLABELLIFORME	GROUND PINE	0.04	1.6	0.04	0.2	1.8
MONOTROPA UNIFLORA	INDIAN PIPE	0.04	1.6	0.04	0.2	1.8
SMILACINA RACEMOSA	FALSE SOLOMAN'S SEAL	0.02	0.8	0.15	0.9	1.7
GALIUM CIRCAEZANS	BEDSTRAW	0.02	0.8	0.10	0.6	1.4
BOTRYCHIUM VIRGINIANUM	RATTLESNAKE FERN	0.02	0.8	0.06	0.3	1.1
HABENARIA LACERA	RAGGED FRINGED ORCHID	0.02	0.8	0.06	0.3	1.1
PANICUM CLANDESTINUM	PANIC-GRASS	0.02	0.8	0.06	0.3	1.1
POLYGONATUM BIFLORUM	SOLOMAN'S SEAL	0.02	0.8	0.06	0.3	1.1
POTENTILLA SIMPLEX	CINQUEFOIL	0.02	0.8	0.06	0.3	1.1
FRAGARIA VIRGINIANA	WILD STRAWBERRY	0.02	0.8	0.04	0.2	1.0
OXALIS STRICTA	YELLOW WOOD SORREL	0.02	0.8	0.04	0.2	1.0
BOTRYCHIUM DISSECTUM	GRAPE FERN	0.02	0.8	0.02	0.1	0.9
CHENOPODIUM ALBUM	LAMB'S QUARTERS	0.02	0.8	0.02	0.1	0.9
LYSIMACHIA QUADRIFOLIA	WHORLED LOOSESTRIFE	0.02	0.8	0.02	0.1	0.9
PHYTOLACCA AMERICANA	POKEWEED	0.02	0.8	0.02	0.1	0.9
TEUCRIUM CANADENSE	WOOD-SAGE	0.02	0.8	0.02	0.1	0.9
GROUND COVER						
LITTER	-	1.00	48.1	92.37	94.1	142.2
MOSS	-	0.54	26.0	2.67	2.7	28.7
BARE SOIL	-	0.31	14.9	2.31	2.4	17.3
ROCK	-	0.23	11.1	0.77	0.8	11.9

Table F-15

Vegetation analysis for trees in the Quarry Hillside Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DENSITY (NO./HA)	RELATIVE DENSITY	DOMINANCE (BA/HA)	RELATIVE DOMINANCE	IMPORT. VALUE
QUERCUS BOREALIS	RED OAK	0.53	16.5	147	22.7	45794	22.0	61.2
FRAXINUS AMERICANA	WHITE ASH	0.40	12.5	113	17.5	28353	13.6	43.6
QUERCUS VELUTINA	BLACK OAK	0.40	12.5	73	11.3	38149	18.3	42.1
QUERCUS PRINUS	CHESTNUT OAK	0.47	14.6	80	12.4	21546	10.3	37.3
ACER RUBRUM	RED MAPLE	0.40	12.5	93	14.4	19206	9.2	36.1
TILIA AMERICANA	BASSWOOD	0.13	4.0	33	5.1	22536	10.8	19.9
PINUS VIRGINIANA	VIRGINIA PINE	0.13	4.0	27	4.2	11844	5.7	13.9
CARYA GLABRA	PIGNUT HICKORY	0.13	4.0	13	2.0	3649	1.8	7.8
SASSAFRAS ALBIDUM	SASSAFRAS	0.13	4.0	13	2.0	2644	1.3	7.3
CARYA TOMENTOSA	MOCKERNUT HICKORY	0.07	2.2	7	1.1	4403	2.1	5.4
BETULA LENTA	SWEET BIRCH	0.07	2.2	13	2.0	2367	1.1	5.3
PRUNUS SEROTINA	BLACK CHERRY	0.07	2.2	7	1.1	3540	1.7	5.0
CELTIS OCCIDENTALIS	HACKBERRY	0.07	2.2	7	1.1	2094	1.0	4.3
POPULUS GRANDIDENTATA	BIG-TOOTHED ASPEN	0.07	2.2	7	1.1	1178	0.6	3.9
CORNUS FLORIDA	FLOWERING DOGWOOD	0.07	2.2	7	1.1	634	0.3	3.6
ULMUS AMERICANA	AMERICAN ELM	0.07	2.2	7	1.1	524	0.3	3.6
TOTAL		-	100.0	647	100.0	08461	100.0	300.0

Table F-16

Vegetation analysis for saplings in the Quarry Hillside Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DENSITY (NO./HA)	RELATIVE DENSITY	DOMINANCE (BA/HA)	RELATIVE DOMINANCE	IMPORT. VALUE
QUERCUS BOREALIS	RED OAK	0.53	13.7	187	22.2	5655	24.4	60.3
ACER RUBRUM	RED MAPLE	0.47	12.1	140	16.6	3917	16.9	45.6
FRAXINUS AMERICANA	WHITE ASH	0.53	13.7	127	15.1	3911	16.8	45.6
CORNUS FLORIDA	FLOWERING DOGWOOD	0.47	12.1	120	14.3	2885	12.4	38.8
QUERCUS PRINUS	CHESTNUT OAK	0.40	10.3	87	10.3	3351	14.4	35.0
CARYA GLABRA	PIGNUT HICKORY	0.27	7.0	27	3.2	298	1.3	11.5
SASSAFRAS ALBIDUM	SASSAFRAS	0.13	3.4	20	2.4	780	3.4	9.2
AMELANCHIER ARBOREA	SHAD-BUSH	0.20	5.2	27	3.2	37	0.2	8.6
TILIA AMERICANA	BASSWOOD	0.13	3.4	27	3.2	319	1.4	8.0
ULMUS AMERICANA	AMERICAN ELM	0.13	3.4	13	1.5	445	1.9	6.8
PINUS VIRGINIANA	VIRGINIA PINE	0.13	3.4	13	1.5	387	1.7	6.6
QUERCUS VELUTINA	BLACK OAK	0.13	3.4	13	1.5	236	1.0	5.9
PRUNUS AVIUM	SWEET CHERRY	0.07	1.8	13	1.5	304	1.3	4.6
CARYA TOMENTOSA	MOCKERNUT HICKORY	0.07	1.8	7	0.8	335	1.4	4.0
JUGLANS NIGRA	BLACK WALNUT	0.07	1.8	7	0.8	257	1.1	3.7
CELTIS OCCIDENTALIS	HACKBERRY	0.07	1.8	7	0.8	84	0.4	3.0
PRUNUS VIRGINIANA	CHOKE CHERRY	0.07	1.8	7	0.8	21	0.1	2.7
TOTAL		-	100.0	842	100.0	23222	100.0	300.0

Table F-17

Vegetation analysis for tree seedlings in the Quarry Hillside Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DENSITY (NO./HA)	RELATIVE DENSITY	DOMINANCE (% COVER)	RELATIVE DOMINANCE	IMPORT. VALUE
ACER RUBRUM	RED MAPLE	0.40	18.4	10000	19.1	0.53	5.5	43.0
ULMUS AMERICANA	AMERICAN ELM	0.10	4.6	5667	10.8	2.57	26.6	42.0
FRAXINUS AMERICANA	WHITE ASH	0.17	7.8	11000	21.0	1.20	12.4	41.2
QUERCUS BOREALIS	RED OAK	0.33	15.2	4333	8.3	1.10	11.4	34.9
PRUNUS SEROTINA	BLACK CHERRY	0.27	12.4	4667	8.9	0.63	6.5	27.8
QUERCUS PRINUS	CHESTNUT OAK	0.20	9.2	5333	10.2	0.67	6.9	26.3
QUERCUS VELUTINA	BLACK OAK	0.10	4.6	333	0.6	1.20	12.4	17.6
SASSAFRAS ALBIDUM	SASSAFRAS	0.17	7.8	2333	4.5	0.33	3.4	15.7
AMELANCHIER ARBOREA	SHAD-BUSH	0.10	4.6	2000	3.8	0.60	6.2	14.6
CORNUS FLORIDA	FLOWERING DOGWOOD	0.07	3.2	4000	7.6	0.23	2.4	13.2
CARYA GLABRA	PIGNUT HICKORY	0.07	3.2	667	1.3	0.07	0.7	5.2
PRUNUS AVIUM	SWEET CHERRY	0.07	3.2	667	1.3	0.07	0.7	5.2
TILIA AMERICANA	BASSWOOD	0.03	1.4	1000	1.9	0.13	1.3	4.6
PINUS STROBUS	WHITE PINE	0.03	1.4	333	0.6	0.13	1.3	3.3
CARYA TOMENTOSA	MOCKERNUT HICKORY	0.03	1.4	0	0.0	0.13	1.3	2.7
PRUNUS VIRGINIANA	CHOKE CHERRY	0.03	1.4	0	0.0	0.07	0.7	2.1
TOTAL		-	100.0	52333	100.0	9.66	100.0	300.0

Table F-18

Vegetation analysis for shrubs, herbs, and ground cover in the Quarry Hillside Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE (% COVER)	RELATIVE DOMINANCE	IMPORTANCE VALUE
SHRUBS						
LINDERA BENZOIN	SPICEBUSH	0.13	12.0	6.93	46.4	58.4
PARTHENOCISSUS QUINQUEFOLIA	VIRGINIA CREEPER	0.37	34.3	1.70	11.4	45.7
HAMAMELIS VIRGINIANA	WITCH HAZEL	0.10	9.3	3.27	21.9	31.2
VACCINIUM VACILLANS	LOW-BUSH BLUEBERRY	0.10	9.3	2.00	13.4	22.7
VITIS AESTIVALIS	SUMMER GRAPE	0.17	15.7	0.23	1.5	17.2
RUBUS ALLEGHENIENSIS	BLACKBERRY	0.07	6.5	0.43	2.9	9.4
VIBURNUM ACERIFOLIUM	MAPLE-LEAF VIBURNUM	0.07	6.5	0.27	1.8	8.3
RHUS RADICANS	POISON IVY	0.07	6.5	0.10	0.7	7.2
HERBS						
ASTER DIVARICATUS	WHITE WOOD ASTER	0.43	12.5	7.67	29.8	42.3
DRYOPTERIS MARGINALIS	MARGINAL WOOD FERN	0.23	6.7	3.23	12.6	19.3
DESCHAMPSIA FLEXUOSA	HAIRGRASS	0.20	5.8	3.07	11.9	17.7
SOLIDAGO CAESIA	BLUE-STEMMED GOLDENROD	0.27	7.9	0.73	2.8	10.7
ARALIA NUDICAULIS	WILD SARSAPARILLA	0.07	2.0	2.13	8.3	10.3
EUPATORIUM RUGOSUM	WHITE SNAKEROOT	0.20	5.8	0.77	3.0	8.8
CAREX SWANNII	SEDGE	0.13	3.8	1.13	4.4	8.2
CAREX PENSYLVANICA	SEDGE	0.17	5.0	0.53	2.1	7.1
UVULARIA SESSILIFOLIA	SESSILE-LEAVED BELLWORT	0.13	3.8	0.37	1.4	5.2
POA COMPRESSA	CANADA BLUEGRASS	0.13	3.8	0.33	1.3	5.1
POLYGONUM VIRGINIANUM	VIRGINIA KNOTWEED	0.07	2.0	0.77	3.0	5.0
POLYSTICHUM ACROSTICHOIDES	CHRISTMAS FERN	0.07	2.0	0.73	2.8	4.8
PANICUM SPP.	PANIC-GRASS	0.10	2.9	0.47	1.8	4.7
ASPLENIUM PLATYNEURON	EBONY SPLEENWORT	0.13	3.8	0.17	0.7	4.5
VIOLA PAPILIONACEA	COMMON BLUE VIOLET	0.10	2.9	0.37	1.4	4.3
DANTHONIA SPICATA	POVERTY OATGRASS	0.10	2.9	0.17	0.7	3.6
CAREX ROSEA	SEDGE	0.07	2.0	0.33	1.3	3.3
GEUM CANADENSE	AVENS	0.07	2.0	0.33	1.3	3.3
SOLIDAGO JUNCEA	EARLY GOLDENROD	0.07	2.0	0.30	1.2	3.2
CAREX LAXIFLORA	SEDGE	0.07	2.0	0.20	0.8	2.8
POTENTILLA SIMPLEX	CINQUEFOIL	0.07	2.0	0.20	0.8	2.8
GALIUM APARINE	CLEAVERS	0.07	2.0	0.17	0.7	2.7
POA PRATENSIS	KENTUCKY BLUEGRASS	0.03	0.9	0.37	1.4	2.3
POLYGONATUM BIFLORUM	SOLOMAN'S SEAL	0.03	0.9	0.27	1.1	2.0
SISYRINCHIUM ANGUSTIFOLIUM	BLUE-EYED GRASS	0.03	0.9	0.17	0.7	1.6
GERANIUM MACULATUM	WILD GERANIUM	0.03	0.9	0.13	0.5	1.4
ARABIS LAEVIGATA	ROCK CRESS	0.03	0.9	0.07	0.3	1.2
PILEA PUMILA	CLEARWEED	0.03	0.9	0.07	0.3	1.2
RANUNCULUS ACRIS	COMMON BUTTERCUP	0.03	0.9	0.07	0.3	1.2
SCROPHULARIA LANCEOLATA	FIGWORT	0.03	0.9	0.07	0.3	1.2
SMILACINA RACEMOSA	FALSE SOLOMAN'S SEAL	0.03	0.9	0.07	0.3	1.2
WOODSIA OBTUSA	BLUNT-LOBED WOODSIA	0.03	0.9	0.07	0.3	1.2
AQUILEGIA CANADENSIS	COLUMBINE	0.03	0.9	0.03	0.1	1.0
CIRCAEA QUADRISULCATA	ENCHANTER NIGHTSHADE	0.03	0.9	0.03	0.1	1.0
COMMANDRA UMBELLATA	BASTARD TOAD-FLAX	0.03	0.9	0.03	0.1	1.0
OXALIS STRICTA	YELLOW WOOD SORREL	0.03	0.9	0.03	0.1	1.0
SOLIDAGO BICOLOR	SILVERROD	0.03	0.9	0.03	0.1	1.0
SOLIDAGO RUGOSA	ROUGH GOLDENROD	0.03	0.9	0.03	0.1	1.0
GROUND COVER						
LITTER	-	1.00	33.3	81.37	82.5	115.8
ROCK	-	0.93	31.0	12.80	13.0	44.0
MOSS	-	0.60	20.0	1.37	1.4	21.4
BARE SOIL	-	0.47	15.7	3.13	3.2	18.9

Table F-19

Vegetation analysis for trees in the Elimsport substation Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DENSITY (NO./HA)	RELATIVE DENSITY	DOMINANCE (BA/HA)	RELATIVE DOMINANCE	IMPORT. VALUE
ACER RUBRUM	RED MAPLE	0.70	20.9	185	26.8	37232	23.6	71.3
BETULA LENTA	SWEET BIRCH	0.85	25.4	160	23.2	28600	18.1	66.7
LIRIODENDRON TULIPIFERA	TULIP-TREE	0.55	16.4	150	21.7	24072	15.3	53.4
QUERCUS PRINUS	CHESTNUT OAK	0.30	9.0	55	8.0	21410	13.6	30.6
NYSSA SYLVATICA	BLACK GUM	0.35	10.4	50	7.2	9986	6.3	23.9
QUERCUS BOREALIS	RED OAK	0.20	6.0	30	4.3	16929	10.7	21.0
PINUS STROBUS	WHITE PINE	0.10	3.0	10	1.4	8486	5.4	9.8
SASSAFRAS ALBIDUM	SASSAFRAS	0.10	3.0	15	2.2	5498	3.5	8.7
ACER PENSYLVANICUM	STRIPED MAPLE	0.05	1.5	15	2.2	1433	0.9	4.6
CARYA GLABRA	PIGNUT HICKORY	0.05	1.5	10	1.4	1041	0.7	3.6
QUERCUS VELUTINA	BLACK OAK	0.05	1.5	5	0.7	1571	1.0	3.2
TSUGA CANADENSIS	EASTERN HEMLOCK	0.05	1.5	5	0.7	1418	0.9	3.1
TOTAL		-	100.0	690	100.0	57676	100.0	300.0

Table F-20

Vegetation analysis for saplings in the Elimsport substation Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DENSITY (NO./HA)	RELATIVE DENSITY	DOMINANCE (BA/HA)	RELATIVE DOMINANCE	IMPORT. VALUE
BETULA LENTA	SWEET BIRCH	1.00	15.9	3115	63.9	42270	47.4	127.2
ACER RUBRUM	RED MAPLE	1.00	15.9	650	13.3	17719	19.9	49.1
SASSAFRAS ALBIDUM	SASSAFRAS	0.90	14.3	420	8.6	13485	15.1	38.0
LIRIODENDRON TULIPIFERA	TULIP-TREE	0.65	10.3	180	3.7	6664	7.5	21.5
QUERCUS PRINUS	CHESTNUT OAK	0.60	9.5	125	2.6	3695	4.1	16.2
QUERCUS BOREALIS	RED OAK	0.40	6.3	95	1.9	1437	1.6	9.8
NYSSA SYLVATICA	BLACK GUM	0.35	5.6	90	1.8	1689	1.9	9.3
CORNUS FLORIDA	FLOWERING DOGWOOD	0.30	4.8	55	1.1	444	0.5	6.4
QUERCUS VELUTINA	BLACK OAK	0.25	4.0	40	0.8	565	0.6	5.4
QUERCUS ALBA	WHITE OAK	0.20	3.2	20	0.4	110	0.1	3.7
PINUS STROBUS	WHITE PINE	0.15	2.4	25	0.5	122	0.1	3.0
AMELANCHIER ARBOREA	SHAD-BUSH	0.10	1.6	10	0.2	20	0.0	1.8
PRUNUS PENSYLVANICA	PIN CHERRY	0.05	0.8	5	0.1	318	0.4	1.3
BETULA PAPYRIFERA	PAPER BIRCH	0.05	0.8	5	0.1	251	0.3	1.2
FAGUS GRANDIFOLIA	AMERICAN BEECH	0.05	0.8	10	0.2	51	0.1	1.1
PRUNUS SEROTINA	BLACK CHERRY	0.05	0.8	5	0.1	141	0.2	1.1
FRAXINUS AMERICANA	WHITE ASH	0.05	0.8	10	0.2	20	0.0	1.0
ACER PENSYLVANICUM	STRIPED MAPLE	0.05	0.8	5	0.1	35	0.0	0.9
CARYA GLABRA	PIGNUT HICKORY	0.05	0.8	5	0.1	16	0.0	0.9
TSUGA CANADENSIS	EASTERN HEMLOCK	0.05	0.8	5	0.1	35	0.0	0.9
TOTAL		-	100.0	4875	100.0	89087	100.0	300.0

Table F-21

Vegetation analysis for tree seedlings in the Elimsport substation Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DENSITY (NO./HA)	RELATIVE DENSITY	DOMINANCE (% COVER)	RELATIVE DOMINANCE	IMPORT. VALUE
ACER RUBRUM	RED MAPLE	0.78	37.3	33000	57.4	1.05	20.8	115.5
SASSAFRAS ALBIDUM	SASSAFRAS	0.35	16.7	11750	20.4	0.95	18.8	55.9
NYSSA SYLVATICA	BLACK GUM	0.30	14.4	5250	9.1	0.47	9.3	32.8
BETULA LENTA	SWEET BIRCH	0.10	4.8	1750	3.0	0.80	15.9	23.7
FRAXINUS AMERICANA	WHITE ASH	0.03	1.4	0	0.0	0.88	17.5	18.9
QUERCUS PRINUS	CHESTNUT OAK	0.15	7.2	2500	4.3	0.25	5.0	16.5
PRUNUS SEROTINA	BLACK CHERRY	0.13	6.2	1500	2.6	0.13	2.6	11.4
QUERCUS ALBA	WHITE OAK	0.05	2.4	500	0.9	0.20	4.0	7.3
QUERCUS BOREALIS	RED OAK	0.05	2.4	0	0.0	0.10	2.0	4.4
PINUS STROBUS	WHITE PINE	0.03	1.4	250	0.4	0.07	1.4	3.2
CRATAEGUS SP.	HAWTHORNE	0.03	1.4	250	0.4	0.05	1.0	2.8
ACER PENSYLVANICUM	STRIPED MAPLE	0.03	1.4	250	0.4	0.03	0.6	2.4
CORNUS FLORIDA	FLOWERING DOGWOOD	0.03	1.4	250	0.4	0.03	0.6	2.4
LIRIODENDRON TULIPIFERA	TULIP-TREE	0.03	1.4	250	0.4	0.03	0.6	2.4
TOTAL		-	100.0	57500	100.0	5.04	100.0	300.0

Table F-22

Vegetation analysis for shrubs, herbs, and ground cover in the Elimsport substation Forest, 1986.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE (% COVER)	RELATIVE DOMINANCE	IMPORTANCE VALUE
SHRUBS						
SMILAX ROTUNDIFOLIA	GREENBRIER	0.42	39.3	8.85	49.8	89.1
HAMAMELIS VIRGINIANA	WITCH HAZEL	0.25	23.4	4.45	25.0	48.4
VACCINIUM VACILLANS	LOW-BUSH BLUEBERRY	0.13	12.1	0.80	4.5	16.6
LINDERA BENZOIN	SPICEBUSH	0.07	6.5	1.15	6.5	13.0
VACCINIUM CORYMBOSUM	HIGH-BUSH BLUEBERRY	0.03	2.8	1.62	9.1	11.9
RUBUS HISPIDUS	DEWBERRY	0.03	2.8	0.63	3.5	6.3
PARTHENOCISSUS QUINQUEFOLIA	VIRGINIA CREEPER	0.05	4.7	0.05	0.3	5.0
RUBUS FLAGELLARIS	DEWBERRY	0.03	2.8	0.13	0.7	3.5
VITIS AESTIVALIS	SUMMER GRAPE	0.03	2.8	0.07	0.4	3.2
RUBUS ALLEGHENIENSIS	BLACKBERRY	0.03	2.8	0.03	0.2	3.0
HERBS						
DENNSTAEDTIA PUNCTILOBULA	HAY-SCENTED FERN	0.40	38.1	5.03	60.7	98.8
THELYPTERIS NOVEBORACENSIS	NEW YORK FERN	0.13	12.4	1.07	12.9	25.3
OSMUNDA CINNAMOMEA	CINNAMON FERN	0.05	4.8	0.85	10.3	15.1
POLYGONATUM BIFLORUM	SOLOMAN'S SEAL	0.07	6.7	0.28	3.4	10.1
MEDEOLA VIRGINIANA	INDIAN CUCUMBER	0.07	6.7	0.10	1.2	7.9
MITCHELLA REPENS	PARTRIDGE-BERRY	0.05	4.8	0.25	3.0	7.8
ARALIA NUDICAULIS	WILD SARSAPARILLA	0.05	4.8	0.20	2.4	7.2
LYSIMACHIA QUADRIFOLIA	WHORLED LOOSESTRIFE	0.05	4.8	0.10	1.2	6.0
ATHYRIUM FILIX-FEMINA	LADY FERN	0.03	2.9	0.13	1.6	4.5
OSMUNDA CLAYTONIANA	INTERRUPTED FERN	0.03	2.9	0.10	1.2	4.1
GLYCERIA STRIATA	FOWL MANNAGRASS	0.03	2.9	0.07	0.8	3.7
CAREX SWANNII	SEDGE	0.03	2.9	0.05	0.6	3.5
CAREX SP.	SEDGE	0.03	2.9	0.03	0.4	3.3
PANICUM SPP.	PANIC-GRASS	0.03	2.9	0.03	0.4	3.3
GROUND COVER						
LITTER	-	0.97	39.0	84.70	86.8	125.8
ROCK	-	0.82	32.9	9.75	10.0	42.9
MOSS	-	0.70	28.1	3.10	3.2	31.3

Table F-23

Daily meteorological data recorded at the SES Biological Laboratory, 1986.

DATE	PRECIP[a] (CM)	WEATHER	FOG	PLUME 1	PLUME 2	AIR TEMPERATURE (C) MIN	TIME	MAX	TIME	MEAN	BAROM. PRES. (IN Hg)[b] 1200	CH	2400	CH
JAN														
1	R	--	--	--	--	-5.0	2000	2.5	1300	-1.3	30.21	+	30.28	+
2	0.00	CLOUDY	NONE	+	+	-4.5	0500	5.5	1300	0.5	30.35	+	30.19	-
3	0.00	CLOUDY	NONE	+	+	-2.0	0100	9.5	1300	3.8	29.85	-	30.10	+
4	R	--	--	--	--	-0.5	0800	3.5	0100	1.5	30.31	+	30.03	-
5	R	--	--	--	--	-2.5	2100	4.5	1300	1.0	29.80	-	29.90	+
6	0.05	PARTLY CLOUDY	NONE	+	+	-6.0	2300	2.5	1100	-1.8	29.99	+	30.08	+
7	T	CLEAR	NONE	+	+	-9.0	0600	-3.5	1200	-6.3	30.18	+	30.39	+
8	0.00	CLEAR	NONE	+	+	-11.5	0700	-2.0	1300	-6.8	30.53	+	30.42	-
9	0.00	CLEAR	NONE	+	+	-8.5	0600	4.5	1400	-2.0	30.20	-	29.92	-
10	0.00	CLOUDY	NONE	+	+	-3.5	0100	6.5	1100	1.5	29.88	-	30.02	+
11	R	--	--	--	--	-5.0	0800	4.5	1400	-0.3	30.07	+	29.93	-
12	R	--	--	--	--	-5.0	0300	13.0	1500	4.0	29.60	-	29.64	+
13	0.00	PARTLY CLOUDY	NONE	+	+	-9.5	2400	4.0	1100	-2.8	29.61	-	29.86	+
14	0.03	CLOUDY	NONE	+	+	-10.5	0100	-3.0	1500	-6.8	29.84	-	30.10	+
15	0.00	CLEAR	NONE	+	+	-12.0	0700	-1.5	1300	-6.8	30.31	+	30.31	0
16	0.00	CLEAR	NONE	+	-	-5.0	0700	7.5	1400	1.3	30.33	-	30.31	-
17	0.00	CLOUDY	NONE	+	-	-2.0	0400	9.5	1300	3.8	30.11	-	30.07	-
18	R	--	--	--	--	5.0	0500	18.0	1500	11.5	30.02	-	29.91	-
19	R	--	--	--	--	8.5	0100	18.0	1500	13.3	29.58	-	29.24	-
20	1.17	LIGHT RAIN	LIGHT	+	-	4.5	2300	15.5	0100	10.0	29.21	+	29.61	+
21	0.79	CLEAR	NONE	+	-	-0.5	2400	11.5	1300	5.5	29.94	+	29.99	+
22	0.00	PARTLY CLOUDY	NONE	+	+	-0.5	0100	10.0	1300	4.8	29.87	-	30.16	+
23	0.03	PARTLY CLOUDY	NONE	+	+	-3.0	2400	4.0	0100	0.5	30.34	+	30.37	+
24	0.00	CLEAR	NONE	+	+	-5.5	0800	2.0	1500	-1.8	30.51	+	30.49	+
25	R	--	--	--	--	-0.5	0100	7.5	1900	3.5	30.18	-	29.88	-
26	R	--	--	--	--	4.0	2200	6.0	0100	5.0	29.65	-	29.35	-
27	4.45	CLEAR	NONE	+	+	-6.5	2400	6.0	1100	-0.3	29.29	+	29.43	+
28	0.05	CLOUDY	NONE	+	+	-11.5	2400	-3.5	1300	-7.5	29.66	+	29.85	+
29	0.00	PARTLY CLOUDY	NONE	+	+	-14.0	0600	-3.5	1300	-8.8	29.88	0	29.90	+
30	0.30	CLOUDY	NONE	+	+	-9.0	0400	2.5	1400	-3.8	30.15	+	30.21	+
31	0.00	CLEAR	NONE	+	+	-12.5	0700	4.0	1300	-4.3	30.27	+	30.34	+
TOTAL:	6.87								MEAN:	0.3				
									SE:	0.99				
FEB														
1	R	--	--	--	--	-11.5	0600	4.5	2300	-3.5	30.45	+	30.08	-
2	R	--	--	--	--	4.5	0100	10.5	1500	7.5	29.98	+	30.08	+
3	0.23	PARTLY CLOUDY	NONE	+	+	0.0	0700	9.0	1400	4.5	30.15	+	30.10	0
4	0.15	LIGHT RAIN	NONE	+	+	2.5	0100	4.0	1000	3.3	30.02	-	29.71	-
5	1.55	CLOUDY	LIGHT	+	+	3.0	0100	6.5	1500	4.8	29.64	+	29.83	+
6	0.00	CLOUDY	NONE	+	+	-1.0	2400	5.0	0200	2.0	30.05	+	30.00	-
7	0.91	SNOW	NONE	+	+	-6.0	0800	-1.0	0100	-3.5	29.88	-	29.94	+
8	R	--	--	--	--	-3.5	0100	7.0	1400	1.8	29.98	+	30.02	+
9	R	--	--	--	--	0.5	0300	5.5	1100	3.0	30.04	+	30.03	-
10	0.43	PARTLY CLOUDY	NONE	+	+	-1.5	0500	5.5	1300	2.0	30.00	-	29.94	-
11	0.97	SNOW	NONE	+	+	-4.0	0400	1.5	1300	-1.3	29.87	-	29.92	+
12	0.03	CLOUDY	NONE	+	+	-12.0	0600	2.0	1400	-5.0	30.01	+	30.01	+
13	0.00	PARTLY CLOUDY	NONE	+	+	-13.0	0700	1.0	1200	-6.0	30.13	+	30.17	+
14	0.00	CLOUDY	NONE	+	+	-10.5	0500	4.5	1200	-3.0	29.97	-	29.79	-
15	R	--	--	--	--	-7.5	2400	5.5	1300	-1.0	29.84	+	29.99	+
16	R	--	--	--	--	-10.0	0200	2.0	1500	-4.0	30.11	+	29.99	-
17	R	--	--	--	--	0.5	0100	6.0	1200	3.3	29.88	-	29.83	-
18	1.40	LIGHT RAIN	DENSE	--	--	5.5	0100	9.0	1400	7.3	29.73	-	29.68	0
19	0.58	CLOUDY	DENSE	--	--	5.0	0200	9.5	1200	7.3	29.69	+	29.76	+
20	0.97	CLOUDY	NONE	-	+	5.5	0600	7.5	1100	6.5	29.94	+	29.94	+
21	0.00	CLOUDY	NONE	-	+	3.0	2300	8.5	1200	5.8	29.73	-	29.96	+
22	R	--	--	--	--	-1.0	0700	7.0	1400	3.0	30.08	+	29.89	-
23	R	--	--	--	--	3.5	0200	10.0	1400	6.8	29.88	+	29.96	+
24	1.65	CLOUDY	NONE	-	+	1.5	0500	9.5	1300	5.5	29.92	-	29.82	-
25	T	PARTLY CLOUDY	NONE	-	+	-5.0	2400	3.0	1400	-1.0	29.78	-	29.78	+
26	0.00	CLEAR	NONE	-	+	-7.0	0600	2.5	1400	-2.3	29.62	-	29.52	-
27	0.03	CLOUDY	NONE	-	+	-4.0	0700	5.0	1500	0.5	29.55	+	29.60	+
28	0.00	PARTLY CLOUDY	NONE	-	+	-5.5	0700	3.5	1700	-1.0	29.83	+	29.87	+
TOTAL:	8.90								MEAN:	1.5				
									SE:	0.78				

Table F-23 (cont.)

DATE	PRECIP[a]	WEATHER	FOG	PLUME		AIR TEMPERATURE (C)					BAROM. PRES. (IN Hg)[b]			
	(CM)			1	2	MIN	TIME	MAX	TIME	MEAN	1200	CH	2400	CH
MAR														
1	R	--	--	--	--	-6.0	0800	7.0	1500	0.5	29.94	+	29.83	-
2	R	--	--	--	--	-3.0	0500	7.0	1600	2.0	29.84	+	29.86	+
3	0.00	PARTLY CLOUDY	NONE	-	+	-1.5	0700	10.0	1400	4.3	29.87	+	29.88	+
4	0.05	SNOW	LIGHT	-	+	0.5	2200	5.5	1400	3.0	29.83	-	29.82	-
5	0.03	CLOUDY	DENSE	-	+	-0.5	2400	8.5	1400	4.0	29.78	-	29.74	-
6	0.03	CLOUDY	NONE	-	+	-1.5	0300	5.5	1000	2.0	29.38	-	29.39	+
7	0.03	CLEAR	NONE	-	+	-10.5	2400	1.0	0100	-4.8	29.61	+	29.99	+
8	R	--	--	--	--	-12.0	0300	-0.5	1400	-6.3	30.25	+	30.16	-
9	R	--	--	--	--	-2.5	0100	6.0	1300	1.8	29.98	-	29.92	-
10	0.00	PARTLY CLOUDY	NONE	-	+	2.0	0100	21.0	1400	11.5	29.84	-	29.51	-
11	0.64	PARTLY CLOUDY	NONE	-	+	-1.0	2400	13.5	0100	6.3	29.70	+	30.07	+
12	T	CLEAR	NONE	-	+	-5.5	0500	5.5	1500	0.0	30.20	+	30.21	+
13	0.36	HEAVY RAIN	NONE	-	+	0.5	0500	5.0	1600	2.8	30.01	-	29.91	-
14	0.43	CLOUDY	LIGHT	-	+	3.0	0300	7.0	1300	5.0	29.78	-	29.34	-
15	R	--	--	--	--	3.0	2400	15.5	1300	9.3	29.69	+	29.76	+
16	R	--	--	--	--	1.5	0400	8.0	1200	4.8	29.85	+	29.99	+
17	6.93	CLOUDY	NONE	-	+	0.5	2400	7.5	1600	4.0	30.07	+	30.12	+
18	0.00	CLEAR	NONE	-	+	-4.0	0600	14.5	1400	5.3	30.15	+	29.88	-
19	0.23	CLOUDY	NONE	-	+	8.5	0100	19.5	1600	14.0	29.41	-	29.61	+
20	0.84	CLOUDY	NONE	-	+	-10.5	2400	9.0	0100	-0.8	29.91	+	30.23	+
21	0.00	CLEAR	NONE	-	+	-12.5	0400	0.5	1600	-6.0	30.34	+	30.33	+
22	R	--	--	--	--	-11.5	0700	6.5	1400	-2.5	30.39	+	30.30	-
23	R	--	--	--	--	-5.5	0700	15.5	1500	5.0	30.18	-	30.08	+
24	0.00	PARTLY CLOUDY	NONE	-	+	-2.0	0600	9.0	1400	3.5	30.40	+	30.50	+
25	0.00	PARTLY CLOUDY	NONE	-	+	-4.0	0400	18.0	1400	7.0	30.49	-	30.36	-
26	0.00	CLEAR	NONE	-	+	2.0	0600	23.0	1300	12.5	30.20	-	29.98	-
27	0.05	CLOUDY	NONE	-	+	4.5	2200	16.5	1200	10.5	29.95	-	30.12	+
28	R	--	--	--	--	3.5	0300	15.0	1500	9.3	30.19	+	30.08	-
29	R	--	--	--	--	3.0	0100	26.5	1500	14.8	30.04	-	29.99	+
30	R	--	--	--	--	6.0	0700	30.0	1600	18.0	29.90	-	29.87	+
31	0.00	CLEAR	NONE	-	+	7.0	2400	21.0	1500	14.0	30.10	+	30.11	+
TOTAL:	9.62								MEAN:	5.0				
									SE:	1.10				
APR														
1	0.00	CLEAR	NONE	-	+	3.0	0600	25.5	1300	14.3	30.00	-	29.83	-
2	0.00	PARTLY CLOUDY	NONE	-	+	6.5	2300	16.5	1300	11.5	29.95	+	30.08	+
3	0.00	CLEAR	NONE	-	+	0.5	0600	19.5	1500	10.0	30.16	+	30.14	+
4	0.00	CLOUDY	NONE	-	+	8.0	0500	13.0	1300	10.5	30.11	-	30.13	+
5	R	--	--	--	--	4.0	2400	10.0	1300	7.0	30.23	+	30.20	-
6	R	--	--	--	--	3.5	0400	6.5	1500	5.0	30.09	-	29.83	-
7	1.37	CLOUDY	LIGHT	-	+	4.5	0100	17.5	1500	11.0	29.77	-	29.62	-
8	0.03	CLOUDY	NONE	-	+	5.5	2400	17.0	1300	11.3	29.48	-	29.50	+
9	0.00	CLOUDY	NONE	-	+	-1.5	0500	6.0	1700	2.3	29.45	-	29.47	+
10	0.00	PARTLY CLOUDY	NONE	-	+	-1.0	0600	5.0	1500	2.0	29.41	-	29.47	+
11	0.03	SNOW	NONE	-	+	-2.0	0500	4.5	1400	1.3	29.43	0	29.53	+
12	R	--	--	--	--	-1.5	2400	9.0	1600	3.8	29.72	+	29.85	+
13	R	--	--	--	--	-5.5	0600	14.5	1500	4.5	29.92	+	29.99	+
14	0.05	CLEAR	NONE	-	+	-3.0	0500	18.5	1400	7.8	30.03	+	29.96	-
15	0.00	CLOUDY	NONE	-	+	1.0	0400	7.5	1500	4.3	29.94	-	29.81	-
16	2.31	CLOUDY	NONE	-	+	4.5	0100	6.0	0400	5.3	29.72	-	29.70	+
17	1.98	HEAVY RAIN	NONE	-	+	2.0	2300	6.5	0100	4.3	29.87	+	29.96	+
18	1.22	FOG	DENSE	--	--	0.0	0500	19.5	1500	9.8	30.08	+	30.14	+
19	R	--	--	--	--	0.5	0600	22.0	1500	11.3	30.09	-	29.95	-
20	R	--	--	--	--	4.0	0400	22.0	1300	13.0	29.79	-	29.60	-
21	T	LIGHT RAIN	NONE	-	+	5.5	2300	14.0	0800	9.8	29.45	-	29.56	+
22	0.53	HEAVY RAIN	NONE	-	+	-0.5	2300	6.0	0500	2.8	29.75	+	29.88	+
23	1.04	CLOUDY	NONE	+	+	-0.5	0100	7.0	1800	3.3	29.92	+	30.02	+
24	0.13	CLEAR	NONE	+	+	-1.5	0500	20.0	1600	9.3	30.08	+	29.97	-
25	0.00	PARTLY CLOUDY	NONE	-	+	3.5	0500	24.5	1400	14.0	29.93	-	29.93	+
26	R	--	--	--	--	5.5	0500	22.0	1600	13.8	29.94	+	29.98	+
27	R	--	--	--	--	8.0	0600	24.5	1400	16.3	29.93	-	29.98	+
28	0.03	CLEAR	NONE	+	+	8.0	0600	28.5	1300	18.3	29.91	-	29.82	-
29	0.00	CLEAR	NONE	+	+	12.5	0100	24.0	1600	18.3	29.83	0	29.94	+
30	0.00	CLEAR	NONE	+	+	7.5	0500	24.0	1400	15.8	30.00	+	29.87	-
TOTAL:	8.72								MEAN:	9.1				
									SE:	0.92				

Table F-23 (cont.)

DATE	PRECIP* (CM)	WEATHER	FOG	PLUME 1	PLUME 2	AIR TEMPERATURE (C) MIN	TIME	MAX	TIME	MEAN	BAROM. PRES. (IN Hg)[b] 1200	CH	2400	CH
MAY														
1	0.00	CLOUDY	NONE	+	+	7.5	2400	28.0	1300	17.8	29.63	-	29.70	+
2	0.10	PARTLY CLOUDY	NONE	+	+	4.5	2400	12.0	1400	8.3	29.88	+	29.98	+
3	R	--	--	--	--	1.5	0600	12.0	1400	6.8	30.05	+	30.07	+
4	R	--	--	--	--	0.0	0600	19.0	1600	9.5	30.10	+	29.91	-
5	0.00	PARTLY CLOUDY	NONE	+	+	7.0	0100	30.5	1400	18.8	29.82	-	29.82	+
6	0.00	CLEAR	NONE	+	+	10.0	0500	30.0	1600	20.0	29.83	+	29.78	-
7	0.03	CLOUDY & HAZE	NONE	+	+	11.5	2400	27.0	1400	19.3	29.70	-	29.79	+
8	0.00	CLEAR	NONE	+	+	5.0	0500	18.0	1300	11.5	29.82	+	30.04	+
9	0.00	PARTLY CLOUDY	NONE	+	+	5.0	0600	16.5	1400	10.8	30.11	+	30.15	+
10	R	--	--	--	--	0.5	0500	21.0	1500	10.8	30.09	-	29.93	-
11	R	--	--	--	--	1.0	0500	21.5	1300	11.3	29.84	-	29.95	+
12	0.00	CLEAR	NONE	+	+	0.5	0400	21.0	1200	10.8	29.85	-	29.96	+
13	0.00	CLEAR	NONE	+	+	1.5	0400	21.0	1200	11.3	29.94	-	30.04	+
14	0.00	PARTLY CLOUDY	NONE	+	+	3.0	0500	20.5	1400	11.8	30.12	+	30.16	+
15	0.00	CLOUDY	NONE	+	+	14.5	0300	20.5	1300	17.5	30.19	+	30.11	-
16	0.00	CLOUDY	NONE	+	+	17.5	0100	26.0	1300	21.8	30.02	-	29.88	-
17	R	--	--	--	--	16.0	0500	30.0	1500	23.0	29.90	+	29.87	-
18	R	--	--	--	--	15.5	0500	34.5	1300	25.0	29.83	-	29.82	+
19	0.56	CLEAR & HAZE	NONE	+	+	18.0	0400	33.5	1100	25.8	29.84	+	29.86	+
20	2.67	LIGHT RAIN	NONE	+	+	18.0	2300	25.0	1400	21.5	29.81	-	29.80	0
21	4.80	CLOUDY	NONE	+	+	15.5	2400	21.5	1300	18.5	29.84	+	29.79	-
22	1.37	CLOUDY	NONE	+	+	13.5	2400	21.0	1600	17.3	29.73	-	29.78	+
23	0.03	CLOUDY	NONE	+	+	11.0	2400	22.0	1400	16.5	29.84	+	29.87	+
24	R	--	--	--	--	9.0	0400	23.5	1600	16.3	29.94	+	29.96	+
25	R	--	--	--	--	10.5	0500	26.5	1600	18.5	29.99	+	30.00	+
26	R	--	--	--	--	11.5	0400	27.5	1400	19.5	30.05	+	30.04	+
27	0.00	PARTLY CLOUDY	NONE	-	-	11.5	0500	26.0	1400	18.8	30.01	-	29.93	-
28	0.00	CLOUDY	NONE	-	-	16.5	0300	30.5	1300	23.5	29.84	-	29.86	+
29	0.00	CLEAR	NONE	-	-	14.5	0500	33.0	1400	23.8	29.86	-	29.76	+
30	0.00	CLEAR	NONE	-	-	16.0	0500	34.0	1200	25.0	29.72	-	29.68	+
31	R	--	--	--	--	15.0	0500	31.5	1500	23.3	29.67	-	29.67	+
TOTAL:	9.56							MEAN:		17.2				
								SE:		0.99				
JUN														
1	R	--	--	--	--	16.0	0600	31.5	1400	23.8	29.61	-	29.59	+
2	0.18	CLOUDY	NONE	-	-	5.0	2400	20.5	0100	12.8	29.88	+	30.13	+
3	0.00	CLEAR	NONE	-	-	0.5	0500	21.0	1400	10.8	30.20	+	30.12	-
4	0.00	CLEAR	NONE	-	-	7.0	0200	27.5	1600	17.3	30.03	-	29.93	-
5	0.00	CLOUDY	NONE	-	-	17.5	0400	29.0	1500	23.3	29.90	-	29.86	+
6	3.00	CLOUDY	LIGHT	-	-	15.5	2400	25.5	1300	20.5	29.86	+	29.85	-
7	R	--	--	--	--	12.5	0500	28.0	1400	20.3	29.80	-	29.69	-
8	R	--	--	--	--	17.0	2400	30.0	1300	23.5	29.62	-	29.81	+
9	0.30	CLEAR	NONE	-	-	11.0	2400	24.5	1500	17.8	30.03	+	30.11	+
10	0.00	CLEAR	NONE	-	-	7.5	0500	28.0	1300	17.8	30.08	-	29.85	-
11	0.56	CLOUDY	NONE	-	-	19.5	0500	32.5	1500	26.0	29.70	-	29.69	+
12	0.76	HEAVY RAIN	NONE	-	-	15.5	2100	22.5	0100	19.0	29.72	+	29.77	+
13	3.05	CLOUDY	NONE	-	-	14.5	0300	25.0	1600	19.8	29.85	+	29.98	+
14	R	--	--	--	--	18.0	2400	28.0	1500	23.0	30.01	+	29.97	-
15	R	--	--	--	--	16.0	0500	31.5	1600	23.8	29.97	-	29.91	0
16	0.03	HAZY	NONE	-	-	14.0	2400	31.5	1300	22.8	29.81	-	29.72	+
17	1.12	PARTLY CLOUDY	NONE	-	-	10.0	2400	21.5	1600	15.8	29.93	+	29.99	+
18	0.00	CLEAR	NONE	-	-	5.5	0500	23.0	1500	14.3	29.98	-	29.98	+
19	0.00	CLEAR	NONE	-	+	5.5	0500	26.0	1300	15.8	29.93	-	29.84	-
20	0.33	CLOUDY	LIGHT	-	+	15.5	2400	25.0	1200	20.3	29.86	+	30.02	+
21	R	--	--	--	--	10.5	0500	26.5	1400	18.5	30.11	+	30.07	-
22	R	--	--	--	--	10.0	0500	30.0	1300	20.0	30.00	-	29.83	-
23	0.08	PARTLY CLOUDY	NONE	+	+	17.0	0100	29.5	1100	23.3	29.77	-	29.81	+
24	0.36	LIGHT RAIN	NONE	+	+	12.0	0500	26.0	1300	19.0	29.70	-	29.84	+
25	0.18	PARTLY CLOUDY	NONE	+	+	8.5	2400	21.5	1400	15.0	29.95	+	30.03	+
26	0.00	PARTLY CLOUDY	NONE	+	+	7.0	0200	26.5	1600	16.8	30.07	+	30.01	-
27	0.00	PARTLY CLOUDY	NONE	+	+	12.0	0500	31.0	1400	21.5	29.86	-	29.73	-
28	R	--	--	--	--	18.5	0400	29.5	1600	24.0	29.72	-	29.65	-
29	R	--	--	--	--	15.5	2400	29.0	1400	22.3	29.64	-	29.72	+
30	0.86	CLOUDY	LIGHT	--	--	12.5	2400	22.5	1100	17.5	29.79	+	29.89	+
TOTAL	10.81							MEAN:		19.5				
								SE:		0.68				

Table F-23 (cont.)

DATE	PRECIP[a] (CM)	WEATHER	FOG	PLUME 1	PLUME 2	AIR TEMPERATURE (C) MIN	TIME	MAX	TIME	MEAN	BAROM. PRES. (IN Hg)[b] 1200	CH	2400	CH
JUL														
1	T	FOG	DENSE	--	--	7.5	0500	26.0	1300	16.8	29.93	-	29.77	-
2	1.47	HEAVY RAIN	NONE	+	+	10.0	0500	25.5	1300	17.8	29.49	-	29.53	+
3	0.53	CLEAR	NONE	+	+	11.0	2400	24.0	1300	17.5	29.67	+	29.87	+
4	R	--	--	--	--	7.5	0500	28.0	1400	17.8	29.90	-	29.87	+
5	R	--	--	--	--	15.0	0500	33.0	1400	24.0	29.91	+	29.94	+
6	R	--	--	--	--	16.5	0500	34.5	1300	25.5	29.93	-	29.93	+
7	0.03	HAZE	NONE	+	+	18.5	0400	35.5	1300	27.0	29.88	-	29.82	+
8	0.00	CLEAR	NONE	+	+	20.5	0500	32.5	1200	26.5	29.82	-	29.65	-
9	0.08	CLOUDY & HAZE	NONE	+	+	19.5	2400	26.0	1800	22.8	29.53	-	29.67	+
10	2.92	CLEAR	NONE	+	+	14.0	0600	28.0	1400	21.0	29.78	+	29.79	+
11	0.00	CLOUDY	NONE	+	+	15.0	0600	22.0	1300	18.5	29.80	0	29.76	-
12	R	--	--	--	--	17.5	0500	25.0	1800	21.2	29.68	-	29.69	+
13	R	--	--	--	--	20.5	0400	30.5	1400	25.5	29.68	-	29.70	+
14	2.77	CLEAR	NONE	+	+	16.5	2400	29.0	1500	22.8	29.73	+	29.86	+
15	0.00	CLEAR	NONE	+	+	13.5	0500	30.0	1400	21.8	29.90	+	29.91	+
16	0.00	CLOUDY	NONE	+	+	15.0	0500	21.0	1400	18.0	29.96	+	30.12	-
17	0.20	CLOUDY & HAZE	NONE	+	+	19.5	0400	28.5	1500	24.0	30.11	0	30.03	-
18	1.65	FOG	LIGHT	+	-	21.5	0100	31.0	1400	26.2	29.98	-	29.93	-
19	R	--	--	--	--	22.5	2400	30.5	1400	26.5	29.94	+	29.93	+
20	R	--	--	--	--	21.5	2400	28.0	1500	24.8	29.88	-	29.87	+
21	0.86	PARTLY CLOUDY	NONE	+	+	17.0	2400	28.0	1400	22.5	30.01	+	30.13	+
22	0.00	PARTLY CLOUDY	LIGHT	+	+	14.5	0500	31.0	1500	22.8	30.19	+	30.18	+
23	0.00	LIGHT RAIN	NONE	+	+	19.0	2400	28.0	1400	23.5	30.23	+	30.22	+
24	0.00	CLEAR	NONE	+	+	16.0	0700	29.5	1400	22.8	30.21	-	30.13	-
25	0.00	CLOUDY	NONE	+	+	19.5	0700	27.5	1700	23.5	30.10	-	30.00	-
26	R	--	--	--	--	19.5	2400	26.5	1800	23.0	29.95	-	29.89	-
27	R	--	--	--	--	17.5	0800	26.0	1600	21.8	29.90	+	29.88	+
28	7.06	CLEAR	NONE	+	+	17.5	0700	29.0	1600	23.2	29.88	0	29.83	-
29	0.03	CLOUDY	NONE	+	+	18.0	0400	30.5	1200	24.2	29.76	-	29.82	+
30	0.79	PARTLY CLOUDY	NONE	+	+	17.5	0500	26.5	1400	22.0	29.84	+	29.86	+
31	0.13	CLOUDY	NONE	+	+	18.0	0700	24.5	1600	21.2	29.91	+	29.94	+
TOTAL	18.52								MEAN:	22.5				
									SE:	0.51				
AUG														
1	1.91	CLOUDY	LIGHT	--	--	16.5	0300	28.5	1300	22.5	29.94	+	29.96	+
2	R	--	--	--	--	16.5	0200	26.0	1300	21.2	29.92	-	29.95	+
3	R	--	--	--	--	15.5	2400	28.0	1400	21.8	29.98	+	30.08	+
4	9.47	FOG	DENSE	--	--	13.5	0400	26.5	1400	20.0	30.15	+	30.17	+
5	0.00	FOG	DENSE	--	--	12.0	0600	27.0	1500	19.5	30.14	-	30.12	+
6	0.03	PARTLY CLOUDY	LIGHT	+	+	15.5	0500	27.5	1400	21.5	30.12	-	30.07	+
7	0.48	PARTLY CLOUDY	NONE	+	+	16.0	0100	27.0	1400	21.5	29.99	-	20.90	-
8	0.74	FOG	DENSE	--	--	16.5	0200	26.5	1400	21.5	29.85	-	29.86	+
9	R	--	--	--	--	16.5	0400	27.5	1500	22.0	29.92	+	30.02	+
10	R	--	--	--	--	12.5	0700	25.5	1700	19.0	30.00	-	29.83	-
11	1.14	PARTLY CLOUDY	NONE	+	-	15.0	2400	25.5	1400	20.2	29.98	+	30.14	+
12	0.03	PARTLY CLOUDY	NONE	+	-	10.5	0500	22.0	1200	16.2	30.26	+	30.29	+
13	0.00	PARTLY CLOUDY	NONE	+	-	8.5	0300	25.0	1200	16.8	30.27	-	30.22	-
14	0.00	PARTLY CLOUDY	NONE	+	-	11.5	0400	27.5	1400	19.5	30.18	-	30.11	0
15	0.00	PARTLY CLOUDY	NONE	+	-	14.0	0400	25.0	1700	19.5	30.03	-	29.97	-
16	R	--	--	--	--	18.5	0500	26.5	1400	22.5	29.94	-	29.94	+
17	R	--	--	--	--	20.0	0400	26.5	1500	23.2	29.95	+	29.96	+
18	0.25	CLOUDY	NONE	+	-	17.5	2400	27.5	1400	22.5	29.91	-	30.02	+
19	T	CLOUDY	NONE	+	-	16.5	0200	26.0	1400	21.2	30.11	+	30.17	+
20	0.00	CLOUDY	NONE	+	-	18.5	0400	24.5	1300	21.5	30.23	+	30.25	+
21	0.00	CLOUDY	NONE	+	-	15.5	2400	18.5	1300	17.0	30.24	+	30.19	-
22	1.22	CLOUDY	LIGHT	+	-	13.5	2400	25.0	1200	19.2	30.23	+	30.20	+
23	R	--	--	--	--	11.5	0500	26.0	1400	18.8	30.02	-	29.80	-
24	R	--	--	--	--	11.5	2400	22.0	1400	16.8	29.94	+	30.06	+
25	2.18	PARTLY CLOUDY	NONE	+	-	6.5	0600	22.5	1500	14.5	30.17	+	30.16	+
26	0.00	CLEAR	NONE	+	-	11.5	0500	28.5	1300	20.0	30.10	-	29.90	-
27	0.00	PARTLY CLOUDY	NONE	+	-	16.0	2300	24.5	1400	20.2	29.82	+	29.91	+
28	0.15	CLOUDY	NONE	+	-	6.0	2400	17.0	1600	11.5	30.04	+	30.21	+
29	0.00	CLEAR	LIGHT	+	-	4.0	0400	19.5	1300	11.8	30.36	+	30.39	+
30	R	--	--	--	--	4.5	0400	22.5	1200	13.5	30.45	+	30.41	+
31	R	--	--	--	--	6.5	0400	25.0	1300	15.8	30.40	+	30.33	+
TOTAL	17.60								MEAN:	19.1				
									SE:	0.57				

Table F-23 (cont.)

DATE	PRECIP[a] (CM)	WEATHER	FOG	PLUME 1	PLUME 2	AIR TEMPERATURE (C) MIN	TIME	MAX	TIME	MEAN	BAROM. PRES. (IN Hg)[b] 1200	CH	2400	CH
SEP														
1	R	--	--	--	--	8.0	0500	24.0	1300	16.0	30.30	-	30.23	-
2	0.00	PARTLY CLOUDY	LIGHT	+	-	11.5	0600	27.5	1300	19.5	30.23	-	30.23	+
3	0.00	CLOUDY	LIGHT	+	-	15.5	0100	28.5	1400	22.0	30.26	+	30.24	+
4	0.00	CLOUDY	NONE	+	-	19.0	0100	23.0	1600	21.0	30.17	-	30.07	-
5	0.00	CLOUDY	NONE	+	-	18.5	2400	23.5	1700	21.0	29.93	-	29.93	+
6	R	--	--	--	--	14.0	2400	27.5	1200	20.7	29.97	+	30.03	+
7	R	--	--	--	--	10.5	2400	20.0	1500	15.2	30.08	+	30.14	+
8	0.36	PARTLY CLOUDY	LIGHT	+	-	7.0	2400	22.0	1400	14.5	30.22	-	30.27	+
9	0.00	CLEAR	DENSE	+	-	3.5	0500	23.0	1400	13.2	30.31	-	30.28	+
10	0.00	PARTLY CLOUDY	NONE	+	-	6.5	0500	24.5	1300	15.5	30.20	-	30.08	-
11	0.00	PARTLY CLOUDY	NONE	+	-	17.0	0600	29.0	1300	23.0	29.95	-	29.81	-
12	0.18	CLOUDY	NONE	+	-	17.0	2300	27.0	1500	22.0	29.74	+	29.99	+
13	R	--	--	--	--	10.0	0600	24.5	1300	17.2	30.16	+	30.21	+
14	R	--	--	--	--	7.5	0600	20.0	1500	13.7	30.34	+	30.31	+
15	T	PARTLY CLOUDY	NONE	-	-	5.5	0300	21.0	1500	13.2	30.23	-	29.95	-
16	0.10	PARTLY CLOUDY	NONE	-	-	4.5	2300	15.5	0100	10.0	30.29	+	30.40	+
17	0.00	CLEAR	LIGHT	-	-	1.5	0400	17.5	1300	9.5	30.43	-	30.37	+
18	0.00	CLEAR	DENSE	-	-	3.0	0400	19.0	1100	11.0	30.28	-	30.18	-
19	0.61	CLOUDY	LIGHT	-	-	11.5	2400	20.0	1400	15.7	30.21	+	30.23	+
20	R	--	--	--	--	10.5	0200	20.0	1400	15.2	30.20	-	30.13	0
21	R	--	--	--	--	10.0	2400	18.0	1500	14.0	30.25	+	30.28	+
22	0.20	CLOUDY	LIGHT	-	-	10.0	0100	18.0	1300	14.0	30.22	-	30.02	-
23	T	CLEAR & HAZE	NONE	+	-	16.5	0100	27.0	1200	21.7	29.81	-	29.84	+
24	1.27	FOG	DENSE	+	-	17.5	2300	26.5	1300	22.0	29.90	+	29.94	+
25	0.03	FOG	DENSE	+	-	15.0	0600	20.0	1300	17.5	30.07	+	30.11	+
26	0.00	CLOUDY	LIGHT	+	-	17.0	0100	29.0	1400	23.0	30.03	-	29.99	+
27	R	--	--	--	--	15.0	2300	20.5	0900	17.7	30.08	+	30.18	+
28	R	--	--	--	--	14.0	0600	18.5	1500	16.2	30.26	+	30.24	0
29	3.05	CLOUDY	LIGHT	+	-	16.5	0100	24.0	1600	20.2	30.21	-	30.12	-
30	T	CLEAR	DENSE	+	-	15.5	0400	30.5	1200	23.0	30.05	-	29.98	+
TOTAL:	5.80							MEAN:		17.3				
								SE:		0.75				
OCT														
1	0.10	CLEAR	LIGHT	+	-	18.5	2300	25.0	1000	21.7	30.01	+	29.95	-
2	0.30	PARTLY CLOUDY	LIGHT	+	-	15.5	2400	28.0	1500	21.7	29.97	+	30.12	+
3	0.03	LIGHT RAIN	NONE	+	-	13.0	0400	19.0	2200	16.0	30.09	-	29.78	-
4	R	--	--	--	--	18.5	0100	24.0	1300	21.2	29.76	-	29.63	+
5	R	--	--	--	--	9.0	2400	20.5	1500	14.7	29.84	+	29.81	+
6	2.51	LIGHT RAIN	NONE	+	-	5.0	2400	17.0	1500	11.0	29.95	+	30.15	+
7	0.00	PARTLY CLOUDY	NONE	+	-	3.0	0300	16.5	1400	9.7	30.27	+	30.23	+
8	0.00	CLEAR	DENSE	+	-	3.5	0500	23.0	1400	13.2	30.18	-	30.14	+
9	0.00	FOG	DENSE	+	+	7.5	2400	23.5	1400	15.5	30.14	+	30.28	+
10	0.13	CLEAR	NONE	+	+	3.5	0600	13.5	1600	8.5	30.45	+	30.47	+
11	R	--	--	--	--	0.0	0600	16.0	1600	8.0	30.53	+	30.42	-
12	R	--	--	--	--	7.5	0700	21.0	1400	14.2	30.32	-	30.21	-
13	0.10	LIGHT RAIN	NONE	--	--	14.5	0100	17.5	1300	16.0	30.09	-	29.97	-
14	1.55	LIGHT RAIN	LIGHT	+	-	7.5	2400	21.0	1200	14.2	29.76	-	29.94	+
15	0.05	PARTLY CLOUDY	NONE	+	-	4.0	0700	13.0	1400	8.5	30.06	+	30.11	+
16	0.00	PARTLY CLOUDY	NONE	+	-	8.0	0600	15.5	1300	11.7	30.09	-	30.11	+
17	T	CLOUDY	NONE	+	-	7.5	0200	11.0	1400	9.2	30.18	+	30.30	+
18	R	--	--	--	--	4.0	2400	14.5	1500	9.2	30.48	+	30.51	+
19	R	--	--	--	--	0.0	0700	16.0	1600	8.0	30.50	-	30.38	-
20	0.15	CLEAR	DENSE	+	-	0.0	0700	19.5	1400	9.7	30.34	-	30.24	+
21	0.03	CLEAR	DENSE	+	-	3.0	0600	21.5	1500	12.2	30.19	-	30.14	+
22	0.00	CLEAR	DENSE	+	-	7.5	0700	23.0	1400	15.2	30.21	+	30.16	-
23	0.00	PARTLY CLOUDY	NONE	+	-	10.0	0500	23.5	1500	16.7	30.13	-	30.16	+
24	0.00	CLEAR	NONE	+	+	5.5	2400	18.5	1400	12.0	30.28	+	30.33	+
25	R	--	--	--	--	2.0	0600	16.5	1400	9.2	30.32	-	30.20	-
26	R	--	--	--	--	11.5	0200	14.5	1500	13.0	30.08	-	29.97	-
27	1.19	CLOUDY	NONE	+	-	12.5	0300	16.0	1300	14.2	29.88	-	29.88	+
28	0.13	PARTLY CLOUDY	NONE	+	-	7.5	2400	20.0	1400	13.7	30.05	+	30.19	+
29	0.00	CLEAR	DENSE	--	--	4.5	0700	22.5	1400	13.5	30.16	-	30.04	-
30	0.00	PARTLY CLOUDY	NONE	+	+	5.5	2200	15.0	1100	10.2	30.24	+	30.50	+
31	0.00	CLEAR	NONE	+	+	0.0	0600	13.0	1400	6.5	30.69	+	30.68	+
TOTAL:	6.27							MEAN:		12.8				
								SE:		0.72				

Table F-23 (cont.)

DATE	PRECIP[a] (CM)	WEATHER	FOG	PLUME 1	PLUME 2	AIR TEMPERATURE (C) MIN	TIME	MAX	TIME	MEAN	BAROM. PRES. (IN Hg)[b] 1200	CH	2400	CH
NOV														
1	R	--	--	--	--	2.0	0300	15.0	1400	8.5	30.55	-	30.33	-
2	R	--	--	--	--	0.5	2400	14.0	0900	7.3	30.25	+	30.29	+
3	0.08	FOG	DENSE	+	+	-2.0	0700	13.0	1500	5.5	30.23	-	30.07	-
4	0.05	CLOUDY	LIGHT	+	+	5.0	2400	13.5	1300	9.3	30.09	+	30.28	+
5	0.03	SNOW	NONE	+	+	2.0	1200	7.5	2400	4.8	30.23	-	29.99	-
6	1.40	CLOUDY	NONE	+	+	5.0	2400	11.5	1700	8.3	30.13	+	30.38	+
7	0.03	CLOUDY	LIGHT	+	+	2.0	0800	10.0	2100	6.0	30.44	+	30.40	-
8	R	--	--	--	--	10.0	0100	16.5	1700	13.3	30.18	-	30.02	-
9	R	--	--	--	--	11.0	2400	17.5	1300	14.3	29.97	+	30.19	+
10	2.57	PARTLY CLOUDY	NONE	+	+	1.0	2400	10.5	0100	5.8	30.45	+	30.41	-
11	0.10	SNOW	NONE	+	+	1.0	0100	4.5	1500	2.8	30.21	-	30.27	+
12	0.81	CLOUDY	LIGHT	+	+	1.5	2300	8.0	1400	4.8	30.28	-	30.18	-
13	0.00	PARTLY CLOUDY	NONE	+	+	-4.5	2400	2.5	0700	-1.0	30.34	+	30.57	+
14	0.00	CLEAR	NONE	+	+	-5.5	0700	3.5	1400	-1.0	30.58	-	30.58	-
15	R	--	--	--	--	-4.5	0200	7.0	1500	-1.3	30.22	-	30.03	-
16	R	--	--	--	--	3.5	0400	9.5	1400	6.5	29.98	-	29.95	-
17	0.00	CLOUDY	NONE	+	+	2.0	2400	13.5	1300	7.8	29.91	-	29.95	+
18	0.00	CLOUDY	LIGHT	+	+	0.0	0300	7.5	1300	3.8	29.99	-	29.71	-
19	2.13	PARTLY CLOUDY	NONE	+	+	-6.5	2400	2.5	0200	-2.0	30.20	+	30.35	+
20	0.00	CLOUDY	NONE	+	+	-7.5	0300	9.5	1900	1.0	30.12	-	29.64	-
21	2.31	CLOUDY	NONE	+	+	2.0	1800	5.5	0800	3.8	29.80	+	30.04	+
22	R	--	--	--	--	-1.5	2400	7.0	1400	2.8	30.21	+	30.29	+
23	R	--	--	--	--	-2.5	0500	10.0	1100	3.8	30.22	-	30.09	-
24	0.30	LIGHT RAIN	DENSE	+	+	2.0	2200	11.0	1400	6.5	30.03	-	30.19	+
25	0.03	CLEAR	NONE	+	+	-1.0	0500	9.5	1400	4.3	30.29	+	30.24	-
26	0.56	HEAVY RAIN	NONE	+	+	0.5	0100	11.5	1600	5.5	29.96	-	29.78	+
27	R	--	--	--	--	-1.0	2400	10.0	1300	4.5	30.14	+	30.19	+
28	R	--	--	--	--	-2.5	0500	8.0	1300	2.8	30.23	-	30.14	-
29	R	--	--	--	--	-0.5	0200	9.0	1300	4.3	30.12	+	30.21	+
30	R	--	--	--	--	-4.5	2400	6.5	1200	1.0	30.34	+	30.52	+
TOTAL	10.40								MEAN:	4.8				
									SE:	0.70				
DEC														
1	1.68	PARTLY CLOUDY	NONE	+	+	-6.5	0600	1.0	1400	-2.8	30.60	+	30.54	-
2	0.00	CLOUDY	NONE	+	+	0.0	0100	9.0	2300	4.5	30.23	-	29.69	-
3	1.22	CLOUDY	NONE	+	+	2.5	2400	9.5	1300	6.0	29.62	+	29.88	+
4	0.05	PARTLY CLOUDY	NONE	+	+	-1.5	1900	3.5	1000	1.0	30.02	+	30.14	+
5	0.00	CLOUDY	NONE	+	+	-2.5	0500	2.5	1300	0.0	30.29	+	30.42	+
6	R	--	--	--	--	-6.5	0800	4.0	1500	-1.3	30.39	-	30.38	+
7	R	--	--	--	--	-1.5	0100	6.0	1500	2.3	30.27	-	30.08	-
8	T	CLOUDY	NONE	+	+	3.0	2100	6.5	0200	4.8	30.26	+	30.25	-
9	0.28	CLOUDY	NONE	+	+	4.0	0100	8.0	1900	6.0	30.03	-	29.80	-
10	1.12	CLOUDY	NONE	+	+	0.5	2400	9.5	1000	5.0	29.89	+	30.15	+
11	0.00	CLOUDY	NONE	+	+	-1.5	0700	2.0	1300	0.3	30.10	-	29.92	-
12	0.10	CLOUDY	NONE	+	-	0.5	0100	4.5	1600	2.5	29.93	+	29.98	+
13	R	--	--	--	--	-9.0	2400	1.5	0100	-3.8	30.42	+	30.58	+
14	R	--	--	--	--	-12.0	0600	4.0	1500	-4.0	30.37	-	30.23	-
15	T	CLEAR	NONE	+	-	-5.5	0500	4.5	1300	-0.5	30.24	-	30.28	+
16	0.00	CLOUDY	NONE	+	-	-3.5	0100	2.5	1200	-0.5	30.22	-	30.23	+
17	0.00	CLOUDY	NONE	+	+	-1.0	0100	3.5	1300	1.3	30.27	+	30.12	-
18	0.43	LIGHT RAIN	NONE	+	+	0.0	2300	3.5	0200	1.8	29.85	-	29.74	-
19	0.89	CLOUDY	NONE	-	+	0.5	0100	3.0	1200	1.8	29.93	+	30.05	+
20	R	--	--	--	--	-1.5	2300	2.0	1400	0.3	30.13	+	30.19	+
21	R	--	--	--	--	-7.0	2400	1.5	1200	-2.8	30.34	+	30.39	+
22	0.00	PARTLY CLOUDY	NONE	-	+	-10.5	0600	4.0	1400	-3.3	30.38	-	30.26	-
23	0.00	CLEAR	NONE	-	+	-7.0	0500	6.5	1300	-0.3	30.18	-	30.19	+
24	0.00	PARTLY CLOUDY	NONE	+	+	-3.0	0200	8.5	2400	2.8	30.11	-	29.67	-
25	R	--	--	--	--	5.5	0700	8.5	0100	7.0	29.71	+	29.98	+
26	R	--	--	--	--	1.5	2400	5.5	0100	3.5	30.13	+	30.18	+
27	R	--	--	--	--	1.5	0100	4.5	1200	3.0	30.26	+	30.21	-
28	R	--	--	--	--	-2.5	2300	4.0	1300	0.8	30.23	+	30.23	+
29	2.31	PARTLY CLOUDY	NONE	-	+	-4.5	0600	4.5	1300	0.0	30.20	-	30.07	-
30	0.00	PARTLY CLOUDY	NONE	+	+	-2.5	0100	3.0	1300	0.3	29.90	-	29.97	+
31	T	PARTLY CLOUDY	NONE	+	+	-5.0	2400	3.5	1300	-0.8	30.19	+	30.28	+
TOTAL:	8.08								MEAN:	1.1				
									SE:	0.53				

[a] R = Rainfall amount accumulated into next reading; T = Trace (<0.02 cm)
[b] + = rising; - = falling; 0 = steady

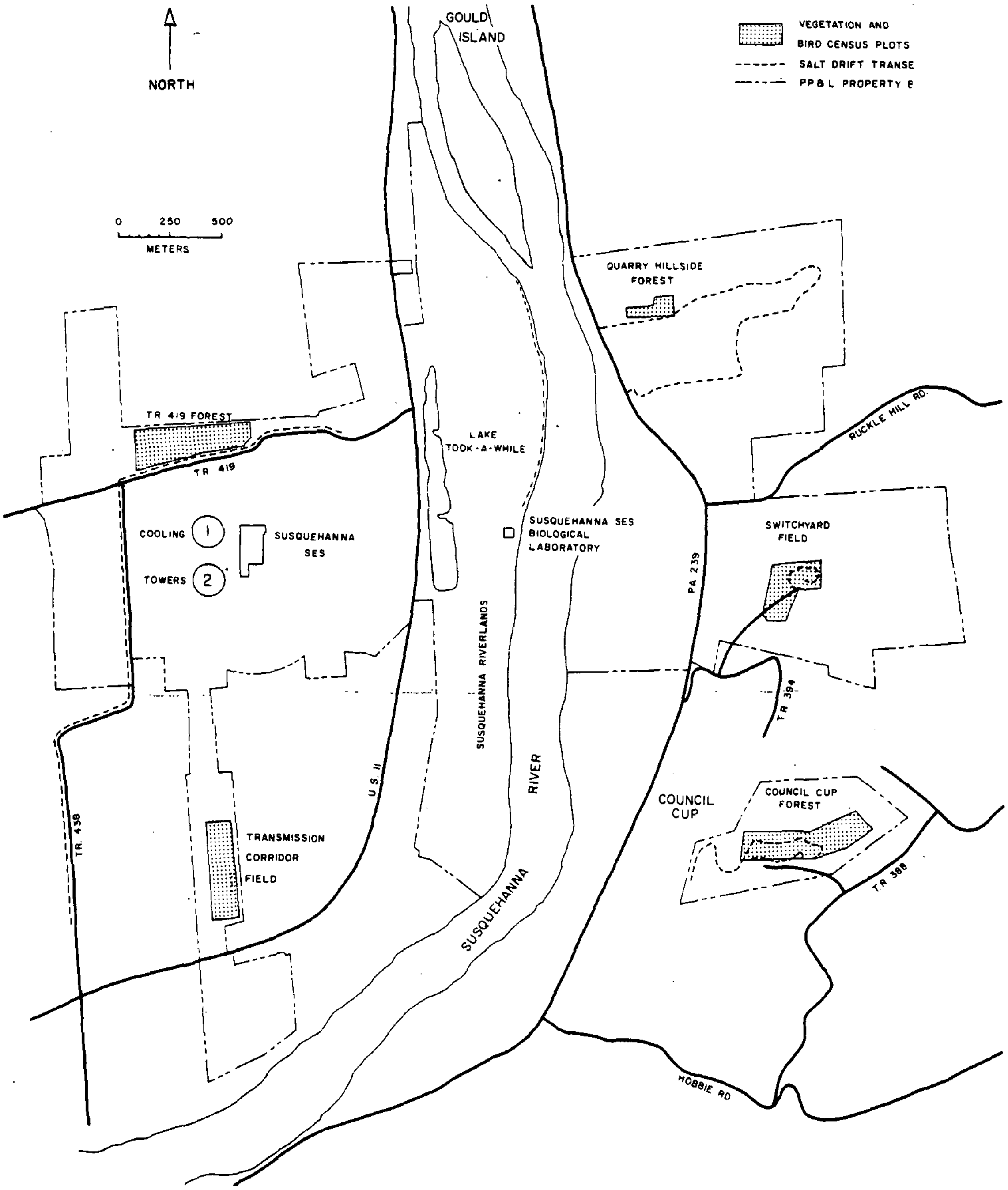

Fig. F-1

Location of vegetation and bird census plots and salt drift transects in the vicinity of the Susquehanna SES site, 1986.

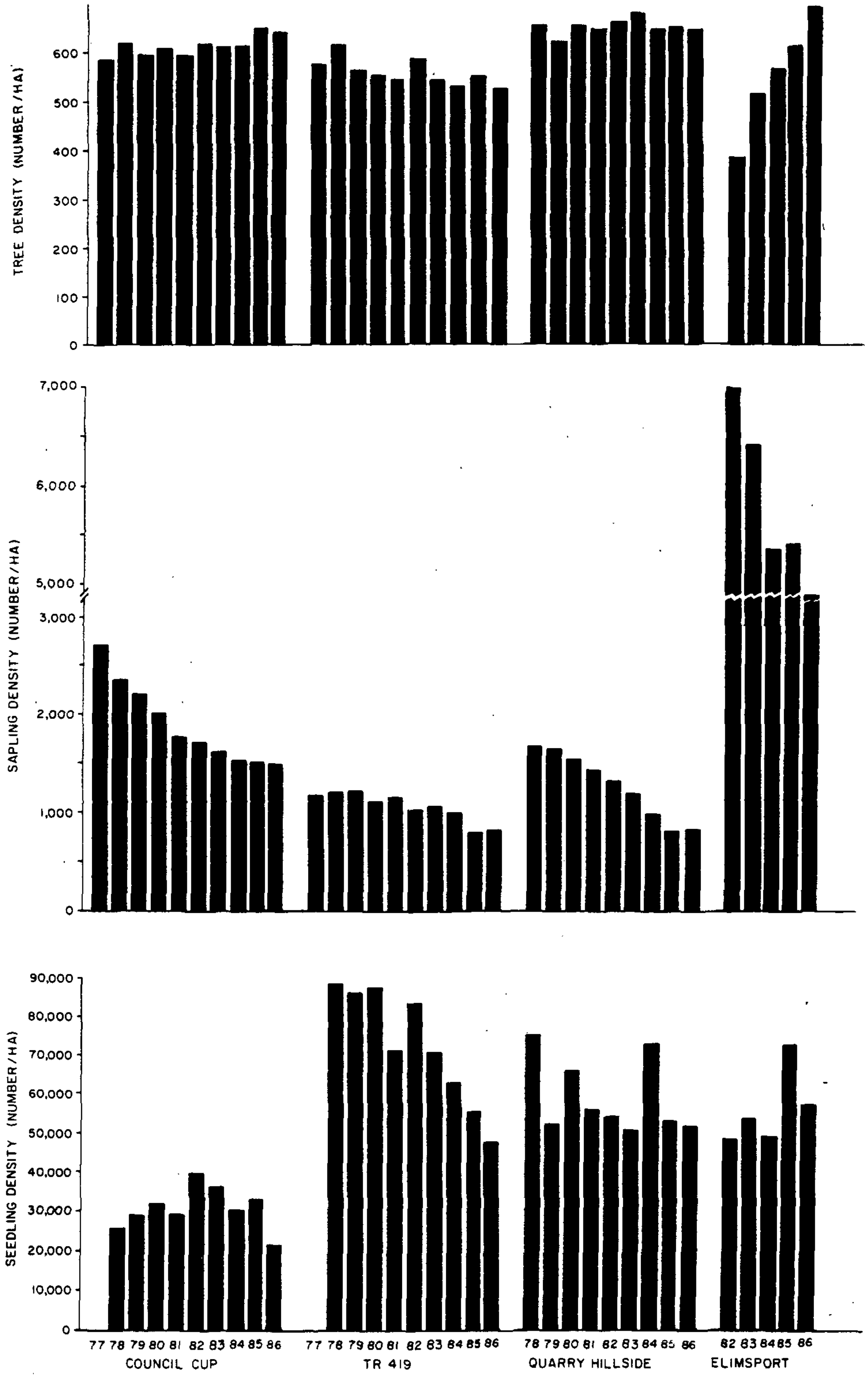

Fig. F-2

Tree, sapling, and seedling density for forest plots, 1977-86.

BIRDS

by

Douglas A. Gross

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Bird studies were conducted near the Susquehanna SES during 1986, the fourth year of plant operation, in order to make comparisons with preoperational data. Twenty-six of the 241 species observed near the Susquehanna SES since 1977 were listed as Pennsylvania species of special concern; 19 of these were observed in 1986. Two species, bald eagle and peregrine falcon, listed as endangered on the Federal List of Endangered Species, were observed migrating near the plant in 1986.

Breeding bird studies in two forest and two abandoned field plots revealed that 59 species nested or demonstrated other evidence of breeding in at least one of the study plots in 1986. Although some species declined from 1985, the breeding densities of most forest species were similar or higher than in preoperational years. Densities of most species nesting in abandoned field plots were higher in operational years as a result of plant succession. The nesting and winter densities of local residents were generally as high or higher than in preoperational years.

In the 1986 bird impaction studies at the Unit 1 and 2 cooling towers, 52 birds of 21 species were collected, more than in the previous three years. Most birds collected (82%) in autumn migration probably impacted on a tower when it was not emitting a visible plume. The 1986 bird impaction data suggest that cooling tower operation either deters bird impaction, impedes collection of impacted birds, or both.

INTRODUCTION

The objectives of the bird studies have been to evaluate effects of the Susquehanna SES on birds by monitoring local bird populations and impactions on the cooling towers during spring and autumn migrations. Preliminary studies of birds at the Susquehanna SES site were conducted from 1971 through 1974 and preoperational studies were conducted from January 1977 through August 1982 (Ichthyological Associates, Inc. 1973-74; Burton 1976; Ruhe 1978; Ruhe and Montgomery 1979; Gross et al. 1980, 1982; Gross and Montgomery 1981, 1983). During preoperational studies, data were collected on bird populations near the Susquehanna SES (within 8 km) and bird impaction mortality at both cooling towers. Postoperational studies, begun in September 1982 (Gross and Montgomery 1983) and conducted through 1986 (Gross and Montgomery 1984-86) were a continuation of the preoperational work with the objectives of monitoring changes in bird populations and evaluating impact mortality which might have been caused by operation of the power plant.

PROCEDURES

Bird Population Studies

In 1986, bird population studies were conducted in four plots: Township Road 419 (TR419) Forest, Council Cup Forest, Transmission Corridor Field, and Switchyard Field (Fig. F-1). TR419 Forest (11.05 ha)and Council Cup Forest (6.00 hectares) were wooded, and Transmission Corridor Field (4.34 ha) and Switchyard Field (6.00 ha) were abandoned fields undergoing secondary vegetation succession.

Identifications were made in the field or in the laboratory, using the references listed in Gross and Montgomery (1984). Nomenclature follows the American Ornithologists' Union Checklist (1983). Time and weather conditions were recorded during each count. Counts were not conducted during periods of inclement weather, such as heavy rains or high winds.

Winter Bird Studies

Seven counts were done in each plot from 15 December to 28 February. All counts were begun prior to 0900 hours. A route along the transect lines was followed in such a way as to cover all sections of the plot without overlap. Each bird was counted and identified either visually or aurally. The following were calculated for bird species in each plot:

$$\text{Frequency} = \frac{\text{number of counts in which a species occurs}}{\text{total number of counts}}$$

$$\text{Mean Density} = \frac{\text{number of a species/km}^2}{\text{total number of counts}}$$

$$\text{Relative Density} = \frac{\text{density of a species}}{\text{total density of all species}} \times 100$$

Breeding Bird Studies

Twelve breeding bird counts were made between 12 April and 31 July. Some observations of breeding bird activity were made during winter counts and nest searches continued until 14 September. Birds were counted by the spot-mapping method in which each contact with a bird was located and registered on a daily count map (Hall 1964, Robbins 1970). The species, sex, and behavioral activity (e.g. singing, aggression, nest building) were noted for each bird. Counts were begun within one hour of sunrise, and conducted in early morning when activity was greatest.

Data from the counts were analyzed to estimate the number of breeding pairs of each species. Registered contacts on the daily count maps were transferred to species maps for each plot. The number of breeding pairs (i.e. home ranges or territories) was usually found by counting the number of clusters formed by the registrations of conspicuous territorial males. The number of breeding pairs was rounded to the nearest half number. When a species was represented by less than 0.5 pair (terriroty) it was assigned a value of 0.1 for the sake of analysis. The locations of nests, female birds, contacts between pair members, and territorial encounters provided supplemental data. Some birds were separable from their neighbors because they were banded. For each species, the following were calculated:

$$\text{Density} = \frac{\text{number of breeding pairs}}{\text{km}^2}$$

$$\text{Relative Density} = \frac{\text{number of breeding pairs of a species}}{\text{total number of breeding pairs of all species}}$$

Bird Impaction

Collections of impacted birds were made during 1986 spring and autumn migrations at the Unit 1 and 2 cooling towers. Each hyperbolic natural draft tower is 165 m tall with diameters at the base, throat, and top of 128 m, 86 m, and 92 m, respectively. In 1986, both towers were illuminated with five, 480-volt aircraft warning strobe lights on the top and seven, 480-volt high-intensity mercury vapor lamps around the lintel, about 12 m above ground level. The strobe lights were installed immediately upon completion of each tower. The towers are about 100 m apart and aligned south to north, with Unit 1 the more northerly (Fig. F-1). They are located approximately 1,400 m west of the Susquehanna River and 650 m south of a ridge which extends east and west along the site boundary. The top of the Unit 1 tower is 381 m above mean sea level, 6 m higher than the top of the Unit 2 tower. Within 1 km of the towers, ground elevations range from 160 m above msl near the river to approximately 326 m on the ridge. Both towers exceed the highest point on the ridge by about 49 m.

Systematic searches for impacted birds were usually begun prior to 0900 h on weekdays, excluding holidays, from 24 March through 6 June and from 18 August through 7 November. Each search included the tower base, cold water outlet, basin interior, and an area extending at least 10 m out from the base. Impacted birds were tagged to record date and point of discovery. Floating specimens were collected with a dip net and those impinged on the trash screens were removed with a rake. An attempt was made to collect all impacted birds during each search; however, some specimens recovered from the turbid water in the cooling tower basins impacted one or more days before collection. All data were, therefore, tabulated in 5-day groups to reduce day-to-day carryover of impacted birds. Birds were usually identified in the laboratory with the aid of keys detailed in Gross and Montgomery (1984). Impacted species were checked against the federal List of Endangered and Threatened Wildlife and Plants (U. S. Department of the Interior 1979) and the Pennsylvania Species of Special Concern (Gill 1985).

Weather conditions were noted daily at the Susquehanna SES site. These notes were augmented with data recorded at the Biological Laboratory, at the Susquehanna SES Meteorological Tower, and at Avoca, Pennsylvania by the National Oceanic and Atmospheric Administration (NOAA 1986). Barometric pressure was monitored constantly at the Biological Laboratory with a Taylor Weather-Hawk Stormscope Barometer adjusted to equivalent sea level pressure.

RESULTS AND DISCUSSION

Bird Population Studies

From 1973-74 and 1977-86, 241 species and 2 hybrids were observed within 8 km of the Susquehanna SES (Table G-1). Three of these were observed for the first time in 1986: golden eagle, alder flycatcher, and red crossbill. An immature golden eagle was observed flying over the Susquehanna Riverlands on 6 November. Alder flycatchers apparently attempted to nest in the Wetlands Nature Area of the Susquehanna Riverlands in late May and June. Red crossbills were observed flying over Council Cup Overlook on 21 October.

Twenty-six species observed near the Susquehanna SES since 1977 were listed as Pennsylvania species of special concern (Gill 1985); nineteen were observed in 1986 (Table G-2). Two of these species were also classified as endangered on the Federal List of Endangered Species (U. S. Department of the Interior 1979), Both of these species, bald eagle and peregrine falcon, migrated through the area but did not nest nearby. Historically, peregrine falcons nested on Council Cup bluff as late as 1961.

Winter Bird Studies

Twenty-six species were observed in the bird study plots during winter counts (Table G-3). Fifteen species were observed in TR419 Forest, twelve in both Council Cup Forest and Switchyard Field, and ten in Transmission Corridor Field. Individuals of 14 of these species were observed to be year-round residents in and near the plots, while the other species migrated into the plots for the winter. The black-capped chickadee was the most common species (highest mean density) in TR419 Forest, the golden-crowned kinglet in Council Cup Forest, and the dark-eyed junco in Transmission Corridor Field. The black-capped chickadee, northern cardinal, and American tree sparrow were the most common species in Switchyard Field.

In both TR419 Forest (Table G-4) and Council Cup Forest (Table G-5), the total mean densities in 1986 were affected by the relatively low densities of migrants; the total mean density of local residents in both plots were similar to prior winters. The densities of migrants have been fairly sporadic and somewhat cyclical from 1979 through 1986. High densities of seed-eating species (e.g. dark-eyed junco, common redpoll, pine siskin, and American goldfinch) usually occurred in both plots in the same years. The densities of resident species were fairly stable from 1979 through 1986. Most residents are small cavity-nesting birds. One of these, black-capped chickadee, was the most common and frequently observed winter species in both forest plots during both the preoperational and operational phases.

The winter densities of birds in Transmission Corridor Field (Table G-6) and Switchyard Field (Table G-7) were generally higher in operational years than in preoperational years. Most species have benefitted from vegetative succession that has occurred in both fields since the beginning of these studies. The increase in the woody plant cover is beneficial to seed-eating migrants (e.g. American tree sparrow and dark-eyed junco), fruit-eating migrants (white-throated sparrow), and residents (e.g. black-capped chickadee and eastern bluebird).

Breeding Bird Studies

Fifty-nine species nested or demonstrated other evidence of breeding in at least one of the study plots in 1986 (Table G-8). There were 35 species in TR419 Forest, 32 in Switchyard Field, 30 in Council Cup Forest, and 18 in Transmission Corridor Field. Scarlet tanager was the most common breeding species in TR419 Forest, ovenbird and black-capped chickadee in Council Cup Forest, and field sparrow in both field plots. Birds that nest in these plots are either local residents or migrants. Local residents are of particular interest because they live near the power plant in all seasons. Migratory birds overwinter either in southern United States or the neotropics (Latin America). Neotropical migrants are also of concern because they may be declining on a continental scale due to the deforestation of their wintering grounds (Terborgh 1980, Hall 1984) or forest fragmentation of their nesting grounds (Robbins 1980).

The total breeding bird density in TR419 Forest was higher in 1986 than in any previous year (Table G-9; Fig. G-1). The densities of most species demonstrated either an increase or a nondecreasing oscillating pattern since 1979. Most species had higher densities in the operational phase than the preoperational phase (Table G-9). Among ground-nesting species, the ovenbird and black-and-white warbler had much higher densities in operational years than in preoperational years. The opposite was true of the rufous-sided towhee. As a group, the cavity-nesting species, especially residents, increased since early years of study. The most common cavity-nesting species in 1986 was the tufted titmouse which increased 5-fold in breeding density since 1979. The hairy woodpecker and white-breasted nuthatch had higher densities than in any previous year. Several limb-nesting species also had higher densities in 1986 than before: blue-gray gnatcatcher, wood thrush, cedar waxwing, red-eyed vireo, and scarlet tanager. Two others, chipping sparrow and American goldfinch, were new breeding species in the plot.

In Council Cup, the total breeding bird density was somewhat lower than in the prior four years, but about average for the entire study period (Table G-10). Several species that declined from 1985 to 1986 had increased previously. Ground-nesting species, particularly black-and-white warbler and ovenbird, accounted for much of the change from 1985 to 1986. As a group, limb-nesting species also declined since 1985 with the largest decreases by eastern wood-pewee, blue-gray gnatcatcher, and red-eyed vireo. Most species, however, were at least as common as they were in 1979 or 1980. Cavity-nesters, especially residents, increased from 1985. As in TR419 Forest, hairy woodpecker and tufted titmouse were among the species which increased the most.

The total breeding bird density in Transmission Corridor Field was similar to the previous three years (Table G-11; Fig. G-2). Field sparrow and song sparrow continued to be the most common species, representing 48% of the nesting birds in the plot. The densities of two late-nesting species, cedar waxwing and American goldfinch, were much higher in 1986 than in 1985. The northern cardinal was the only species which had a higher density in 1986 than in any previous year. Only one species, the willow flycatcher, decreased appreciably since 1985.

Since 1979, the total breeding bird density in Switchyard Field has nearly tripled, and the number of breeding species has nearly doubled (Table G-12). These increases were related to a combination of plant succession and increased habitat diversity. There is now a mixture of habitats ranging from dense thickets to open grassy areas. Most species that increased in density since 1979 either forage or nest in shrubs and saplings. These include gray catbird, cedar waxwing, yellow warbler, northern cardinal, American goldfinch, and others. In addition, blue jay, American robin, and rose-breasted grosbeak, species more typical of woodlands, also nested in Switchyard Field in 1986. Yet, the field sparrow persisted as the most common breeding species in the plot because it thrived in the grassy area maintained for transmission tower service. A similar set of species were associated with old field plant succession elsewhere in eastern United States (Lanyon 1981).

In summary, changes in winter and breeding bird densities in these four plots did not seem affected by from the operation of Susquehanna SES. Most bird densities in operational years were similar to or higher than densities in preoperational years. Resident species have generally increased, an important sign because these species cope throughout the year with any effects power plant operation may have on the local natural environment. We can only speculate as to why several forest species, including many neotropical migrants, increased in density since 1979. Fairly moderate winters since 1979 may have aided local residents by allowing more winter survival. Since most residents nest in cavities, they may have benefitted from the increase in dead standing timber caused by the past gypsy moth infestation, the ongoing dogwood leaf anthracnose dieback, and the decrease in the number of saplings, implying some sapling mortality (see Flora, Vegetation, and Meteorology). Other forest species that increased since 1981 may have recovered from short-term low densities during the gypsy moth infestation years. Most forest interior species probably benefitted from the lack of human disturbance in these forest tracts (other than transmission corridor servicing) quite unlike many other forests in eastern United States (Robbins 1980). The changes in densities in the abandoned field plots are more easily explained as resulting from old field plant succession.

Bird Impaction

In 1986, 52 birds of 21 species were collected during systematic searches for impacted birds at Unit 1 and 2 cooling towers of the Susquehanna SES. During spring migration, seven birds of six species were collected from 24 March through 6 June (Table G-13); five specimens were found at the Unit 1 tower and two specimens at the Unit 2 tower. During autumn migration, 45 birds of 18 species were collected from 18 August through 7 November (Table G-14); 17 specimens were found at the Unit 1 tower and 28 specimens at the Unit 2 tower. In addition to these birds, one little brown bat (*Myotis lucifugus*) was found at the Unit 1 tower in April (Hall and Kelson 1959). Since 1 September 1978, 1,505 birds of at least 68 species have been collected at the towers.

In 1986, almost all collected birds (90%) were small passerines known to be nocturnal migrants (Terres 1980). Most of these birds migrate long distances to and from wintering grounds in the American tropics. The four species most commonly collected were: red-eyed vireo (10), magnolia warbler (7), Blackburnian warbler (5), and common yellowthroat (5). Together they composed 52% of the birds collected.

No federally listed threatened or endangered species were collected in 1986, nor have any been found since the study began in 1978. No Pennsylvania species of special concern were collected in 1986. However, one game bird, a wild turkey, was found in the Unit 1 trash rack. It probably impacted or drowned in the tower basin. Wild turkeys have been observed in recent years in TR419 Forest less than 400 m north of the Unit 1 tower (Gross and Montgomery 1985, 1986). One of these birds probably blundered into the tower.

Like other operational years, the 1986 spring impaction total was smaller than spring impaction totals during preoperational years (Fig. G-3). No more than one specimen was found on any morning and no more than two specimens were found of any species. All but one of the collected birds apparently collided with a tower that was not operating and creating a visible plume. The first four impactions (through April 2) occurred during a scheduled refueling outage of Unit 1 and the last two spring impactions occurred when both units were shut down. Both units were operating in late April and early May when spring migration is most intense. Only one bird was collected during this period.

The impaction collection of autumn 1986 was higher than in any previous operational year except 1982 when the Unit 1 cooling tower did not create a plume for most of the autumn migration period and Unit 2 was still under construction (Fig. G-3). Most birds collected (82%) in autumn 1986 probably impacted on a tower when it was not emitting a visible plume. For the first time since studies began, the autumn impaction collection at Unit 2 tower was greater than the collection at the Unit 1 tower. This was probably related to the fact that the Unit 2 tower was not operating during most of the autumn collection period. The collections of 15, 16, and 17 September accounted for 22 specimens and 49% of the autumn impaction total. These impactions were associated with a strong cold front that entered Pennsylvania from the northwest. Most autumn impaction collections in past years were also associated with cold front movement when southbound migration is heaviest in northeastern United States (Pettingill 1970). The single day collection of 14 specimens on 16 September was larger than any single day collection in the prior three years, but small in comparison to collections of 79 and 81 birds made in 1981 during the preoperational phase (Gross et al. 1982).

An operating cooling tower has characteristics which both attract and warn birds of its presence and dangers. Night-flying birds are sometimes attracted to, then blinded by, bright lights, accounting for impactions on tall buildings (Pettingill 1970). When cloud ceiling is low or visibility poor, birds tend to fly at low altitudes and can be confused by bright, flashing tower lights (Cochran and Graber 1958). However, it seems that the flight direction of nocturnal migrants at high altitudes is not overtly affected by nuclear power plant lights and the birds are not drawn to towers from great distances (Marsden et al. 1980). At least three characteristics of operating towers may warn approaching birds of their presence: 1) visible plume, 2) air turbulence, and 3) noise. The well-lit plume can be several hundred meters in length and visible from great distances. Air currents and turbulence caused by operating natural draft towers probably make flight difficult for small birds and discourage them from flying very close. Also, the noise levels near towers of this size can reach 80 to 90 dBa due to the resonance of air drafts and waterfall (Edmunds et al. 1975). This broad-band low frequency noise is well within the hearing range of most birds (Terres 1980). However, when a tower is not operating, these three warning characteristics are diminished or absent. Therefore, when cooling towers are shut down, they are hazardous to night-migrating songbirds, especially for birds that are flying low in bad weather.

The observed decline in bird impaction since the start of tower operation may be real, but perhaps not as pronounced as the collection data indicate. Results indicate that tower operation deters bird impaction, assuming that this operation does not hinder the recovery of impacted birds. However, this may not be a valid assumption because water turbulence and flow in the cooling tower basin and cold water outlet may cause many bird carcasses to sink, thus preventing their collection.

REFERENCES CITED

American Ornithologists' Union. 1983. Checklist of North American birds, 6th ed. Allen Press, Inc., Lawrence, KS. 877 pp.

Burton, R. J. 1976. Terrestrial ecology. Pages 280-314 *in* T. V. Jacobsen (ed.), Ecological studies of the North Branch Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Progress report for the period January-December 1974). Ichthyological Associates, Inc., Berwick, PA.

Cochran, W. W. and R. R. Graber. 1958. Attraction of nocturnal migrants by lights on a television tower. Wilson Bull. 70: 378-380.

Edmunds, P. R., H. K. Roffman, and R. C. Maxwell. 1975. Some terrestrial considerations associated with cooling-tower systems for electric power generation. Pages 393-407 in S. R. Hanna and J. Pell (coordinators), Cooling tower environment - 1974. Nat. Techn. Info. Serv., U.S. Dept. Comm., Springfield, VA.

Gill, F. B. (ed.). 1985. Birds. Pages 299-351 in H. M. Genoways and F. J. Benner (eds.), Species of special concern in Pennsylvania. Carnegie Mus. of Nat. Hist., Pittsburgh, PA.

Gross, D. A., R. M. Ruhe, and J. D. Montgomery. 1980. Birds. Pages 250-288 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1979). Ichthyological Associates, Inc., Berwick, PA.

________ and J. D. Montgomery. 1981. Birds. Pages 255-295 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1980). Ichthyological Associates, Inc., Berwick, PA.

________, D. G. Richie, and J. D. Montgomery. 1982. Birds. Pages 279-325 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1981 annual report). Ichthyological Associates, Inc., Berwick, PA.

_______ and J. D. Montgomery. 1983. Birds. Pages 286-342 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1982 annual report). Ichthyological Associates, Inc., Berwick, PA.

_______ and _______. 1984. Birds. Pages 283-326 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1983 annual report). Ichthyological Associates, Inc., Berwick, PA.

________ and _______. 1985. Birds. Pages 286-331 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1984 annual report). Ichthyological Associates, Inc., Berwick, PA.

________ and ________. 1986. Birds. Pages 222-253 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (1985 annual report). Ecology III, Inc., Berwick, PA.

Hall, E. R. and K. R. Kelson. 1959. The mammals of North America, vol. 1. Roland Press Co., New York, NY. 546 pp.

Hall, G. A. 1964. Breeding-bird censuses -- why and how. Am. Birds 18: 413-416.

________. 1984. Population decline of neotropical migrants in an Appalachian forest. Am. Birds. 38: 14-18.

Ichthyological Associates, Inc. 1973. An ecological study of the North Branch Susquehanna River in the vicinity of Berwick, Pennsylvania (Progress report for the period January-December 1972). Pa. Power and Light Co., Allentown, PA. 658 pp.

________. 1974. An ecological study of the North Branch Susquehanna River in the vicinity of Berwick, Pennsylvania (Progress report for the period January-December 1973). Pa. Power and Light Co., Allentown, PA. 838 pp.

Lanyon, W. 1981. Breeding birds and old field succession on fallow Long Island farmland. Bull. Am. Mus. Nat. Hist. Vol. 168: Art. 1: 1-60.

Marsden, J. E., T. C. Williams, V. Krauthamer, and H. Krauthamer. 1980. Effect of nuclear power plant lights on migrants. J. Field Ornithol. 51: 315-318.

National Oceanic and Atmospheric Administration. 1986. Local climatological data, monthly summaries (Jan-Dec 1986) at Wilkes-Barre/Scranton Airport, Avoca, Pennsylvania. Nat. Climatic Cent., Asheville, NC.

Pettingill, O. S. 1970. Ornithology in laboratory and field. Burgess Publ. Co., Minneapolis, MN. 524 pp.

Robbins, C. S. 1970. An international standard for a mapping method in bird census work recommended by the international bird census committee. Audubon Field Notes 24: 722-726.

________. 1980. Effect of forest fragmentation on breeding bird populations in the piedmont of the Mid-Atlantic region. In J. F. Lynch (ed.), Bird populations - a litmus test of the environment, proceedings of the Mid-Atlantic natural history symposium, Atl. Nat. 33: 31-36.

Ruhe, R. M. 1978. Birds. Pages 311-342 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1977). Ichthyological Associates, Inc., Berwick, PA.

________ and J. D. Montgomery. 1979. Birds. Pages 250-283 in T. V. Jacobsen (ed.), Ecological studies of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Annual report for 1978). Ichthyological Associates, Inc., Berwick, PA.

Terborgh, J. W. 1980. The conservation status of neotropical migrants: present and future. In A. Kerst and E. S. Morton (eds.), Migrant birds in the neotropics: ecology, behavior, distribution and conservation. Smithsonian Institution Press, Washington, DC.

Terres, J. K. 1980. The Audubon Society encyclopedia of North American birds. Alfred A. Knopf, Inc., New York, NY. 1109 pp.

U.S. Department of the Interior. 1979. List of endangered and threatened wildlife and plants. Federal Register 44: 3636-3654.

Table G-1

Species of birds observed near the Susquehanna SES, 1973 through 1974 and 1977 through 1986. An asterisk (*) denotes new species observed in 1986.

Gaviidae
- *Gavia stellata* - red-throated loon
- *G. immer* - common loon

Podicipedidae
- *Podilymbus podiceps* - pied-billed grebe
- *Podiceps auritus* - horned grebe
- *P. grisegena* - red-necked grebe

Phalacrocoracidae
- *Phalacrocorax auritus* - double-crested cormorant

Ardeidae
- *Botaurus lentiginosus* - American bittern
- *Ixobrychus exilis* - least bittern
- *Ardea herodias* - great blue heron
- *Casmerodius albus* - great egret
- *Egretta thula* - snowy egret
- *E. caerulea* - little blue heron
- *Bubulcus ibis* - cattle egret
- *Butorides striatus* - green-backed heron
- *Nycticorax nycticorax* - black-crowned night-heron

Threskiornithidae
- *Plegadis falcinellus* - glossy ibis

Anatidae
- *Cygnus columbianus* - tundra swan
- *Chen caerulescens* - snow goose
- *Branta bernicla* - brant
- *B. canadensis* - Canada goose
- *Aix sponsa* - wood duck
- *Anas crecca* - green-winged teal
- *A. rubripes* - American black duck
- *A. platyrhynchos* - mallard
- *A. platyrhynchos x A. rubripes* - mallard-black duck
- *A. acuta* - northern pintail
- *A. discors* - blue-winged teal
- *A. clypeata* - northern shoveler
- *A. strepera* - gadwall
- *A. americana* - American wigeon
- *Aythya valisineria* - canvasback
- *A. americana* - redhead
- *A. collaris* - ring-necked duck
- *A. marila* - greater scaup
- *A. affinis* - lesser scaup
- *Clangula hyemalis* - oldsquaw
- *Melanitta nigra* - black scoter
- *M. perspicillata* - surf scoter
- *M. fusca* - white-winged scoter
- *Bucephala clangula* - common goldeneye
- *B. albeola* - bufflehead
- *Lophodytes cucullatus* - hooded merganser
- *Mergus merganser* - common merganser
- *M. serrator* - red-breasted merganser
- *Oxyura jamaicensis* - ruddy duck

Cathartidae
- *Cathartes aura* - turkey vulture

Accipitridae
- *Pandion haliaetus* - osprey
- *Haliaeetus leucocephalus* - bald eagle
- *Circus cyaneus* - northern harrier
- *Accipiter striatus* - sharp-shinned hawk
- *A. cooperii* - Cooper's hawk
- *A. gentilis* - northern goshawk
- *Buteo lineatus* - red-shouldered hawk
- *B. platypterus* - broad-winged hawk
- *B. swainsoni* - Swainson's hawk
- *B. jamaicensis* - red-tailed hawk
- *B. lagopus* - rough-legged hawk
- * *Aquila chrysaetos* - golden eagle

Falconidae
- *Falco sparverius* - American kestrel
- *F. columbarius* - merlin
- *F. peregrinus* - peregrine falcon

Phasianidae
- *Phasianus colchicus* - ring-necked pheasant
- *Bonasa umbellus* - ruffed grouse
- *Meleagris gallopavo* - wild turkey
- *Colinus virginianus* - northern bobwhite

Rallidae
- *Rallus limicola* - Virginia rail
- *Porzana carolina* - sora
- *Gallinula chloropus* - common moorhen
- *Fulica americana* - American coot

Charadriidae
- *Pluvialis squatarola* - black-bellied plover
- *Charadrius semipalmatus* - semipalmated plover
- *C. vociferus* - killdeer

Scolopacidae
- *Tringa melanoleucus* - greater yellowlegs
- *T. flavipes* - lesser yellowlegs
- *T. solitaria* - solitary sandpiper
- *Actitis macularia* - spotted sandpiper
- *Calidris pusillus* - semipalmated sandpiper
- *C. minutilla* - least sandpiper
- *C. fuscicollis* - white-rumped sandpiper
- *C. melanotos* - pectoral sandpiper
- *Calidris alpina* -dunlin
- *Limnodromus griseus* - short-billed dowitcher
- *Gallinago gallinago* - common snipe
- *Scolopax minor* - American woodcock
- *Phalaropus tricolor* - Wilson's phalarope

Laridae
- *Larus atricilla* - laughing gull
- *L. philadelphia* - Bonaparte's gull
- *L. delawarensis* - ring-billed gull
- *L. argentatus* - herring gull
- *L. marinus* - great black-backed gull
- *Sterna hirundo* - common tern

Table G-1 (cont.)

Columbidae
Columba livia - rock dove
Zenaida macroura - mourning dove

Cuculidae
Coccyzus erythropthalmus - black-billed cuckoo
C. americanus - yellow-billed cuckoo

Tytonidae
Tyto alba - common barn-owl

Strigidae
Otus asio - eastern screech-owl
Bubo virginianus - great horned owl
Asio otus - long-eared owl
A. flammeus - short-eared owl

Caprimulgidae
Chordeiles minor - common nighthawk

Apodidae
Chaetura pelagica - chimney swift

Trochilidae
Archilochus colubris - ruby-throated hummingbird

Alcedinidae
Ceryle alcyon - belted kingfisher

Picidae
Melanerpes erythrocephalus - red-headed woodpecker
M. carolinus - red-bellied woodpecker
Sphyrapicus varius - yellow-bellied sapsucker
Picoides pubescens - downy woodpecker
P. villosus - hairy woodpecker
Colaptes auratus - northern flicker
Dryocopus pileatus - pileated woodpecker

Tyrannidae
Contopus borealis - olive-sided flycatcher
C. virens - eastern wood-pewee
Empidonax flaviventris - yellow-bellied flycatcher
E. virescens - acadian flycatcher
* *E. alnorum* - alder flycatcher
E. traillii - willow flycatcher
E. minimus - least flycatcher
Sayornis phoebe - eastern phoebe
Myiarchus crinitus - great crested flycatcher
Tyrannus verticalis - western kingbird
T. tyrannus - eastern kingbird

Alaudidae
Eremophila alpestris - horned lark

Hirundinidae
Progne subis - purple martin
Tachycineta bicolor - tree swallow
Stelgidopteryx serripennis - northern rough-winged swallow
Riparia riparia - bank swallow
Hirundo pyrrhonota - cliff swallow
H. rustica - barn swallow

Corvidae
Cyanocitta cristata - blue jay
Corvus brachyrhynchos - American crow
C. ossifragus - fish crow
C. corax - common raven

Paridae
Parus atricapillus - black-capped chickadee
P. bicolor - tufted titmouse

Sittidae
Sitta canadensis - red-breasted nuthatch
S. carolinensis - white-breasted nuthatch

Certhiidae
Certhia americana - brown creeper

Troglodytidae
Thryothorus ludovicianus - Carolina wren
Troglodytes aedon - house wren
T. troglodytes - winter wren
Cistothoros palustris - marsh wren

Muscicapidae
Regulus satrapa - golden-crowned kinglet
R. calendula - ruby-crowned kinglet
Polioptila caerulea - blue-gray gnatcatcher
Sialia sialis - eastern bluebird
Catharus fuscescens - veery
C. minimus - gray-cheeked thrush
C. ustulata - Swainson's thrush
C. guttata - hermit thrush
Hylocichla mustelina - wood thrush
Turdus migratorius - American robin

Mimidae
Dumetella carolinensis - gray catbird
Mimus polyglottos - northern mockingbird
Toxostoma rufum - brown thrasher

Motacillidae
Anthus spinoletta - water pipit

Table G-1 (cont.)

Bombycillidae
Bombycilla cedrorum - cedar waxwing

Laniidae
Lanius ludovicianus - loggerhead shrike

Sturnidae
Sturnus vulgaris - European starling

Vireonidae
Vireo griseus - white-eyed vireo
V. solitarius - solitary vireo
V. flavifrons - yellow-throated vireo
V. gilvus - warbling vireo
V. philadelphicus - Philadelphia vireo
V. olivaceus - red-eyed vireo

Emberizidae
Vermivora pinus - blue-winged warbler
V. chrysoptera - golden-winged warbler
V. chrysoptera x V. pinus - Brewster's warbler
V. peregrina - Tennessee warbler
V. celata - orange-crowned warbler
V. ruficapilla - Nashville warbler
Parula americana - northern parula
Dendroica petechia - yellow warbler
D. pensylvanica - chestnut-sided warbler
D. magnolia - magnolia warbler
D. tigrina - Cape May warbler
D. caerulescens - black-throated blue warbler
D. coronata - yellow-rumped warbler
D. virens - black-throated green warbler
D. fusca - Blackburnian warbler
D. dominica - yellow-throated warbler
D. pinus - pine warbler
D. discolor - prairie warbler
D. palmarum - palm warbler
D. castanea - bay-breasted warbler
D. striata - blackpoll warbler
D. cerulea - cerulean warbler
Mniotilta varia - black-and-white warbler
Setophaga ruticilla - American redstart
Protonotaria citrea - prothonotary warbler
Helmitheros vermivorus - worm-eating warbler
Seiurus aurocapillus - ovenbird
S. noveboracensis - northern waterthrush
S. motacilla - Louisiana waterthrush
Oporornis formosus - Kentucky warbler
O. agilis - Connecticut warbler
O. philadelphia - mourning warbler
Geothlypis trichas - common yellowthroat
Wilsonia citrina - hooded warbler
W. pusilla - Wilson's warbler
W. canadensis - Canada warbler
Icteria virens - yellow-breasted chat
Piranga rubra - summer tanager
P. olivacea - scarlet tanager
Cardinalis cardinalis - northern cardinal
Pheucticus ludovicianus - rose-breasted grosbeak
Guiraca caerulea - blue grosbeak
Passerina cyanea - indigo bunting
Spiza americana - dickcissel
Pipilo erythrophthalmus - rufous-sided towhee
Spizella arborea - American tree sparrow
S. passerina - chipping sparrow
S. pusilla - field sparrow

Emberizidae (cont.)
Pooecetes gramineus - vesper sparrow
Passerculus sandwichensis -savannah sparrow
Ammodramus savannarum - grasshopper sparrow
A. caudacuta - sharp-tailed sparrow
Passerella iliaca - fox sparrow
Melospiza melodia - song sparrow
M. lincolnii - Lincoln's sparrow
M. georgiana - swamp sparrow
Zonotrichia albicollis - white-throated sparrow
Z. leucophrys - white-crowned sparrow
Junco hyemalis - dark-eyed junco
Plectrophenax nivalis - snow bunting
Dolichonyx oryzivorus - bobolink
Agelaius phoeniceus - red-winged blackbird
Sturnella magna - eastern meadowlark
Euphagus carolinus - rusty blackbird
Quiscalus quiscula - common grackle
Molothrus ater - brown-headed cowbird
Icterus spurius - orchard oriole
I. galbula - northern oriole

Fringillidae
Pinicola enucleator - pine grosbeak
Carpodacus purpureus - purple finch
C. mexicanus - house finch
* *Loxia curvirostra* - red crossbill
L. leucoptera - white-winged crossbill
Carduelis flammea - common redpoll
C. pinus - pine siskin
C. tristis - American goldfinch
Coccothraustes vespertinus - evening grosbeak

Passeridae
Passer domesticus - house sparrow

Table G-2

Pennsylvania bird species of special concern observed near the Susquehanna SES site, 1977 through 1986.

Category*/Species	1986 Status Near Site
Extirpated	
Osprey	Common migrant along the Susquehanna River.
** Peregrine falcon	Single individuals observed in autumn 1986 migration near Berwick.
Common tern	Not observed in 1986; last observed 2 September 1985.
Loggerhead shrike	Not observed in 1986; last sighting, 23 April 1983.
Endangered	
** Bald eagle	Single birds observed at Council Cup, 6 and 7 September 1986.
Short-eared owl	None observed in 1986; last observed 30 December 1985.
Threatened	
American bittern	Single birds observed in Susquehanna Riverlands during April and May 1986.
Least bittern	At least three birds observed in the Susquehanna Riverlands in May 1986.
Vulnerable	
Great blue heron	Common migrant at most bodies of water; may nest in area.
Cooper's hawk	Uncommon in all seasons; a pair may have nested near Council Cup.
Red-shouldered hawk	Uncommon migrant in area, most often observed at Council Cup.
Northern harrier	Uncommon migrant and winter resident; a pair nested near Hobbie.
Northern bobwhite	Not observed in 1986; last sighting, 30 January 1978.
Common barn-owl	Uncommon summer resident on farms near power plant.
Red-headed woodpecker	Not observed in 1986; last observed, 8 September 1985.
Purple martin	Several pairs nested in Nescopeck birdhouses.
Marsh wren	Uncommon migrant in the Susquehanna Riverlands.
Eastern bluebird	At least eight pairs nested within one mile of the power plant, others near Council Cup and Switchyard Field; increasingly common nesting and winter resident.
Grasshopper sparrow	Pairs apparently nested in fields near Council Cup.
Vesper sparrow	Uncommon migrant in fields; nesting population near Berwick.
Status Undetermined	
Sharp-shinned hawk	Most frequently observed migrant hawk at Council Cup Overlook; uncommon elsewhere in all seasons.
Northern goshawk	Not observed in 1986; last observed, 10 December 1985.
Long-eared owl	Not observed in 1986; last sighting, 4 October 1982.
Yellow-bellied sapsucker	Uncommon migrant and winter resident in forested areas.
Least flycatcher	Uncommon migrant in forested areas; small nesting population in Susquehanna Riverlands.
Bobolink	Uncommon migrant in open fields; several pairs nested in hay fields between Council Cup and Hobbie.

* Breeding status within the state.
** Federal endangered species list.

Table G-3

Mean density (MD), relative density (RD), and frequency (F) of birds observed in TR419 and Council Cup Forests and Transmission Corridor and Switchyard Fields during winter counts, 20 December 1985 through 28 February 1986.

	TR419 FOREST			COUNCIL CUP FOREST			TRANS CORR FIELD			SWITCHYARD FIELD		
STATUS/SPECIES	MD	RD	F	MD	RD	F	MD	RD	F	MD	RD	F
RESIDENTS												
RED-TAILED HAWK	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	2.4	2.1	0.14
RUFFED GROUSE	7.8	3.2	0.57	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
WILD TURKEY	10.3	4.2	0.14	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
EASTERN SCREECH-OWL	0.0	0.0	0.00	2.4	0.8	0.14	0.0	0.0	0.00	0.0	0.0	0.00
DOWNY WOODPECKER	11.6	4.7	0.71	21.4	7.1	0.71	3.3	1.5	0.14	0.0	0.0	0.00
HAIRY WOODPECKER	2.6	1.1	0.29	9.5	3.1	0.43	0.0	0.0	0.00	0.0	0.0	0.00
PILEATED WOODPECKER	2.6	1.1	0.29	2.4	0.8	0.14	0.0	0.0	0.00	0.0	0.0	0.00
BLACK-CAPPED CHICKADEE	56.9	23.2	1.00	64.3	21.3	1.00	9.9	4.4	0.29	28.8	25.0	0.43
TUFTED TITMOUSE	36.2	14.7	1.00	31.0	10.2	0.86	3.3	1.5	0.14	0.0	0.0	0.00
WHITE-BREASTED NUTHATCH	14.2	5.8	0.57	21.4	7.1	0.57	0.0	0.0	0.00	0.0	0.0	0.00
CAROLINA WREN	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	2.4	2.1	0.14
EASTERN BLUEBIRD	0.0	0.0	0.00	0.0	0.0	0.00	23.0	10.3	0.29	4.8	4.2	0.14
NORTHERN MOCKINGBIRD	0.0	0.0	0.00	0.0	0.0	0.00	3.3	1.5	0.14	2.4	2.1	0.14
NORTHERN CARDINAL	15.5	6.3	0.71	0.0	0.0	0.00	3.3	1.5	0.14	28.8	25.0	0.71
TOTAL	157.7	64.2	1.00	152.4	50.4	1.00	46.1	20.6	0.43	69.5	60.4	1.00
MIGRANTS												
BLUE JAY	1.3	0.5	0.14	4.8	1.6	0.14	3.3	1.5	0.14	0.0	0.0	0.00
RED-BREASTED NUTHATCH	0.0	0.0	0.00	11.9	3.9	0.71	0.0	0.0	0.00	0.0	0.0	0.00
BROWN CREEPER	3.9	1.6	0.29	19.0	6.3	0.57	0.0	0.0	0.00	0.0	0.0	0.00
GOLDEN-CROWNED KINGLET	34.9	14.2	1.00	95.2	31.5	0.86	0.0	0.0	0.00	2.4	2.1	0.14
AMERICAN ROBIN	28.4	11.6	0.14	0.0	0.0	0.00	0.0	0.0	0.00	7.2	6.3	0.29
CEDAR WAXWING	16.8	6.8	0.14	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
EUROPEAN STARLING	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	2.4	2.1	0.14
AMERICAN TREE SPARROW	0.0	0.0	0.00	0.0	0.0	0.00	69.1	30.9	0.71	28.8	25.0	0.43
WHITE-THROATED SPARROW	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	2.4	2.1	0.14
DARK-EYED JUNCO	2.6	1.1	0.14	0.0	0.0	0.00	75.7	33.8	0.43	2.4	2.1	0.14
COMMON REDPOLL	0.0	0.0	0.00	19.0	6.3	0.14	0.0	0.0	0.00	0.0	0.0	0.00
AMERICAN GOLDFINCH	0.0	0.0	0.00	0.0	0.0	0.00	29.6	13.2	0.14	0.0	0.0	0.00
TOTAL	87.9	35.8	1.00	150.0	49.6	1.00	177.7	79.4	1.00	45.5	39.6	0.71
TOTAL	245.6	100.0	1.00	302.4	100.0	1.00	223.8	100.0	1.00	115.1	100.0	1.00

Table G-4

Mean densities of birds observed in TR419 Forest during winter counts, 1979 through 1986.

	PREOPERATION				OPERATION				MEAN		
	1979	1980	1981	1982	1983	1984	1985	1986	PREOP	OPER	ALL
RESIDENTS											
RED-TAILED HAWK	1.8	3.9	0.0	1.3	0.0	0.0	0.0	0.0	1.8	0.0	0.9
RUFFED GROUSE	10.9	7.8	6.5	1.3	9.0	2.6	9.0	7.8	6.6	7.1	6.9
WILD TURKEY	0.0	0.0	0.0	0.0	0.0	3.9	32.3	10.3	0.0	11.6	5.8
MOURNING DOVE	0.0	0.0	0.0	3.9	0.0	0.0	0.0	0.0	1.0	0.0	0.5
DOWNY WOODPECKER	12.7	19.4	19.4	24.6	18.1	14.2	19.4	11.6	19.0	15.8	17.4
HAIRY WOODPECKER	7.2	3.9	1.3	3.9	6.5	3.9	5.2	2.6	4.1	4.6	4.3
PILEATED WOODPECKER	0.0	0.0	0.0	1.3	0.0	3.9	1.3	2.6	0.3	2.0	1.1
AMERICAN CROW	0.0	0.0	6.5	1.3	1.3	0.0	0.0	0.0	2.0	0.3	1.1
BLACK-CAPPED CHICKADEE	59.7	50.4	24.6	75.0	67.2	63.3	71.1	56.9	52.4	64.6	58.5
TUFTED TITMOUSE	16.3	14.2	11.6	19.4	25.9	20.7	25.9	36.2	15.4	27.2	21.3
WHITE-BREASTED NUTHATCH	5.4	9.0	10.3	9.0	15.5	7.8	11.6	14.2	8.4	12.3	10.4
CAROLINA WREN	0.0	0.0	0.0	3.9	0.0	1.3	0.0	0.0	1.0	0.3	0.7
EASTERN BLUEBIRD	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0.0	0.0	1.6	0.8
NORTHERN CARDINAL	12.7	14.2	7.8	11.6	7.8	0.0	16.8	15.5	11.6	10.0	10.8
TOTAL	126.7	122.8	88.0	156.5	151.3	121.6	199.1	157.7	123.5	157.4	140.5
MIGRANTS											
YELLOW-BELLIED SAPSUCKER	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.3	0.2
BLUE JAY	0.0	0.0	12.9	27.1	0.0	5.2	6.5	1.3	10.0	3.3	6.6
RED-BREASTED NUTHATCH	0.0	0.0	0.0	12.9	0.0	7.8	0.0	0.0	3.2	2.0	2.6
BROWN CREEPER	3.6	5.2	11.6	6.5	9.0	7.8	7.8	3.9	6.7	7.1	6.9
GOLDEN-CROWNED KINGLET	7.2	36.2	18.1	28.4	67.2	22.0	60.8	34.9	22.5	46.2	34.4
HERMIT THRUSH	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.3	0.0	0.2
AMERICAN ROBIN	0.0	0.0	0.0	0.0	0.0	1.3	10.3	28.4	0.0	10.0	5.0
CEDAR WAXWING	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.8	0.0	4.2	2.1
PINE WARBLER	0.0	0.0	0.0	0.0	2.6	0.0	3.9	0.0	0.0	1.6	0.8
AMERICAN TREE SPARROW	0.0	0.0	0.0	1.3	0.0	0.0	7.8	0.0	0.3	2.0	1.1
SONG SPARROW	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.3
WHITE-THROATED SPARROW	34.4	0.0	3.9	11.6	0.0	0.0	25.9	0.0	12.5	6.5	9.5
DARK-EYED JUNCO	27.1	2.6	19.4	55.6	2.6	0.0	121.5	2.6	26.2	31.7	28.9
PURPLE FINCH	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.3	0.2
COMMON REDPOLL	0.0	0.0	0.0	15.5	0.0	0.0	0.0	0.0	3.9	0.0	1.9
PINE SISKIN	0.0	0.0	0.0	55.6	0.0	0.0	0.0	0.0	13.9	0.0	7.0
AMERICAN GOLDFINCH	48.9	12.9	2.6	0.0	2.6	0.0	54.3	0.0	16.1	14.2	15.2
EVENING GROSBEAK	0.0	0.0	2.6	0.0	0.0	37.5	0.0	0.0	0.7	9.4	5.0
TOTAL	121.2	59.5	71.1	215.8	85.3	81.6	300.1	87.9	116.9	138.7	127.8
TOTAL	247.9	182.3	159.1	372.3	236.6	203.2	499.2	245.6	240.4	296.2	268.3

Table G-5

Mean densities of birds observed in Council Cup Forest during winter counts, 1979 through 1986.

	PREOPERATION				OPERATION				MEAN		
	1979	1980	1981	1982	1983	1984	1985	1986	PREOP	OPER	ALL
RESIDENTS											
RUFFED GROUSE	6.7	2.4	4.8	4.8	4.8	4.8	0.0	0.0	4.7	2.4	3.5
WILD TURKEY	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.3
EASTERN SCREECH-OWL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.6	0.3
GREAT HORNED OWL	0.0	0.0	0.0	0.0	4.8	0.0	7.1	0.0	0.0	3.0	1.5
DOWNY WOODPECKER	23.3	16.7	38.1	14.3	19.0	35.7	14.3	21.4	23.1	22.6	22.9
HAIRY WOODPECKER	10.0	4.8	7.1	9.5	0.0	11.9	19.0	9.5	7.9	10.1	9.0
PILEATED WOODPECKER	10.0	2.4	4.8	2.4	2.4	2.4	2.4	2.4	4.9	2.4	3.6
AMERICAN CROW	0.0	0.0	9.5	0.0	11.9	0.0	4.8	0.0	2.4	4.2	3.3
BLACK-CAPPED CHICKADEE	83.3	78.6	64.3	71.4	116.7	78.6	107.1	64.3	74.4	91.7	83.0
TUFTED TITMOUSE	23.3	4.8	31.0	14.3	33.3	38.1	38.1	31.0	18.4	35.1	26.7
WHITE-BREASTED NUTHATCH	63.3	7.1	19.0	11.9	14.3	31.0	16.7	21.4	25.3	20.9	23.1
TOTAL	219.9	116.8	181.0	128.6	207.2	202.5	209.5	152.4	161.6	192.9	177.2
MIGRANTS											
SHARP-SHINNED HAWK	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.6	0.0	0.3
LONG-EARED OWL	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.3
BLUE JAY	0.0	0.0	0.0	4.8	0.0	4.8	11.9	4.8	1.2	5.4	3.3
RED-BREASTED NUTHATCH	0.0	0.0	2.4	0.0	0.0	4.8	0.0	11.9	0.6	4.2	2.4
BROWN CREEPER	33.3	7.1	14.3	16.7	23.8	23.8	9.5	19.1	17.9	19.0	18.4
GOLDEN-CROWNED KINGLET	70.0	16.7	28.6	31.0	81.0	57.1	50.0	95.2	36.6	70.8	53.7
AMERICAN TREE SPARROW	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	1.2	0.6
DARK-EYED JUNCO	243.3	9.5	0.0	4.8	0.0	0.0	166.7	0.0	64.4	41.7	53.0
WHITE-WINGED CROSSBILL	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	3.6	0.0	1.8
COMMON REDPOLL	0.0	0.0	0.0	45.2	0.0	0.0	0.0	19.1	11.3	4.8	8.0
PINE SISKIN	0.0	0.0	0.0	57.1	0.0	0.0	0.0	0.0	14.3	0.0	7.1
AMERICAN GOLDFINCH	83.3	11.9	0.0	59.5	0.0	0.0	16.7	0.0	38.7	4.2	21.4
EVENING GROSBEAK	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.6	0.0	0.3
TOTAL	429.9	45.2	47.7	238.2	104.8	90.5	259.6	150.0	190.3	151.2	170.7
TOTAL	649.8	162.0	228.7	366.8	312.0	293.0	469.1	302.4	351.8	344.1	348.0

Table G-6

Mean densities of birds observed in Transmission Corridor Field during winter counts, 1980 through 1986.

	PREOPERATION				OPERATION				MEAN		
	1979	1980	1981	1982	1983	1984	1985	1986	PREOP	OPER	ALL
RESIDENTS											
DOWNY WOODPECKER	--	0.0	6.6	3.3	0.0	0.0	19.7	3.3	3.3	5.7	4.7
AMERICAN CROW	--	3.3	0.0	0.0	0.0	3.3	0.0	0.0	1.1	0.8	0.9
BLACK-CAPPED CHICKADEE	--	3.3	52.7	0.0	29.6	3.3	19.7	9.9	18.7	15.6	16.9
TUFTED TITMOUSE	--	0.0	0.0	0.0	13.2	0.0	29.6	3.3	0.0	11.5	6.6
EASTERN BLUEBIRD	--	0.0	0.0	0.0	0.0	0.0	23.0	23.0	0.0	11.5	6.6
NORTHERN MOCKINGBIRD	--	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.8	0.5
NORTHERN CARDINAL	--	0.0	26.3	6.6	0.0	6.6	9.9	3.3	11.0	4.9	7.5
TOTAL	--	6.6	85.6	9.9	42.8	13.2	101.9	46.1	34.0	51.0	43.7
MIGRANTS											
NORTHERN HARRIER	--	0.0	3.3	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.5
NORTHERN FLICKER	--	0.0	0.0	0.0	0.0	0.0	6.6	0.0	0.0	1.7	0.9
BLUE JAY	--	0.0	6.6	0.0	0.0	0.0	49.4	3.3	2.2	13.2	8.5
GOLDEN-CROWNED KINGLET	--	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.8	0.5
PALM WARBLER	--	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.8	0.5
AMERICAN TREE SPARROW	--	32.9	19.7	29.6	42.8	32.9	79.0	69.1	27.4	56.0	43.7
SONG SPARROW	--	0.0	0.0	0.0	0.0	3.3	6.6	0.0	0.0	2.5	1.4
DARK-EYED JUNCO	--	82.3	26.3	3.3	52.7	26.3	26.3	75.7	37.3	45.3	41.8
AMERICAN GOLDFINCH	--	0.0	0.0	0.0	0.0	0.0	0.0	29.6	0.0	7.4	4.2
TOTAL	--	115.2	55.9	32.9	102.1	62.5	167.9	177.7	68.0	127.6	102.0
TOTAL	--	121.8	141.5	42.8	144.9	75.7	269.8	223.8	102.0	178.6	145.8

Table G-7

Mean densities of birds observed in Switchyard Field during winter counts, 1979 through 1986.

	PREOPERATION				OPERATION				MEAN		
	1979	1980	1981	1982	1983	1984	1985	1986	PREOP	OPER	ALL
RESIDENTS											
RED-TAILED HAWK	0.0	0.0	0.0	0.0	0.0	0.0	2.4	2.4	0.0	1.2	0.6
MOURNING DOVE	0.0	0.0	0.0	2.4	2.4	0.0	0.0	0.0	0.6	0.6	0.6
DOWNY WOODPECKER	0.0	0.0	2.4	7.2	2.4	2.4	4.8	0.0	2.4	2.4	2.4
AMERICAN CROW	0.0	7.2	0.0	0.0	0.0	0.0	2.4	0.0	1.8	0.6	1.2
BLACK-CAPPED CHICKADEE	0.0	19.2	16.8	14.4	26.4	33.6	50.3	28.8	12.6	34.8	23.7
TUFTED TITMOUSE	0.0	0.0	0.0	2.4	12.0	7.2	12.0	0.0	0.6	7.8	4.2
CAROLINA WREN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.6	0.3
EASTERN BLUEBIRD	0.0	0.0	0.0	0.0	7.2	4.8	31.2	4.8	0.0	12.0	6.0
NORTHERN MOCKINGBIRD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.6	0.3
NORTHERN CARDINAL	0.0	0.0	0.0	0.0	0.0	0.0	28.8	28.8	0.0	14.4	7.2
TOTAL	0.0	26.4	19.2	26.4	50.4	48.0	131.9	69.5	18.0	75.0	46.5
MIGRANTS											
NORTHERN HARRIER	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.6	0.3
BLUE JAY	0.0	0.0	12.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	1.5
GOLDEN-CROWNED KINGLET	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.6	0.3
AMERICAN ROBIN	0.0	0.0	16.8	0.0	0.0	0.0	43.1	7.2	4.2	12.6	8.4
CEDAR WAXWING	0.0	0.0	0.0	0.0	0.0	2.4	38.4	0.0	0.0	10.2	5.1
EUROPEAN STARLING	0.0	2.4	14.4	0.0	21.6	12.0	86.3	2.4	4.2	30.6	17.4
AMERICAN TREE SPARROW	3.4	7.2	2.4	57.5	9.6	12.0	50.3	28.8	17.6	25.2	21.4
SONG SPARROW	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.3
WHITE-THROATED SPARROW	0.0	0.0	0.0	0.0	0.0	0.0	69.5	2.4	0.0	18.0	9.0
SPARROW SP.	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.4
DARK-EYED JUNCO	0.0	9.6	21.6	12.0	16.8	2.4	155.8	2.4	10.8	44.4	27.6
RED-WINGED BLACKBIRD	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.6	0.3
AMERICAN GOLDFINCH	0.0	0.0	0.0	0.0	7.2	0.0	67.1	0.0	0.0	18.6	9.3
TOTAL	6.9	21.6	67.2	69.5	57.6	31.2	510.5	45.6	41.3	161.2	101.3
TOTAL	6.9	48.0	86.4	95.9	108.0	79.2	642.4	115.1	59.3	236.2	147.7

Table G-8

Number, density (no./sq km), and relative density (RD) of breeding pairs observed in TR419 and Council Cup Forests and Transmission Corridor and Switchyard Fields during breeding bird studies, 9 January through 12 September 1986.

	TR419 FOREST			COUNCIL CUP FOREST			TRANS CORR FIELD			SWITCHYARD FIELD		
NEST LOCATION/SPECIES	PAIRS	DENS	RD	PAIRS	DENS	RD	PAIRS	DENS	RD	PAIRS	DENS	RD
GROUND												
RUFFED GROUSE	0.1	0.9	0.1	0.1	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0
AMERICAN WOODCOCK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.7	0.1
VEERY	0.0	0.0	0.0	0.1	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0
BLUE-WINGED WARBLER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	16.8	1.2
GOLDEN-WINGED WARBLER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	8.4	0.6
BLACK-AND-WHITE WARBLER	3.0	27.1	3.5	0.1	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0
WORM-EATING WARBLER	2.0	18.1	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OVENBIRD	5.5	49.8	6.4	5.5	91.7	13.0	0.0	0.0	0.0	0.0	0.0	0.0
COMMON YELLOWTHROAT	0.0	0.0	0.0	0.0	0.0	0.0	2.0	46.1	5.6	10.0	167.8	12.0
RUFOUS-SIDED TOWHEE	0.1	0.9	0.1	0.1	1.7	0.2	0.1	2.3	0.3	4.0	67.1	4.8
FIELD SPARROW	0.0	0.0	0.0	0.0	0.0	0.0	9.0	207.4	25.2	10.5	176.2	12.6
SONG SPARROW	0.0	0.0	0.0	0.0	0.0	0.0	8.0	184.3	22.4	6.5	109.1	7.8
TOTAL	10.7	96.8	12.4	5.9	98.3	14.0	19.1	440.1	53.5	32.6	547.0	39.1
LEDGE												
BARN SWALLOW	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.3	0.3	0.0	0.0	0.0
CAVITY												
AMERICAN KESTREL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.7	0.1
EASTERN SCREECH-OWL	1.0	9.0	1.2	0.1	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0
DOWNY WOODPECKER	3.0	27.1	3.5	0.5	8.3	1.2	0.0	0.0	0.0	0.1	1.7	0.1
HAIRY WOODPECKER	2.5	22.6	2.9	2.0	33.3	4.7	0.0	0.0	0.0	0.0	0.0	0.0
NORTHERN FLICKER	0.1	0.9	0.1	0.5	8.3	1.2	0.0	0.0	0.0	0.5	8.4	0.6
PILEATED WOODPECKER	0.0	0.0	0.0	0.5	8.3	1.2	0.0	0.0	0.0	0.0	0.0	0.0
GREAT CRESTED FLYCATCHER	0.1	0.9	0.1	1.5	25.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0
BLACK-CAPPED CHICKADEE	4.5	40.7	5.2	5.5	91.7	13.0	0.1	2.3	0.3	0.1	1.7	0.1
TUFTED TITMOUSE	5.5	49.8	6.4	3.5	58.3	8.3	0.0	0.0	0.0	0.0	0.0	0.0
WHITE-BREASTED NUTHATCH	2.0	18.1	2.3	1.0	16.7	2.4	0.0	0.0	0.0	0.0	0.0	0.0
HOUSE WREN	0.5	4.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EASTERN BLUEBIRD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.7	0.1
EUROPEAN STARLING	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	33.6	2.4
TOTAL	19.2	173.8	22.3	15.1	251.7	35.8	0.1	2.3	0.3	2.9	48.7	3.5
LIMB												
COOPER'S HAWK	0.0	0.0	0.0	0.1	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0
RED-TAILED HAWK	0.5	4.5	0.6	0.1	1.7	0.2	0.0	0.0	0.0	0.1	1.7	0.1
GREAT HORNED OWL	0.1	0.9	0.1	0.1	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0
RUBY-THROATED HUMMINGBIRD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	8.4	0.6
EASTERN WOOD-PEWEE	3.0	27.1	3.5	3.0	50.0	7.1	0.0	0.0	0.0	0.0	0.0	0.0
WILLOW FLYCATCHER	0.0	0.0	0.0	0.0	0.0	0.0	1.5	34.6	4.2	2.0	33.6	2.4
EASTERN KINGBIRD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	16.8	1.2
BLUE JAY	3.0	27.1	3.5	2.5	41.7	5.9	0.1	2.3	0.3	1.0	16.8	1.2
AMERICAN CROW	0.5	4.5	0.6	0.1	1.7	0.2	0.0	0.0	0.0	0.1	1.7	0.1
BLUE-GRAY GNATCATCHER	2.0	18.1	2.3	0.1	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0
WOOD THRUSH	7.5	67.9	8.7	2.5	41.7	5.9	0.0	0.0	0.0	0.0	0.0	0.0
AMERICAN ROBIN	1.0	9.0	1.2	0.5	8.3	1.2	1.5	34.6	4.2	2.0	33.6	2.4
GRAY CATBIRD	0.5	4.5	0.6	0.0	0.0	0.0	2.0	46.1	5.6	6.5	109.1	7.8
NORTHERN MOCKINGBIRD	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.3	0.3	0.0	0.0	0.0
CEDAR WAXWING	4.0	36.2	4.6	2.0	33.3	4.7	2.0	46.1	5.6	6.0	100.7	7.2
WHITE-EYED VIREO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.7	0.1
RED-EYED VIREO	7.5	67.9	8.7	4.0	66.7	9.5	0.0	0.0	0.0	0.0	0.0	0.0
YELLOW WARBLER	0.0	0.0	0.0	0.0	0.0	0.0	2.0	46.1	5.6	8.0	134.2	9.6
PINE WARBLER	1.0	9.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PRAIRIE WARBLER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	58.7	4.2
AMERICAN REDSTART	1.5	13.6	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOODED WARBLER	1.5	13.6	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
YELLOW-BREASTED CHAT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	33.6	2.4
SCARLET TANAGER	8.5	76.9	9.9	3.0	50.0	7.1	0.0	0.0	0.0	0.0	0.0	0.0
NORTHERN CARDINAL	1.5	13.6	1.7	0.0	0.0	0.0	2.0	46.1	5.6	2.5	41.9	3.0
ROSE-BREASTED GROSBEAK	4.0	36.2	4.6	1.0	16.7	2.4	0.0	0.0	0.0	1.5	25.2	1.8
INDIGO BUNTING	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	25.2	1.8
CHIPPING SPARROW	1.5	13.6	1.7	0.1	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0
RED-WINGED BLACKBIRD	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.3	0.3	0.0	0.0	0.0
COMMON GRACKLE	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.3	0.3	0.0	0.0	0.0
NORTHERN ORIOLE	0.1	0.9	0.1	0.1	1.7	0.2	0.0	0.0	0.0	0.1	1.7	0.1
AMERICAN GOLDFINCH	2.0	18.1	2.3	0.0	0.0	0.0	4.0	92.2	11.2	7.5	125.8	9.0
TOTAL	51.2	463.3	59.5	19.2	320.0	45.5	15.4	354.8	43.1	45.9	770.1	55.0
SOCIAL PARASITE												
BROWN-HEADED COWBIRD	5.0	45.2	5.8	2.0	33.3	4.7	1.0	23.0	2.8	2.0	33.6	2.4
TOTAL	86.1	779.2	100.0	42.2	703.3	100.0	35.7	822.6	100.0	83.4	1399.3	100.0

Table G-9

Breeding bird densities (pairs/sq km) in TR419 Forest, 1979 through 1986.

	PREOPERATION				OPERATION				MEAN		
NEST LOCATION/SPECIES	1979	1980	1981	1982	1983	1984	1985	1986	PREOP	OPER	ALL
GROUND											
RUFFED GROUSE	9.0	0.0	0.0	0.0	0.9	0.9	0.9	0.9	2.3	0.9	1.6
VEERY	0.0	4.5	0.9	0.0	0.9	0.0	0.0	0.0	1.4	0.2	0.8
BLACK-AND-WHITE WARBLER	27.1	13.6	9.0	0.9	27.1	27.1	27.1	27.1	12.7	27.1	19.9
WORM-EATING WARBLER	9.0	9.0	0.0	0.0	9.0	9.0	9.0	18.1	4.5	11.3	7.9
OVENBIRD	13.6	22.6	18.1	13.6	9.0	54.3	36.2	49.8	17.0	37.3	27.1
COMMON YELLOWTHROAT	0.0	9.0	0.9	0.0	0.9	0.9	0.0	0.0	2.5	0.5	1.5
RUFOUS-SIDED TOWHEE	22.6	18.1	13.6	9.0	9.0	0.9	0.9	0.9	15.8	2.9	9.4
TOTAL	81.4	76.9	42.5	23.5	57.0	93.2	74.2	96.8	56.1	80.3	68.2
CAVITY											
EASTERN SCREECH-OWL	0.0	0.0	0.0	0.0	0.9	0.0	0.0	9.0	0.0	2.5	1.2
DOWNY WOODPECKER	18.1	18.1	13.6	18.1	13.6	22.6	18.1	27.2	17.0	20.4	18.7
HAIRY WOODPECKER	0.0	0.9	0.9	9.0	0.9	0.9	9.0	22.6	2.7	8.4	5.5
NORTHERN FLICKER	9.0	9.0	9.0	13.6	9.0	9.0	0.9	0.9	10.2	5.0	7.6
PILEATED WOODPECKER	0.0	0.0	0.0	0.9	0.9	0.9	0.9	0.0	0.2	0.7	0.5
GREAT CRESTED FLYCATCHER	9.0	4.5	4.5	0.9	0.9	0.9	9.0	0.9	4.8	2.9	3.8
BLACK-CAPPED CHICKADEE	22.6	27.1	31.7	45.2	49.8	54.3	54.3	40.7	31.7	49.8	40.7
TUFTED TITMOUSE	9.0	9.0	31.7	31.7	36.2	36.2	27.1	49.8	20.4	37.3	28.8
WHITE-BREASTED NUTHATCH	9.0	9.0	4.5	9.0	0.9	0.9	9.0	18.1	7.9	7.2	7.6
BROWN CREEPER	0.0	9.0	9.0	0.0	9.0	9.0	0.0	0.0	4.5	4.5	4.5
HOUSE WREN	9.0	0.9	0.9	0.0	13.6	0.9	0.9	4.5	2.7	5.0	3.8
TOTAL	86.0	87.8	105.9	128.5	135.7	135.7	129.4	173.7	102.0	143.7	122.8
LIMB											
RED-TAILED HAWK	0.0	9.0	0.0	0.0	0.9	0.0	0.9	4.5	2.3	1.6	1.9
YELLOW-BILLED CUCKOO	0.0	0.0	13.6	0.9	0.0	0.0	0.0	0.0	3.6	0.0	1.8
GREAT HORNED OWL	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.9	0.0	0.7	0.3
EASTERN WOOD-PEWEE	18.1	9.0	18.1	31.7	27.1	27.1	45.2	27.1	19.2	31.7	25.5
BLUE JAY	18.1	22.6	45.2	22.6	27.1	36.2	27.1	27.1	27.1	29.4	28.3
AMERICAN CROW	0.0	0.0	0.0	0.0	0.9	0.9	0.0	4.5	0.0	1.6	0.8
FISH CROW	0.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0	0.0	2.3	1.1
BLUE-GRAY GNATCATCHER	13.6	0.0	0.9	9.0	9.0	4.5	4.5	18.1	5.9	9.0	7.5
WOOD THRUSH	45.2	49.8	40.7	36.2	31.7	45.2	54.3	67.9	43.0	49.8	46.4
AMERICAN ROBIN	13.6	9.0	18.1	13.6	0.9	9.0	9.0	9.0	13.6	7.0	10.3
GRAY CATBIRD	0.9	22.6	9.0	13.6	9.0	22.6	18.1	4.5	11.5	13.6	12.6
CEDAR WAXWING	0.0	0.0	9.0	9.0	18.1	9.0	18.1	36.2	4.5	20.4	12.4
RED-EYED VIREO	13.6	27.1	27.1	27.1	40.7	45.2	58.8	67.9	23.8	53.2	38.5
CHESTNUT-SIDED WARBLER	0.0	4.5	0.9	0.0	0.0	0.9	0.0	0.0	1.4	0.2	0.8
PINE WARBLER	0.0	9.0	0.0	0.0	0.0	0.0	0.0	9.0	2.3	2.3	2.3
AMERICAN REDSTART	18.1	0.9	0.9	0.9	0.9	22.6	4.5	13.6	5.2	10.4	7.8
HOODED WARBLER	0.0	9.0	13.6	18.1	13.6	9.0	18.1	13.6	10.2	13.6	11.9
SCARLET TANAGER	18.1	27.1	40.7	54.3	72.4	54.3	63.3	76.9	35.1	66.7	50.9
NORTHERN CARDINAL	22.6	18.1	9.0	22.6	22.6	27.1	18.1	13.6	18.1	20.4	19.2
ROSE-BREASTED GROSBEAK	27.1	27.1	54.3	40.7	40.7	18.1	27.1	36.2	37.3	30.5	33.9
INDIGO BUNTING	0.0	0.9	0.9	0.9	0.9	0.9	0.9	0.0	0.7	0.7	0.7
CHIPPING SPARROW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6	0.0	3.4	1.7
NORTHERN ORIOLE	0.9	9.0	4.5	0.9	9.0	4.5	9.0	0.9	3.8	5.9	4.9
AMERICAN GOLDFINCH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.1	0.0	4.5	2.3
TOTAL	210.0	255.2	306.8	302.3	334.8	338.5	378.3	463.3	268.6	378.7	323.6
SOCIAL PARASITE											
BROWN-HEADED COWBIRD	45.2	45.2	45.2	31.7	45.2	31.7	27.1	45.2	41.9	37.3	39.6
TOTAL	422.6	465.2	500.5	486.0	572.9	599.1	609.0	779.1	468.6	640.0	554.3

Table G-10

Breeding bird densities (pairs/sq km) in Council Cup Forest, 1979 through 1986.

	PREOPERATION				OPERATION				MEAN		
NEST LOCATION/SPECIES	1979	1980	1981	1982	1983	1984	1985	1986	PREOP	OPER	ALL
GROUND											
RUFFED GROUSE	16.7	1.7	1.7	1.7	1.7	0.0	0.0	1.7	5.4	0.8	3.1
VEERY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.4	0.2
HERMIT THRUSH	0.0	1.7	0.0	0.0	0.0	1.7	1.7	0.0	0.4	0.8	0.6
BLACK-AND-WHITE WARBLER	25.0	16.7	33.3	41.7	33.3	33.3	25.0	1.7	29.2	23.3	26.3
WORM-EATING WARBLER	16.7	8.3	0.0	1.7	0.0	0.0	1.7	0.0	6.7	0.4	3.5
OVENBIRD	75.0	33.3	50.0	83.3	75.0	108.3	133.3	91.7	60.4	102.1	81.3
RUFOUS-SIDED TOWHEE	0.0	1.7	8.3	1.7	1.7	8.3	1.7	1.7	2.9	3.3	3.1
TOTAL	133.3	63.3	93.3	130.0	111.7	151.7	163.3	98.3	105.0	131.3	118.1
CAVITY											
EASTERN SCREECH-OWL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.4	0.2
DOWNY WOODPECKER	16.7	1.7	8.3	1.7	16.7	25.0	33.3	8.3	7.1	20.8	14.0
HAIRY WOODPECKER	0.0	8.3	8.3	8.3	8.3	8.3	8.3	33.3	6.3	14.6	10.4
NORTHERN FLICKER	16.7	0.0	16.7	16.7	8.3	1.7	0.0	8.3	12.5	4.6	8.5
PILEATED WOODPECKER	1.7	1.7	1.7	1.7	1.7	1.7	1.7	8.3	1.7	3.3	2.5
GREAT CRESTED FLYCATCHER	33.3	33.3	33.3	33.3	33.3	41.7	41.7	25.0	33.3	35.4	34.4
BLACK-CAPPED CHICKADEE	33.3	50.0	75.0	108.3	91.7	100.0	83.3	91.7	66.7	91.7	79.2
TUFTED TITMOUSE	16.7	16.7	16.7	33.3	41.7	25.0	41.7	58.3	20.8	41.7	31.2
RED-BREASTED NUTHATCH	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.2
WHITE-BREASTED NUTHATCH	0.0	16.7	8.3	1.7	16.7	16.7	16.7	16.7	6.7	16.7	11.7
BROWN CREEPER	0.0	0.0	0.0	0.0	16.7	16.7	1.7	0.0	0.0	8.8	4.4
TOTAL	118.3	128.3	170.0	205.0	235.0	236.7	228.3	251.7	155.4	237.9	196.7
LIMB											
COOPER'S HAWK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.4	0.2
BROAD-WINGED HAWK	0.0	16.7	1.7	16.7	1.7	0.0	0.0	0.0	8.8	0.4	4.6
RED-TAILED HAWK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.4	0.2
BLACK-BILLED CUCKOO	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.4	0.0	0.2
YELLOW-BILLED CUCKOO	1.7	16.7	33.3	16.7	0.0	0.0	0.0	0.0	17.1	0.0	8.5
GREAT-HORNED OWL	0.0	0.0	0.0	1.7	1.7	1.7	1.7	1.7	0.4	1.7	1.0
RUBY-THROATED HUMMINGBIRD	0.0	0.0	0.0	1.7	1.7	0.0	1.7	0.0	0.4	0.8	0.6
EASTERN WOOD-PEWEE	16.7	8.3	25.0	25.0	25.0	66.7	66.7	50.0	18.8	52.1	35.4
BLUE JAY	25.0	33.3	41.7	33.3	33.3	41.7	33.3	41.7	33.3	37.5	35.4
AMERICAN CROW	0.0	0.0	8.3	0.0	0.0	0.0	0.0	1.7	2.1	0.4	1.3
BLUE-GRAY GNATCATCHER	1.7	1.7	25.0	25.0	16.7	16.7	25.0	1.7	13.3	15.0	14.2
WOOD THRUSH	41.7	41.7	33.3	50.0	66.7	50.0	50.0	41.7	41.7	52.1	46.9
AMERICAN ROBIN	1.7	1.7	16.7	16.7	1.7	1.7	16.7	8.3	9.2	7.1	8.1
CEDAR WAXWING	0.0	0.0	33.3	16.7	50.0	33.3	16.7	33.3	12.5	33.3	22.9
SOLITARY VIREO	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.4	0.0	0.2
RED-EYED VIREO	58.3	58.3	58.3	58.3	100.0	83.3	83.3	66.7	58.3	83.3	70.8
CHESTNUT-SIDED WARBLER	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.2
CANADA WARBLER	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.4	0.2
SCARLET TANAGER	33.3	41.7	66.7	50.0	58.3	41.7	58.3	50.0	47.9	52.1	50.0
NORTHERN CARDINAL	0.0	0.0	0.0	8.3	1.7	0.0	0.0	0.0	2.1	0.4	1.3
ROSE-BREASTED GROSBEAK	16.7	1.7	16.7	8.3	16.7	25.0	25.0	16.7	10.8	20.8	15.8
INDIGO BUNTING	0.0	1.7	1.7	1.7	1.7	1.7	0.0	0.0	1.3	0.8	1.0
CHIPPING SPARROW	0.0	0.0	1.7	1.7	33.3	25.0	8.3	1.7	0.8	17.1	9.0
NORTHERN "BALTIMORE" ORIOLE	1.7	0.0	0.0	0.0	1.7	8.3	1.7	1.7	0.4	3.3	1.9
AMERICAN GOLDFINCH	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.4	0.0	0.2
TOTAL	198.3	225.0	363.3	336.7	413.3	396.7	388.3	320.0	280.8	379.6	330.2
SOCIAL PARASITE											
BROWN-HEADED COWBIRD	33.3	58.3	58.3	41.7	66.7	41.7	50.0	33.3	47.9	47.9	47.9
TOTAL	483.3	475.0	685.0	713.3	826.7	826.7	830.0	703.3	589.2	796.7	692.9

Table G-11

Breeding bird densities (pairs/sq km) in Transmission Corridor Field, 1979 through 1986.

	PREOPERATION				OPERATION				MEAN		
NEST LOCATION/SPECIES	1979	1980	1981	1982	1983	1984	1985	1986	PREOP	OPER	ALL
GROUND											
MALLARD	0.0	0.0	23.0	0.0	0.0	23.0	0.0	0.0	5.8	5.8	5.8
COMMON YELLOWTHROAT	80.6	57.6	57.6	34.6	57.6	57.6	80.6	46.1	57.6	60.5	59.0
RUFOUS-SIDED TOWHEE	0.0	2.3	0.0	2.3	57.6	2.3	0.0	2.3	1.2	15.6	8.4
FIELD SPARROW	138.2	161.3	172.8	195.9	241.9	230.4	218.9	207.4	167.1	224.7	195.9
SONG SPARROW	138.2	184.3	161.3	195.9	207.4	195.9	184.3	184.3	169.9	193.0	181.5
TOTAL	357.1	405.5	414.7	428.6	564.5	509.2	483.9	440.1	401.5	499.4	450.5
LEDGE											
BARN SWALLOW	0.0	0.0	0.0	0.0	0.0	2.3	2.3	2.3	0.0	1.7	0.9
CAVITY											
BLACK-CAPPED CHICKADEE	0.0	0.0	0.0	0.0	0.0	2.3	0.0	2.3	0.0	1.2	0.6
LIMB											
RED-TAILED HAWK	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.6	0.3
WILLOW FLYCATCHER	23.0	46.1	46.1	69.1	69.1	69.1	92.2	34.6	46.1	66.2	56.2
EASTERN KINGBIRD	0.0	0.0	0.0	0.0	2.3	2.3	23.0	0.0	0.0	6.9	3.5
BLUE JAY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.6	0.3
AMERICAN ROBIN	2.3	0.0	2.3	0.0	11.5	34.6	34.6	34.6	1.2	28.8	15.0
GRAY CATBIRD	0.0	2.3	11.5	34.6	46.1	34.6	57.6	46.1	12.1	46.1	29.1
NORTHERN MOCKINGBIRD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.6	0.3
CEDAR WAXWING	0.0	0.0	46.1	23.0	57.6	2.3	2.3	46.1	17.3	27.1	22.2
YELLOW WARBLER	0.0	0.0	23.0	23.0	46.1	46.1	34.6	46.1	11.5	43.2	27.4
PRAIRIE WARBLER	0.0	0.0	0.0	0.0	11.5	0.0	0.0	0.0	0.0	2.9	1.4
NORTHERN CARDINAL	0.0	0.0	2.3	2.3	23.0	2.3	34.6	46.1	1.2	26.5	13.8
INDIGO BUNTING	0.0	0.0	0.0	2.3	2.3	11.5	2.3	0.0	0.6	4.0	2.3
RED-WINGED BLACKBIRD	46.1	92.2	69.1	46.1	23.0	11.5	2.3	2.3	63.4	9.8	36.6
COMMON GRACKLE	2.3	0.0	2.3	0.0	0.0	0.0	2.3	2.3	1.2	1.2	1.2
NORTHERN ORIOLE	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.6	0.3
AMERICAN GOLDFINCH	23.0	23.0	46.1	80.6	92.2	69.1	46.1	92.2	43.2	74.9	59.0
TOTAL	96.8	163.6	248.8	281.1	387.1	283.4	334.1	354.8	197.6	339.9	268.7
SOCIAL PARASITE											
BROWN-HEADED COWBIRD	0.0	0.0	0.0	0.0	23.0	11.5	11.5	23.0	0.0	17.3	8.6
TOTAL	453.9	569.1	663.6	709.7	974.7	808.8	831.8	822.6	599.1	859.4	729.3

Table G-12

Breeding bird densitites (pairs/sq km) in Switchyard Field, 1979 through 1986.

	PREOPERATION				OPERATION				MEAN		
NEST LOCATION/SPECIES	1979	1980	1981	1982	1983	1984	1985	1986	PREOP	OPER	ALL
GROUND											
RING-NECKED PHEASANT	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.4	0.0	0.2
AMERICAN WOODCOCK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.4	0.2
BLUE-WINGED WARBLER	16.7	16.7	8.3	1.7	16.7	16.7	33.3	16.7	10.8	20.8	15.8
GOLDEN-WINGED WARBLER	8.3	8.3	16.7	16.7	16.7	16.7	25.0	8.3	12.5	16.7	14.6
COMMON YELLOWTHROAT	75.0	116.7	166.7	175.0	175.0	158.3	158.3	166.7	133.3	164.6	149.0
RUFOUS-SIDED TOWHEE	50.0	41.7	33.3	33.3	33.3	50.0	41.7	66.7	39.6	47.9	43.8
FIELD SPARROW	116.7	108.3	166.7	166.7	191.7	183.3	191.7	175.0	139.6	185.4	162.5
SONG SPARROW	58.3	91.7	91.7	75.0	83.3	108.3	91.7	108.3	79.2	97.9	88.5
TOTAL	325.0	383.3	483.3	470.0	516.7	533.3	541.7	543.3	415.4	533.8	474.6
LEDGE											
EASTERN PHOEBE	0.0	0.0	0.0	0.0	0.0	1.7	1.7	0.0	0.0	0.8	0.4
CAVITY											
AMERICAN KESTREL	0.0	1.7	1.7	1.7	1.7	0.0	0.0	1.7	1.3	0.8	1.0
EASTERN SCREECH-OWL	0.0	0.0	1.7	0.0	0.0	1.7	0.0	0.0	0.4	0.4	0.4
DOWNY WOODPECKER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.4	0.2
NORTHERN FLICKER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0	2.1	1.0
BLACK-CAPPED CHICKADEE	0.0	0.0	0.0	0.0	0.0	1.7	1.7	1.7	0.0	1.3	0.6
HOUSE WREN	0.0	0.0	0.0	0.0	0.0	1.7	1.7	0.0	0.0	0.8	0.4
EASTERN BLUEBIRD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.4	0.2
EUROPEAN STARLING	33.3	50.0	33.3	25.0	25.0	25.0	25.0	33.3	35.4	27.1	31.2
TOTAL	33.3	51.7	36.7	26.7	26.7	30.0	28.3	48.3	37.1	33.3	35.2
LIMB											
RED-TAILED HAWK	0.0	0.0	0.0	0.0	1.7	0.0	0.0	1.7	0.0	0.8	0.4
BLACK-BILLED CUCKOO	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	4.2	0.0	2.1
RUBY-THROATED HUMMINGBIRD	0.0	0.0	0.0	0.0	0.0	1.7	8.3	8.3	0.0	4.6	2.3
WILLOW FLYCATCHER	16.7	0.0	16.7	33.3	33.3	41.7	33.3	33.3	16.7	35.4	26.0
EASTERN KINGBIRD	0.0	0.0	16.7	8.3	1.7	8.3	16.7	16.7	6.3	10.8	8.5
BLUE JAY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	4.2	2.1
AMERICAN CROW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.4	0.2
AMERICAN ROBIN	8.3	8.3	0.0	0.0	0.0	8.3	16.7	33.3	4.2	14.6	9.4
GRAY CATBIRD	1.7	25.0	16.7	50.0	100.0	100.0	83.3	108.3	23.3	97.9	60.6
BROWN THRASHER	0.0	0.0	0.0	1.7	0.0	16.7	0.0	0.0	0.4	4.2	2.3
CEDAR WAXWING	0.0	0.0	66.7	33.3	66.7	33.3	116.7	100.0	25.0	79.2	52.1
WHITE-EYED VIREO	0.0	0.0	0.0	0.0	8.3	1.7	1.7	1.7	0.0	3.3	1.7
RED-EYED VIREO	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.4	0.2
YELLOW WARBLER	0.0	0.0	16.7	58.3	83.3	100.0	125.0	133.3	18.8	110.4	64.6
PRAIRIE WARBLER	0.0	33.3	41.7	50.0	50.0	58.3	66.7	58.3	31.3	58.3	44.8
AMERICAN REDSTART	0.0	0.0	0.0	0.0	0.0	16.7	16.7	0.0	0.0	8.3	4.2
YELLOW-BREASTED CHAT	33.3	16.7	41.7	33.3	33.3	33.3	41.7	33.3	31.3	35.4	33.3
NORTHERN CARDINAL	8.3	0.0	8.3	1.7	1.7	33.3	41.7	41.7	4.6	29.6	17.1
ROSE-BREASTED GROSBEAK	0.0	0.0	0.0	0.0	0.0	16.7	16.7	25.0	0.0	14.6	7.3
INDIGO BUNTING	33.3	33.3	25.0	33.3	25.0	41.7	33.3	25.0	31.3	31.3	31.3
NORTHERN ORIOLE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.4	0.2
AMERICAN GOLDFINCH	16.7	33.3	41.7	83.3	100.0	83.3	100.0	125.0	43.8	102.1	72.9
TOTAL	118.3	150.0	291.7	403.3	505.0	596.7	718.3	765.0	240.8	646.3	443.5
SOCIAL PARASITE											
BROWN-HEADED COWBIRD	0.0	0.0	0.0	1.7	33.3	16.7	16.7	33.3	0.4	25.0	12.7
TOTAL	476.7	585.0	811.7	901.7	1081.7	1178.3	1306.7	1390.0	693.6	1239.2	966.5

Table G-13

Weekly bird impaction totals from Unit 1 and 2 cooling towers, 24 March through 6 June 1986.

Family/Species	Mar 24-27	Mar 31-4	Apr 7-11	Apr 14-18	Apr 21-25	Apr 28-2	May 5-9	May 12-16	May 19-23	May 26-30	Jun 2-6	Total
UNIT 1												
Phasianidae												
Wild turkey	1	0	0	0	0	0	0	0	0	0	0	1
Columbidae												
Rock dove	0	1	0	0	0	0	0	0	0	0	0	1
Vireonidae												
Red-eyed vireo	0	0	0	0	0	0	0	0	0	1	0	1
Emberizidae												
Common yellowthroat	0	1	0	0	0	0	0	0	0	0	0	1
Song sparrow	0	1	0	0	0	0	0	0	0	0	0	1
Total Individuals	1	3	0	0	0	0	0	0	0	1	0	5
Total Species	1	3	0	0	0	0	0	0	0	1	0	5
UNIT 2												
Emberizidae												
Common yellowthroat	0	0	0	0	0	0	0	1	0	0	0	1
Common grackle	0	0	0	0	0	0	0	0	0	0	1	1
Total Individuals	0	0	0	0	0	0	0	1	0	0	1	2
Total Species	0	0	0	0	0	0	0	1	0	0	1	2

Table G-14

Weekly bird impaction totals from Unit 1 and 2 cooling towers, 18 August through 7 November 1986.

Family/Species	Aug 18-22	Aug 25-29	Sep 2-5	Sep 8-12	Sep 15-19	Sep 22-26	29-3	Oct 6-10	Oct 13-17	Oct 20-24	Oct 27-31	Nov 3-7	Total
UNIT 1													
Muscicapidae													
Ruby-crowned kinglet	0	0	0	0	0	0	0	0	0	1	0	0	1
Vireonidae													
Philadelphia vireo	0	0	0	0	1	0	0	0	0	0	0	0	1
Red-eyed vireo	0	1	0	0	2	0	1	3	0	0	0	0	7
Emberizidae													
Magnolia warbler	0	0	0	0	4	0	0	0	0	0	0	0	4
Blackpoll warbler	0	0	0	0	0	0	0	1	0	0	0	0	1
Black-and-white warbler	0	0	0	0	1	0	0	0	0	0	0	0	1
Common yellowthroat	0	0	0	0	1	0	0	0	1	0	0	0	2
Total Individuals	0	1	0	0	9	0	1	4	1	1	0	0	17
Total Species	0	1	0	0	5	0	1	2	1	1	0	0	7
UNIT 2													
Columbidae													
Rock dove	0	0	0	2	0	0	0	0	0	0	0	0	2
Troglodytidae													
House wren	0	0	0	0	1	0	0	0	0	0	0	0	1
Muscicapidae													
Ruby-crowned kinglet	0	0	0	0	0	0	0	0	1	0	0	0	1
Vireonidae													
Solitary vireo	0	0	0	0	0	0	0	0	0	2	0	0	2
Yellow-throated vireo	0	0	0	0	1	0	0	0	0	0	0	0	1
Philadelphia vireo	0	0	0	0	1	0	0	0	0	0	0	0	1
Red-eyed vireo	0	0	1	0	1	0	0	0	0	0	0	0	2
Emberizidae													
Northern parula	0	0	0	0	1	0	0	0	0	0	0	0	1
Chestnut-sided warbler	0	0	0	0	0	0	0	0	1	0	0	0	1
Magnolia warbler	1	0	0	0	2	0	0	0	0	0	0	0	3
Black-throated green warbler	0	0	0	0	2	0	1	0	0	0	0	0	3
Blackburnian warbler	0	1	0	1	3	0	0	0	0	0	0	0	5
Pine warbler	0	0	0	0	1	0	0	0	0	0	0	0	1
Blackpoll warbler	0	0	0	0	0	0	1	0	0	0	0	0	1
American redstart	1	0	0	0	0	0	0	0	0	0	0	0	1
Common yellowthroat	0	0	0	0	1	0	0	0	0	0	0	0	1
Blue grosbeak	1	0	0	0	0	0	0	0	0	0	0	0	1
Total Individuals	3	1	1	3	14	0	2	0	2	2	0	0	28
Total Species	3	1	1	2	10	0	2	0	2	1	0	0	17

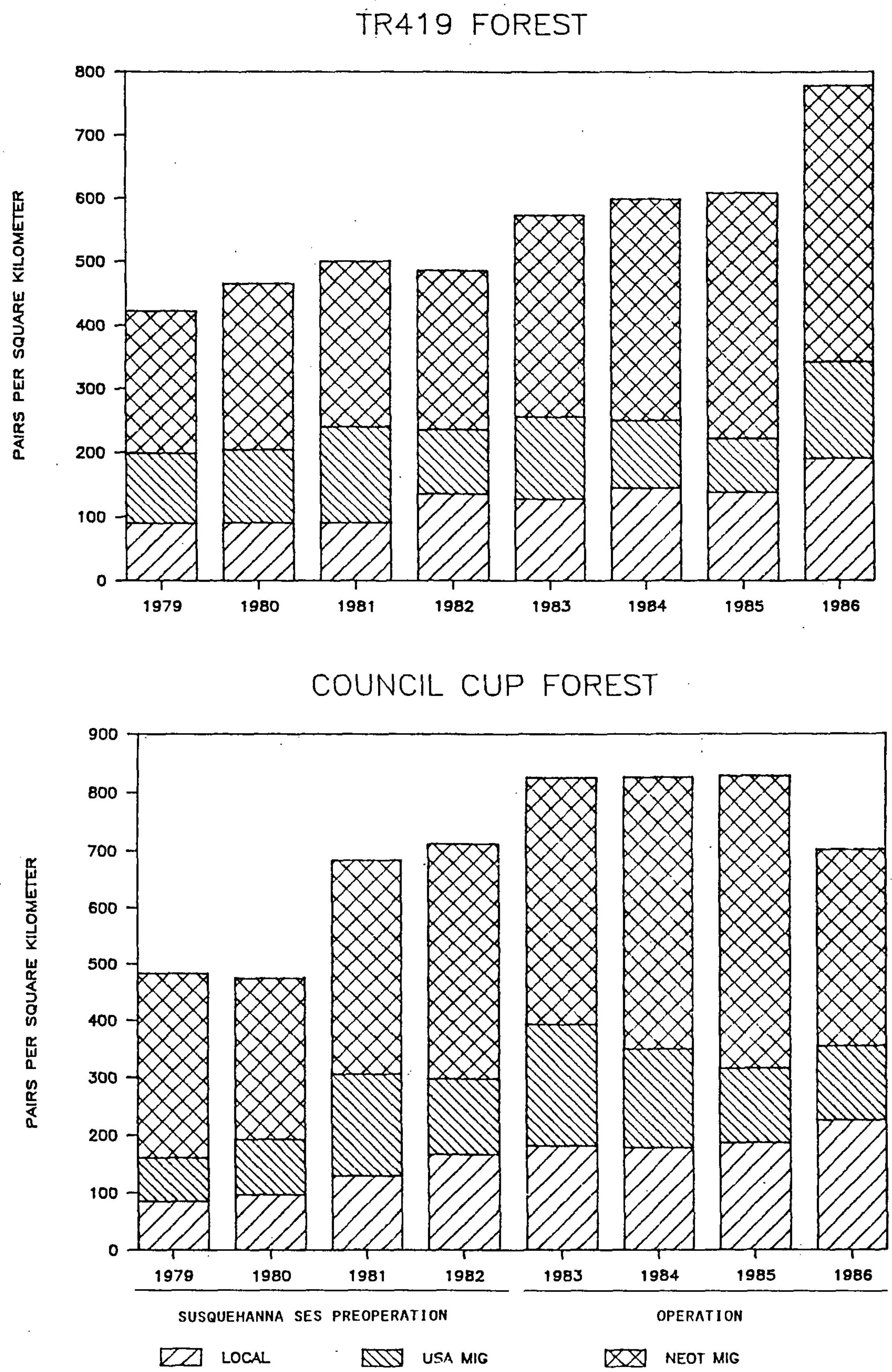

Fig. G-1

Total breeding densities (pairs/sq km) in TR419 and Council Cup Forests, 1979 through 1986. Local residents (LOCAL RES), migrants that overwinter in southern United States (USA MIG), and migrants that overwinter in the neotropics (NEOT MIG).

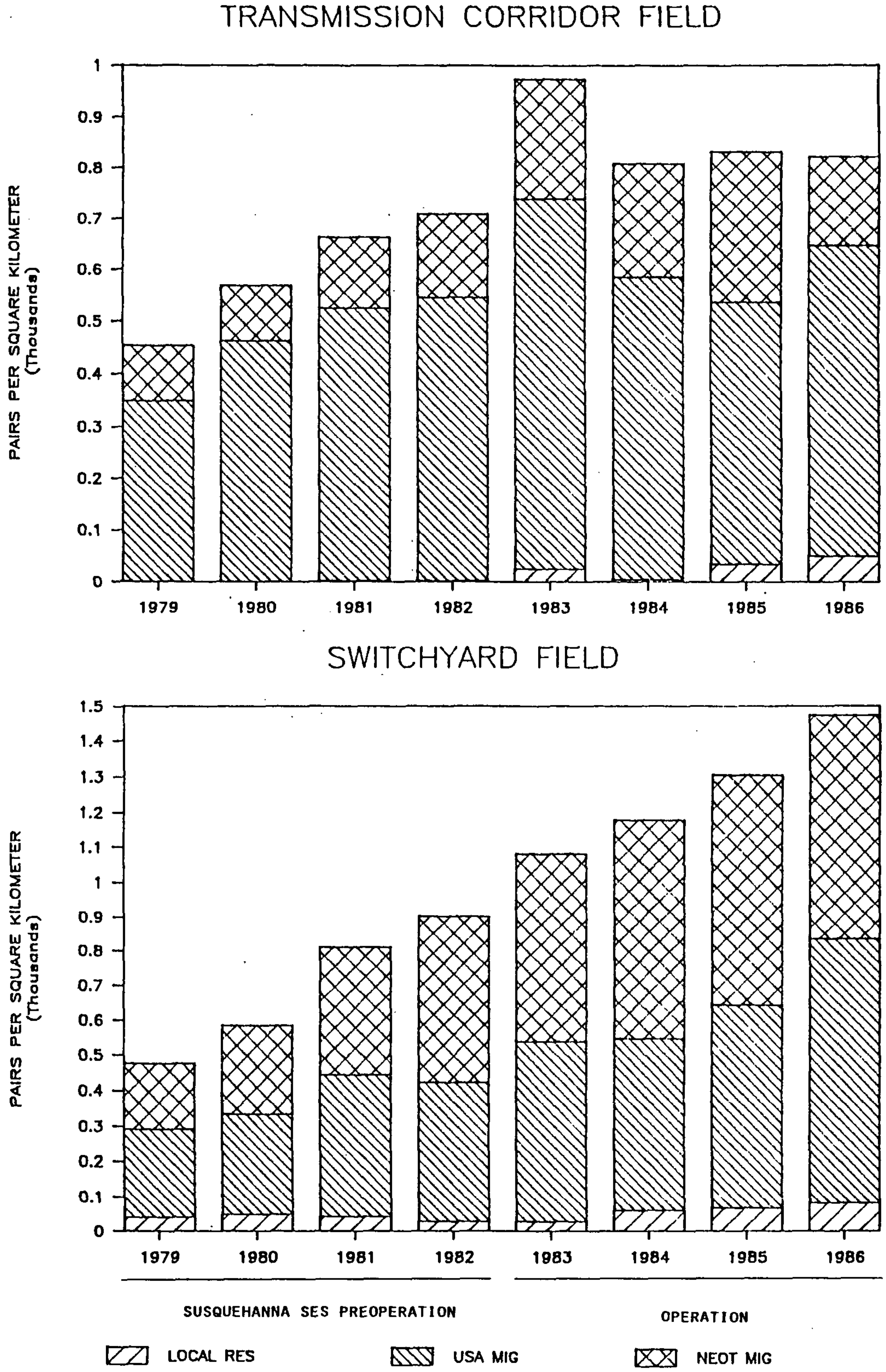

Fig. G-2

Total breeding densities (pairs/sq km) in Transmission Corridor and Switchyard Fields, 1979 through 1986. Local residents (LOCAL RES), migrants that overwinter in southern United States (USA MIG), and migrants that overwinter in the neotropics (NEOT MIG).

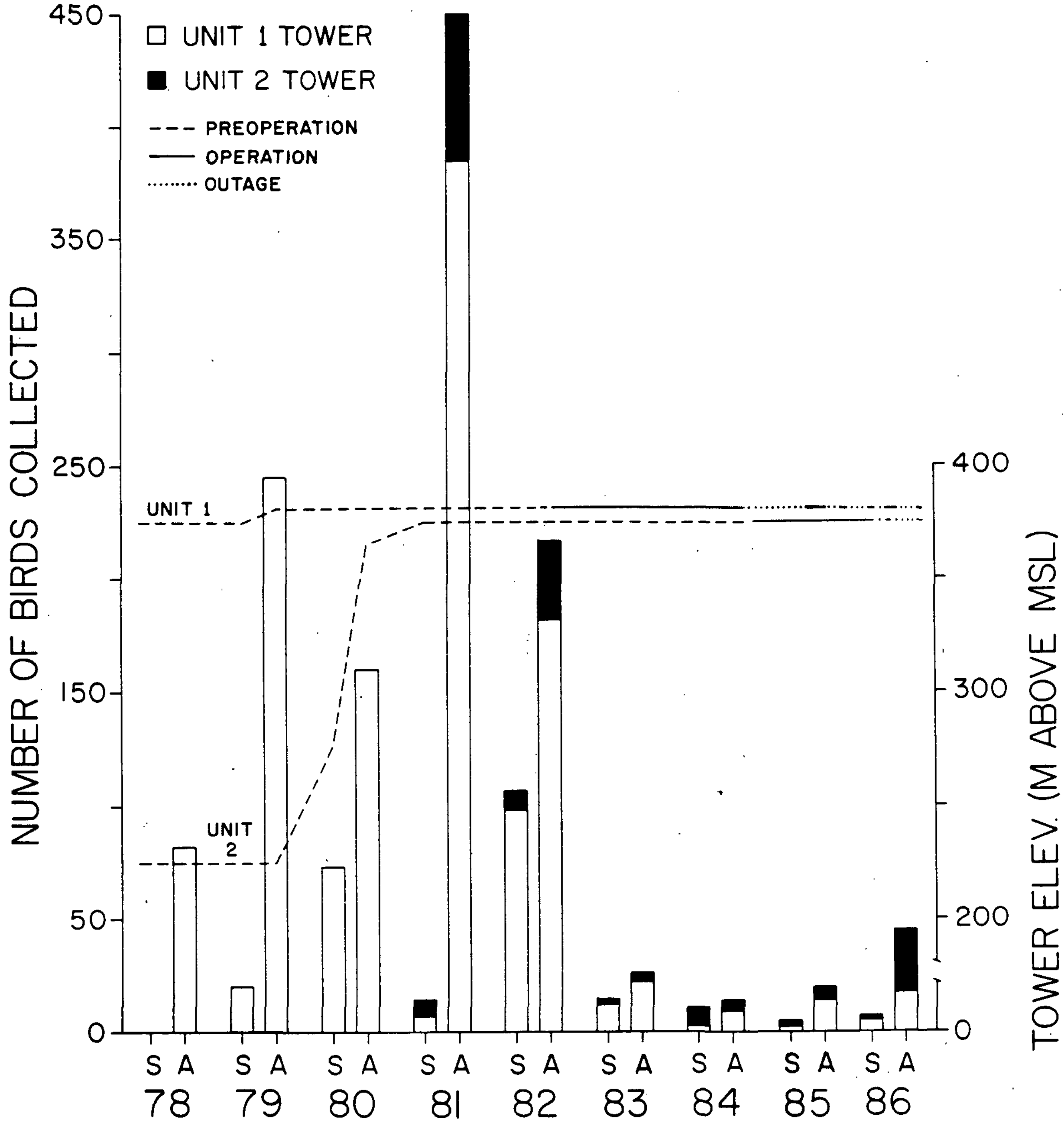

Fig. G-3

Total number of impacted birds collected at the Unit 1 and 2 cooling towers of the Susquehanna SES during spring and autumn migrations, 1978 through 1986, with the elevation of each tower during the same period. No data were collected at the Unit 1 tower before 1978 and at the Unit 2 tower before spring 1981.

ACKNOWLEDGMENTS

Special recognition is due Wayne B. Laubach for computerization of data, statistical analyses, and assistance with interpretation of the results. Sincere thanks are extended to Dr. Barry Towers, Pennsylvania Department of Environmental Resources, for identification of parasitic plant diseases. Appreciation is extended to Marion S. Hidlay who typed and collated the report and assured the uniformity of its format. Jerome S. Fields, Senior Environmental Scientist-Nuclear; Curtis H. Saxton, Environmental Specialist-Nuclear; and Douglas J. Walters, Project Licensing Specialist, Pennsylvania Power and Light Company, also deserve credit for constructive review of the report and guidance with various managerial aspects of the project.

PERSONNEL INVOLVED IN THE PROJECT DURING 1986

Project Director

Theodore V. Jacobsen, A.A.S. Paul Smith's College; A.S. Luzerne County Community College; B.S. Cornell University; M.S. Iowa State University

Environmental Studies Director, Terrestrial

James D. Montgomery, B.S. Bucknell University; M.S., Ph.D. Rutgers University

Senior Environmental Biologists

Douglas A. Gross, B.S. Pennsylvania State University; M.S. Bloomsburg State College

Andrew J. Gurzynski, B.S. Bloomsburg State College

Walter J. Soya, B.A. Hiram Scott College

Lynn S. Zelenak, B.A., M.A. Southern Illinois University

Environmental Biologists

Linda S. Imes, B.S. Kutztown State College

Brian P. Mangan, B.S. Pennsylvania State University; candidate for M.S. Bloomsburg University of Pennsylvania

Curtis H. Saxton, B.S., M.S. Pennsylvania State University

Environmental Technicians

Ruth C. Sterner, Berwick Area High School

Sharon A. Wisniewski, Columbia-Montour Area Vocational Technical School

Technical Assistants

Dean C. Arner, Columbia-Montour Area Vocational Technical School

John A. Breach, Columbia-Montour Area Vocational Technical School

Donald S. Karchner, candidate for B.S. Pennsylvania State University

Jami K. McGregor, candidate for B.S. Lycoming College

Michael R. Shelhamer, candidate for A.S. Luzerne County Community College

Programmer

Wayne B. Laubach, A.A.S. Luzerne County Community College; B.S. Bloomsburg University of Pennsylvania

Executive Secretary

Marion S. Hidlay, CPS, Institute for Certifying Secretaries; A.S. Luzerne County Community College

Draftsperson

Barbara L. Jacobsen, B.S. Iowa State University

Consultants

Dr. Rex L. Lowe, Department of Biological Sciences, Bowling Green State University, Bowling Green, Ohio (algae identification and enumeration)

Dr. Frederick M. Williams, Biology Department, Pennsylvania State University, University Park, Pennsylvania (statistics)

ABSTRACTS OF SCIENTIFIC PUBLICATIONS BY THE STAFF OF THE SUSQUEHANNA SES BIOLOGICAL LABORATORY, 1986

Deutsch, W. G. 1986. Food habits of Susquehanna River (Pennsylvania) muskellunge. Proc. Pa. Acad. Sci. 60(2): 169-173.

Food habits were determined for 48 muskellunge (*Esox masquinongy*), 37-117 cm total length (TL), electrofished (25 fish) and angled (23 fish) from the Susquehanna River (Wyoming, Luzerne, and Columbia counties, PA) in May 1983-April 1985. All prey were fish of three families and 12 species; 54% of stomachs contained food. Cylindrical, soft-rayed fish composed 72% of food items. Both prey TL and maximum body depth (MD) were positively correlated ($P<0.01$) with muskellunge TL. Muskellunge seemed to change their diet at about 60 cm TL, from eating multiple, small prey (primarily minnows) to single large prey (especially suckers). Muskellunge $\geqslant$60 cm TL ate proportionately longer (mean prey TL = 36% muskellunge TL) and deeper-bodied (mean prey MD = 74% of muskellunge mouth width) prey than smaller muskellunge (prey TL and MD averaged 17% and 33% of muskellunge TL and mouth width, respectively). A fish skeleton reference collection proved essential in the species identification and size estimation of most prey items.

SCIENTIFIC PUBLICATIONS BY THE STAFF OF THE SUSQUEHANNA SES BIOLOGICAL LABORATORY, 1974-86

Gale, W. F. and J. D. Thompson. 1974. Aids to benthic sampling by scuba divers in rivers. Limnol. and Oceanogr. 19(6): 1004-1007.

Gale, W. F. and J. D. Thompson. 1974. Placement and retrieval of artificial substrate samplers by scuba. Prog. Fish-Cult. 36(4): 231-233.

Gale, W. F. 1975. Ultrasonic removal of epilithic algae in a bar-clamp sampler. J. Phycol. 11(4): 472-473.

Gale, W. F. 1975. A quick-opening bucket for plankton and larval fish nets. Prog. Fish-Cult. 37(3): 164.

Gale, W. F. and J. D. Thomspon. 1975. A suction sampler for quantitatively sampling benthos on rocky substrates in rivers. Trans. Am. Fish. Soc. 104(2): 398-405.

Gale, W. F. and J. D. Thompson. 1975. A scuba diver's ladder for small boats. Prog. Fish-Cult. 37(1): 63-64.

Gale, W. F. and C. A. Gale. 1976. Selection of artificial spawning sites by the spotfin shiner (*Notropis spilopterus*). J. Fish. Res. Board Can. 33(9): 1906-1913.

Gale, W. F. and H. W. Mohr, Jr. 1976. Fish spawning in a large Pennsylvania river receiving mine effluents. Proc. Pa. Acad. Sci. 50: 160-162.

Gale, W. F., T. V. Jacobsen, and K. M. Smith. 1976. Iron, and its role in a river polluted by mine effluents. Proc. Pa. Acad. Sci. 50: 182-195.

Mackiewicz, J. S. and W. G. Deutsch. 1976. *Rowardleus* and *Janiszewskella*, new caryophyllid genera (Cestoidea: Caryophyllidae) from *Carpiodes cyprinus* (Catostomidae) in eastern North America. Proc. Helminthol. Soc. Wash. 43(1): 9-17.

Deutsch, W. G. 1977. Fish parasites from the Susquehanna River in Pennsylvania, with new host records. Proc. Pa. Acad. Sci. 51: 122-124.

Gale, W. F. 1977. Miniature aquarium system for rearing small numbers of fish larvae. Prog. Fish-Cult. 39(1): 10-13.

Gale, W. F. 1977. Scuba, the problem solver in sampling river benthos. Pages 13-29 in G. M. Simmons (ed.), The use of underwater research equipment in freshwater environments. Sea Grant VPI-SG-77-03. Va. Polytech. Inst. State Univ., Blacksburg, Va.

Gale, W. F. and C. A. Gale. 1977. Spawning habits of the spotfin shiner (*Notropis spilopterus*) -- a fractional, crevice spawner. Trans. Am. Fish. Soc. 106(2): 170-177.

Buynak, G. L. and A. J. Gurzynski. 1978. Lymphocystis disease in walleye (*Stizostedion vitreum*) captured in the Susquehanna River. Proc. Pa. Acad. Sci. 52(1): 49-50.

Buynak, G. L. and A. J. Gurzynski. 1978. Age and growth of smallmouth bass (*Micropterus dolomieui*) in a large river polluted by acid mine drainages. Proc. Pa. Acad. Sci. 52(2): 176-178.

Buynak, G. L. and H. W. Mohr, Jr. 1978. Micro-projector for drawing larval fishes. Prog. Fish-Cult. 40(1): 37-38.

Buynak, G. L. and H. W. Mohr, Jr. 1978. Larval development of the northern hog sucker (*Hypentelium nigricans*) from the Susquehanna River. Trans. Am. Fish. Soc. 107(4): 595-599.

Buynak, G. L. and H. W. Mohr, Jr. 1978. Larval development of the redbreast sunfish (*Lepomis auritus*) from the Susquehanna River. Trans. Am. Fish. Soc. 107(4): 600-604.

Buynak, G. L. and H. W. Mohr, Jr. 1978. Larval development of the white sucker (*Catostomus commersoni*) from the Susquehanna River. Proc. Pa. Acad. Sci. 52(2): 143-145.

Deutsch, W. G. 1978. *Lernaea cyprinacea* on two catostomid fishes. Proc. Pa. Acad. Sci. 52(1): 57-59.

Gale, W. F. and G. L. Buynak. 1978. Spawning frequency and fecundity of satinfin shiner (*Notropis analostanus*) -- a fractional, crevice spawner. Trans. Am. Fish. Soc. 107(3): 460-463.

Gale, W. F. and H. W. Mohr, Jr. 1978. Larval fish drift in a large river with a comparison of sampling methods. Trans. Am. Fish. Soc. 107(1): 46-54.

Buynak, G. L. and H. W. Mohr, Jr. 1979. Larval development of rock bass from the Susquehanna River. Prog. Fish-Cult. 41(1): 39-42.

Buynak, G. L. and H. W. Mohr, Jr. 1979. Larval development of creek chub and fallfish from two Susquehanna River tributaries. Prog. Fish-Cult. 41(3): 124-129.

Buynak, G. L. and H. W. Mohr, Jr. 1979. Larval development of the shorthead redhorse (*Moxostoma macrolepidotum*) from the Susquehanna River. Trans. Am. Fish. Soc. 108(2): 161-165.

Buynak, G. L. and H. W. Mohr, Jr. 1979. Larval development of the blacknose dace (*Rhinichthys atratulus*) and longnose dace (*Rhinichthys cataractae*) from a Susquehanna River tributary. Proc. Pa. Acad. Sci. 53(1): 56-60.

Buynak, G. L. and H. W. Mohr, Jr. 1979. Larval development of the northern pike (*Esox lucius*) and muskellunge (*Esox masquinongy*) from northeast Pennsylvania. Proc. Pa. Acad. Sci. 53(1): 69-73.

Buynak, G. L. and H. W. Mohr, Jr. 1979. Larval development of the bluntnose minnow (*Pimephales notatus*) and fathead minnow (*Pimephales promelas*) from northeast Pennsylvania. Proc. Pa. Acad. Sci. 53(2): 172-176.

Gale, W. F., A. J. Gurzynski, and R. L. Lowe. 1979. Colonization and standing crops of epilithic algae in the Susquehanna River, Pennsylvania. J. Phycol. 15: 117-123.

Ruhe, R. M. 1979. Forty-second breeding bird census: mixed oak-pine forest I. Am. Birds 33(1): 70.

Ruhe, R. M. 1979. Forty-second breeding bird census: mixed oak-pine forest II. Am. Birds 33(1): 70.

Ruhe, R. M. 1979. Forty-second breeding bird census: inland freshwater marsh. Am. Birds 33(1): 103.

Buynak, G. L. and H. W. Mohr, Jr. 1980. Collapsible fish-holding cage. Prog. Fish-Cult. 42(1): 41-42.

Buynak, G. L. and H. W. Mohr, Jr. 1980. Larval development of stoneroller, cutlips minnows, and river chub with diagnostic keys, including four additional cyprinids. Prog. Fish-Cult. 42(3): 127-135.

Buynak, G. L. and H. W. Mohr, Jr. 1980. Larval development of golden shiner and comely shiner from northeastern Pennsylvania. Prog. Fish-Cult. 42(4): 206-211.

Buynak, G. L. and H. W. Mohr, Jr. 1980. Key to the identification of sucker larvae in the Susquehanna River near Berwick, Pennsylvania. Proc. Pa. Acad. Sci. 54: 161-164.

Buynak, G. L. and H. W. Mohr, Jr. 1980. Larval development of the common shiner (*Notropis cornutus*) from northeast Pennsylvania. Proc. Pa. Acad. Sci. 54: 165-168.

Buynak, G. L., A. J. Gurzynski, and H. W. Mohr, Jr. 1980. Age and growth, food habits, and abundance of walleye (*Stizostedion vitreum*) in the Susquehanna River near Berwick, Pennsylvania. Proc. Pa. Acad. Sci. 54: 136-140.

Chance, J. M. and W. G. Deutsch. 1980. A comparison of four similarity indexes in the cluster analysis of Susquehanna River macrobenthos samples. Proc. Pa. Acad. Sci. 54: 169-173.

Deutsch, W. G. 1980. Macroinvertebrate colonization of acrylic plates in a large river. Hydrobiologia 75: 65-72.

Buynak, G. L. and H. W. Mohr, Jr. 1981. Small-scale culture techniques for obtaining spawns from fish. Prog. Fish-Cult. 43(1): 38-39.

Deutsch, W. G. 1981. Suppression of macrobenthos in an iron-polluted stretch of the Susquehanna River (Pennsylvania). Proc. Pa. Acad. Sci. 55: 37-42.

Gale, W. F. 1981. A floatable, benthic corer for use with scuba. Hydrobiologia 77: 273-275.

Gross, D. A. 1981. Forty-fourth breeding bird census: mixed oak-pine forest I. Am. Birds 35(1): 65.

Gross, D. A. 1981. Forty-fourth breeding bird census: mixed oak-pine forest II. Am. Birds 35(1): 65.

Gross, D. A. 1981. Forty-fourth breeding bird census: abandoned field. Am. Birds 35(1): 102.

Gross, D. A. 1981. Forty-fourth breeding bird census: abandoned field II. Am. Birds 35(1): 102-103.

Buynak, G. L., H. W. Mohr, Jr., and A. J. Gurzynzki. 1982. Some observations of food selectivity by small walleye (*Stizostedion vitreum*) under aquarium conditions. Proc. Pa. Acad. Sci. 56(1): 26-28.

Buynak, G. L., A. J. Gurzynski, and H. W. Mohr, Jr. 1982. Comparison of the food habits of smallmouth bass (*Micropterus dolomieui*) at two stations on the Susquehanna River. Proc. Pa. Acad. Sci. 56(2): 127-132.

Gale, W. F. and G. L. Buynak. 1982. Fecundity and spawning frequency of the fathead minnow - a fractional spawner. Trans. Am. Fish. Soc. 111(1): 35-40.

Gross, D. A. 1982. Forty-fifth breeding bird census: mixed oak-pine forest I. Am. Birds 36(1): 67.

Gross, D. A. 1982. Forty-fifth breeding bird census: mixed oak-pine forest II. Am. Birds 36(1): 67.

Gross, D. A. 1982. Forty-fifth breeding bird census: abandoned field I. Am. Birds 36(1): 104.

Gross, D. A. 1982. Forty-fifth breeding bird census: abandoned field II. Am. Birds 36(1): 104.

Gale, W. F. 1983. Fecundity and spawning frequency of caged bluntnose minnows - fractional spawners. Trans. Am. Fish. Soc. 112(3): 398-402.

Gale, W. F. 1983. Bucketed dip net to collect zooplankton and larval fish. Prog. Fish-Cult. 45(2): 102.

Gross, D. A. 1983. Forty-sixth breeding bird census: mixed oak-pine forest I. Am. Birds 37(1): 106

Gross, D. A. 1983. Forty-sixth breeding bird census: mixed oak-pine forest II. Am. Birds 37(1): 106-107.

Gross, D. A. 1983. Forty-sixth breeding bird census: abandoned field I. Am. Birds 37(1): 107.

Gross, D. A. 1983. Forty-sixth breeding bird census: abandoned field II. Am. Birds 37(1): 107.

Montgomery, J. D. 1983. Some additions to the flora in Luzerne County, Pennsylvania. Bartonia 49: 27-31.

Deutsch, W. G. 1984. Oviposition of Hydropsychidae (Trichoptera) in a large river. Can. J. Zool. 62: 1988-1994.

Gross, D. A. 1984. Forty-seventh breeding bird census: mixed oak-pine forest I. Am. Birds 38(1): 126.

Gross, D. A. 1984. Forty-seventh breeding bird census: mixed oak-pine forest II. Am. Birds 38(1): 126.

Gross, D. A. 1984. Forty-seventh breeding bird census: abandoned field I. Am. Birds 38(1): 128.

Gross, D. A. 1984. Forty-seventh breeding bird census: abandoned field II. Am. Birds 38(1): 128-129.

Deutsch, W. G. 1985. Swimming modifications of adult female Hydropsychidae compared with other Trichoptera. Freshwat. Invertebr. Biol. V. 4(1): 35-40.

Gale, W. F. and W. G. Deutsch. 1985. Fecundity and spawning frequency of captive tessellated darters - fractional spawners. Trans. Am. Fish. Soc. 114(2): 220-229.

Montgomery, J. D. 1985. Some observations on the ecology and phenology of *Botrychium dissectum* in eastern Pennsylvania. Am. J. Botany 72(6): 925.

Deutsch, W. G. 1986. Food habits of Susquehanna River (Pennsylvania) muskellunge. Pa. Acad. Sci. 60(2): 169-173.

Mangan, B. P. 1986. Natural reproduction of the muskellunge (*Esox masquinongy*) in the Susquehanna River near Berwick, Pennsylvania. Pa. Acad. Sci. 60(2): 200.