APPENDIX A

Color Photographs from Site Investigation

December 14, 2011

PHOTO # 1 – View from North Market Street looking east across the proposed development site. The two existing Susquehanna Steam Electric Station cooling towers are visible in close proximity in the background.

PHOTO # 2 – View from North Market Street, existing gravel road and PPL security sign.

PHOTO # 3 – Looking north along North Market Street, the development site is located to the right.

PHOTO # 4 – View from U.S. 11 in proximity to the proposed future access drive. The existing cooling towers and power transmission lines are evident.

PHOTO # 5 – Closer view of the neighboring Susquehanna Steam Electric Station facility from Confers Lane looking north.

PHOTO # 6 – Looking west across the proposed development site from Confers Lane. Another PPL security sign marks the boundary.

PHOTO # 7 – View of the existing cooling towers from Confers Lane, looking southeast.

PHOTO # 8 – Looking northwest from Confers Lane, the proposed PPL Bell Bend development site is located in the background behind the tree line.

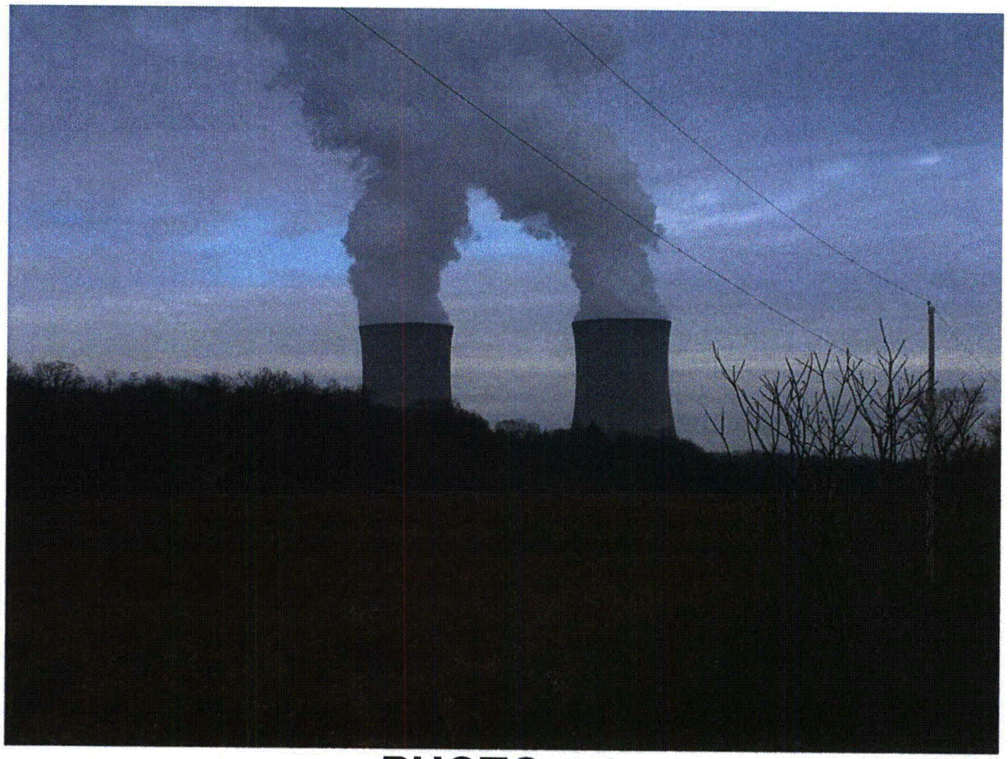

PHOTO # 1

PHOTO # 2

PHOTO # 3

PHOTO # 4

PHOTO # 5

PHOTO # 6

PHOTO # 7

PHOTO # 8

APPENDIX B

Curriuclum Vitae

MARTIN AND MARTIN, INCORPORATED
STATEMENT OF QUALIFICATIONS
FOR PROFESSIONAL MUNICIPAL
ENGINEERING AND PLANNING CONSULTING

Prepared by:

Martin and Martin, Incorporated
Planning and Engineering Consultants
37 South Main Street • Suite A
Chambersburg, Pennsylvania 17201

2012

MARTIN AND MARTIN, INCORPORATED

STATEMENT OF QUALIFICATIONS

FOR

PROFESSIONAL MUNICIPAL ENGINEERING AND PLANNING CONSULTING

Martin and Martin, Incorporated has been providing engineering and planning consultation services to both public and private sector clientele since its incorporation in 1973. Our experience in municipal engineering and planning has been a cornerstone of the firm since its inception. Local municipalities, County agencies, municipal authorities, and State Departments have been served over the course of the last 37 years in a variety of capacities. Our staff always strives for excellence in quality, efficiency, and effectiveness in all of the firm's appointed tasks. It has been Martin and Martin's privilege to continuously provide its array of clients with a sense of progress, accessibility and satisfaction.

Municipal consulting services are available on a wide range of professional engineering and surveying specialties. Townships, Boroughs, and Counties look to Martin and Martin for assistance with the design, review, permitting, funding and inspection of roadway construction projects; public facility services such as water systems, sanitary sewer systems, and stormwater management facilities; subdivision and land development plan review; solid waste management strategies; bridge construction projects; environmental assessments and impact statements; recreation facilities; building expansions; traffic studies for speed restriction, weight restriction, and the placement of traffic control or warning signs.

The planning staff at Martin and Martin is well-versed in an abundance of planning activities which regional and local municipal entities often find themselves confronted with from time to time in order to better provide for the future of its constituency. Our professional planning staff combines backgrounds in planning, engineering, architecture,

environmental science, geography, and cartography with the firm's extensive involvement in numerous public and private endeavors to provide the client with the luxury of both "hands-on" experience and knowledge of the latest advancements and innovations in planning practices. Our staff is actively involved in the preparation of comprehensive plans, specialized land use plans, zoning ordinances, subdivision and land development ordinances, official maps, recreation plans, sewage facilities plans, airport zoning regulations, and a myriad of other specialty guidance documents and regulatory tools.

Municipal authorities, particularly water and sanitary sewer agencies, have also been a staple client of Martin and Martin's through the years. Our engineering and technical staff have assisted these bodies in design and permitting procedures, plan review and advisement, the development of standards and specifications for individual systems, construction inspection, research into funding alternatives, and general problem solving and "trouble-shooting". Regular attendance at monthly meetings, accessibility for emergency situations, and an outstanding rapport with State and Federal regulatory agencies are just a few of the advantages which our technical staff offers to its range of Authority clientele.

Martin and Martin has developed an exemplary reputation during its existence in all facets of municipal consulting. The firm continues to strive for excellence in all fields through education, experience, innovation, and awareness.

Martin and Martin is dedicated to providing its municipal clientele with efficient, effective and intelligent professional engineering and planning consulting services. Continuing education and research adds constantly to the available resource base which serves to further solidify Martin and Martin's reputation as a leader in the professional consulting community.

Municipal Engineering Clients
(* indicates current as of 05/12)

St. Thomas Township, Franklin County, PA *

Antrim Township, Franklin County, PA *

Montgomery Township, Franklin County, PA *

Washington Township, Franklin County, PA

Southampton Township, Franklin County, PA *

Letterkenny Township, Franklin County, PA *

Quincy Township, Franklin County, PA *

Shippensburg Township, Cumberland County, PA *

Southampton Township, Cumberland County, PA

Upper Frankford Township, Cumberland County, PA

Upper Mifflin Township, Cumberland County, PA *

South Newton Township, Cumberland County, PA *

Franklin Township, Adams County, PA

Hamiltonban Township, Adams County, PA

Liberty Township, Adams County, PA

Cumberland Township, Adams County, PA

Arendtsville Borough, Adams County, PA

Hamilton Township, Adams County, PA

Shrewsbury Township, York County, PA

Hopewell Township, York County, PA *

Peach Bottom Township, York County, PA

Metal Township, Franklin County, PA *

Fannett Township, Franklin County, PA *

Planning and Zoning Clients

St. Thomas Township, Franklin County, PA *
Comprehensive Plan, Zoning Ordinance, Sewage Facilities Plan

Antrim Township, Franklin County, PA *
Zoning Ordinance, Subdivision Ordinance, Sewage Facilities Plan, Conservation by Design Ordinances

Washington Township, Franklin County, PA
Comprehensive Plan, Zoning Ordinance

Southampton Township, Franklin County, PA *
Comprehensive Plan, Subdivision Ordinance, Zoning Ordinance

Metal Township, Franklin County, PA *
Sewage Facilities Plan, Subdivision Ordinance

Letterkenny Township, Franklin County, PA *
Sewage Facilities Plan, Subdivision & Land Development Ordinance

Shippensburg Township, Cumberland County, PA *
Subdivision Ordinance, Zoning Ordinance

Southampton Township, Cumberland County, PA
Comprehensive Plan, Subdivision Ordinance

Upper Frankford Township, Cumberland County, PA
Comprehensive Plan, Subdivision Ordinance

Warren Township, Franklin County, PA*
Subdivision and Land Development Ordinance

East Pennsboro Township, Cumberland County, PA
Zoning Ordinance

Liberty Township, Adams County, PA
Comprehensive Plan, Subdivision Ordinance, Airport Zoning

Hamiltonban Township, Adams County, PA
Comprehensive Plan, Zoning Ordinance, Subdivision Ordinance, Conservation by Design Ordinances

Western Cumberland County Council of Governments, PA
Eight Municipality Regional Comprehensive Plan

Cumberland Township, Adams County, PA
Zoning Ordinance, Subdivision Ordinance, Airport Zoning

Hamilton Township, Adams County, PA
Sewage Facilities Plan

Straban Township, Adams County, PA
Comprehensive Plan, Zoning Ordinance

East Berlin Borough, Adams County, PA
Zoning Ordinance, Subdivision Ordinance

Franklin Township, Adams County, PA
Comprehensive Plan, Subdivision Ordinance

Delta Borough, York County, PA
Sewage Facilities Plan

Shrewsbury Township, York County, PA
Sewage Facilities Plan

Hopewell Township, York County, PA *
Sewage Facilities Plan, Comprehensive Plan

Taylor Township, Fulton County, PA
Sewage Facilities Plan

Bethel Township, Fulton County, PA
Sewage Facilities Plan

Franklin County, PA *
Comprehensive Plan, Letterkenny Army Depot JLUS, Solid Waste Plan, Solid Waste Management Plan

North Manheim Township, Schuylkill County, PA
Sewage Facilities Plan

Northern Franklin County Joint Planning Consortium
Multi-Municipal Comprehensive Plan

Fannett Township, Franklin County, PA *
Sewage Facilities Plan

Montgomery Township, Franklin County, PA *
Subdivision and Land Development Ordinance

NAME: Timothy C. Cormany, A.I.C.P.

POSITION: Vice-President of Planning, Martin and Martin, Incorporated

EDUCATION: Bachelor of Arts in Geography - 1986
Shippensburg University
Shippensburg, Pennsylvania

PROFESSIONAL EXPERIENCE:

<u>Martin and Martin, Incorporated - 1990 to present</u>

As a Planner and Partner with the firm, Mr. Cormany is a project coordinator for the company's environmental and land use planning activities. Designated projects include municipal and regional comprehensive planning, subdivision and land development design, environmental assessments, zoning ordinance and subdivision ordinance preparation, land use studies, and municipal engineering. Mr. Cormany has also participated in a number of Pennsylvania Department of Environmental Protection training sessions and advisory committees and has served as an expert witness for professional planning testimony in a variety of arenas. He served as a consultant for the Pennsylvania Department of Community Affairs in preparation of its updated zoning manual for local municipalities. He also supervises a regular schedule of interns from the Geography/Earth Science and Geoenvironmental Studies Departments of Shippensburg University.

<u>Statler-Brehm Associates, Incorporated - 1988 - 1990</u>

Mr. Cormany assumed the responsibility of planning director and, as such, performed and supervised the preparation of municipal ordinances, environmental assessments, comprehensive plans, subdivision and land development plans; project coordination with wetlands consultants and hydrogeologists; and provided both public and private sector client representation at municipal meetings.

<u>Statler and Lahr, Incorporated - 1987 - 1988</u>

Mr. Cormany's duties as a staff planner centered around assistance with comprehensive planning, subdivision and land development design, procurement of miscellaneous state agency permits and surveying and drafting activities.

PROFESSIONAL AFFILIATIONS:

American Planning Association

Pennsylvania Planning Association

National Geographic Society

National Association of Environmental Professionals

American Institute of Certified Planners

Advisor, Letterkenny Army Depot Reuse Committee, Environmental Subcommittee

Enclosure 6

NRHH-05 – 1995 Ecology III Report

ENVIRONMENTAL STUDIES IN THE VICINITY OF THE SUSQUEHANNA STEAM ELECTRIC STATION

1994 ANNUAL REPORT

Prepared By

Ecology III, Inc.
R R #1, Box 1795
Berwick, Pennsylvania 18603

For

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

June 1995

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EXECUTIVE SUMMARY

The objective of the nonradiological environmental monitoring studies is to assess the impact of operating the Susquehanna Steam Electric Station (Susquehanna SES) on the water quality, algae, benthic macroinvertebrates, and fishes of the Susquehanna River and on the flora, vegetation, and birds in the local terrestrial environment. These assessments were continued in 1994 by evaluating data collected at control and indicator sites and by comparing results of preoperational (1971-82) and operational (1983-94) studies. To more objectively assess the impact of operating the Susquehanna SES on the Susquehanna River, a statistical procedure called BACI (Before-After:Control-Impact) analysis was applied to preoperational and operational monitoring data from water quality, algae, and fishes.

The algae, benthic macroinvertebrate, flora and vegetation, and birds monitoring programs were terminated at the end of 1994.

Water Quality

Water quality of the Susquehanna River near the Susquehanna SES was monitored at two control sites and two indicator sites. In 1994, all parameters encompassed by the Pennsylvania Department of Environmental Resources water quality criteria were within the critera, except for some iron and aluminum samples. High river flow, acid mine drainage, and bridge construction upriver each caused these parameters to exceed the criteria at the Susquehanna site. Total mixing of the blowdown was complete in all the Bell

Bend indicator samples due to the high river water dilution ratio throughout the year. BACI analysis showed conductivity, sulfate, and total dissolved solids were significantly higher at Bell Bend since operation began.

Algae

Algae (periphyton and phytoplankton) samples were collected at three sites in the Susquehanna River in 1994. Periphyton density was highest at the SSES control site and slightly less at the indicator sites (Bell Bend and Bell Bend I). Phytoplankton densities were also slightly higher at the control site than at the indicator sites. BACI analysis revealed that the abundances of *Gomphonema, Navicula,* and *Surirella* were significantly less at Bell Bend than at SSES. One genus of phytoplankton (*Kirchemeriella*) also tested significant; its abundance decreased significantly more at SSES than at Bell Bend. Overall, algae densities have decreased in operational years compared to preoperational years. These changes occurred at both control and indicator sites and were not caused by operation of the Susquehanna SES.

Benthic Macroinvertebrates

Benthic macroinvertebrates were collected at a control site (SSES I) and two indicator sites (Bell Bend III and IV) in June, August, and October 1994. Ephemeropterans composed a majority of the macroinvertebrate biomass at all three sites. The total mean biomass at SSES I was greater than that found at either Bell Bend III or IV, as it always has been in both preoperational (1980-82) and operational (1983-94) years. In 1994, the

percentage of trichopterans in the biomass was greatest at SSES I. This has been the case in all years since 1980, except during the drought in 1991 when it was greater at one of the indicator sites.

Fishes

Fish were sampled at two control sites and two indicator sites with an electrofisher (May through August, and October) and seine (June, September, and October) in 1994. During electrofishing 855 fish of 21 species were observed, while 890 fish of 17 species were captured by seining. BACI analysis, performed on 20 fish species or categories from the electrofishing data, indicated adverse statistical significance in the numbers of 10 species at the indicator locations. Consequently, as a partial result of these findings, an investigation was begun in 1993 into the possible relationship between habitat (water depth and velocity, and substrate size) and fish distribution in this area of the river. This study continued in 1994 and preliminary data analysis was begun. Samples have been collected on 27 dates (both years combined) and have resulted in the observations of 6,728 fish in approximately 2,000 sampled sections (5,662 fish identified to 22 species). These samples also included 200 plus substrate and cover measurements, and 16,200 measurements of water depth and velocity (combined). BACI analysis applied to 12 species of seined fish indicated a marginal decline in the numbers of young-of-the-year smallmouth bass. However, this outcome was predicted in the 1993 annual report because smallmouth bass then showed a trend toward decline at the downriver stations.

Flora and Vegetation

In 1994, 40 plant diseases were observed on 56 host species. These numbers were within ranges recorded during preoperational and operational studies of 1977-93. No effects of salt drift were observed. Quantitative vegetation studies were conducted in two upland forests (indicator sites) near the Susquehanna SES and at an upland forest near Elimsport (control site). Most important species and significant changes in species were similar to those found in previous years, and could be attributed to normal vegetation dynamics (succession, animal interaction, etc.). No significant changes showed a pattern that could be attributed to the operation of the Susquehanna SES.

Birds

Seven Pennsylvania endangered or threatened bird species were observed near the power station in 1994: Osprey, Bald Eagle, Peregrine Falcon, Black Tern, Great Egret, Common Snipe, and Yellow-bellied Flycatcher. Bald Eagle and Peregrine Falcon are listed as federal endangered species. Bald Eagle was reported more frequently in 1994 than in any previous year. All Pennsylvania Birds of Special Concern were observed in migration, but did not nest within15 km of the power station. Most were observed near the river or on PP&L property. Breeding bird population studies have been conducted in two forested plots in a consistent manner since 1980. In both plots, the total breeding bird densities were above average in 1994. The breeding densities of several species have significantly increased since 1980, but a few have decreased. Most increasing species were either year-round residents or long-distance migrants that favor forest interiors or a

mature tree canopy. Most birds that decreased during the period were species typical of younger forests. Birds that live in the forest interior seemed to increase, hold steady, or vary without obvious trend from 1980 through 1994. This is contrary to downward trends observed elsewhere in northeastern United States, but similar to many statewide patterns. Most breeding bird densities during operational years were similar to or higher than preoperational years, but it is difficult to reach many conclusions about the effect of the power station on birds because there was a gypsy moth infestation in both plots during the preoperational period.

INTRODUCTION

The Susquehanna Steam Electric Station (Susquehanna SES) is a nuclear power station with two boiling water reactors, each with a net electrical generating capacity of 1,100 megawatts. It is located on a 1,500-acre site in Salem Township, Luzerne County, 5 miles northeast of Berwick, Pennsylvania. The Pennsylvania Power and Light Company (PP&L) owns 90 percent of the station and the Allegheny Electric Cooperative owns 10 percent.

The objective of the nonradiological environmental monitoring program is to assess the impact of operating the Susquehanna SES on the Susquehanna River and the local terrestrial environment. This was done in 1994 by evaluating data from monitoring studies and comparing these results with similar data from previous years, especially before the power station began operation in 1982. Ecology III has conducted these studies at the Susquehanna SES since 1985 with key personnel who have been involved with this work since 1971. Preoperational studies established a baseline of environmental conditions prior to operation of the Susquehanna SES (Ichthyological Associates, Inc. 1972-83). These same studies were continued after 1983, although sampling effort was reduced, particularly since 1985 (Ichthyological Associates, Inc. 1984-85; Ecology III, Inc. 1986-94).

This report presents results of aquatic and terrestrial studies conducted in the vicinity of the Susquehanna SES in 1994. Water quality, algae, benthic macroinvertebrates, and fishes were monitored in the Susquehanna River. Terrestrial monitoring at the power station site dealt with studies of flora and vegetation and birds.

WATER QUALITY

PROCEDURES

Water quality of the Susquehanna River relative to the Susquehanna SES was monitored throughout 1994 at four sampling sites. The Susquehanna SES Environmental Laboratory and SSES were control sites; Bell Bend and Bell Bend I were indicator sites (Fig. A-1).

River temperature and level were monitored continuously at the Environmental Laboratory located on the west river bank, 495 m upriver from the Susquehanna SES intake. The daily mean temperature and level were determined by averaging hourly readings. River flow was calculated from river level using two equations based on historical U. S. Geological Survey (USGS) flow data and direct flow measurements made by Ecology III, Inc. (Table A-1).

Water quality samples were collected at the SSES, Bell Bend, and Bell Bend I river sites. SSES is 230 m upriver from the intake and about 40 m from the west bank; Bell Bend is 690 m downriver from the Susquehanna SES discharge and about 40 m from the west bank; Bell Bend I is 400 m downriver from the discharge and about 55 m from the west bank. Samples were collected once per week from April through September, twice per month for March, October, November, and December, and once in February. Extreme winter weather froze the river surface and prevented collection the entire month of January and most of February. All samples were collected between 1200 and 1400 h. A grab sample of surface water, the dissolved oxygen concentration, and surface water

temperature were collected while drifting over each site in a boat (Table A-1). The order of sampling and analysis was randomly determined for the three sites. River elevation was recorded with the SSES data.

Samples were immediately transported to the Environmental Laboratory and analyzed for turbidity, pH, conductivity, total alkalinity, sulfate, and solids (total and total suspended). Aliquots of each sample were preserved for total and dissolved iron analysis by the PP&L Chemical Laboratory at the System Facilities Center, Hazleton, Pennsylvania. All analyses were conducted within the holding time recommended by the U. S. Environmental Protection Agency (EPA 1979). Results and associated calculations were maintained in bound notebooks. Accuracy of results was assured by quarterly analysis of quality control mineral and residue samples secured by PP&L.

Once each month, a blowdown sample and duplicate SSES and Bell Bend river samples were collected for a comprehensive inorganic profile by the PP&L Chemical Laboratory. Blowdown is water discharged to the river from the Susquehanna SES cooling tower basins. It is river water that has been used in the cooling cycle and has high conductivity and mineral solids concentrations due to the evaporative loss of water in the cooling towers (about 15,000 gallons/minute/tower during operation). The blowdown sample was collected at the automatic composite sampler located in the sewage treatment plant on the Susquehanna SES site (Fig. A-1). Water temperature and dissolved oxygen were measured by Environmental Laboratory personnel; all other analyses were completed at the PP&L Chemical Laboratory (Table A-2). No data were collected in January due to the frozen river.

Water quality data collected at SSES from 1973 through 1994 were statistically analyzed to document natural changes in river water quality. Friedman's nonparametric two-way analysis of variance test was used to determine if significant year-to-year changes occurred in the data. Page's distribution-free test for ordered alternatives was used to determine if year-to-year changes established a trend (Hollander and Wolfe 1973). These tests were based on monthly mean values, and a 5% probability level was used to determine significance.

The BACI (Before-After:Control-Indicator) model was used to determine if the Susquehanna SES blowdown had a significant effect on downriver water quality in 1994. A detailed description of the BACI procedure is presented in the "BACI Basics" section of *Environmental Studies in the Vicinity of the Susquehanna Steam Electric Station, 1989 Annual Report* (Ecology III, Inc. 1990). The SSES and Bell Bend databases from 1978 through 1994 were used in the analysis.

RESULTS AND DISCUSSION

River Flow, Level, and Temperature

The Susquehanna River Basin was affected by a record accumulated winter snowfall and extremely cold temperatures in the first quarter of the year. For the second consecutive year, there was an extended river freshet in March and April. The April mean flow, 66,200 cfs (Fig. A-2), was the second highest flow of any month in the past 34 years, and the March flow was the ninth highest (47,000 cfs).

Daily mean river flow ranged from 3,000 to 146,000 cfs in 1994 (Table A-3). The winter snowfall coupled with abundant precipitation throughout the year produced above average river flow for 8 of the 12 months. The 1994 August mean flow (21,700 cfs) was the highest for that month in our database and was about 17,000 cfs above normal. There was no period of low flow in 1994. The volume of water that flowed down the river, 6.46 billion cubic feet, was the third highest flow since 1961 (Fig. A-3).

The daily mean river level ranged from 486.9 ft above msl, from 28 through 31 October, to 504.8 ft above msl on 26 March (Table A-4). The highest river level recorded was 505.2 ft above msl on 26 March. The monthly mean level was lowest (487.8 ft above msl) in October and highest (497.4 ft above msl) in April.

Daily mean river temperature ranged from 0.0 C, recorded on many days in January, February, and March, to 27.0 C on 22 July (Table A-5). Mean river temperature was below average for January through May, August, and September.

River Water Quality at the Susquehanna SES

Water quality of the Susquehanna River has been monitored annually since 1973, when the SSES control site was first established and constant monitoring of temperature and level began. Indicator site data were first collected in 1978 at Bell Bend, five years before operation of the Susquehanna SES. The Bell Bend I indicator site was added to the water quality program in 1986 to collect data closer to the center of the effluent plume. The 1994 water quality data from these sites are presented in Table A-6 and summarized in Table A-7.

A new bridge crossing the Susquehanna River between Shickshinny and Mocanaqua was completed in 1994. This bridge, about 3.9 miles upriver from the Susquehanna SES site, was opened in August. The old bridge was razed by explosion in October and the removal of it from the river bed continued through the end of the year. The construction and razing impacted water quality in the river, but the extent of the impact is not known since no samples were collected upstream from the construction site.

One new minimum was established for the database in 1994 (Table A-8). The sulfate concentration at Bell Bend on 30 June (2 mg/L) was 2 mg/L lower than the previous minimum of 4 mg/L. Due to high river flow throughout the year, there was low variation in river samples for parameters affected by operation of the Susquehanna SES (conductivity, total solids, and dissolved solids). Conversely, the high river flow also caused high variation for some other parameters (turbidity, total iron, and total suspended solids).

Data collected in 1994 at the control and indicator sites were compared to water quality criteria (Table A-9) established for this reach of the Susquehanna River by the PaDER (1979). Parameters encompassed by the criteria were dissolved oxygen, total alkalinity, pH, nitrogen (ammonia and nitrate), total dissolved solids, temperature, and metals (total and dissolved iron, aluminum, and manganese). Data from both the Environmental Laboratory (Table A-6) and the PP&L Chemical Laboratory (Tables A-10 and A-11) were compared to the criteria.

There were samples where the data exceeded the criteria in 1994. The parameters that exceeded the criteria were total iron, dissolved iron, and total aluminum. Upriver abandoned coal mine drainages which flow into the Susquehanna are the source of high

iron concentrations. There were 65 of 105 (61.9%) total iron samples within the criterion (1.5 mg/L) in 1994, the eighth consecutive year the ratio was more than 50%. During preoperation (1978-82), only 17% of all the total iron samples collected at SSES were within the criterion. Dissolved iron concentrations were within the PaDER criterion (0.3 mg/L) in all but 14 of the 105 samples (87%).

There were three monthly samples in 1994 when total aluminum exceeded the criteria of 0.5 mg/L (Tables A-10 and A-11). The first occurred on 22 February when the river was in a condition of rapidly increasing flow, from 12,700 to 63,900 cfs in three days. The second occurred on 28 March when the river was in a high flow stage, 96,400 cfs, and just two days after the highest crest of the year. These two total aluminum events were the result of scouring of the river substrate by the river flow. This is supported by the high values for turbidity, total suspended solids, and total iron in the respective samples. The last event occurred on 11 July when there was high turbidity (48 NTU) and high concentrations of suspended solids (75 mg/L) and total iron (4.51 mg/L), but not high river flow (10,700 cfs). Construction at the new Shickshinny-Mocanaqua bridge upriver from the Susquehanna site was the probable cause of this event.

On 22 February, the total aluminum concentration of the control site was at the maximum of the criteria, 0.5 mg/L. The concentration of the indicator site, 0.6 mg/L exceeded the criteria. The blowdown concentration was 0.9 mg/L. It could be inferred from these data that the effluent of the Susquehanna SES caused the total aluminum concentraton to exceed the criteria, but the situation was the result of an elevated

background concentration in the river. This was the first instance where the criteria was exceeded only at the indicator site since the Susquehanna SES became operaional.

Based on the Friedman-Page statistical tests for data collected at SSES since 1973, significant water quality trends continued in 1994. Turbidity, sulfate, total iron, and total suspended solids had decreasing trends; pH and total alkalinity had increasing trends. The end of coal mining in the Wyoming Valley is the reason for these trends. They were first documented in 1976 (Ichthyological Associates, Inc. 1977) and have been associated with the end of ground water pumping from the mines into the river during the early 1970's. Monthly mean data for each of these parameters were fitted with curvilinear regression lines to detail the changes over time (Figs. A-4 and A-5). For the second consecutive year, a significant increasing trend was also recorded for dissolved oxygen. This trend is based mostly on high concentrations recorded the past two years. The mean dissolved oxygen concentration in 1994 was above average every month except July.

Control and Indicator Site Comparisons

Water quality of the Susquehanna River at the indicator sites has been impacted by high concentrations of mineral solids from the Susquehanna SES blowdown during low river flow (Ecology III, Inc., 1992). This happens because mineral solids concentrations in the blowdown are generally 2 to 8 times greater than those in the river (Tables A-10 and A-12). However in 1994, the high dilution ratio of river water to blowdown throughout the year minimized the effect of the downriver solids plume (Fig. A-6).

There was complete mixing of the Susquehanna SES blowdown with river water at the Bell Bend indicator site in all 11 monthly PP&L samples. Based on the mass balance of total mineral solids (tms),

$$Q_1C_1 + Q_2C_2 = Q_3C_3$$

where: Q_1 = River flow at Environmental Lab (Table A-3)
C_1 = SSES tms (Table A-10)
Q_2 = Blowdown flow (provided by PP&L)
C_2 = Blowdown tms (Table A-12)
$Q_3 = Q_1 + Q_2$

the measured Bell Bend tms concentration was within ±4 mg/L of the expected concentration in all samples (Table A-13). These measured concentrations were also within ±4 mg/L of the control concentration.

There was low variation between control and indicator data for parameters affected by operation of the Susquehanna SES in 1994. However, the conductivity, alkalinity, total solids, and total dissolved solids were higher at both indicator sites (than the control) in a majority of samples. These parameters have exhibited this tendency each year of Susquehanna SES operation. Concentrations at Bell Bend I were usually higher than those at Bell Bend because Bell Bend I was 290 m closer to the discharge diffuser and was centered in the discharge plume. The concentrations of total and dissolved iron at the control site were higher than the indicator concentrations in a majority of samples.

BACI analysis of the water quality database, including the 1994 data, statistically showed that conductivity ($P \leq 0.001$), sulfate ($P \leq 0.003$), and total dissolved solids ($P \leq 0.012$) were significantly higher at Bell Bend. Conductivity was also highly significant in the

original BACI analysis (Williams and Thórarinsson 1988) and in each annual analysis since (Ecology III, Inc. 1990-93). Sulfate and total dissolved solids were significant for the fourth consecutive year.

Table A-1

Water quality parameters and methods of analyses utilized by the Susquehanna SES Environmental Laboratory, 1994.

PARAMETER	METHOD	REFERENCE[a]
River level	Seven-day continuous recording from an Acco Bristol, Model No. G500-15 bubbler-type water level gauge.	ACCO (1971)
River flow	At level <486.0 ft, log flow = $-0.0525(\text{level})^2 + 51.478501(\text{level}) - 12612.85672$ At level ≥486.0 ft, flow = $319.96989(\text{level})^2 - 309316.24395(\text{level}) + 74753300$	Soya (1991)
River temperature	Seven-day continuous recordings from a calibrated, Leeds and Northrup Speedomax Thermistor-type, Model R temperature recorder. Method 2550 B	Standard Methods (1992)
	Calibrated, mercury thermometer. Method 2550 B	Standard Methods (1992)
Turbidity	Nephelometric. Method 2130 B	Standard Methods (1992)
pH	Glass electrode. Method 4500-H^+ B	Standard Methods (1992)
Conductivity	Self-contained conductivity meter. Method 2510 B	Standard Methods (1992)
Dissolved oxygen	Membrane electrode. Method 4500-O G	Standard Methods (1992)
Total alkalinity	Potentiometric titration to 4.5 pH. Method 2320 B	Standard Methods (1992)
Sulfate	Turbidimetric. Method 4500-SO_4^{2-} E	Standard Methods (1992)
Total iron	Atomic absorption spectrophotometric determination of extractable iron. Method 3030 C	Standard Methods (1992)
Dissolved iron	Atomic absorption spectrophotometric determination of dissolved iron upon filtration through a membrane filter. Method 3030 B	Standard Methods (1992)
Total solids	Evaporation, dried at 105° C. Method 2540 B	Standard Methods (1992)
Total suspended solids	Solids retained on a glass fiber filter, dried at 105° C. Method 2540 D	Standard Methods (1992)
Total dissolved solids	Calculation; total solids minus total suspended solids.	

[a]Listed in references cited.

Table A-2

Water quality parameters and methods of analyses utilized by the Pennsylvania Power and Light Company Chemical Laboratory, 1994.[a]

PARAMETER	METHOD	REFERENCE[b]
Turbidity	Nephelometric	Std Methods, 1980, Method 214A
pH	Electrometric measurement	Std Methods, 1980, Method 423
Conductivity	Electrometric measurement	Std Methods, 1980, Method 205
Total suspended solids @ 103C	Gravimetric determination	Std Methods, 1980, Method 209D
Ammonia as N	Direct nesslerization	Std Methods, 1980, Method 417B
Nitrate as NO_3 or N	Ion chromatography	Std Methods, 1992, Method 4110B
Pht Alk as $CaCO_3$	Colorimetric titration	ASTM D1067-70
MO Alk as $CaCO_3$	Colorimetric titration	ASTM D1067-70
Hardness as $CaCO_3$	Calculation	Std Methods, 1980, Method 314A
Silicon dioxide, as SiO_2	Heteropoly blue	Std Methods, 1985, Method 425D
Sulfate, as SO_4	Ion chromatography	Std Methods, 1992, Method 4110B
Chloride, as Cl	Ion chromatography	Std Methods, 1992, Method 4110B
Phosphorus, total P as PO_4	Colorimetric, ascorbic acid reduction	ASTM D515-78, Method A
Cation/anion balance	Calculation, using Table 103:I	Std Methods, 1980, Method 104C
Total mineral solids	Calculation, cations + anions + SiO_2	
Dissolved metals	AA, preservation and preparation	EPA, 1983, 4.1.1 Page Metals-5
a) Iron, Fe	Atomic absorption, direct aspiration	EPA, 1983, Method 236.1
b) Manganese, Mn	Atomic absorption, direct aspiration	EPA, 1983, Method 243.1
c) Copper, Cu	Atomic absorption, direct aspiration	EPA, 1983, Method 220.1
d) Zinc, Zn	Atomic absorption, direct aspiration	EPA, 1983, Method 289.1
e) Nickel, Ni	Atomic absorption, direct aspiration	EPA, 1983, Method 249.1
f) Chromium, Cr	Atomic absorption, direct aspiration	EPA, 1983, Method 218.1
g) Aluminum, Al	Atomic absorption, direct aspiration	EPA, 1983, Method 202.1
h) Molybdenum, Mo	Atomic absorption, direct aspiration	EPA, 1983, Method 246.1
Total recoverable metals	AA, preservation and preparation	EPA, 1983, 4.1.4 Page Metals-5
a) Iron, Fe	Atomic absorption, direct aspiration	EPA, 1983, Method 236.1
b) Manganese, Mn	Atomic absorption, direct aspiration	EPA, 1983, Method 243.1
c) Copper, Cu	Atomic absorption, direct aspiration	EPA, 1983, Method 220.1
d) Zinc, Zn	Atomic absorption, direct aspiration	EPA, 1983, Method 289.1
e) Nickel, Ni	Atomic absorption, direct aspiration	EPA, 1983, Method 249.1
f) Chromium, Cr	Atomic absorption, direct aspiration	EPA, 1983, Method 218.1
g) Aluminum, Al	Atomic absorption, direct aspiration	EPA, 1983, Method 202.1
h) Molybdenum, Mo	Atomic absorption, direct aspiration	EPA, 1983, Method 246.1
Dissolved metals	Atomic absorption	
a) Calcium, Ca	Atomic absorption, direct aspiration	EPA, 1983, Method 215.1
b) Magnesium, Mg	Atomic absorption, direct aspiration	EPA, 1983, Method 242-1
c) Sodium, Na	Flame emission, direct aspiration	Std Methods, 1980, Method 325B
d) Potassium, K	Flame emission, direct aspiration	Std Methods, 1980, Method 322B

[a] Provided by D. A. Dusheck, PP&L.
[b] Listed in references cited.

Table A-3

Daily mean flow (cfs) of the Susquehanna River at the Susquehanna SES Environmental Laboratory, 1994.

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	5590	29400	18700	67600	18700	5880	25700	7780	14400	12700	3230	24600
2	5590	27500	17200	71400	20200	5590	21300	7450	11900	13500	5020	20200
3	6490	24600	16700	85500	22300	6180	19200	6800	10300	14400	20700	17200
4	6180	21800	14400	113000	20700	7450	15800	6180	9180	11900	30000	14900
5	6180	20200	14900	110000	18200	6180	12700	5880	8120	10300	22300	16200
6	5300	18700	15800	94200	16200	5300	11900	6800	7450	8820	17200	35200
7	4480	17200	14400	98600	14400	5020	11900	7780	6800	7780	14000	48500
8	5880	15800	14900	107000	14400	4480	11900	7780	6180	6800	11900	40900
9	6800	14000	17200	92000	15300	4480	14000	6490	5590	6180	10300	37300
10	6800	13500	24600	77300	15800	5020	13500	5590	5300	5590	10300	30000
11	6490	11900	34600	78300	15300	5020	10700	4740	4740	5300	9910	28800
12	6800	11500	37300	76300	14900	5300	9180	4210	4740	5020	9540	28800
13	7780	11500	35900	79300	14000	5880	7780	3960	4480	4740	9540	26300
14	7450	11500	33900	104000	13100	8120	6800	4210	4210	4480	8470	22300
15	8120	10700	33200	97500	11900	32600	6490	9910	3960	4210	7780	18200
16	9540	9910	36600	82400	12300	53400	7450	25700	3470	3960	7450	16200
17	11100	9910	38700	81400	11900	28100	7450	20200	3470	3710	6800	15300
18	13500	9540	35900	79300	11500	19200	6490	28800	3960	3710	6490	14400
19	12700	9180	31300	67600	11500	14000	6180	96400	3710	3710	5880	14400
20	13100	8820	27500	56800	11900	10700	8470	74300	3710	3710	5590	14000
21	11900	12700	24600	47000	10700	8470	--[a]	54300	3470	3710	5880	13500
22	11100	31900	28800	38700	9540	7120	--	45400	3230	3710	7120	12700
23	11100	63900	56000	32600	8820	6180	--	44600	3470	3710	8120	11500
24	10300	46200	93100	28100	7780	5590	--	37300	3470	3710	8470	10700
25	9910	36600	131000	24600	7120	5020	--	28800	3470	3710	7780	12300
26	9910	30600	146000	22300	7120	10700	8470	23500	3710	3470	7120	13500
27	9540	24000	107000	20700	7780	12700	9910	22300	11500	3230	6800	13500
28	10300	21300	96400	19700	8470	11500	8120	18200	33900	3000	14900	13100
29	15300		97500	17700	8120	26300	7450	17700	24000	3000	29400	12300
30	21800		87700	16200	7120	32600	8470	20200	16700	3000	29400	10700
31	29400		76300		6490		8470	18200		3000		9910
MEAN	9880	20500	47000	66200	12700	12100	11000	21700	7750	5730	11600	19900

[a] Equipment failure

Table A-4

Daily mean level (ft above msl) of the Susquehanna River at the Susquehanna SES Environmental Laboratory, 1994.

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	487.9	493.1	491.2	498.0	491.2	488.0	492.5	488.6	490.3	489.9	487.0	492.3
2	487.9	492.8	490.9	498.4	491.5	487.9	491.7	488.5	489.7	490.1	487.7	491.5
3	488.2	492.3	490.8	499.8	491.9	488.1	491.3	488.3	489.3	490.3	491.6	490.9
4	488.1	491.8	490.3	502.2	491.6	488.5	490.6	488.1	489.0	489.7	493.2	490.4
5	488.1	491.5	490.4	502.0	491.1	488.1	489.9	488.0	488.7	489.3	491.9	490.7
6	487.8	491.2	490.6	500.6	490.7	487.8	489.7	488.3	488.5	488.9	490.9	494.0
7	487.5	490.9	490.3	501.0	490.3	487.7	489.7	488.6	488.3	488.6	490.2	495.8
8	488.0	490.6	490.4	501.7	490.3	487.5	489.7	488.6	488.1	488.3	489.7	494.8
9	488.3	490.2	490.9	500.4	490.5	487.5	490.2	488.2	487.9	488.1	489.3	494.3
10	488.3	490.1	492.3	499.0	490.6	487.7	490.1	487.9	487.8	487.9	489.3	493.2
11	488.2	489.7	493.9	499.1	490.5	487.7	489.4	487.6	487.6	487.8	489.2	493.0
12	488.3	489.6	494.3	498.9	490.4	487.8	489.0	487.4	487.6	487.7	489.1	493.0
13	488.6	489.6	494.1	499.2	490.2	488.0	488.6	487.3	487.5	487.6	489.1	492.6
14	488.5	489.6	493.8	501.5	490.0	488.7	488.3	487.4	487.4	487.5	488.8	491.9
15	488.7	489.4	493.7	500.9	489.7	493.6	488.2	489.2	487.3	487.4	488.6	491.1
16	489.1	489.2	494.2	499.5	489.8	496.4	488.5	492.5	487.1	487.3	488.5	490.7
17	489.5	489.2	494.5	499.4	489.7	492.9	488.5	491.5	487.1	487.2	488.3	490.5
18	490.1	489.1	494.1	499.2	489.6	491.3	488.2	493.0	487.3	487.2	488.2	490.3
19	489.9	489.0	493.4	498.0	489.6	490.2	488.1	500.8	487.2	487.2	488.0	490.3
20	490.0	488.9	492.8	496.8	489.7	489.4	488.8	498.7	487.2	487.2	487.9	490.2
21	489.7	489.9	492.3	495.6	489.4	488.8	--[a]	496.5	487.1	487.2	488.0	490.1
22	489.5	493.5	493.0	494.5	489.1	488.4	--	495.4	487.0	487.2	488.4	489.9
23	489.5	497.6	496.7	493.6	488.9	488.1	--	495.3	487.1	487.2	488.7	489.6
24	489.3	495.5	500.5	492.9	488.6	487.9	--	494.3	487.1	487.2	488.8	489.4
25	489.2	494.2	503.7	492.3	488.4	487.7	--	493.0	487.1	487.2	488.6	489.8
26	489.2	493.3	504.8	491.9	488.4	489.4	488.8	492.1	487.2	487.1	488.4	490.1
27	489.1	492.2	501.7	491.6	488.6	489.9	489.2	491.9	489.6	487.0	488.3	490.1
28	489.3	491.7	500.8	491.4	488.8	489.6	488.7	491.1	493.8	486.9	490.4	490.0
29	490.5		500.9	491.0	488.7	492.6	488.5	491.0	492.2	486.9	493.1	489.8
30	491.8		500.0	490.7	488.4	493.6	488.8	491.5	490.8	486.9	493.1	489.4
31	493.1		498.9		488.2		488.8	491.1		486.9		489.2
MEAN	489.1	491.3	494.8	497.4	489.8	489.4	489.4	491.0	488.3	487.8	489.4	491.3

[a] Equipment failure

Table A-5

Daily mean temperature (C) of the Susquehanna River at the Susquehanna SES Environmental Laboratory, 1994.

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.0	0.0	0.0	3.6	14.9	20.7	22.5	25.3	20.3	15.3	12.1	4.7
2	0.0	0.0	0.0	4.4	14.0	20.2	22.9	25.8	20.0	14.8	11.2	4.4
3	0.0	0.0	0.0	4.9	13.1	19.7	23.2	25.9	19.5	14.2	10.0	4.2
4	0.0	0.0	0.2	4.9	12.9	20.0	23.5	26.1	19.5	13.7	10.2	4.6
5	0.0	0.0	0.3	4.7	13.3	19.8	24.1	25.3	19.3	13.2	10.9	5.5
6	0.0	0.0	0.4	5.0	13.3	19.7	24.9	23.5	19.2	12.8	11.6	6.9
7	0.0	0.0	0.6	5.0	13.6	20.6	25.5	23.1	19.3	12.9	11.9	7.6
8	0.0	0.0	0.9	4.4	14.2	20.7	26.3	23.5	19.5	13.5	11.3	6.7
9	0.0	0.0	0.7	4.6	13.7	20.8	26.5	23.8	19.7	14.3	11.1	5.1
10	0.0	0.0	0.5	5.1	14.0	21.2	26.4	24.2	20.2	14.2	10.8	4.2
11	0.0	0.0	0.8	5.5	13.7	21.1	25.8	23.8	19.3	13.6	9.9	4.0
12	0.0	0.0	0.8	5.8	13.5	20.6	25.8	23.6	18.6	13.2	9.0	3.2
13	0.0	0.0	1.1	5.8	13.0	21.2	25.9	23.8	19.0	13.1	8.8	2.4
14	0.0	0.0	1.5	6.3	13.7	22.8	25.9	23.8	19.7	13.0	9.1	2.2
15	0.0	0.0	1.9	7.2	14.4	23.0	25.8	22.6	20.4	13.0	9.8	2.3
16	0.0	0.0	1.9	8.5	14.4	20.4	25.8	21.2	20.8	12.9	9.8	--[a]
17	0.0	0.0	1.2	9.1	13.1	21.8	25.9	20.8	21.4	12.8	9.3	--
18	0.0	0.0	0.6	9.1	12.0	23.4	26.1	20.2	21.3	12.8	9.6	--
19	0.0	0.0	0.6	9.2	11.2	25.3	26.4	19.2	20.4	13.0	9.9	--
20	0.0	0.6	1.4	9.3	11.5	25.8	26.6	19.4	20.1	13.2	9.5	3.6
21	0.0	1.1	2.0	9.6	13.2	25.4	26.9	20.0	20.1	13.6	9.0	3.4
22	0.0	0.3	2.8	9.7	15.2	25.0	27.0	20.2	19.5	13.7	8.9	3.2
23	0.0	0.0	2.8	9.7	17.3	25.0	26.1	19.7	19.0	13.8	7.4	3.0
24	0.0	0.0	2.0	10.1	18.5	24.8	25.9	19.7	18.8	13.7	5.8	3.0
25	0.0	0.1	1.9	11.1	19.1	24.0	26.4	19.9	18.9	13.0	5.1	3.4
26	0.0	0.2	1.8	11.8	18.9	23.5	26.0	20.1	19.0	12.3	4.9	3.2
27	0.0	0.0	2.1	13.3	18.2	23.2	25.0	20.7	19.2	12.0	4.1	3.0
28	0.0	0.0	2.4	14.5	17.4	22.0	24.4	21.3	18.1	11.5	4.5	2.9
29	0.0		2.4	14.3	17.7	22.2	24.4	21.8	16.8	11.9	4.9	2.9
30	0.0		2.8	14.2	18.7	21.9	24.9	21.6	15.9	12.3	4.6	2.0
31	0.0		3.2		19.9		24.8	20.9		12.2		1.2
MEAN	0.0	0.1	1.3	8.0	14.9	22.2	25.4	22.3	19.4	13.2	8.8	3.8

[a] Equipment failure

Table A-6

Water quality data collected from the Susquehanna River at SSES, Bell Bend, and Bell Bend I, February through December 1994.

PARAMETER	22 FEB	14 MAR	28 MAR	5 APR	12 APR	20 APR	26 APR
SSES							
Time	1209	1253	1201	1208	1208	1223	1210
River level (ft above msl)	492.7	493.9	500.7	502.1	499.0	497.9	491.9
River temperature (C)	0.5	2.0	3.0	5.0	5.5	10.0	12.5
Turbidity (NTU)	13	11	26	24	12	12	6.7
pH	7.2	7.2	7.1	7.1	7.1	7.2	7.3
Conductivity (μmhos/cm)	225	180	120	110	125	130	220
Analysis (mg/L)							
Oxygen							
Dissolved	14.50	14.20	14.10	12.70	13.10	12.80	10.90
Percent saturation	99	103	105	99	102	113	102
Total alkalinity	40	33	23	22	28	33	49
Sulfate	25	22	15	13	28	29	33
Iron							
Total	2.67	1.50	2.74	3.13	1.49	1.78	1.36
Dissolved	0.11	0.15	0.13	0.06	0.10	0.14	0.25
Percent dissolved	4	10	5	2	7	8	18
Solids							
Total	175	165	142	168	130	125	155
Total suspended	40	27	58	72	32	34	14
Total dissolved	135	138	84	96	98	91	141
BELL BEND							
Time	1216	1249	1208	1213	1204	1215	1216
River temperature (C)	0.5	2.0	3.0	5.0	5.5	10.0	12.5
Turbidity (NTU)	12	9.3	27	24	12	11	6.7
pH	7.2	7.2	7.1	7.1	7.1	7.2	7.3
Conductivity (μmhos/cm)	225	180	120	110	125	135	220
Analysis (mg/L)							
Oxygen							
Dissolved	14.70	14.20	14.10	12.70	13.10	12.80	10.80
Percent saturation	100	103	105	99	102	113	101
Total alkalinity	40	32	24	23	28	33	49
Sulfate	26	22	14	13	27	30	31
Iron							
Total	2.52	1.28	2.78	3.10	1.42	1.83	1.33
Dissolved	0.10	0.12	0.05	0.07	0.09	0.12	0.23
Percent dissolved	4	9	2	2	6	7	17
Solids							
Total	178	153	144	157	128	132	154
Total suspended	36	21	60	72	28	34	14
Total dissolved	142	132	84	85	100	98	140
BELL BEND I							
Time	1214	1247	1206	1216	1201	1219	1214
River temperature (C)	0.5	2.0	3.0	5.0	5.5	10.0	12.5
Turbidity (NTU)	11	9.5	27	26	12	12	6.6
pH	7.2	7.3	7.1	7.1	7.1	7.2	7.3
Conductivity (μmhos/cm)	225	180	120	110	125	130	220
Analysis (mg/L)							
Oxygen							
Dissolved	14.70	14.00	14.10	12.70	13.20	12.70	10.80
Percent saturation	100	101	105	99	103	112	101
Total alkalinity	40	33	24	23	28	33	50
Sulfate	26	23	16	17	27	29	30
Iron							
Total	2.19	1.22	2.81	3.12	1.50	1.88	1.28
Dissolved	0.11	0.10	0.06	0.06	0.08	0.12	0.24
Percent dissolved	5	8	2	2	5	6	19
Solids							
Total	171	150	141	160	128	128	156
Total suspended	36	24	63	74	30	36	14
Total dissolved	135	126	78	86	98	92	142

Table A-6 (cont.)

PARAMETER	3 MAY	10 MAY	17 MAY	24 MAY	31 MAY	9 JUN	15 JUN	23 JUN	30 JUN
SSES									
Time	1256	1306	1229	1211	1218	1325	1228	1200	1350
River level (ft above msl)	492.0	490.7	489.7	488.6	488.2	487.6	494.8	488.1	493.7
River temperature (C)	14.0	15.0	13.5	19.0	20.0	21.5	24.5	25.5	22.0
Turbidity (NTU)	4.7	3.3	3.6	4.3	3.9	6.0	13	5.7	72
pH	7.6	7.6	7.4	8.0	7.9	7.7	7.9	8.4	7.1
Conductivity (μmhos/cm)	230	230	235	260	290	330	270	260	170
Analysis (mg/L)									
Oxygen									
Dissolved	12.20	11.20	10.30	10.60	10.00	9.90	12.70	11.20	7.20
Percent saturation	117	111	99	114	109	112	151	137	83
Total alkalinity	54	55	55	60	67	69	75	60	44
Sulfate	33	37	40	47	50	62	35	50	5
Iron									
Total	1.24	0.89	0.95	1.00	0.88	1.38	5.16	1.08	8.05
Dissolved	0.29	0.31	0.30	0.08	0.09	0.07	0.05	0.09	0.06
Percent dissolved	23	35	32	8	10	5	1	8	1
Solids									
Total	180	165	155	194	231	228	280	206	285
Total suspended	14	4	4	6	6	12	84	16	168
Total dissolved	166	161	151	188	225	216	196	190	117
BELL BEND									
Time	1250	1302	1235	1206	1206	1320	1234	1206	1344
River temperature (C)	14.0	15.0	13.5	19.0	20.0	21.5	24.5	25.5	22.0
Turbidity (NTU)	4.7	3.3	3.4	4.1	3.9	5.7	16	5.4	76
pH	7.7	7.7	7.4	8.0	8.0	7.7	7.9	8.4	7.3
Conductivity (μmhos/cm)	230	230	240	260	300	330	275	265	165
Analysis (mg/L)									
Oxygen									
Dissolved	12.20	11.50	10.30	10.60	10.40	9.90	12.60	10.90	7.20
Percent saturation	117	114	99	114	114	112	150	133	83
Total alkalinity	53	55	55	60	67	69	75	60	42
Sulfate	31	36	38	45	50	62	34	51	2
Iron									
Total	1.15	0.92	0.94	0.99	0.88	1.27	5.80	0.98	8.23
Dissolved	0.29	0.21	0.21	< 0.05	< 0.05	< 0.05	< 0.05	0.08	0.06
Percent dissolved	25	23	22	< 5	< 6	< 4	< 1	8	1
Solids									
Total	172	165	155	197	230	230	307	208	282
Total suspended	18	5	5	6	6	11	100	15	172
Total dissolved	154	160	150	191	224	219	207	193	110
BELL BEND I									
Time	1253	1300	1233	1204	1210	1318	1232	1204	1346
River temperature (C)	14.0	15.0	13.5	19.0	20.0	21.5	24.5	25.5	22.0
Turbidity (NTU)	4.7	3.3	3.4	4.1	3.9	5.8	12	5.7	76
pH	7.7	7.7	7.4	8.0	8.0	7.7	7.9	8.4	7.4
Conductivity (μmhos/cm)	230	230	240	265	300	335	275	270	170
Analysis (mg/L)									
Oxygen									
Dissolved	12.20	11.20	10.30	11.00	10.20	9.90	12.50	10.70	7.20
Percent saturation	117	111	99	119	112	112	148	131	83
Total alkalinity	54	56	55	60	68	71	75	60	43
Sulfate	32	36	38	45	50	65	35	52	4
Iron									
Total	1.17	0.88	0.93	1.02	0.87	1.27	3.24	1.05	8.62
Dissolved	0.28	0.25	0.17	< 0.05	0.06	< 0.05	0.06	0.09	0.05
Percent dissolved	24	28	18	< 5	7	< 4	2	9	1
Solids									
Total	177	159	156	193	230	237	237	212	296
Total suspended	16	6	5	6	6	10	86	16	186
Total dissolved	161	153	151	187	224	227	151	196	110

Table A-6 (cont.)

PARAMETER	5 JUL	11 JUL	18 JUL	25 JUL	3 AUG	10 AUG	17 AUG	24 AUG	31 AUG
SSES									
Time	1232	1217	1312	1252	1227	1207	1221	1300	1249
River level (ft above msl)	489.9	489.5	488.2	488.8	488.3	487.8	491.4	494.3	491.1
River temperature (C)	24.0	25.5	26.0	26.0	25.5	24.0	20.5	19.5	20.5
Turbidity (NTU)	15	48	9.8	11	7.7	4.7	21	66	19
pH	7.4	7.4	7.9	7.5	7.7	8.6	7.3	7.2	7.3
Conductivity (μmhos/cm)	195	230	300	270	255	275	225	160	220
Analysis (mg/L)									
Oxygen									
Dissolved	7.60	6.40	8.60	7.40	9.00	11.40	7.70	8.00	9.30
Percent saturation	89	78	105	91	109	134	85	86	103
Total alkalinity	50	55	70	61	61	65	54	42	55
Sulfate	36	38	47	47	41	52	32	10	41
Iron									
Total	2.11	4.51	1.52	1.67	1.17	0.74	3.25	5.50	2.37
Dissolved	0.18	0.06	0.11	0.26	0.18	< 0.05	0.10	0.07	0.17
Percent dissolved	9	1	7	16	15	< 7	3	1	7
Solids									
Total	181	247	258	221	192	208	225	213	180
Total suspended	34	75	25	18	12	10	58	100	41
Total dissolved	147	172	233	203	180	198	167	113	139
BELL BEND									
Time	1223	1213	1303	1256	1232	1212	1214	1306	1253
River temperature (C)	24.0	25.5	26.0	26.0	25.5	24.0	20.5	19.5	20.5
Turbidity (NTU)	16	54	9.2	12	7.3	4.7	19	66	20
pH	7.4	7.4	7.9	7.5	7.7	8.5	7.4	7.2	7.4
Conductivity (μmhos/cm)	200	235	300	280	260	280	230	160	220
Analysis (mg/L)									
Oxygen									
Dissolved	7.60	6.50	8.80	7.40	9.00	11.20	7.70	8.00	9.30
Percent saturation	89	79	108	91	109	132	85	86	103
Total alkalinity	52	56	71	62	62	66	53	42	57
Sulfate	38	37	46	49	42	48	32	10	41
Iron									
Total	2.15	4.76	1.38	1.76	1.10	0.74	2.70	5.30	2.48
Dissolved	0.18	0.05	0.09	0.12	0.13	< 0.05	0.09	0.07	0.14
Percent dissolved	8	1	7	7	12	< 7	3	1	6
Solids									
Total	184	253	257	231	198	216	225	208	186
Total suspended	37	84	24	20	12	11	53	102	42
Total dissolved	147	169	233	211	186	205	172	106	144
BELL BEND I									
Time	1227	1211	1306	1300	1230	1210	1216	1302	1255
River temperature (C)	24.0	25.5	26.0	26.0	25.5	24.0	20.5	19.5	20.5
Turbidity (NTU)	16	50	8.7	11	7.3	4.7	17	66	20
pH	7.5	7.5	8.0	7.5	7.8	8.5	7.4	7.2	7.3
Conductivity (μmhos/cm)	205	235	305	280	265	290	230	160	225
Analysis (mg/L)									
Oxygen									
Dissolved	7.60	6.50	8.60	7.40	9.00	11.10	7.50	8.00	9.20
Percent saturation	89	79	105	91	109	130	82	86	102
Total alkalinity	51	56	73	62	63	67	53	43	57
Sulfate	38	37	47	48	43	49	28	9	41
Iron									
Total	2.10	4.31	1.29	1.45	1.08	0.78	2.18	5.42	2.40
Dissolved	0.17	0.06	0.08	0.17	0.15	< 0.05	0.06	0.09	0.15
Percent dissolved	8	1	6	12	14	< 6	3	2	6
Solids									
Total	183	255	257	222	201	221	217	218	185
Total suspended	36	73	21	14	11	10	58	107	37
Total dissolved	147	182	236	208	190	211	159	111	148

Table A-6 (cont.)

PARAMETER	6 SEP	12 SEP	19 SEP	26 SEP	12 OCT	24 OCT
SSES						
Time	1240	1327	1201	1251	0	1211
River level (ft above msl)	488.5	487.5	487.2	487.1	487.7	487.2
River temperature (C)	19.0	18.5	20.0	19.0	13.0	13.0
Turbidity (NTU)	6.1	5.8	5.3	4.7	4.7	6.5
pH	7.7	7.9	7.4	7.5	7.5	7.7
Conductivity (μmhos/cm)	280	330	360	375	280	330
Analysis (mg/L)						
Oxygen						
Dissolved	10.00	10.00	8.80	8.60	11.50	11.60
Percent saturation	108	106	96	93	107	109
Total alkalinity	70	78	72	78	66	76
Sulfate	45	60	58	68	50	60
Iron						
Total	1.21	1.03	0.91	1.05	1.14	1.19
Dissolved	0.26	< 0.05	< 0.05	0.08	0.36	< 0.05
Percent dissolved	21	< 5	< 5	8	32	< 4
Solids						
Total	203	246	252	264	210	225
Total suspended	8	8	5	5	3	6
Total dissolved	195	238	247	259	207	219
BELL BEND						
Time	1233	1322	1207	1246	1357	1207
River temperature (C)	19.0	18.5	20.0	19.0	13.0	13.0
Turbidity (NTU)	6.0	5.8	5.5	4.8	4.7	6.5
pH	7.7	7.9	7.5	7.4	7.5	7.7
Conductivity (μmhos/cm)	285	340	365	390	285	340
Analysis (mg/L)						
Oxygen						
Dissolved	10.00	10.00	8.60	8.60	11.40	11.70
Percent saturation	108	106	94	93	106	110
Total alkalinity	70	78	75	79	67	79
Sulfate	44	59	59	69	53	60
Iron						
Total	1.16	1.07	0.96	1.00	1.17	1.21
Dissolved	0.31	< 0.05	< 0.05	< 0.05	0.39	< 0.05
Percent dissolved	27	< 5	< 5	< 5	33	< 4
Solids						
Total	203	256	259	271	221	228
Total suspended	7	8	6	5	4	6
Total dissolved	196	248	253	266	217	222
BELL BEND I						
Time	1235	1320	1205	1243	1355	1204
River temperature (C)	19.0	18.5	20.0	19.0	13.0	13.0
Turbidity (NTU)	6.1	6.2	5.8	5.0	4.5	6.7
pH	7.7	7.9	7.6	7.6	7.5	7.7
Conductivity (μmhos/cm)	290	350	375	400	285	350
Analysis (mg/L)						
Oxygen						
Dissolved	10.00	10.00	8.80	8.60	11.60	11.90
Percent saturation	108	106	96	93	108	112
Total alkalinity	71	79	78	82	67	82
Sulfate	44	62	62	70	52	63
Iron						
Total	1.23	1.13	0.96	1.03	1.17	1.27
Dissolved	0.26	< 0.05	< 0.05	0.06	0.32	< 0.05
Percent dissolved	21	< 4	< 5	6	27	< 4
Solids						
Total	209	264	268	280	220	236
Total suspended	7	8	4	5	5	6
Total dissolved	202	256	264	275	215	230

Table A-6 (cont.)

PARAMETER	7 NOV	17 NOV	5 DEC	20 DEC
SSES				
Time	1252	1248	1205	1322
River level (ft above msl)	490.2	488.3	490.6	490.3
River temperature (C)	12.0	9.0	5.0	3.5
Turbidity (NTU)	10	3.3	5.5	3.6
pH	7.2	7.4	7.0	7.2
Conductivity (μmhos/cm)	200	260	190	210
Analysis (mg/L)				
Oxygen				
Dissolved	10.40	13.60	13.40	14.30
Percent saturation	95	116	105	106
Total alkalinity	52	65	43	52
Sulfate	37	47	35	33
Iron				
Total	1.54	0.88	1.03	0.85
Dissolved	0.22	0.37	0.31	0.29
Percent dissolved	14	42	30	34
Solids				
Total	160	163	137	131
Total suspended	21	1	6	4
Total dissolved	139	162	131	127
BELL BEND				
Time	1259	1243	1202	1318
River temperature (C)	12.0	9.0	5.0	3.5
Turbidity (NTU)	10	3.3	5.3	3.7
pH	7.2	7.4	7.0	7.2
Conductivity (μmhos/cm)	200	260	190	210
Analysis (mg/L)				
Oxygen				
Dissolved	10.40	13.60	13.40	14.30
Percent saturation	95	116	105	106
Total alkalinity	52	66	44	52
Sulfate	39	43	34	32
Iron				
Total	1.55	0.89	1.03	0.82
Dissolved	0.21	0.39	0.31	0.33
Percent dissolved	14	44	30	40
Solids				
Total	166	168	131	139
Total suspended	24	2	6	4
Total dissolved	142	166	125	135
BELL BEND I				
Time	1257	1241	1200	1316
River temperature (C)	12.0	9.0	5.0	3.5
Turbidity (NTU)	10	3.3	5.2	3.8
pH	7.2	7.4	7.0	7.2
Conductivity (μmhos/cm)	200	270	190	210
Analysis (mg/L)				
Oxygen				
Dissolved	10.40	13.60	13.40	14.20
Percent saturation	95	116	105	105
Total alkalinity	53	68	44	52
Sulfate	41	49	34	33
Iron				
Total	1.43	0.88	1.02	0.84
Dissolved	0.21	0.38	0.32	0.30
Percent dissolved	15	43	31	36
Solids				
Total	165	171	137	139
Total suspended	20	2	6	6
Total dissolved	145	169	131	133

Table A-7

Summary of water quality data collected from the Susquehanna River at SSES, Bell Bend, and Bell Bend I, 1994.

PARAMETER	MINIMUM	MAXIMUM	MEAN	SE
SSES				
Turbidity (NTU)	3.3	72	14	2.8
pH	7.0	8.6	7.5	0.06
Conductivity (μmhos/cm)	110	375	238	11.3
Analysis (mg/L)				
Oxygen				
Dissolved	6.40	14.50	10.72	0.386
Percent saturation	78	151	105	2.5
Total alkalinity	22	78	55	2.6
Sulfate	5	68	39	2.5
Iron				
Total	0.74	8.05	1.97	0.272
Dissolved	< 0.05	0.37	0.15	0.019
Percent dissolved	1	42	12	2.0
Solids				
Total	125	285	197	7.5
Total suspended	1	168	29	6.0
Total dissolved	84	259	168	7.9
BELL BEND				
Turbidity (NTU)	3.3	76	14	2.9
pH	7.0	8.5	7.5	0.06
Conductivity (μmhos/cm)	110	390	241	11.7
Analysis (mg/L)				
Oxygen				
Dissolved	6.50	14.70	10.73	0.385
Percent saturation	79	150	105	2.4
Total alkalinity	23	79	56	2.6
Sulfate	2	69	38	2.6
Iron				
Total	0.74	8.23	1.96	0.282
Dissolved	< 0.05	0.39	0.13	0.020
Percent dissolved	< 1	44	10	2.1
Solids				
Total	128	307	200	8.0
Total suspended	2	172	30	6.2
Total dissolved	84	266	169	8.4
BELL BEND I				
Turbidity (NTU)	3.3	76	14	2.9
pH	7.0	8.5	7.5	0.06
Conductivity (μmhos/cm)	110	400	244	12.2
Analysis (mg/L)				
Oxygen				
Dissolved	6.50	14.70	10.71	0.385
Percent saturation	79	148	105	2.4
Total alkalinity	23	82	56	2.7
Sulfate	4	70	39	2.6
Iron				
Total	0.78	8.62	1.86	0.265
Dissolved	< 0.05	0.38	0.13	0.018
Percent dissolved	1	43	10	1.9
Solids				
Total	128	296	199	7.8
Total suspended	2	186	30	6.4
Total dissolved	78	275	169	8.8

Table A-8

Comparison of water quality data collected from the Susquehanna River at SSES and Bell Bend during preoperation (1978-82) and operation (1983-94) of the Susquehanna SES.

	PREOPERATION				OPERATION			
	MINIMUM	MAXIMUM	MEAN	SE	MINIMUM	MAXIMUM	MEAN	SE
SSES								
Turbidity (NTU)	3.3	450	17	1.8	2.1	440	14	1.2
pH	6.6	9.0	7.5	0.02	6.8	8.9	7.5	0.01
Conductivity (µmhos/cm)	76	540	293	5.4	90	515	274	4.0
Analysis (mg/L)								
Oxygen								
Dissolved	5.20	14.70	10.26	0.098	5.40	15.20	10.27	0.119
Percent saturation	60	145	100	0.8	66	182	99	0.9
Total alkalinity	16	87	55	0.7	16	88	55	0.6
Sulfate	8	158	63	1.8	3	150	52	1.2
Iron								
Total	0.96	22.00	2.30	0.105	0.37	35.20	1.91	0.095
Dissolved	0.01	2.25	0.51	0.020	<0.05	1.47	0.32	0.011
Percent dissolved	1	98	28	1.2	1	79	21	0.8
Solids								
Total	106	736	222	4.2	104	822	214	3.2
Total suspended	1	658	26	3.0	1	708	24	2.2
Total dissolved	61	363	194	3.8	54	360	190	2.9
BELL BEND								
Turbidity (NTU)	3.1	450	17	1.8	2.3	460	14	1.2
pH	6.6	8.9	7.5	0.02	6.8	8.9	7.5	0.01
Conductivity (µmhos/cm)	74	525	293	5.4	91	540	279	4.3
Analysis (mg/L)								
Oxygen								
Dissolved	5.00	14.50	10.31	0.099	5.30	15.40	10.28	0.121
Percent saturation	58	157	100	0.8	65	160	99	0.9
Total alkalinity	16	88	55	0.7	16	92	56	0.7
Sulfate	9	158	62	1.8	2	152	53	1.2
Iron								
Total	0.72	22.50	2.22	0.104	0.45	35.10	1.85	0.093
Dissolved	0.01	2.23	0.50	0.019	<0.05	1.50	0.31	0.011
Percent dissolved	0	92	28	1.2	0	81	21	0.8
Solids								
Total	107	710	224	4.2	104	826	218	3.3
Total suspended	1	649	26	2.9	1	758	24	2.2
Total dissolved	55	366	195	3.8	62	384	194	3.1

Table A-9

Pennsylvania Department of Environmental Resources water quality criteria applicable to selected water quality parameters monitored at SSES, Bell Bend, and Bell Bend I on the Susquehanna River, 1994.

PARAMETER	CRITERIA
Aluminum	Not to exceed 0.5 mg/L.[a]
Alkalinity	Minimum 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 discharge should not further reduce the alkalinity of the receiving waters.
Ammonia nitrogen	Not to exceed 4.57 mg/L, based on a median pH of 7.5 and a median temperature of 23.5 C from monthly samples collected at Bell Bend in July, August, and September, 1983-88.[a]
Dissolved oxygen	Minimum daily average 5.0 mg/L; minimum 4.0 mg/L.
Iron	Daily average 1.5 mg/L as total iron; maximum 0.3 mg/L as dissolved iron.
Manganese	Maximum 1.0 mg/L.
Nitrite plus nitrate	Maximum 10 mg/L as nitrogen.
pH	From 6.0 to 9.0 inclusive.
Temperature	As described in $Temp_2$ of Table 3 § 93.7 (C).
Total dissolved solids	500 mg/L as a monthly average value; maximum 750 mg/L

[a]Personal communication, Pennsylvania Department of Environmental Resources, Wilkes-Barre, Pennsylvania.

Table A-10

Water quality data collected from the Susquehanna River at SSES, 1994. Analyses were performed by the PP&L Chemical Laboratory, Hazleton, PA.

	SSES										
Date	22 Feb	28 Mar	26 Apr	24 May	23 Jun	11 Jul	10 Aug	19 Sep	24 Oct	17 Nov	5 Dec
Time	1209	1201	1210	1211	1200	1217	1207	1201	1211	1248	1205
River temperature (C)	0.5	3.0	12.5	19.0	25.5	25.5	24.0	20.0	13.0	9.0	5.0
Turbidity (NTU)	14	28	8.6	5.2	6.9	50	5.1	5.8	7.2	3.4	--
pH	7.30	7.00	7.20	8.10	8.60	7.40	8.80	7.40	8.00	7.70	7.40
Conductivity (μmhos/cm)	234	128	226	274	268	237	280	379	353	269	206
Analysis (mg/L)											
Total suspended solids	31.5	55.5	17.3	5.2	14.3	82.8	6.7	6.6	4.8	3.2	6.5
Ammonia nitrogen	0.26	0.15	< 0.10	0.24	0.40	0.18	0.24	0.12	0.19	0.26	0.14
Nitrate nitrogen	1.04	1.00	0.88	0.41	< 0.43	0.75	< 0.43	0.72	0.62	0.68	0.62
M. O. Alkalinity	40	24	52	61	63	58	70	77	78	59	42
Hardness	68.6	41.7	80.1	101.3	97.8	85.9	103.0	127.1	128.1	98.8	71.9
Silicon dioxide	3.81	4.25	3.51	0.18	1.57	4.55	0.40	1.26	0.35	3.13	3.86
Calcium	20.2	12.4	23.8	28.8	27.4	24.8	29.0	34.5	35.4	28.3	20.5
Magnesium	4.4	2.6	5.0	7.1	7.1	5.8	7.4	9.9	9.6	6.8	5.0
Sodium	16.2	6.5	10.6	11.5	11.9	11.7	13.5	22.7	17.8	12.6	9.3
Potassium	1.5	1.5	1.3	1.5	2.1	2.3	2.1	2.4	2.1	2.1	1.5
Bicarbonate	48.8	29.3	63.4	74.4	54.9	70.8	65.9	93.9	95.2	72.0	51.2
Sulfate	23.0	16.0	25.2	40.0	41.3	27.9	37.1	52.9	50.5	34.0	26.2
Chloride	28.5	10.6	16.8	19.4	17.6	18.8	21.8	34.0	25.5	18.5	14.3
Nitrate	4.61	4.41	3.88	1.83	< 1.90	3.31	< 1.90	3.17	2.76	3.00	2.76
Phosphate	0.37	0.46	0.21	0.12	0.21	0.74	0.18	0.15	0.15	0.09	0.12
Total mineral solids	151.4	88.0	153.7	184.8	176.8	170.7	188.9	254.9	239.4	180.5	134.7
Dissolved oxygen	14.50	14.10	10.90	10.60	11.20	6.40	11.40	8.80	11.60	13.60	13.40
Analysis (me/L)[a]											
Positive ions											
Calcium	1.01	0.62	1.19	1.44	1.37	1.24	1.45	1.72	1.77	1.41	1.02
Magnesium	0.36	0.21	0.41	0.58	0.58	0.48	0.61	0.81	0.79	0.56	0.41
Sodium	0.70	0.28	0.46	0.50	0.52	0.51	0.59	0.99	0.77	0.55	0.40
Potassium	0.04	0.04	0.03	0.04	0.05	0.06	0.05	0.06	0.05	0.05	0.04
Total	2.11	1.15	2.09	2.56	2.52	2.29	2.70	3.58	3.38	2.57	1.87
Negative ions											
Bicarbonate	0.80	0.48	1.04	1.22	0.90	1.16	1.08	1.54	1.56	1.18	0.84
Sulfate	0.48	0.33	0.52	0.83	0.86	0.58	0.77	1.10	1.05	0.71	0.55
Chloride	0.80	0.30	0.47	0.55	0.50	0.53	0.61	0.96	0.72	0.52	0.40
Nitrate	0.07	0.07	0.06	0.03	< 0.03	0.05	< 0.03	0.05	0.04	0.05	0.04
Phosphate	0.01	0.01	0.01	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00
Total	2.16	1.19	2.10	2.63	2.24	2.34	2.44	3.65	3.37	2.46	1.83
Trace metals (mg/L)											
Iron											
Total	2.24	2.34	1.20	0.98	0.90	3.94	0.64	0.88	1.15	0.83	0.95
Dissolved	0.13	0.06	0.27	0.12	0.10	0.09	< 0.05	< 0.05	< 0.05	0.38	0.37
Aluminum											
Total	0.50	1.10	0.30	< 0.20	0.20	2.00	< 0.20	< 0.20	< 0.20	< 0.20	0.20
Dissolved	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Manganese											
Total	0.16	0.15	0.14	0.15	0.17	0.21	0.10	0.17	0.19	0.14	0.13
Dissolved	0.10	0.06	0.12	0.10	0.03	0.04	< 0.02	0.11	0.17	0.13	0.12
Copper											
Total	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dissolved	< 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	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01
Dissolved	0.02	< 0.01	0.01	< 0.01	0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel											
Total	< 0.05	< 0.05	< 0.05	0.05	0.05	0.07	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Dissolved	< 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	< 0.05
Dissolved	< 0.05	< 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	< 0.10
Dissolved	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10

[a]Milliequivalents per liter (me/L) calculated using Table 103:I, Standard Methods (1985).

Table A-11

Water quality data collected from the Susquehanna River at Bell Bend, 1994. Analyses were performed by the PP&L Chemical Laboratory, Hazleton, PA.

BELL BEND											
Date	22 Feb	28 Mar	26 Apr	24 May	23 Jun	11 Jul	10 Aug	19 Sep	24 Oct	17 Nov	5 Dec
Time	1216	1208	1216	1206	1206	1213	1212	1207	1207	1243	1202
River temperature (C)	0.5	3.0	12.5	19.0	25.5	25.5	24.0	20.0	13.0	9.0	5.0
Turbidity (NTU)	15	28	8.4	4.8	6.6	55	5.4	5.8	7.2	3.4	–
pH	7.40	7.00	7.30	8.10	8.60	7.40	8.75	7.50	7.90	7.70	7.40
Conductivity (µmhos/cm)	236	128	224	274	269	237	283	382	358	274	205
Analysis (mg/L)											
Total suspended solids	32.5	71.0	16.5	5.1	12.8	87.5	8.1	7.0	5.2	3.5	6.9
Ammonia nitrogen	0.26	0.14	< 0.10	0.21	0.43	0.18	0.27	0.11	0.21	0.26	0.14
Nitrate nitrogen	0.94	1.25	0.90	0.42	< 0.43	0.80	< 0.43	0.69	0.64	0.68	0.62
M. O. Alkalinity	40	24	51	62	63	58	70	75	78	62	43
Hardness	69.1	41.5	79.9	101.5	97.6	85.9	102.8	129.5	129.5	98.5	72.1
Silicon dioxide	3.84	4.08	3.55	0.15	1.59	4.60	0.48	1.33	0.38	3.19	3.91
Calcium	20.4	12.3	23.7	28.7	27.3	24.8	28.9	35.3	35.8	28.2	20.6
Magnesium	4.4	2.6	5.0	7.2	7.1	5.8	7.4	10.0	9.7	6.8	5.0
Sodium	16.4	6.5	10.7	11.6	12.0	11.6	13.6	23.0	18.1	12.8	9.6
Potassium	1.5	1.5	1.3	1.6	2.1	2.3	2.1	2.4	2.2	2.1	1.6
Bicarbonate	48.8	29.3	62.2	75.6	57.3	70.8	65.9	91.5	95.2	75.6	52.5
Sulfate	20.4	16.0	25.7	40.5	41.5	27.8	37.7	53.5	51.3	34.0	26.1
Chloride	27.9	10.6	16.7	18.8	17.6	17.0	21.2	33.4	26.1	18.5	14.3
Nitrate	4.17	5.54	3.98	1.88	< 1.90	3.52	< 1.90	3.05	2.84	2.99	2.73
Phosphate	0.37	0.46	0.18	0.12	0.21	0.77	0.21	0.15	0.12	0.09	0.12
Total mineral solids	148.2	88.9	153.0	186.2	178.2	169.0	189.0	253.6	241.7	184.3	136.5
Dissolved oxygen	14.70	14.10	10.80	10.60	10.90	6.50	11.20	8.60	11.70	13.60	13.40
Analysis (me/L)[a]											
Positive ions											
Calcium	1.02	0.61	1.18	1.43	1.36	1.24	1.44	1.76	1.79	1.41	1.03
Magnesium	0.36	0.21	0.41	0.59	0.58	0.48	0.61	0.82	0.80	0.56	0.41
Sodium	0.71	0.28	0.47	0.50	0.52	0.50	0.59	1.00	0.79	0.56	0.42
Potassium	0.04	0.04	0.03	0.04	0.05	0.06	0.05	0.06	0.06	0.05	0.04
Total	2.13	1.14	2.09	2.56	2.51	2.28	2.69	3.64	3.44	2.58	1.90
Negative ions											
Bicarbonate	0.80	0.48	1.02	1.24	0.94	1.16	1.08	1.50	1.56	1.24	0.86
Sulfate	0.42	0.33	0.54	0.84	0.86	0.58	0.78	1.11	1.07	0.71	0.54
Chloride	0.79	0.30	0.47	0.53	0.50	0.48	0.60	0.94	0.74	0.52	0.40
Nitrate	0.07	0.09	0.06	0.03	< 0.03	0.06	< 0.03	0.05	0.05	0.05	0.04
Phosphate	0.01	0.01	0.01	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00
Total	2.09	1.21	2.10	2.64	2.28	2.30	2.44	3.60	3.42	2.52	1.84
Trace metals (mg/L)											
Iron											
Total	2.17	2.51	1.08	0.94	0.92	4.12	0.67	0.92	1.14	0.81	0.95
Dissolved	0.14	0.05	0.22	< 0.05	0.11	0.07	< 0.05	< 0.05	< 0.05	0.38	0.36
Aluminum											
Total	0.60	1.20	0.30	< 0.20	0.20	1.90	< 0.20	0.20	< 0.20	< 0.20	0.20
Dissolved	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Manganese											
Total	0.16	0.15	0.14	0.15	0.17	0.20	0.10	0.16	0.19	0.14	0.13
Dissolved	0.10	0.06	0.12	0.10	< 0.02	0.04	< 0.02	0.10	0.16	0.13	0.12
Copper											
Total	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dissolved	< 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	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
Dissolved	0.01	0.01	0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Nickel											
Total	< 0.05	< 0.05	< 0.05	0.05	0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Dissolved	< 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	< 0.05
Dissolved	< 0.05	< 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	< 0.10
Dissolved	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10

[a]Milliequivalents per liter (me/L) calculated using Table 103:I, Standard Methods (1985).

Table A-12

Water quality data collected from the Susquehanna SES blowdown, 1994. Analyses were performed by the PP&L Chemical Laboratory, Hazleton, PA.

	BLOWDOWN										
Date	22 Feb	28 Mar	26 Apr	24 May	23 Jun	11 Jul	10 Aug	19 Sep	24 Oct	17 Nov	5 Dec
Time	1200	1200	1200	1200	1130	1200	1200	1200	1238	1200	1200
River temperature (C)	15.0	16.5	24.0	25.0	28.0	26.0	28.0	25.0	18.0	20.0	16.0
Turbidity (NTU)	30	175	45	13	70	180	110	19	18	39	--
pH	8.90	8.60	8.90	8.90	8.70	8.75	8.70	8.80	8.80	8.90	8.70
Conductivity (μmhos/cm)	1400	708	932	977	705	628	780	915	1010	903	642
Analysis (mg/L)											
Total suspended solids	62.0	423.0	90.0	25.5	245.0	735.0	882.0	31.0	29.5	102.8	49.0
Ammonia nitrogen	0.36	0.35	0.29	0.34	0.91	0.07	0.61	0.43	0.60	0.93	0.43
Nitrate nitrogen	8.48	5.33	4.86	3.01	1.67	2.80	1.84	2.31	2.76	3.16	2.67
M. O. Alkalinity	292	137	234	256	175	173	197	200	247	233	151
Hardness	544.9	248.9	390.6	422.8	285.2	261.5	316.8	357.1	411.8	360.9	241.9
Silicon dioxide	25.20	19.10	18.91	3.84	8.90	12.61	5.99	3.71	2.28	12.34	10.60
Calcium	157.0	74.0	117.0	122.0	80.8	76.4	89.8	99.0	112.0	104.0	69.7
Magnesium	37.0	15.5	23.8	28.6	20.2	17.1	22.4	26.6	32.0	24.5	16.4
Sodium	94.0	44.0	52.4	47.6	35.6	31.7	43.0	55.0	53.0	47.4	38.0
Potassium	10.0	9.2	7.7	6.9	6.7	6.7	7.0	6.9	7.4	8.0	5.9
Bicarbonate	287.9	137.9	234.2	256.2	164.7	159.8	189.1	202.5	255.0	240.3	172.0
Sulfate	271.0	97.4	128.0	163.0	121.0	82.0	117.0	144.0	172.0	124.0	91.3
Chloride	172.3	77.5	85.9	81.9	52.2	49.1	68.6	84.3	83.7	75.8	53.7
Nitrate	37.50	23.60	21.50	13.30	7.38	12.40	8.15	10.20	12.20	14.00	11.80
Phosphate	3.04	5.25	2.82	2.12	5.77	6.93	8.68	1.93	2.42	2.55	1.93
Total mineral solids	1128.5	517.8	717.4	753.1	527.2	479.9	584.9	654.5	754.8	674.5	477.3
Dissolved oxygen	11.80	11.50	9.00	9.00	8.20	8.50	6.60	9.80	10.30	7.90	9.30
Analysis (me/L)[a]											
Positive ions											
Calcium	7.83	3.69	5.84	6.09	4.03	3.81	4.48	4.94	5.59	5.19	3.48
Magnesium	3.04	1.28	1.96	2.35	1.66	1.41	1.84	2.19	2.63	2.02	1.35
Sodium	4.09	1.91	2.28	2.07	1.55	1.38	1.87	2.39	2.31	2.06	1.65
Potassium	0.26	0.24	0.20	0.18	0.17	0.17	0.18	0.18	0.19	0.20	0.15
Total	15.22	7.12	10.28	10.69	7.41	6.77	8.37	9.70	10.72	9.47	6.63
Negative ions											
Bicarbonate	4.72	2.26	3.84	4.20	2.70	2.62	3.10	3.32	4.18	3.94	2.82
Sulfate	5.64	2.03	2.66	3.39	2.52	1.71	2.44	3.00	3.58	2.58	1.90
Chloride	4.86	2.19	2.42	2.31	1.47	1.38	1.93	2.38	2.36	2.14	1.51
Nitrate	0.60	0.38	0.35	0.21	0.12	0.20	0.13	0.16	0.20	0.23	0.19
Phosphate	0.10	0.17	0.09	0.07	0.18	0.22	0.27	0.06	0.08	0.08	0.06
Total	15.92	7.03	9.36	10.18	6.99	6.13	7.87	8.92	10.40	8.97	6.48
Trace metals (mg/L)											
Iron											
Total	5.60	18.6	4.67	2.43	21.7	25.9	37.0	2.73	3.52	5.10	3.58
Dissolved	0.19	0.10	0.32	0.10	0.22	0.10	0.21	0.15	0.26	0.67	0.57
Aluminum											
Total	0.90	8.50	1.60	0.50	6.00	11.5	13.0	0.60	0.60	1.20	0.80
Dissolved	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Manganese											
Total	0.65	0.90	0.27	0.25	3.00	1.83	4.50	0.27	0.27	0.40	0.25
Dissolved	0.04	0.03	0.02	0.02	< 0.02	0.04	< 0.02	0.02	0.03	0.04	0.04
Copper											
Total	0.03	0.05	0.02	0.02	0.04	0.05	0.08	< 0.02	0.02	0.02	0.02
Dissolved	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Zinc											
Total	0.13	0.19	0.08	0.04	0.24	0.22	0.34	0.03	0.03	0.05	0.04
Dissolved	0.02	0.01	0.01	0.01	< 0.01	0.03	0.01	< 0.01	0.01	0.01	< 0.01
Nickel											
Total	0.05	< 0.05	< 0.05	0.07	0.10	0.10	0.11	< 0.05	< 0.05	< 0.05	< 0.05
Dissolved	< 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	0.07	< 0.05	< 0.05	< 0.05	< 0.05
Dissolved	< 0.05	< 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	< 0.10
Dissolved	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10

[a]Milliequivalents per liter (me/L) calculated using Table 103:I, Standard Methods (1985).

Table A-13

Comparison of measured and calculated total mineral solids (tms) concentrations at Bell Bend on the Susquehanna River, 1994. Data from SSES and blowdown samples were mass balanced to calculate the Bell Bend concentration.

DATE	SSES		BLOWDOWN		BELL BEND		DIFFERENCE	
	Flow (cfs)	tms (mg/L)	Flow (cfs)	tms (mg/L)	Measured tms (mg/L)	Calculated tms (mg/L)	tms (mg/L)	%
22 Feb	31900	151.4	7.1	1128.5	148.2	151.6	-3.4	-2.3
28 Mar	96400	88.0	4.7	517.8	88.9	88.0	0.9	1.0
26 Apr	22300	153.7	5.1	717.4	153.0	153.8	-0.8	-0.5
24 May	7780	184.8	7.1	753.1	186.2	185.3	0.9	0.5
23 Jun	6180	176.8	21.9	527.2	178.2	178.0	0.2	0.1
11 Jul	10700	170.7	12.4	479.9	169.0	171.1	-2.1	-1.2
10 Aug	5590	188.9	23.3	584.9	189.0	190.5	-1.5	-0.8
19 Sep	3710	254.9	24.4	654.5	253.6	257.5	-3.9	-1.5
24 Oct	3710	239.4	19.6	754.8	241.7	242.1	-0.4	-0.2
17 Nov	6800	180.5	15.8	674.5	184.3	181.6	2.7	1.4
05 Dec	16200	134.7	11.0	477.3	136.5	134.9	1.6	1.1

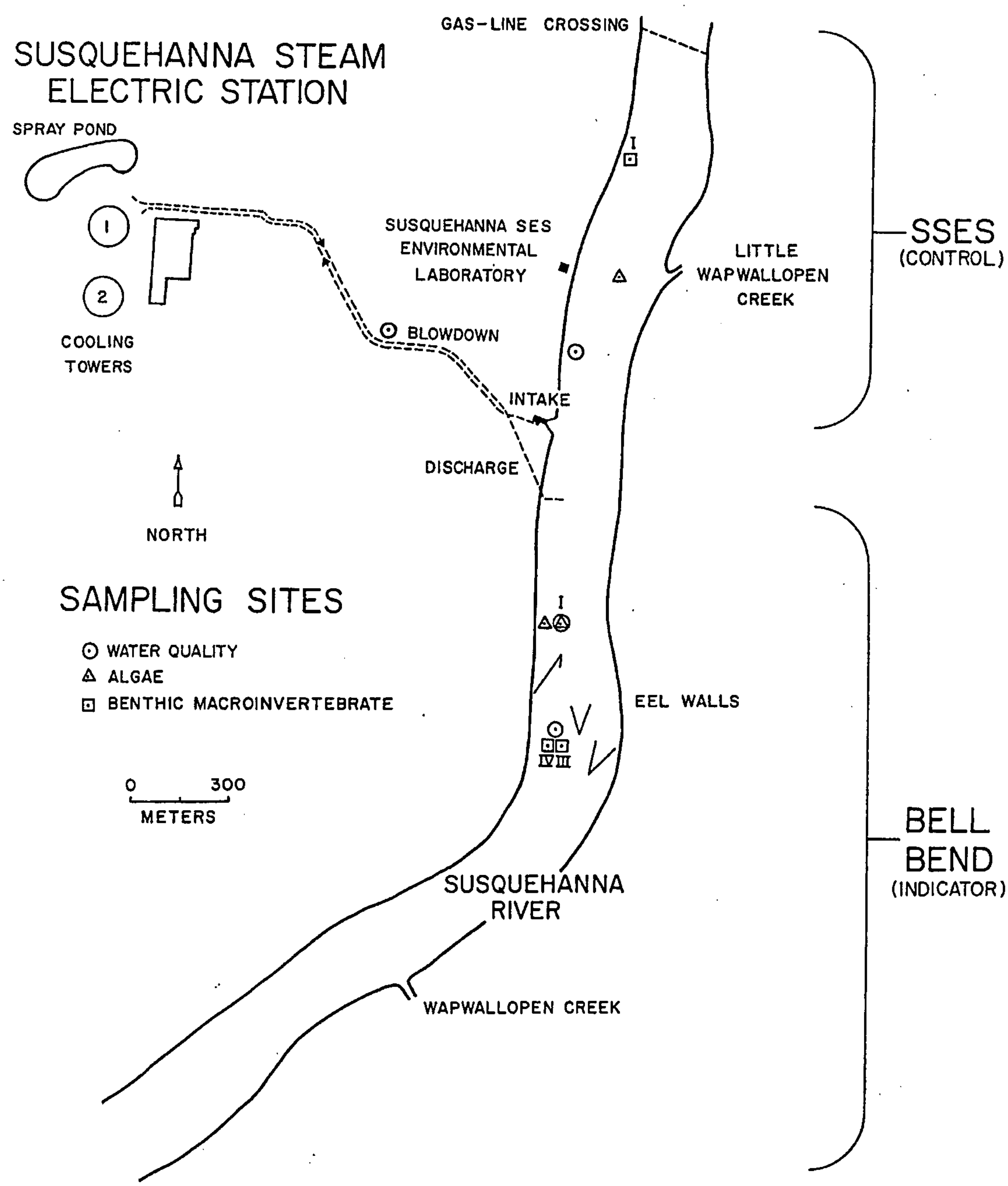

Fig. A-1

Water quality, algae, and benthic macroinvertebrate sampling sites at SSES and Bell Bend on the Susquehanna River, 1994.

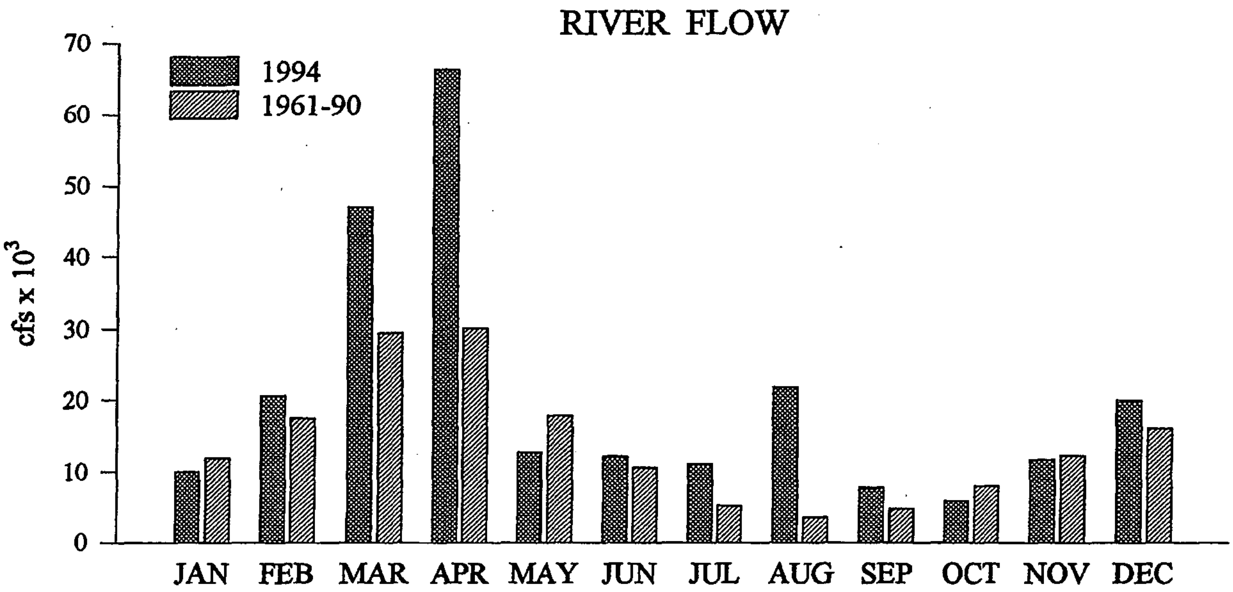

Fig. A-2

The 1994 monthly mean flow of the Susquehanna River at the Susquehanna SES Environmental Laboratory compared to the thirty year (1961-90) mean. The 1961-90 means were calculated from U.S. Geological Survey data.

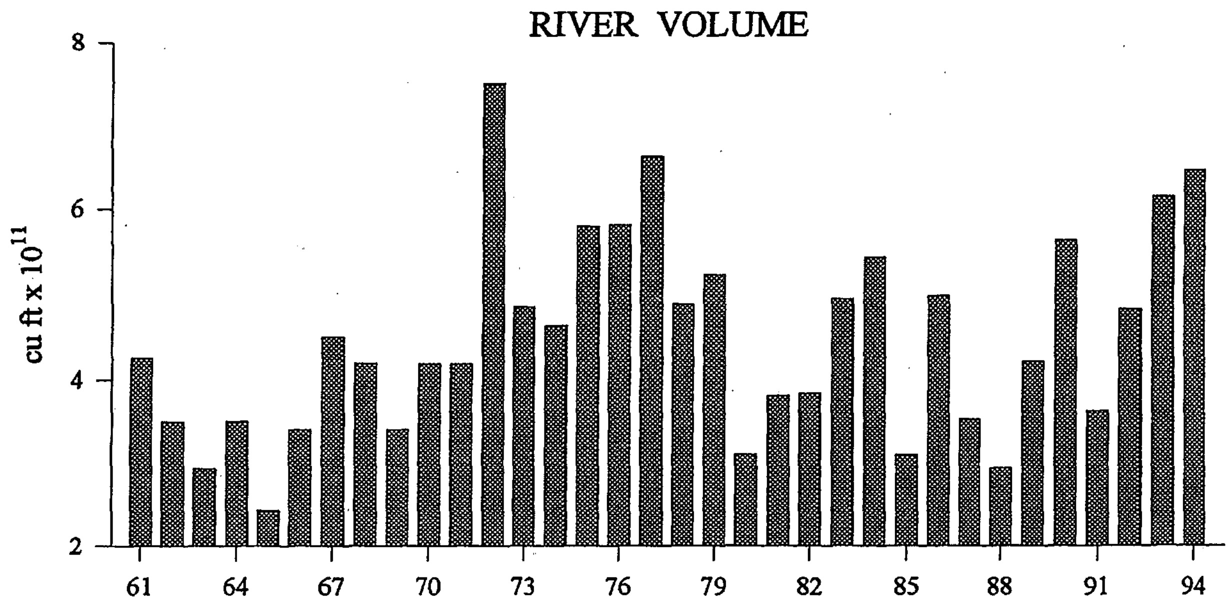

Fig. A-3

Volume of Susquehanna River flow at the Susquehanna SES Environmental Laboratory, 1961-94. The 1961-90 volumes were calculated from U.S. Geological Survey data, the 1991-94 volumes were calculated from Susquehanna SES Environmental Laboratory data.

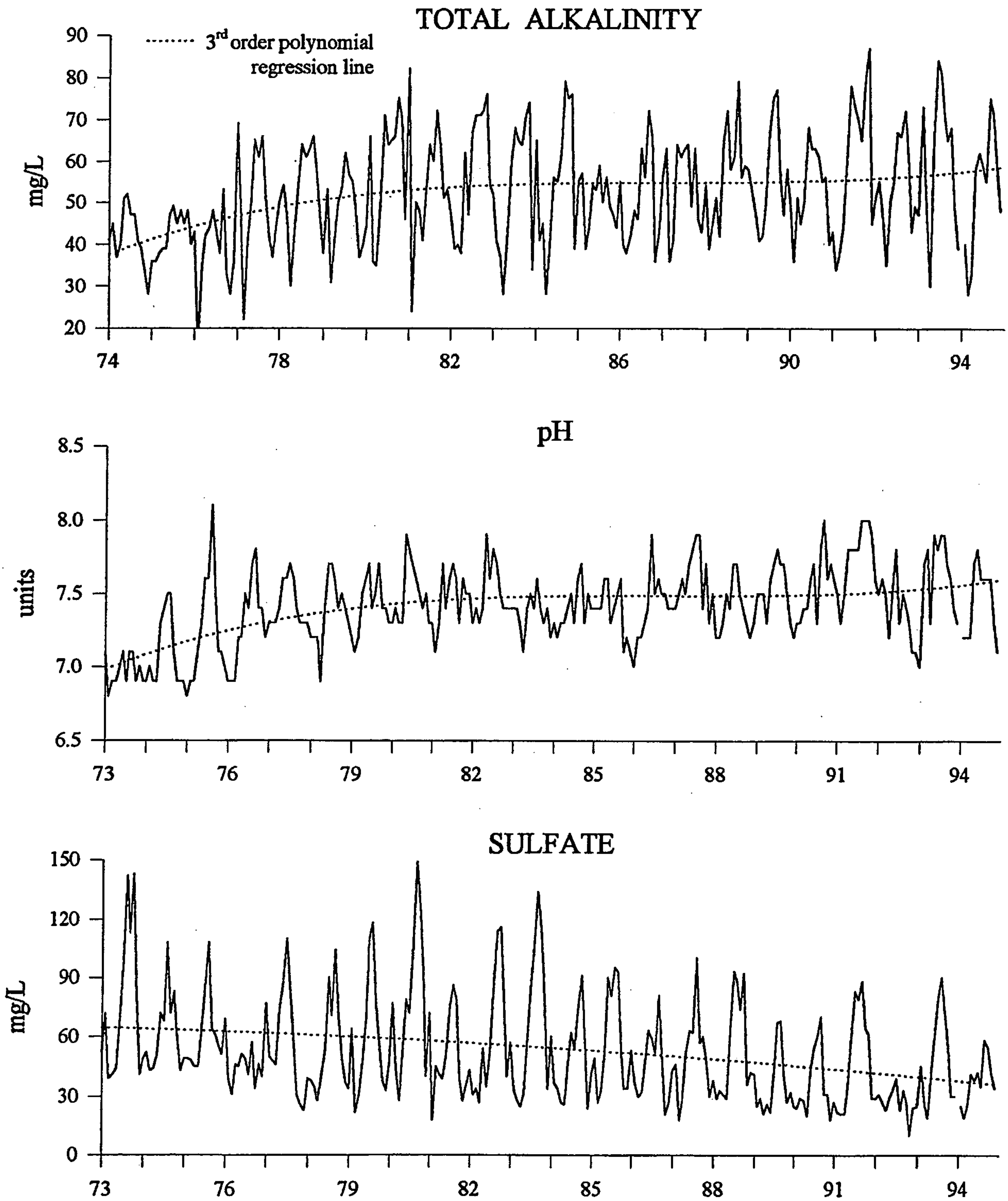

Fig. A-4

Monthly mean total alkalinity, pH, and sulfate of the Susquehanna River at the SSES sampling site during preoperation and operation of the Susquehanna SES, 1973-94.

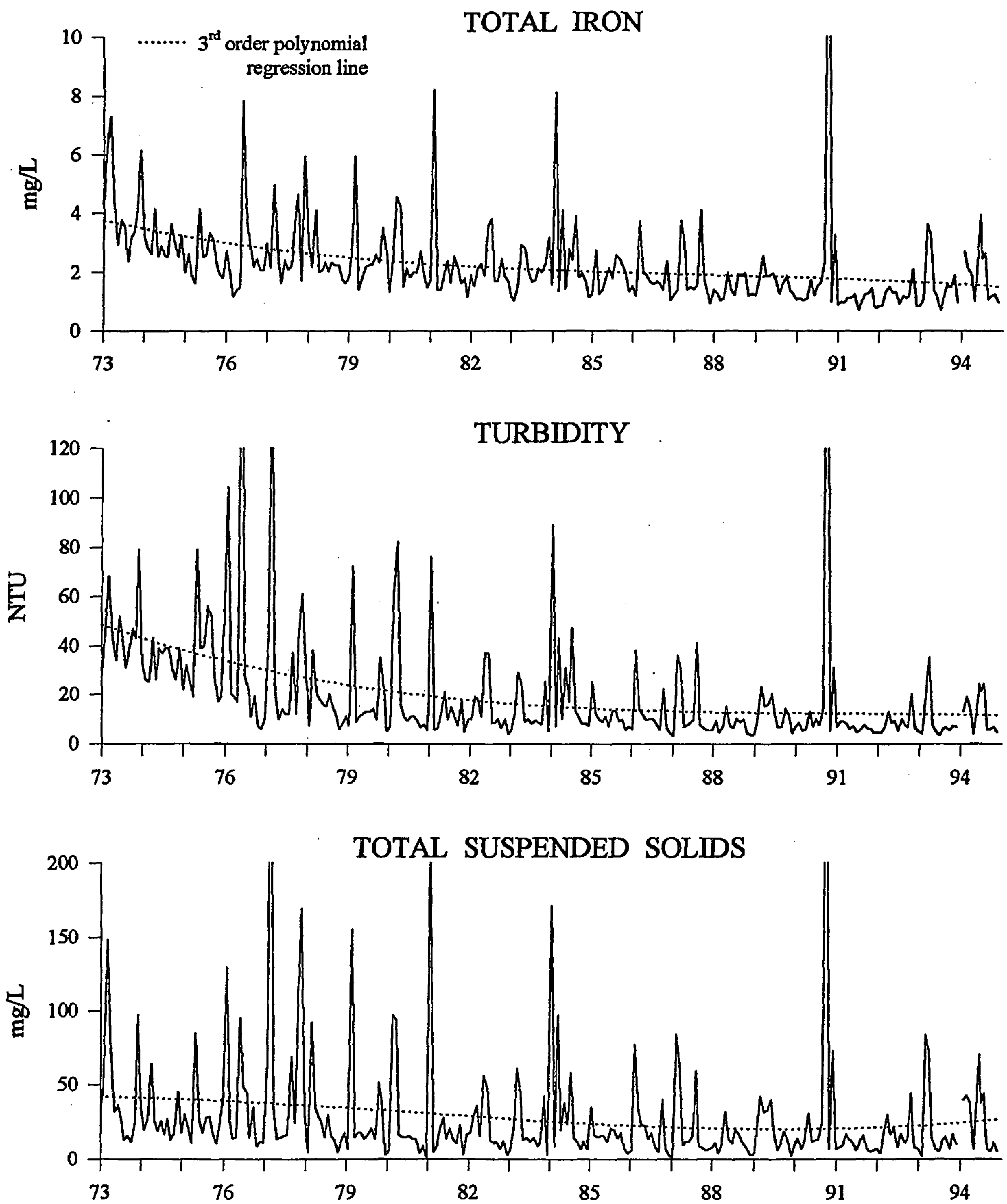

Fig. A-5

Monthly mean total iron, turbidity, and total suspended solids of the Susquehanna River at the SSES sampling site during preoperation and operation of the Susquehanna SES, 1973-94.

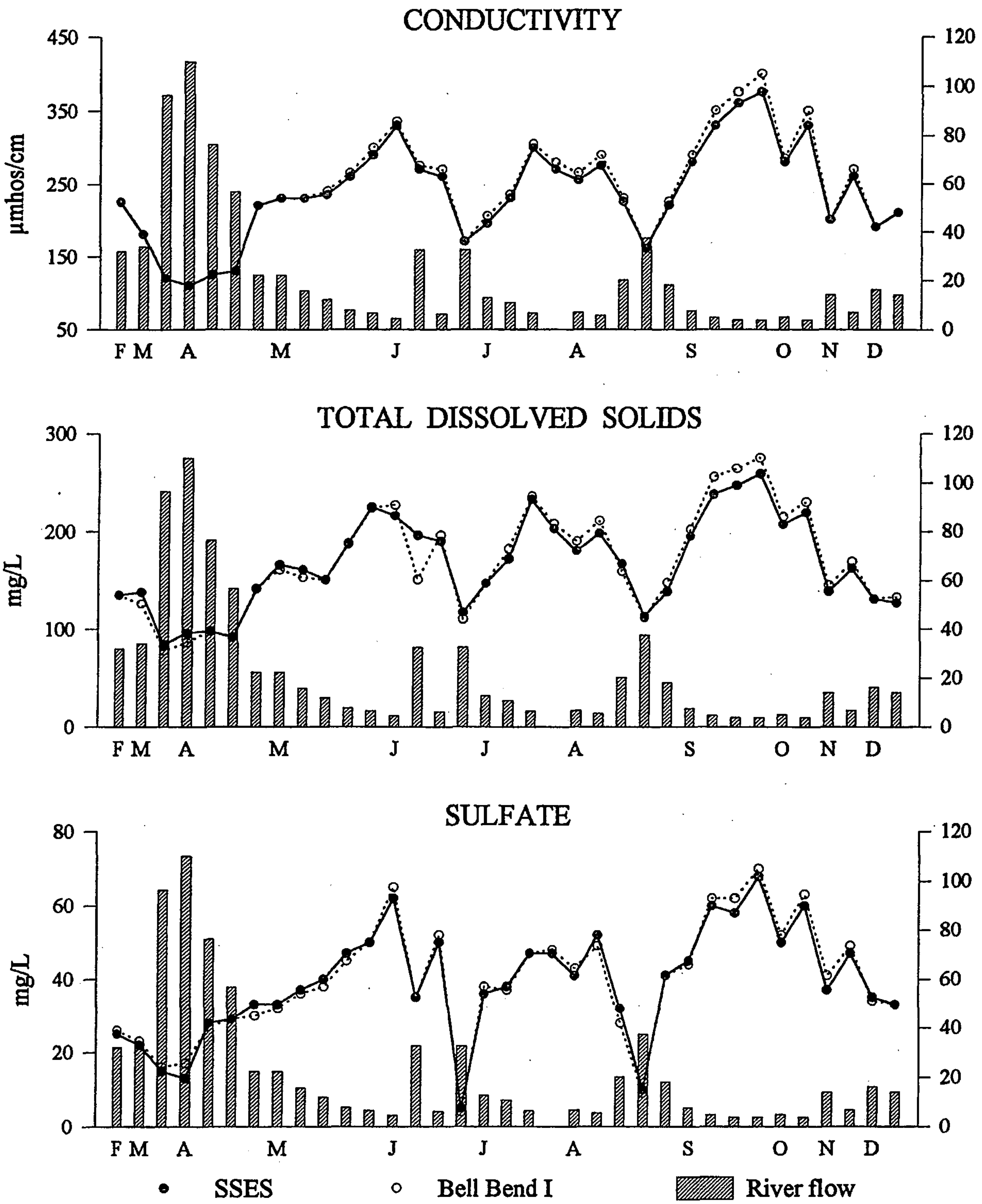

Fig. A-6

The conductivity and concentrations of total dissolved solids and sulfate of the Susquehanna River at SSES and Bell Bend I relative to river flow for each sampling date in 1994.

ALGAE

PROCEDURES

Algae samples were collected at a control site (SSES) and two indicator sites (Bell Bend and Bell Bend I) in 1994 (Fig. A-1). The SSES site is located 460 m upriver from the Susquehanna SES intake structure, 135 m from the west bank. The Bell Bend and Bell Bend I sites are 400 m downriver from the discharge diffuser, 30 m and 55 m from the west bank, respectively. Results of a dye study (Sutron Corporation 1985) revealed that both indicator sites are in the diffuser plume, but Bell Bend I is more centrally located.

Periphyton samples were collected from artificial substrates that consisted of three sandblasted plates of clear acrylic (22 x 30 cm) in "detritus-free" holders similar to those of Gale et al. (1976). A holder containing four plates is located on the river bottom at each site near the main channel at each sampling site. River depth at the Susquehanna SES Environmental Laboratory, near SSES, ranged from 3.9 to 19.2 feet in 1994. At each site, one plate was sampled in June, August, and October. The remaining plate can be used as a spare in the event the scheduled plate to be sampled is lost. All plates were exposed to colonization for at least 12 months. 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 the following year. The schedule for plate removal is a continuation of a plan established in 1977.

A 415 mm^2 area per subsample was cleaned from the plate by scraping and vibrating (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. 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 the Environmental Laboratory 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 were concentrated similarly to 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).

Algae cells in periphyton and phytoplankton samples that contained chloroplasts were enumerated as "units" (Gale and Lowe 1971). The first 250-300 algal units were counted and identified using an algal counting program (Lowe 1992). Counts were made using a microscope (400X) and a Palmer counting cell. Higher magnification, (1000X) including oil immersion, was used for some identifications. Algae were identified by Dr. Lowe to genus and the more abundant forms to species.

The 1977-94 data set of 59 periphyton and phytoplankton genera were tested with the BACI (Before-After:Control-Impact) analysis to determine if operation of the Susquehanna SES significantly impacted any of these genera. Data from 1977 through

1982 were considered preoperational; operational data began in 1985 when both Units 1 and 2 were operating and continued through 1994.

RESULTS AND DISCUSSION

Periphyton

Nine samples were collected at each site in 1994. Totals of 42, 39, and 40 genera of periphytic algae were found at SSES (control), Bell Bend, and Bell Bend I (indicators), 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 as mean densities of periphytic algae in Tables B-1 through B-3.

Large differences in the mean densities of periphyton occurred at SSES and both Bell Bend sites from June through October 1994. Densities at SSES ranged from a low of 365 units/mm^2 in June to a high of 3,298 units/mm^2 in October (Table B-1). At Bell Bend, they ranged from a low of 1,029 units/mm^2 in August to a high of 2,145 units/mm^2 in June (Table B-2). The density at Bell Bend I ranged from a low of 901 units/mm^2 in August to a high of 1,167 units/mm^2 in June (Table B-3). Overall, mean periphyton density was slightly higher at SSES (1,456 units/mm^2) than at Bell Bend (1,414 units/mm^2) or Bell Bend I (999 units/mm^2) (Table B-4).

The composition of periphyton varied at each site in 1994. Diatoms (Bacillariophyta) were the most abundant forms at SSES, Bell Bend, and Bell Bend I composing 83%, 75%, and 76% of the total units counted at each site, respectively. Blue-

green algae (Cyanophyta) were second most abundant at SSES and composed 10% of the total units counted. Green algae (Chlorophyta) were the second most abundant forms at Bell Bend and Bell Bend I and composed 14% and 16% of the total units at the two sites (Table B-4). Green algae were least abundant at SSES with 7% of the total units counted. Blue-green algae were third in abundance at Bell Bend and Bell Bend I and composed 11% and 9% of the total units counted, respectively.

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

The average annual density of periphyton was always lower at SSES than at Bell Bend throughout each preoperational year (1977-82). This also occurred in seven of the twelve operational years from 1983 through 1994 (Table B-4; Fig. B-1). The preoperational mean density at SSES was 1,283 units/mm^2, while at Bell Bend, it was 3,281 units/mm^2.

The relative abundance of greens, diatoms, and blue-greens changed little between sites in 1994 as in past years. Green algae composed 7% and 14% of the total units at SSES and Bell Bend, respectively; diatoms composed 83% and 75% and blue-green algae composed about 10% at both sites. In operational years, the mean density at SSES was 1,155 units/mm^2, while at Bell Bend, it was 2,128 units/mm^2. The major component of this density was diatoms rather than green algae and diatoms as in

preoperational years. Diatoms made up about 61% of the total units at SSES and Bell Bend; green algae composed 24% and 32%, respectively, and blue-green algae composed 15% and 6% of the total. When data were compared between Bell Bend and Bell Bend I, density and composition of periphyton were similar from 1986 through 1994 (Table B-4) suggesting that conditions at both sites remained similar.

In summary, densities of periphyton at the SSES and Bell Bend sites in the Susquehanna River have decreased in operational years compared to preoperational years. Furthermore, the composition of the periphyton has shifted from mainly green algae and diatoms during the preoperational period to predominantly diatoms after operation of both units began in 1985. These changes occurred at both the control and indicator sites, and therefore, were not caused by operation of the Susquehanna SES.

Phytoplankton

Three phytoplankton samples were collected at each site in 1994 for totals of 30, 34, and 36 genera at SSES (control), Bell Bend, and Bell Bend I (indicators), respectively (Tables B-6 through B-8). None of the genera that occurred at only one site composed more than 1% of the total units counted. Phytoplankton density was slightly greater at SSES (7,969 units/ml) than at Bell Bend (7,861 units/ml) and Bell Bend I (7,281 units/ml). Diatoms were the major component of the phytoplankton, composing 70% of the total standing crop at the three sites. Green algae were second in abundance and composed 29% of the total standing crop at the three sites; blue-green algae composed about 1%.

Nine species of phytoplankton were identified that composed 5% or more of the total units counted in at least one sample from the three sites (Table B-9). Three species were green algae and six were diatoms. Of the diatom species, two were rated as "alkaliphilous" by Lowe (1974), one was "indifferent," and three were "unknown" with respect to pH preference.

Similar densities of phytoplankton were found in preoperational (1977-82) samples collected at SSES and Bell Bend. Mean density averaged about 20,500 units/ml at SSES and 20,000 units/ml at Bell Bend (Table B-10; Fig. B-2). Green algae were the most abundant forms of phytoplankton composing 57% and 53% of the total units at SSES and Bell Bend, respectively. Diatoms were next in abundance (SSES, 39%; Bell Bend, 42%) and blue-green algae composed about 4% of the total at both sites.

Operational densities (1983-94) averaged 12,100 units/ml at SSES, 12,276 units/ml at Bell Bend, and 12,160 units/ml at Bell Bend I (1986-94). Diatoms were the major component of the phytoplankton composing 53% of the total units at SSES, 50% at Bell Bend, and 58% at Bell Bend I. Green algae composed 42% at SSES, 44% at Bell Bend, and 39% at Bell Bend I. Blue-green algae composed about 5% of the total units at SSES, 6% at Bell Bend, and 3% at Bell Bend I.

Comparison of data from the Bell Bend and Bell Bend I sites showed that density and composition of phytoplankton were similar from 1986 through 1994 (Table B-10). These results suggest that conditions at these sites are very similar.

BACI Analysis

BACI analysis was done on the 1977-82 preoperational vs. 1985-94 operational data for 33 genera of periphyton and 26 genera of phytoplankton. Three genera of periphyton (*Surirella*, *Gomphonema*, and *Navicula*) tested significant at $P \leq 0.05$. The genera *Gomphonema* and *Navicula* were also significant in 1993, but this was the first year *Surirella* tested significant. Compared with SSES, the abundance of *Surirella* was significantly less at Bell Bend in the operational period than it was in the preoperational period. The abundance of *Gomphonema* increased significantly less at Bell Bend during operation than at SSES, whereas, *Navicula* increased significantly more at SSES than at Bell Bend. Both *Surirella* and *Gomphonema* accounted for less than 2% of the total algae collected at the sites from 1977 through 1994. The relative abundance of *Navicula* was consistently higher. For example, it amounted to 5.4% of the total algae at SSES and 1.8% at Bell Bend in 1993. However, in 1994, it increased to 25.5% at SSES and 6.7% at Bell Bend. Only one genus of phytoplankton, *Kirchneriella*, tested significant at $P \leq 0.05$. The abundance of *Kirchneriella*, which was about 1% of the total phytoplankton at both sites, decreased significantly more at SSES during operation than at Bell Bend. This also occurred in 1992 and 1993.

In summary, these results suggest that, statistically, between the SSES and the Bell Bend sites, four genera of algae are significantly different. It is questionable if these results are biologically significant. Monitoring for algae will be discontinued in 1995.

Table B-1

Mean density (units/mm²) of periphytic algae on one acrylic plate submerged for 12 months at SSES on the Susquehanna River, 1994.

TAXON	27 JUN	15 AUG	14 OCT	% TOTAL
CHLOROPHYTA				
Actinastrum	8.9	1.2	0.0	0.2
Ankistrodesmus	28.5	29.1	30.4	2.0
Bulbochaete	0.6	0.0	0.0	< 0.1
Chlamydomonas	2.4	0.0	1.4	< 0.1
Closterium	0.0	1.2	1.4	< 0.1
Coelastrum	0.0	33.2	0.0	0.8
Cosmarium	0.6	0.0	1.4	< 0.1
Crucigenia	1.2	1.2	0.0	< 0.1
Dictyosphaerium	0.0	1.2	0.0	< 0.1
Dimorphococcus	0.0	0.6	0.0	< 0.1
Gonium	0.0	0.6	0.0	< 0.1
Kirchneriella	0.0	4.7	1.4	0.1
Micractinium	2.4	0.0	0.0	< 0.1
Oocystis	0.0	2.4	1.4	< 0.1
Scenedesmus	14.2	37.4	22.1	1.7
Tetraedron	1.8	2.4	0.0	< 0.1
Tetrastrum	0.0	7.1	2.8	0.2
Unidentified	23.7	9.5	6.9	0.9
BACILLARIOPHYTA				
Achnanthes	4.2	1.8	4.2	0.2
Amphora	0.0	0.6	1.4	< 0.1
Cocconeis	4.7	8.9	2.8	0.4
Cyclotella	97.3	54.6	85.8	5.4
Cymbella	1.2	5.9	2.8	0.2
Diatoma	0.0	0.6	0.0	< 0.1
Eunotia	1.2	0.0	0.0	< 0.1
Fragilaria	17.8	0.0	0.0	0.4
Gomphonema	1.8	4.7	29.1	0.8
Gyrosigma	0.0	0.6	8.3	0.2
Melosira	0.0	161.4	132.8	6.7
Navicula	4.7	155.5	954.5	25.5
Nitzschia	18.4	45.7	1727.8	41.0
Rhoicosphenia	0.0	0.6	1.4	< 0.1
Skeletonema	3.6	5.3	0.0	0.2
Stephanodiscus	10.7	8.3	44.3	1.4
Surirella	0.0	0.0	2.8	< 0.1
Synedra	1.8	8.3	5.5	0.4
Unidentified	0.0	0.0	6.9	0.2
CYANOPHYTA				
Aphanothece	0.0	0.6	0.0	< 0.1
Chroococcus	0.6	2.4	0.0	< 0.1
Gomphosphaeria	1.2	0.0	0.0	< 0.1
Lyngbya	0.0	0.0	31.8	0.7
Merismopedia	5.9	0.0	0.0	0.1
Oscillatoria	0.0	8.3	55.3	1.5
Schizothrix	70.0	100.3	131.4	6.9
Unidentified	35.6	0.0	0.0	0.8
TOTAL	364.9	706.1	3297.9	

Table B-2

Mean density (units/mm²) of periphytic algae on one acrylic plate submerged for 12 months at Bell Bend on the Susquehanna River, 1994.

TAXON	27 JUN	15 AUG	14 OCT	% TOTAL
CHLOROPHYTA				
Actinastrum	57.6	1.2	0.0	1.4
Ankistrodesmus	107.6	27.9	13.6	3.5
Chlamydomonas	2.8	4.7	1.2	0.2
Coelastrum	0.0	22.0	1.8	0.6
Cosmarium	2.4	2.4	2.4	0.2
Eudorina	0.0	0.6	0.0	< 0.1
Kirchneriella	11.4	0.6	0.0	0.3
Lagerheimia	0.0	0.0	0.6	< 0.1
Oocystis	1.2	1.2	0.0	< 0.1
Pediastrum	0.0	2.4	0.0	< 0.1
Scenedesmus	145.1	30.9	50.4	5.3
Tetraedron	20.7	0.0	0.6	0.5
Tetrastrum	0.0	3.6	1.2	0.1
Unidentified	26.0	1.8	48.1	1.8
BACILLARIOPHYTA				
Achnanthes	8.6	0.6	14.8	0.6
Amphora	0.0	0.0	3.6	< 0.1
Asterionella	0.0	0.0	0.6	< 0.1
Cocconeis	34.0	23.7	6.5	1.5
Cyclotella	1109.2	366.7	112.7	37.5
Cymbella	6.8	9.5	10.7	0.6
Diatoma	0.0	4.7	4.2	0.2
Eunotia	0.0	1.8	0.0	< 0.1
Gomphonema	8.9	1.8	8.9	0.5
Gyrosigma	0.0	6.5	23.1	0.7
Melosira	0.0	126.4	102.6	5.4
Navicula	17.8	59.9	207.7	6.7
Nitzschia	103.7	67.6	344.1	12.2
Rhoicosphenia	0.0	0.6	4.2	0.1
Skeletonema	60.4	28.5	0.0	2.1
Stephanodiscus	122.8	92.6	55.2	6.4
Surirella	0.0	0.0	3.0	< 0.1
Synedra	6.6	8.9	10.1	0.6
CYANOPHYTA				
Anabaena	0.0	0.0	1.8	< 0.1
Chroococcus	3.5	0.0	0.0	< 0.1
Gomphosphaeria	18.8	1.2	0.0	0.5
Lyngbya	0.0	0.0	4.7	0.1
Merismopedia	15.8	0.0	0.0	0.4
Oscillatoria	0.0	11.3	14.2	0.6
Schizothrix	172.0	116.3	12.5	7.1
Unidentified	81.4	1.8	0.0	2.0
EUGLENOPHYTA				
Euglena	0.0	0.0	1.8	< 0.1
TOTAL	2144.9	1029.4	1066.8	

Table B-3

Mean density (units/mm²) of periphytic algae on one acrylic plate submerged for 12 months at Bell Bend I on the Susquehanna River, 1994.

TAXON	27 JUN	15 AUG	14 OCT	% TOTAL
CHLOROPHYTA				
Actinastrum	39.6	0.6	0.0	1.3
Ankistrodesmus	70.7	24.9	7.1	3.4
Bulbochaete	0.6	0.0	0.0	< 0.1
Chlamydomonas	3.0	0.6	3.0	0.2
Closterium	2.9	0.0	0.0	< 0.1
Coelastrum	1.9	15.4	0.0	0.6
Cosmarium	0.0	0.0	1.2	< 0.1
Euastrum	0.6	0.0	0.0	< 0.1
Lagerheimia	4.2	0.0	0.0	0.1
Micractinium	8.7	0.0	0.0	0.3
Oocystis	0.0	1.2	0.0	< 0.1
Pediastrum	5.5	0.0	0.0	0.2
Scenedesmus	75.4	30.3	27.3	4.4
Staurastrum	0.0	0.0	0.6	< 0.1
Tetraedron	12.7	0.6	0.6	0.5
Tetrastrum	4.7	3.0	0.6	0.3
Unidentified	128.0	0.0	0.6	4.3
BACILLARIOPHYTA				
Achnanthes	4.5	13.1	8.9	0.9
Amphora	1.9	0.0	0.0	< 0.1
Cocconeis	11.2	2.4	12.5	0.9
Cyclotella	476.1	327.5	125.8	31.0
Cymbella	11.1	14.8	16.0	1.4
Diatoma	0.0	0.6	3.6	0.1
Fragilaria	0.0	0.0	3.6	0.1
Gomphonema	0.0	11.3	13.6	0.8
Gyrosigma	0.0	6.5	26.7	1.1
Melosira	20.5	140.6	71.2	7.8
Meridion	0.0	0.0	6.5	0.2
Navicula	12.2	78.9	197.6	9.6
Nitzschia	39.7	38.6	288.4	12.2
Rhoicosphenia	0.0	0.0	3.6	0.1
Skeletonema	32.7	23.1	0.0	1.9
Stephanodiscus	50.9	80.7	63.5	6.5
Surirella	0.0	0.0	0.6	< 0.1
Synedra	6.9	6.5	7.7	0.7
CYANOPHYTA				
Chroococcus	1.0	0.0	0.0	< 0.1
Lyngbya	0.0	0.0	7.1	0.2
Merismopedia	5.9	0.0	0.0	0.2
Oscillatoria	0.0	13.1	5.3	0.6
Schizothrix	99.6	67.0	20.2	6.2
Unidentified	34.4	0.0	0.0	1.1
RHODOPHYTA				
Rhodochorton	0.0	0.0	3.6	0.1
TOTAL	1166.9	901.3	926.8	

Table B-4

Comparison of average density (units/mm²) and relative abundance (% total) of periphytic algae on one acrylic plate at SSES, Bell Bend, and Bell Bend I on the Susquehanna River collected in spring, summer, and autumn during preoperation and operation of the Susquehanna SES, 1977-94.

YEAR	GREENS		DIATOMS		BLUE GREENS		OTHER		TOTAL	
	Units/mm²	% Total	Units/mm²	% Total	Units/mm²	% Total	Units/mm²	% Total	Units/mm²	% Total
SSES										
PREOPERATION										
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	561	41.6	758	56.2	30	2.2	0	0.0	1349	100.0
1980	678	42.5	892	55.9	26	1.6	0	0.0	1596	100.0
1981	1581	75.8	490	23.5	15	0.7	<1	<0.1	2086	100.0
1982	585	56.5	440	42.5	10	1.0	0	0.0	1035	100.0
MEAN	668	52.1	588	45.8	27	2.1	<1	<0.1	1283	100.0
OPERATION										
1983	336	45.8	350	47.7	47	6.4	<1	<0.1	733	99.9
1984	130	10.7	1071	88.4	11	0.9	0	0.0	1212	100.0
1985	663	34.9	1210	63.9	23	1.2	4	0.2	1900	100.2
1986	80	17.7	316	69.8	57	12.6	<1	<0.1	453	100.1
1987	466	36.8	754	59.5	47	3.7	1	<0.1	1268	100.0
1988	126	19.7	387	60.4	127	19.8	1	0.2	641	100.1
1989	84	6.7	828	65.8	344	27.3	2	0.2	1258	100.0
1990	61	5.8	759	71.9	213	20.2	22	2.1	1055	100.0
1991	241	20.4	356	30.2	578	49.0	4	0.3	1179	99.9
1992	28	3.5	460	57.3	315	38.9	3	0.4	806	100.1
1993	964	50.7	800	42.0	117	6.1	22	1.2	1903	100.0
1994	95	6.5	1213	83.3	148	10.2	0	0.0	1456	100.0
MEAN	273	23.6	709	61.3	169	14.6	5	0.4	1155	99.9
BELL BEND										
PREOPERATION										
1977	988	37.3	1473	55.7	181	6.8	4	0.2	2646	100.0
1978	293	16.6	1437	81.6	29	1.6	1	<0.1	1760	99.8
1979	1125	48.4	1096	47.1	104	4.5	<1	<0.1	2325	100.0
1980	2795	40.2	4082	58.8	70	1.0	0	0.0	6947	100.0
1981	2915	70.4	1197	28.9	28	0.7	1	<0.1	4141	100.0
1982	1074	57.6	754	40.4	36	1.9	1	<0.1	1865	99.9
MEAN	1532	46.7	1673	51.0	75	2.3	1	<0.1	3281	100.0
OPERATION										
1983	1195	54.2	690	31.3	317	14.4	1	<0.1	2203	99.9
1984	107	15.3	519	74.0	75	10.7	<1	<0.1	701	100.0
1985	229	14.8	1302	84.3	13	0.8	0	0.0	1544	99.9
1986	89	14.8	447	74.1	67	11.1	<1	<0.1	603	100.0
1987	1103	36.0	1890	61.7	70	2.3	1	<0.1	3064	100.0
1988	1226	28.2	2999	68.9	129	3.0	1	<0.1	4355	100.1
1989	92	4.0	2077	90.2	130	5.6	3	0.1	2302	99.9
1990	117	13.1	605	67.7	169	18.9	2	0.2	893	99.9
1991	956	52.8	659	36.4	194	10.7	2	0.1	1811	100.0
1992	41	6.1	500	74.1	133	19.7	1	0.1	675	100.0
1993	2839	47.6	2994	50.2	72	1.2	56	0.9	5961	99.9
1994	198	14.0	1064	75.2	152	10.7	<1	<0.1	1414	99.9
MEAN	683	32.1	1312	61.7	127	6.0	6	0.3	2128	100.1
BELL BEND I										
OPERATION										
1986	119	17.9	500	75.1	47	7.1	0	0.0	666	100.1
1987	633	32.3	1243	63.5	81	4.1	0	0.0	1957	99.9
1988	856	22.2	2928	75.8	79	2.0	0	0.0	3863	100.0
1989	73	3.8	1667	87.6	162	8.5	2	0.1	1904	100.0
1990	75	9.6	545	69.6	163	20.8	<1	<0.1	783	100.0
1991	757	45.8	750	45.4	144	8.7	1	<0.1	1652	99.9
1992	41	6.4	414	64.7	185	28.9	<1	<0.1	640	100.0
1993	839	44.4	981	52.0	63	3.3	5	0.3	1888	100.0
1994	159	15.9	754	75.5	85	8.5	1	0.1	999	100.0
MEAN	395	24.7	1087	68.2	112	7.0	1	<0.1	1595	99.9

Table B-5

Species of periphytic algae 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, 1994. pH affinity as rated by Lowe (1974): 1 = alkaliphilous, 2 = acidophilous, 3 = indifferent, and 4 = unknown.

TAXON Species	pH AFFINITY	SSES	BELL BEND	BELL BEND I
CHLOROPHYTA				
Ankistrodesmus falcatus		Jun	Jun	Jun
Coelastrum cambricum		Aug		
Scenedesmus quadricauda		Jun, Aug	Jun, Oct	Jun
BACILLARIOPHYTA				
Cyclotella atomus	(4)	Jun	Jun, Aug	Jun, Aug
Cyclotella meneghiniana	(1)		Aug	Aug
C. pseudostelligera	(3)	Jun	Jun, Aug, Oct	Jun, Aug, Oct
Fragilaria sp.		Jun		
Melosira varians	(1)	Aug, Oct	Aug, Oct	Aug, Oct
Navicula salinarum var. *intermedia*	(4)	Aug, Oct	Oct	Oct
N. symmetrica	(4)	Aug, Oct	Oct	Aug, Oct
Nitzschia dissipata	(1)	Oct	Oct	Oct
N. palea	(3)	Oct	Oct	Oct
Stephanodiscus invisitatus	(4)		Jun, Aug, Oct	Aug, Oct
CYANOPHYTA				
Schizothrix calcicola		Jun, Aug	Jun, Aug	Jun, Aug

Table B-6

Density (units/ml) of phytoplankton in samples collected at SSES on the Susquehanna River, 1994.

TAXON	27 JUN	15 AUG	14 OCT	MEAN	% TOTAL
CHLOROPHYTA					
Actinastrum	397	86	0	161.2	2.0
Ankistrodesmus	685	414	130	409.5	5.1
Chlamydomonas	164	12	68	81.5	1.0
Closterium	27	0	0	9.1	0.1
Coelastrum	82	302	0	128.2	1.6
Cosmarium	27	0	0	9.1	0.1
Crucigenia	110	0	0	36.5	0.5
Dictyosphaerium	205	19	0	74.7	0.9
Gloeocystis	0	19	0	6.2	< 0.1
Kirchneriella	205	56	11	90.8	1.1
Lagerheimia	0	0	17	5.7	< 0.1
Oocystis	27	6	0	11.2	0.1
Pediastrum	27	12	0	13.2	0.2
Scenedesmus	1233	735	68	678.4	8.5
Selenastrum	41	0	0	13.7	0.2
Tetraedron	82	6	11	33.2	0.4
Tetrastrum	164	228	0	130.9	1.6
Unidentified	247	31	62	113.2	1.4
BACILLARIOPHYTA					
Achnanthes	0	25	6	10.1	0.1
Cocconeis	14	0	0	4.6	< 0.1
Cyclotella	5439	1228	418	2361.7	29.6
Cymbella	0	0	17	5.7	< 0.1
Diatoma	0	12	0	4.1	< 0.1
Melosira	0	56	407	154.1	1.9
Navicula	0	136	17	50.9	0.6
Nitzschia	507	364	0	290.4	3.6
Skeletonema	0	383	0	127.6	1.6
Stephanodiscus	3247	321	4972	2846.6	35.7
Synedra	14	31	0	14.9	0.2
CYANOPHYTA					
Gomphosphaeria	0	19	0	6.2	< 0.1
Merismopedia	151	6	0	52.3	0.7
Unidentified	82	19	0	33.6	0.4
TOTAL	13178	4525	6204	7969.0	

Table B-7

Density (units/ml) of phytoplankton in samples collected at Bell Bend on the Susquehanna River, 1994.

TAXON	27 JUN	15 AUG	14 OCT	MEAN	% TOTAL
CHLOROPHYTA					
Actinastrum	831	110	0	313.5	4.0
Ankistrodesmus	600	426	113	379.6	4.8
Carteria	0	6	0	2.2	< 0.1
Chlamydomonas	477	13	62	184.0	2.3
Chlorella	0	6	0	2.2	< 0.1
Closterium	62	0	0	20.5	0.3
Coelastrum	62	355	0	138.8	1.8
Cosmarium	0	19	0	6.5	< 0.1
Crucigenia	31	6	0	12.4	0.2
Dictyosphaerium	323	58	0	127.1	1.6
Dimorphococcus	0	58	0	19.4	0.2
Kirchneriella	123	45	17	61.7	0.8
Lagerheimia	15	0	6	7.0	< 0.1
Oocystis	0	6	0	2.2	< 0.1
Pediastrum	15	0	0	5.1	< 0.1
Scenedesmus	1554	723	96	790.9	10.1
Selenastrum	62	19	0	27.0	0.3
Tetraedron	185	19	0	68.0	0.9
Tetrastrum	462	265	0	242.0	3.1
Unidentified	92	32	0	41.5	0.5
BACILLARIOPHYTA					
Achnanthes	0	226	17	80.9	1.0
Cocconeis	15	0	0	5.1	< 0.1
Cyclotella	3123	1490	424	1679.1	21.4
Cymbella	0	6	0	2.2	< 0.1
Diatoma	0	39	0	12.9	0.2
Gyrosigma	0	13	0	4.3	< 0.1
Melosira	0	65	283	115.7	1.5
Navicula	15	71	40	42.0	0.5
Nitzschia	600	497	0	365.6	4.7
Skeletonema	108	232	0	113.3	1.4
Stephanodiscus	3108	374	5006	2829.3	36.0
Synedra	62	6	0	22.7	0.3
CYANOPHYTA					
Aphanocapsa	46	0	0	15.4	0.2
Gomphosphaeria	0	6	0	2.2	< 0.1
Merismopedia	200	0	0	66.7	0.8
Unidentified	138	19	0	52.6	0.7
TOTAL	12308	5213	6062	7861.2	

Table B-8

Density (units/ml) of phytoplankton in samples collected at Bell Bend I on the Susquehanna River, 1994.

TAXON	27 JUN	15 AUG	14 OCT	MEAN	% TOTAL
CHLOROPHYTA					
Actinastrum	395	102	0	165.6	2.3
Ankistrodesmus	303	388	175	288.5	4.0
Cerasterias	0	7	0	2.3	< 0.1
Chlamydomonas	368	7	34	136.4	1.9
Chlorella	0	14	0	4.5	< 0.1
Coelastrum	224	395	0	206.1	2.8
Cosmarium	0	20	0	6.8	< 0.1
Crucigenia	158	0	0	52.6	0.7
Dictyosphaerium	408	0	0	136.0	1.9
Dimorphococcus	0	54	0	18.1	0.2
Gonium	26	0	0	8.8	0.1
Kirchneriella	171	122	6	99.7	1.4
Lagerheimia	13	0	0	4.4	< 0.1
Micractinium	13	0	0	4.4	< 0.1
Oedogonium	0	14	0	4.5	< 0.1
Oocystis	26	14	0	13.3	0.2
Pediastrum	13	20	0	11.2	0.2
Scenedesmus	1461	782	141	794.7	10.9
Selenastrum	13	34	0	15.7	0.2
Tetraedron	79	20	0	33.1	0.5
Tetrastrum	224	177	11	137.3	1.9
Unidentified	211	41	6	85.7	1.2
BACILLARIOPHYTA					
Achnanthes	0	156	45	67.2	0.9
Cocconeis	13	7	0	6.7	< 0.1
Cyclotella	2789	1680	401	1623.7	22.3
Cymbella	0	0	11	3.8	< 0.1
Diatoma	0	41	0	13.6	0.2
Gyrosigma	0	7	0	2.3	< 0.1
Melosira	0	102	266	122.5	1.7
Navicula	0	143	0	47.6	0.7
Nitzschia	697	320	0	339.0	4.7
Rhizosolenia	0	7	0	2.3	< 0.1
Skeletonema	184	150	0	111.3	1.5
Stephanodiscus	2895	415	4554	2621.2	36.0
Synedra	0	34	0	11.3	0.2
CYANOPHYTA					
Merismopedia	211	7	0	72.4	1.0
Schizothrix	0	7	0	2.3	< 0.1
Unidentified	0	14	0	4.5	< 0.1
TOTAL	10895	5300	5650	7281.5	

Table B-9

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, 1994. pH affinity as rated by Lowe (1974): 1 = alkaliphilous, 2 = acidophilous, 3 = indifferent, and 4 = unknown.

TAXON Species	pH AFFINITY	SSES	BELL BEND	BELL BEND I
CHLOROPHYTA				
Actinastrum hantzschii			Jun	
Ankistrodesmus falcatus		Jun, Aug	Aug	Aug
Scenedesmus quadricauda		Jun, Aug	Jun, Aug	Jun, Aug
BACILLARIOPHYTA				
Cyclotella atomus	(4)	Jun, Aug	Jun, Aug	Jun, Aug
C. pseudostelligera	(3)	Jun, Aug, Oct	Jun, Aug, Oct	Jun, Aug, Oct
Melosura varians	(1)	Oct	Oct	Oct
Nitzschia dissipata	(1)	Aug	Aug	
Skeletonema potamos	(4)	Aug		
Stephanodiscus invisitatus	(4)	Jun, Oct	Jun, Aug, Oct	Jun, Aug, Oct

Table B-10

Comparison of average density (units/ml) and relative abundance (% total) of phytoplankton at SSES, Bell Bend, and Bell Bend I on the Susquehanna River collected in spring, summer, and autumn during preoperation and operation of the Susquehanna SES, 1977-94.

YEAR	GREENS		DIATOMS		BLUE GREENS		OTHER		TOTAL	
	Units/ml	% Total	Units/ml	% Total	Units/ml	% Total	Units/ml	% Total	Units/ml	% Total
SSES										
PREOPERATION										
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										
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
1987	6971	49.2	7061	49.9	131	0.9	0	0.0	14164	100.0
1988	7859	53.2	6649	45.0	260	1.8	0	0.0	14768	100.0
1989	3354	12.4	23484	86.9	191	0.7	6	<0.1	27035	100.0
1990	2550	24.3	7882	75.0	75	0.7	6	<0.1	10513	100.0
1991	4175	57.2	2092	28.7	1018	14.0	11	0.1	7296	100.0
1992	1972	29.8	4616	69.8	26	0.4	2	<0.1	6616	100.0
1993	6247	63.9	3203	32.7	326	3.3	7	<0.1	9783	99.9
1994	2006	25.2	5870	73.7	92	1.2	0	0.0	7968	100.1
MEAN	5057	41.8	6405	52.9	633	5.2	5	<0.1	12100	99.9
BELL BEND										
PREOPERATION										
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										
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
1987	8567	58.1	6036	40.9	142	1.0	0	0.0	14745	100.0
1988	6046	45.9	6254	47.3	898	6.8	0	0.0	13198	100.0
1989	3397	13.4	21780	86.1	95	0.4	18	<0.1	25290	99.9
1990	2482	25.5	7231	74.2	28	0.3	0	0.0	9741	100.0
1991	5723	67.5	1704	20.1	1051	12.4	0	0.0	8478	100.0
1992	2029	32.4	4213	67.3	20	0.3	0	0.0	6262	100.0
1993	8308	69.9	3046	25.6	526	4.4	0	0.0	11880	99.9
1994	2451	31.2	5273	67.1	137	1.7	0	0.0	7861	100.0
MEAN	5385	43.9	6120	49.9	768	6.3	2	<0.1	12276	100.1
BELL BEND I										
OPERATION										
1986	3709	30.3	8077	65.9	472	3.9	1	<0.1	12259	100.1
1987	8678	58.1	6006	40.2	250	1.7	1	<0.1	14935	100.0
1988	6703	49.2	6552	47.9	390	2.9	0	0.0	13645	100.0
1989	3415	13.9	21086	85.6	109	0.4	12	<0.1	24622	99.9
1990	2679	25.5	7730	73.6	90	0.9	4	<0.1	10503	100.0
1991	5438	67.1	1602	19.8	1059	13.1	0	0.0	8099	100.0
1992	2166	32.5	4488	67.3	18	0.3	0	0.0	6672	100.1
1993	7340	64.2	3388	29.6	700	6.1	0	0.0	11428	99.9
1994	2230	30.6	4972	68.3	79	1.1	0	0.0	7281	100.0
MEAN	4706	38.7	7100	58.4	352	2.9	2	<0.1	12160	100.0

PERIPHYTIC ALGAE

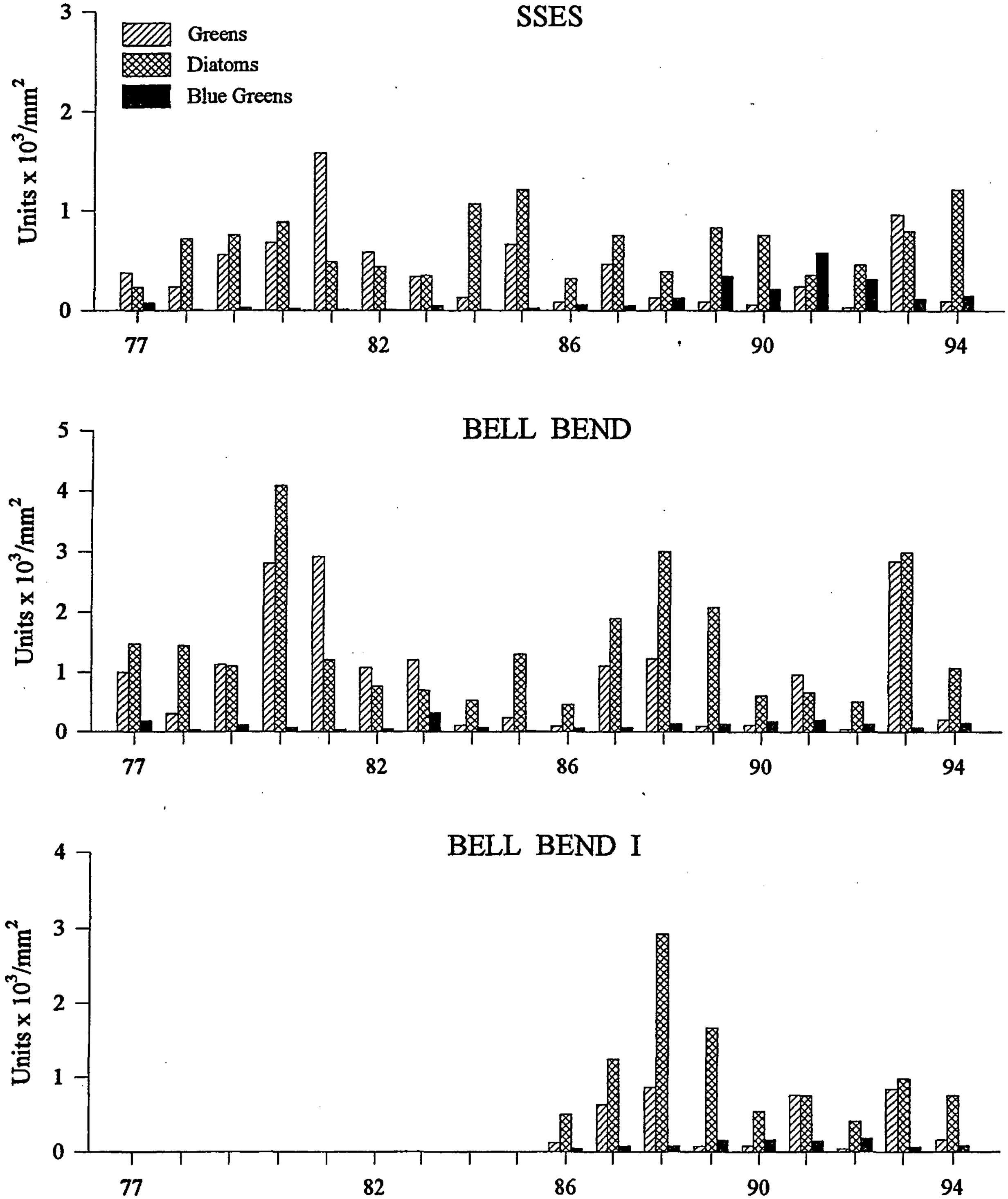

Fig. B-1

Standing crop of periphytic algae at SSES, Bell Bend, and Bell Bend I on the Susquehanna River during preoperation (1977-82) and operation (1983-94) of the Susquehanna SES.

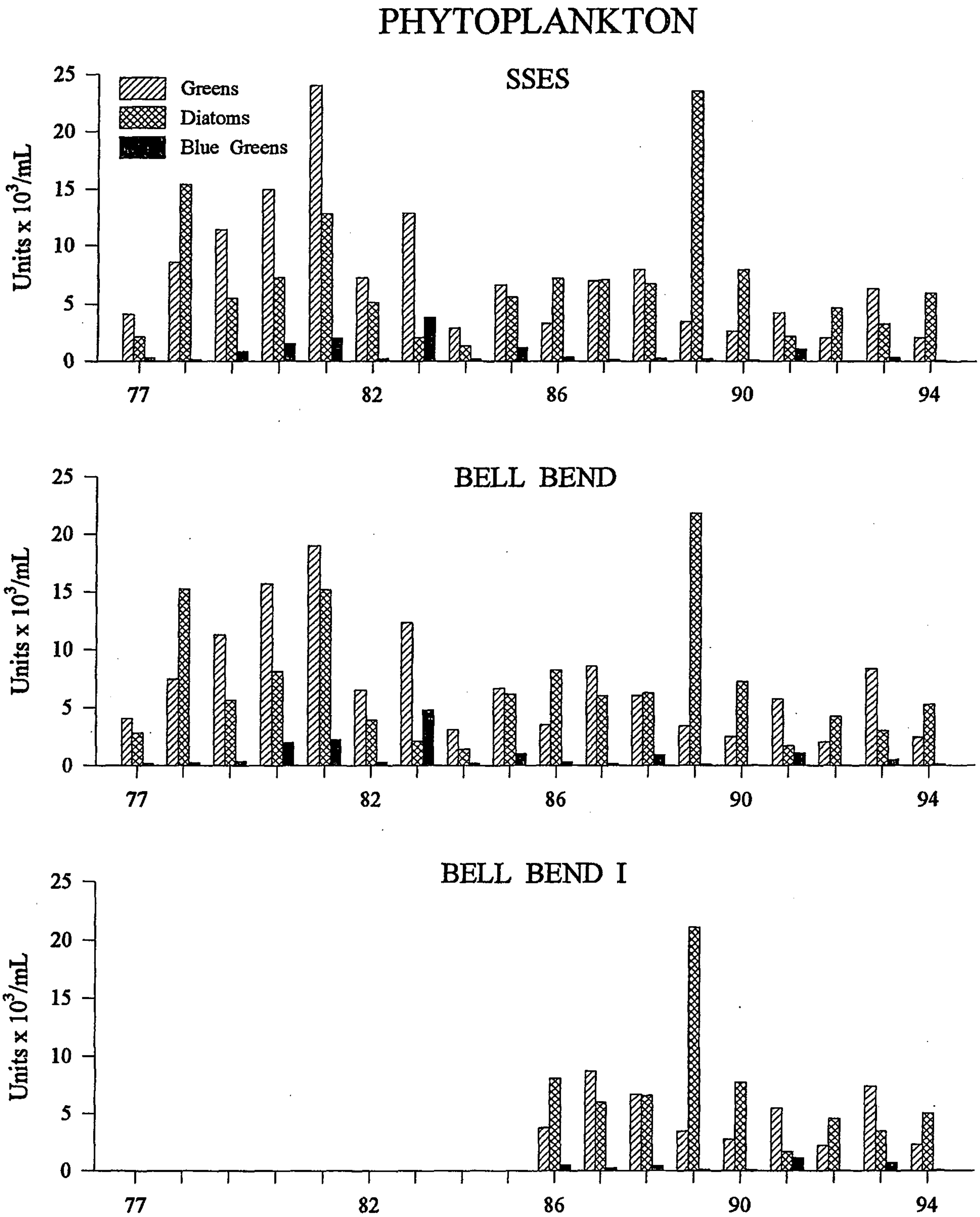

Fig. B-2

Standing crop of phytoplankton at SSES, Bell Bend, and Bell Bend I on the Susquehanna River during preoperation (1977-82) and operation (1983-94) of the Susquehanna SES.

BENTHIC MACROINVERTEBRATES

PROCEDURES

Benthic macroinvertebrates were collected at a control site (SSES I) and two indicator sites (Bell Bend III and IV) in 1994 (Fig. A-1). The SSES I site is located 850 m upriver from the intake structure, 30 m from the west bank. The Bell Bend III and IV sites are 710 m downriver from the discharge diffuser, 70 m and 55 m from the west bank, respectively. Bell Bend III is located downriver from the diffuser, but a dye study in 1985 (Sutron 1985) revealed that it was not in the center of the discharge plume. As a result, Bell Bend IV was established closer to the center of the plume in 1986.

Macroinvertebrate samples were collected from river substrate with a dome suction sampler (Gale and Thompson 1975). 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 could be made between the sampler band and the substrate. The diver then vacuumed the substrate inside the sampler for five minutes with a screened intake nozzle leading to the sampler's pump. Sediments (silt, sand, and gravel) and organisms were pumped into a nylon net (216-micron mesh). The net was removed from the sampler and brought to the surface before retrieving the dome.

In the laboratory, the sample was washed from the net into a tub. It was diluted with tap water, swirled to float off organisms and silt, and then poured through a sieve (841-micron mesh). This was repeated until the slurry was no longer turbid. Sediments in the

tub were checked for molluscs and the net was examined for clinging organisms. Organisms and silt were placed in white pans with ice water. Organisms were sorted from the sediments. By chilling the organisms, it was possible to avoid the use of preservatives that distort their weight (Howmiller 1972; Wiederholm and Eriksson 1977).

Organisms were identified and counted for density estimates and then placed into nine major groups for biomass estimates, usually within 12 hours of collection. Because it was necessary to process these unpreserved samples quickly, invertebrates were only identified to the lowest practical level. All organisms, except oligochaetes, were counted. The groups used for biomass analysis were dried in aluminum dishes at 100±3 C for at least 12 hours, cooled to room temperature in a desiccator, and weighed on an analytical balance to the nearest 0.0001 gram. Before molluscs were dried, their shells were decalcified in 5% HCl. The number of each taxon and the weight of each group of organisms found in the area sampled by the dome sampler (0.163 m^2) was multiplied by a conversion factor (6.13) to determine taxon density and the biomass of each group per square meter.

RESULTS AND DISCUSSION

In 1994, total mean biomass (weight) at the SSES I control site was 4.48 g/m^2 (Table C-1). Most of the biomass was composed of two groups, ephemeropterans (56%) and trichopterans (25%). From June to August, the biomass of ephemeropterans decreased by 73% and in October, it decreased by an additional 14%. Trichopteran

biomass decreased by 33% from June to August, and then it increased by over 3-fold in October. These changes in biomass were caused mainly by the natural growth of larvae and the emergence of adults within each group.

The total mean density at SSES I was 4,441 organisms/m^2 in 1994 (Table C-2). Most of these organisms were ephemeropterans (36%) and trichopterans (39%). The density of ephemeropterans decreased by almost 3,000 organisms/m^2 from June to August. This decrease occurred mainly because of the abundance of *Ephoron* sp., *Potamanthus* sp., and the heptageniids. In the October sample, ephemeropteran density increased by only 158 organisms/m^2. In 1994, 77% of trichopterans collected were *Cheumatopsyche* sp. as they were from 1991 through 1993. From June to August, the density of this genus decreased by 43%, but nearly tripled from August to October.

The total mean biomass at the two indicator sites, Bell Bend III (1.85 g/m^2) and Bell Bend IV (1.51 g/m^2), was less than one-half of the biomass at the SSES I control site (Table C-1). The ephemeropteran group was the principal component of the biomass at both indicator sites. It accounted for 74% of the weight at Bell Bend III and 65% at Bell Bend IV. Trichopterans composed 8% and 13% of the biomass at Bell Bend III and IV, respectively, and 25% at the SSES I control site. Dipterans composed 4% of the biomass at Bell Bend III and 9% at Bell Bend IV, but only 1% of it at the SSES I control site.

The total mean density at Bell Bend III (2,168 organisms/m^2) and at Bell Bend IV (2,155 organisms/m^2) was almost equal as shown in Tables C-3 and C-4. Similar numbers of ephemeropterans composed the highest percentage of organisms at Bell Bend III (46%) and at Bell Bend IV (45%). At both sites, most of the ephemeropterans were

Potamanthus sp., heptageniids, and *Ephoron* sp. Dipterans were the second most abundant group at the indicator sites. They were almost exclusively chironomidae. From June to August, total density decreased 63% at Bell Bend III and 39% at Bell Bend IV. This was primarily caused by decreases in ephemeropterans. From August to October, densities increased 147% at Bell Bend III and 70% at Bell Bend IV. Densities of ephemeropterans and dipterans increased substantially.

The total mean biomass at the SSES I control site was over 2.4-fold greater than that found at either of the Bell Bend indicator sites (Table C-1). The majority of the biomass at all three sites was composed of ephemeropterans. Relative to the Bell Bend sites, the weight of the ephemeropterans was about twice as great at SSES I. Trichopterans were the next largest component of the biomass at all sites; this group was 6.5 times greater at the control site compared to the indicator sites.

The annual mean density of benthic organisms was over 2-fold greater at SSES I compared to the average annual mean density at the Bell Bend sites (Tables C-2 through C-4). Ephemeropterans were the most numerous group of organisms at the Bell Bend sites and they were second in abundance at SSES I. Total mean density of ephemeropterans was greatest at SSES I (1,620 organisms/m^2) compared to Bell Bend III (1,000 organisms/m^2) and IV (960 organisms/m^2). The most numerous group at SSES I was the trichopterans (1,750 organisms/m^2). Trichopteran densities were much lower at both Bell Bend sites, less than 370 organisms/m^2. Dipterans were the second most numerous group at Bell Bend III (370 organisms/m^2) and Bell Bend IV (530 organisms/m^2). At SSES I, they were less abundant (320 organisms/m^2).

The percent composition of ephemeropterans and trichopterans in the biomass at SSES I and Bell Bend III and IV is shown from 1980 through 1994 in Fig. C-1. The percentage of trichopteran biomass was greater at the control site throughout 1987, but since 1988, ephemeropterans have dominated. In more recent years, the percentages of ephemeropterans have been similar at all three sites, except in 1993 and 1994 when they were much greater at both Bell Bend sites. The percentage of trichopterans in the 1994 biomass was greatest at SSES I (25%) compared to Bell Bend III (8%) and IV (13%). Trichopteran percentages have always been greatest at SSES I in all years since 1980, except during the drought in 1991 when it was greater at Bell Bend III (Ecology III 1992).

In both preoperational and operational years from 1980 through 1994, total mean biomass (June and October) has always been greater at the control site than at either indicator site (Table C-5). Overall, the ephemeropteran group made up a major portion of the biomass in each year since 1983 when the Susquehanna SES began operation. This group is indicative of good water quality, and it is encouraging to find it dominating in samples at both the control and the indicator sites. Benthic macroinvertebrate monitoring will be discontinued in 1995.

Table C-1

Weight, biomass (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, 1994.

GROUP	13-15 JUN			1-3 AUG			10-12 OCT			MEAN	
	Grams	g/m²	% Total	Grams	g/m²	% Total	Grams	g/m²	% Total	g/m²	% Total
SSES I											
Oligochaeta	0.0061	0.04	0.6	0.0019	0.01	0.4	0.0018	0.01	0.2	0.02	0.4
Crustacea	0.0000	0.00	0.0	0.0006	0.00	0.0	0.2451	1.50	33.5	0.50	11.2
Plecoptera	0.0010	0.01	0.2	0.0025	0.02	0.8	0.0019	0.01	0.2	0.01	0.2
Ephemeroptera	0.8633	5.29	80.3	0.2333	1.43	59.8	0.1225	0.75	16.7	2.49	55.6
Trichoptera	0.1379	0.85	12.9	0.0924	0.57	23.8	0.3273	2.01	44.9	1.14	25.4
Coleoptera	0.0463	0.28	4.2	0.0478	0.29	12.1	0.0266	0.16	3.6	0.24	5.4
Diptera	0.0124	0.08	1.2	0.0106	0.06	2.5	0.0012	0.01	0.2	0.05	1.1
Mollusca	0.0045	0.03	0.5	0.0006	0.00	0.0	0.0033	0.02	0.4	0.02	0.4
Other	0.0022	0.01	0.2	0.0020	0.01	0.4	0.0013	0.01	0.2	0.01	0.2
TOTAL	1.0737	6.59	100.1	0.3917	2.39	99.8	0.7310	4.48	99.9	4.48	99.9
BELL BEND III											
Oligochaeta	0.0019	0.01	0.4	0.0020	0.01	0.6	0.0018	0.01	0.8	0.01	0.5
Crustacea	0.0029	0.02	0.8	0.0000	0.00	0.0	0.0013	0.01	0.8	0.01	0.5
Plecoptera	0.0007	0.00	0.0	0.0138	0.08	4.9	0.0002	0.00	0.0	0.03	1.6
Ephemeroptera	0.3496	2.14	80.8	0.2021	1.24	75.6	0.1148	0.70	55.1	1.36	73.5
Trichoptera	0.0247	0.15	5.7	0.0147	0.09	5.5	0.0357	0.22	17.3	0.15	8.1
Coleoptera	0.0266	0.16	6.0	0.0121	0.07	4.3	0.0162	0.10	7.9	0.11	5.9
Diptera	0.0072	0.04	1.5	0.0191	0.12	7.3	0.0149	0.09	7.1	0.08	4.3
Mollusca	0.0184	0.11	4.2	0.0012	0.01	0.6	0.0113	0.07	5.5	0.06	3.2
Other	0.0025	0.02	0.8	0.0037	0.02	1.2	0.0115	0.07	5.5	0.04	2.2
TOTAL	0.4345	2.65	100.2	0.2687	1.64	100.0	0.2077	1.27	100.0	1.85	99.8
BELL BEND IV											
Oligochaeta	0.0037	0.02	0.7	0.0007	0.00	0.0	0.0061	0.04	4.0	0.02	1.3
Crustacea	0.0119	0.07	2.6	0.0003	0.00	0.0	0.0000	0.00	0.0	0.02	1.3
Plecoptera	0.0068	0.04	1.5	0.0057	0.03	3.4	0.0017	0.01	1.0	0.03	2.0
Ephemeroptera	0.3460	2.12	79.4	0.0564	0.35	39.3	0.0775	0.48	48.0	0.98	64.9
Trichoptera	0.0373	0.23	8.6	0.0240	0.15	16.9	0.0371	0.23	23.0	0.20	13.2
Coleoptera	0.0138	0.08	3.0	0.0098	0.06	6.7	0.0087	0.05	5.0	0.06	4.0
Diptera	0.0130	0.08	3.0	0.0358	0.22	24.7	0.0192	0.12	12.0	0.14	9.3
Mollusca	0.0055	0.03	1.1	0.0115	0.07	7.9	0.0008	0.00	0.0	0.03	2.0
Other	0.0005	0.00	0.0	0.0019	0.01	1.1	0.0107	0.07	7.0	0.03	2.0
TOTAL	0.4385	2.67	99.9	0.1461	0.89	100.0	0.1618	1.00	100.0	1.51	100.0

Table C-2

Number, density (no./m²), and percent total of benthic macroinvertebrates collected with a dome sampler at SSES I on the Susquehanna River, 1994.

GROUP	14 JUN			3 AUG			12 OCT			MEAN	
Taxon	No.	No./m²	% Total	No.	No./m²	% Total	No.	No./m²	% Total	No./m²	% Total
OLIGOCHAETA											
Unidentified	--	--	--	--	--	--	--	--	--	--	--
CRUSTACEA											
Amphipoda	0	0	0.0	1	6	0.3	1	6	0.2	4	0.1
Decapoda	0	0	0.0	0	0	0.0	1	6	0.2	2	0.0
PLECOPTERA											
Unidentified	4	25	0.3	1	6	0.3	5	31	0.8	21	0.5
EPHEMEROPTERA											
Ephoron sp.	221	1355	18.6	21	129	5.4	0	0	0.0	495	11.1
Potamanthus sp.	190	1165	16.0	14	86	3.6	25	153	4.2	468	10.5
Caenis sp.	3	18	0.2	3	18	0.8	0	0	0.0	12	0.3
Tricorythodes sp.	0	0	0.0	0	0	0.0	2	12	0.3	4	0.1
Isonychia sp.	15	92	1.3	0	0	0.0	49	300	8.2	131	2.9
Heptageniidae	132	809	11.1	50	307	12.9	44	270	7.4	462	10.4
Unidentified	14	86	1.2	8	49	2.1	2	12	0.3	49	1.1
TRICHOPTERA											
Chimarra sp.	1	6	0.1	4	25	1.1	9	55	1.5	29	0.6
Neureclipsis sp.	1	6	0.1	0	0	0.0	1	6	0.2	4	0.1
Polycentropus sp.	1	6	0.1	0	0	0.0	0	0	0.0	2	0.0
Hydropsychidae	31	190	2.6	0	0	0.0	10	61	1.7	84	1.9
Cheumatopsyche sp.	209	1281	17.6	120	736	31.0	331	2029	55.5	1349	30.4
Hydropsyche sp.	14	86	1.2	0	0	0.0	2	12	0.3	33	0.7
H. morosa	9	55	0.8	0	0	0.0	6	37	1.0	31	0.7
H. phalerata	26	159	2.2	0	0	0.0	19	116	3.2	92	2.1
Macrostemum sp.	2	12	0.2	2	12	0.5	10	61	1.7	28	0.6
Hydroptila sp.	1	6	0.1	0	0	0.0	0	0	0.0	2	0.0
Brachycentrus sp.	16	98	1.3	0	0	0.0	0	0	0.0	33	0.7
Leptoceridae	22	135	1.9	1	6	0.3	1	6	0.2	49	1.1
Unidentified	1	6	0.1	0	0	0.0	0	0	0.0	2	0.0
Unidentified (pupa)	7	43	0.6	1	6	0.3	0	0	0.0	16	0.4
COLEOPTERA											
Dineutes sp.	1	6	0.1	0	0	0.0	0	0	0.0	2	0.0
Berosus sp.	1	6	0.1	0	0	0.0	0	0	0.0	2	0.0
Elmidae (adult)	19	116	1.6	47	288	12.1	10	61	1.7	155	3.5
Macronychus sp.	0	0	0.0	1	6	0.3	1	6	0.2	4	0.1
Stenelmis sp.	92	564	7.7	89	546	23.0	52	319	8.7	476	10.7
DIPTERA											
Tipulidae (pupa)	1	6	0.1	0	0	0.0	0	0	0.0	2	0.0
Simuliidae (pupa)	1	6	0.1	0	0	0.0	0	0	0.0	2	0.0
Chironomidae	122	748	10.3	18	110	4.6	8	49	1.3	302	6.8
Chironomidae (pupa)	6	37	0.5	0	0	0.0	2	12	0.3	16	0.4
Empididae (adult)	1	6	0.1	0	0	0.0	0	0	0.0	2	0.0
MOLLUSCA											
Ferrissia sp.	0	0	0.0	1	6	0.3	0	0	0.0	2	0.0
Pisidium sp.	3	18	0.2	1	6	0.3	0	0	0.0	8	0.2
Sphaerium sp.	7	43	0.6	1	6	0.3	3	18	0.5	22	0.5
OTHER											
Alloeocoela	4	25	0.3	2	12	0.5	1	6	0.2	14	0.3
Tricladida	5	31	0.4	1	6	0.3	2	12	0.3	16	0.4
Nematoda	6	37	0.5	0	0	0.0	0	0	0.0	12	0.3
Coenagrionidae	0	0	0.0	1	6	0.3	0	0	0.0	2	0.0
TOTAL	1189	7288	100.2	388	2378	100.6	597	3656	100.1	4441	99.5

Table C-3

Number, density (no./m²), and percent total of benthic macroinvertebrates collected with a dome sampler at Bell Bend III on the Susquehanna River, 1994.

GROUP	15 JUN			2 AUG			10 OCT			MEAN	
Taxon	No.	No./m²	% Total	No.	No./m²	% Total	No.	No./m²	% Total	No./m²	% Total
OLIGOCHAETA											
Unidentified	--	--	--	--	--	--	--	--	--	--	--
CRUSTACEA											
Amphipoda	0	0	0.0	0	0	0.0	1	6	0.2	2	0.1
Decapoda	1	6	0.2	0	0	0.0	0	0	0.0	2	0.1
PLECOPTERA											
Unidentified	1	6	0.2	6	37	3.5	2	12	0.5	18	0.8
EPHEMEROPTERA											
Ephoron sp.	51	313	11.1	21	129	12.2	0	0	0.0	147	6.8
Potamanthus sp.	97	595	21.1	5	31	2.9	125	766	29.2	464	21.4
Caenis sp.	5	31	1.1	2	12	1.1	0	0	0.0	14	0.7
Isonychia sp.	1	6	0.2	0	0	0.0	2	12	0.5	6	0.3
Heptageniidae	91	558	19.8	35	215	20.3	47	288	11.0	354	16.3
Unidentified	0	0	0.0	2	12	1.1	4	25	1.0	12	0.6
TRICHOPTERA											
Neureclipsis sp.	2	12	0.4	3	18	1.7	2	12	0.5	14	0.6
Hydropsychidae	0	0	0.0	0	0	0.0	2	12	0.5	4	0.2
Cheumatopsyche sp.	17	104	3.7	25	153	14.4	72	441	16.8	233	10.7
Hydropsyche phalerata	0	0	0.0	2	12	1.1	1	6	0.2	6	0.3
Brachycentrus sp.	3	18	0.6	0	0	0.0	0	0	0.0	6	0.3
Leptoceridae	10	61	2.2	1	6	0.6	5	31	1.2	33	1.5
Unidentified (pupa)	8	49	1.7	1	6	0.6	0	0	0.0	18	0.8
COLEOPTERA											
Berosus sp.	0	0	0.0	0	0	0.0	1	6	0.2	2	0.1
Elmidae (adult)	4	25	0.9	2	12	1.1	1	6	0.2	14	0.7
Stenelmis sp.	101	619	21.9	32	196	18.5	31	190	7.3	335	15.5
DIPTERA											
Ceratopogonidae	1	6	0.2	0	0	0.0	0	0	0.0	2	0.1
Chironomidae	40	245	8.7	23	141	13.3	111	680	26.0	355	16.4
Chironomidae (pupa)	2	12	0.4	2	12	1.1	1	6	0.2	10	0.5
Chironomidae (adult)	1	6	0.2	0	0	0.0	0	0	0.0	2	0.1
MOLLUSCA											
Ferrissia sp.	10	61	2.2	2	12	1.1	2	12	0.5	28	1.3
Pisidium sp.	2	12	0.4	0	0	0.0	3	18	0.7	10	0.5
Sphaerium sp.	8	49	1.7	1	6	0.6	8	49	1.9	35	1.6
Lampsilis sp.	0	0	0.0	0	0	0.0	1	6	0.2	2	0.1
OTHER											
Alloeocoela	0	0	0.0	0	0	0.0	1	6	0.2	2	0.1
Tricladida	0	0	0.0	1	6	0.6	1	6	0.2	4	0.2
Nematoda	4	25	0.9	6	37	3.5	1	6	0.2	23	1.0
Coenagrionidae	1	6	0.2	0	0	0.0	1	6	0.2	4	0.2
Sialis sp.	0	0	0.0	1	6	0.6	2	12	0.5	6	0.3
TOTAL	461	2825	100.0	173	1059	99.9	428	2620	100.1	2168	100.2

Table C-4

Number, density (no./m²), and percent total of benthic macroinvertebrates collected with a dome sampler at Bell Bend IV on the Susquehanna River, 1994.

GROUP	13 JUN			1 AUG			11 OCT			MEAN	
Taxon	No.	No./m²	% Total	No.	No./m²	% Total	No.	No./m²	% Total	No./m²	% Total
OLIGOCHAETA											
Unidentified	--	--	--	--	--	--	--	--	--	--	--
CRUSTACEA											
Amphipoda	1	6	0.2	1	6	0.4	0	0	0.0	4	0.2
Decapoda	5	31	1.3	0	0	0.0	0	0	0.0	10	0.5
PLECOPTERA											
Unidentified	1	6	0.2	3	18	1.2	5	31	1.2	18	0.9
EPHEMEROPTERA											
Ephoron sp.	33	202	8.3	3	18	1.2	0	0	0.0	73	3.4
Potamanthus sp.	86	527	21.7	18	110	7.4	108	662	26.0	433	20.1
Caenis sp.	9	55	2.3	1	6	0.4	0	0	0.0	20	0.9
Tricorythodes sp.	0	0	0.0	0	0	0.0	1	6	0.2	2	0.1
Isonychia sp.	3	18	0.7	0	0	0.0	4	25	1.0	14	0.7
Heptageniidae	125	766	31.5	30	184	12.3	47	288	11.3	413	19.2
Unidentified	2	12	0.5	1	6	0.4	1	6	0.2	8	0.4
TRICHOPTERA											
Polycentropodidae	0	0	0.0	2	12	0.8	1	6	0.2	6	0.3
Neureclipsis sp.	0	0	0.0	8	49	3.3	2	12	0.5	20	0.9
Polycentropus sp.	0	0	0.0	1	6	0.4	0	0	0.0	2	0.1
Hydropsychidae	10	61	2.5	0	0	0.0	5	31	1.2	31	1.4
Cheumatopsyche sp.	15	92	3.8	52	319	21.4	53	325	12.8	245	11.4
Hydropsyche sp.	1	6	0.2	0	0	0.0	0	0	0.0	2	0.1
H. bifida gr.	1	6	0.2	0	0	0.0	0	0	0.0	2	0.1
H. morosa	1	6	0.2	0	0	0.0	0	0	0.0	2	0.1
H. phalerata	0	0	0.0	0	0	0.0	1	6	0.2	2	0.1
Macrostemum sp.	0	0	0.0	3	18	1.2	1	6	0.2	8	0.4
Brachycentrus sp.	1	6	0.2	0	0	0.0	2	12	0.5	6	0.3
Leptoceridae	10	61	2.5	3	18	1.2	1	6	0.2	28	1.3
Unidentified (pupa)	2	12	0.5	1	6	0.4	0	0	0.0	6	0.3
COLEOPTERA											
Dineutes sp.	1	6	0.2	0	0	0.0	0	0	0.0	2	0.1
Elmidae (adult)	2	12	0.5	1	6	0.4	0	0	0.0	6	0.3
Dubiraphia sp.	0	0	0.0	2	12	0.8	0	0	0.0	4	0.2
Stenelmis sp.	30	184	7.6	32	196	13.1	19	116	4.6	165	7.7
DIPTERA											
Ceratopogonidae	1	6	0.2	0	0	0.0	2	12	0.5	6	0.3
Chironomidae	36	221	9.1	65	398	26.7	146	895	35.2	505	23.4
Chironomidae (pupa)	5	31	1.3	1	6	0.4	3	18	0.7	18	0.9
MOLLUSCA											
Ferrissia sp.	5	31	1.3	0	0	0.0	0	0	0.0	10	0.5
Pisidium sp.	1	6	0.2	2	12	0.8	0	0	0.0	6	0.3
Sphaerium sp.	3	18	0.7	11	67	4.5	5	31	1.2	39	1.8
OTHER											
Alloeocoela	1	6	0.2	0	0	0.0	3	18	0.7	8	0.4
Tricladida	0	0	0.0	0	0	0.0	1	6	0.2	2	0.1
Nematoda	6	37	1.5	0	0	0.0	1	6	0.2	14	0.7
Sialis sp.	0	0	0.0	3	18	1.2	3	18	0.7	12	0.6
TOTAL	397	2431	99.6	244	1491	99.9	415	2542	99.7	2155	100.5

Table C-5

Annual mean biomass (g/m^2) of major groups of benthic macroinvertebrates collected with a dome sampler in June and October at SSES I, Bell Bend III, and Bell Bend IV on the Susquehanna River during preoperation and operation of the Susquehanna SES, 1980-94.[a]

GROUP	PREOPERATION			OPERATION											
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
SSES I															
Oligochaeta	0.17	0.36	0.19	0.34	0.18	0.01	0.05	0.02	0.10	0.07	0.02	<0.01	0.01	0.00	0.02
Crustacea	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.21	0.02	<0.01	0.80
Plecoptera	0.24	0.01	0.13	0.04	0.02	0.01	0.02	0.05	<0.01	0.08	0.01	0.33	<0.01	0.14	0.01
Ephemeroptera	0.32	0.68	1.18	1.63	0.70	1.11	0.88	2.13	2.75	1.80	1.36	5.50	1.96	3.48	3.02
Trichoptera	2.01	2.11	3.74	2.02	3.22	3.23	1.81	2.25	0.95	1.02	1.16	1.74	1.44	2.76	1.43
Coleoptera	0.18	0.06	0.10	0.17	0.07	0.17	0.09	0.19	0.19	0.14	0.20	0.64	0.18	0.41	0.22
Diptera	0.43	0.16	0.17	0.11	0.02	0.08	0.01	0.04	0.15	0.02	0.08	0.06	0.02	0.01	0.04
Mollusca	0.23	0.84	0.36	0.06	0.10	0.25	0.03	0.15	0.16	0.02	0.04	0.10	0.08	<0.01	0.02
Other	0.10	0.08	0.10	0.05	0.01	0.02	<0.01	0.17	0.18	0.01	0.01	0.04	0.02	0.06	0.01
TOTAL	3.69	4.30	5.97	4.42	4.32	4.88	<2.90	5.00	<4.50	3.17	2.88	<8.63	<3.74	<6.88	5.57
BELL BEND III															
Oligochaeta	0.23	0.22	0.26	0.07	0.02	0.01	0.02	0.03	0.04	0.09	0.03	<0.01	0.06	<0.01	0.01
Crustacea	0.00	0.01	0.00	0.02	<0.01	0.08	0.01	0.00	0.01	<0.01	<0.01	<0.01	0.01	0.00	0.02
Plecoptera	<0.01	<0.01	0.01	0.00	<0.01	<0.01	<0.01	<0.01	0.03	0.02	0.02	0.14	<0.01	0.00	0.00
Ephemeroptera	0.47	0.84	1.02	0.91	0.48	0.68	1.21	1.86	2.10	1.26	1.02	3.46	0.51	1.60	1.42
Trichoptera	0.24	0.48	0.22	0.23	1.55	0.33	0.52	0.25	0.17	0.07	0.07	1.98	0.33	0.05	0.18
Coleoptera	0.02	0.02	0.02	0.07	0.03	0.09	0.09	0.06	0.12	0.14	0.18	0.81	0.15	0.02	0.13
Diptera	0.30	0.07	0.40	0.20	0.08	0.06	0.02	0.01	0.03	0.06	0.30	0.12	0.04	0.12	0.06
Mollusca	0.32	0.73	0.36	0.14	0.01	0.10	0.27	0.07	0.11	0.15	0.19	0.22	0.07	<0.01	0.09
Other	0.24	0.11	0.08	0.09	<0.01	0.02	0.04	0.18	0.05	0.01	0.01	0.15	0.02	0.07	0.04
TOTAL	<1.83	<2.49	2.37	1.73	<2.20	<1.38	<2.19	<2.47	2.66	<1.81	<1.83	<6.90	<1.20	<1.88	1.95
BELL BEND IV															
Oligochaeta	–	–	–	–	–	–	0.01	0.02	0.04	0.08	0.04	<0.01	0.02	0.02	0.03
Crustacea	–	–	–	–	–	–	0.00	0.02	0.08	<0.01	<0.01	<0.01	0.00	0.00	0.04
Plecoptera	–	–	–	–	–	–	0.01	0.01	0.08	0.05	0.04	0.02	<0.01	0.00	0.02
Ephemeroptera	–	–	–	–	–	–	1.10	1.97	1.74	1.12	1.02	3.64	1.20	1.66	1.30
Trichoptera	–	–	–	–	–	–	0.64	0.34	0.71	0.12	0.20	0.50	0.50	0.04	0.23
Coleoptera	–	–	–	–	–	–	0.05	0.06	0.11	0.12	0.26	0.40	0.18	0.01	0.06
Diptera	–	–	–	–	–	–	0.02	0.01	0.03	0.04	0.18	0.12	0.02	0.05	0.10
Mollusca	–	–	–	–	–	–	0.11	0.15	0.45	0.12	0.12	0.16	0.16	0.02	0.02
Other	–	–	–	–	–	–	0.10	0.01	0.13	0.02	0.04	0.22	0.12	0.14	0.04
TOTAL	–	–	–	–	–	–	2.04	2.59	3.37	<1.68	<1.91	<5.08	<2.21	1.94	1.84

[a] August data were not included in this table because biomass samples were not always collected in this month during all years. In 1990, high river levels prevented the collection of October samples until 5-7 November.

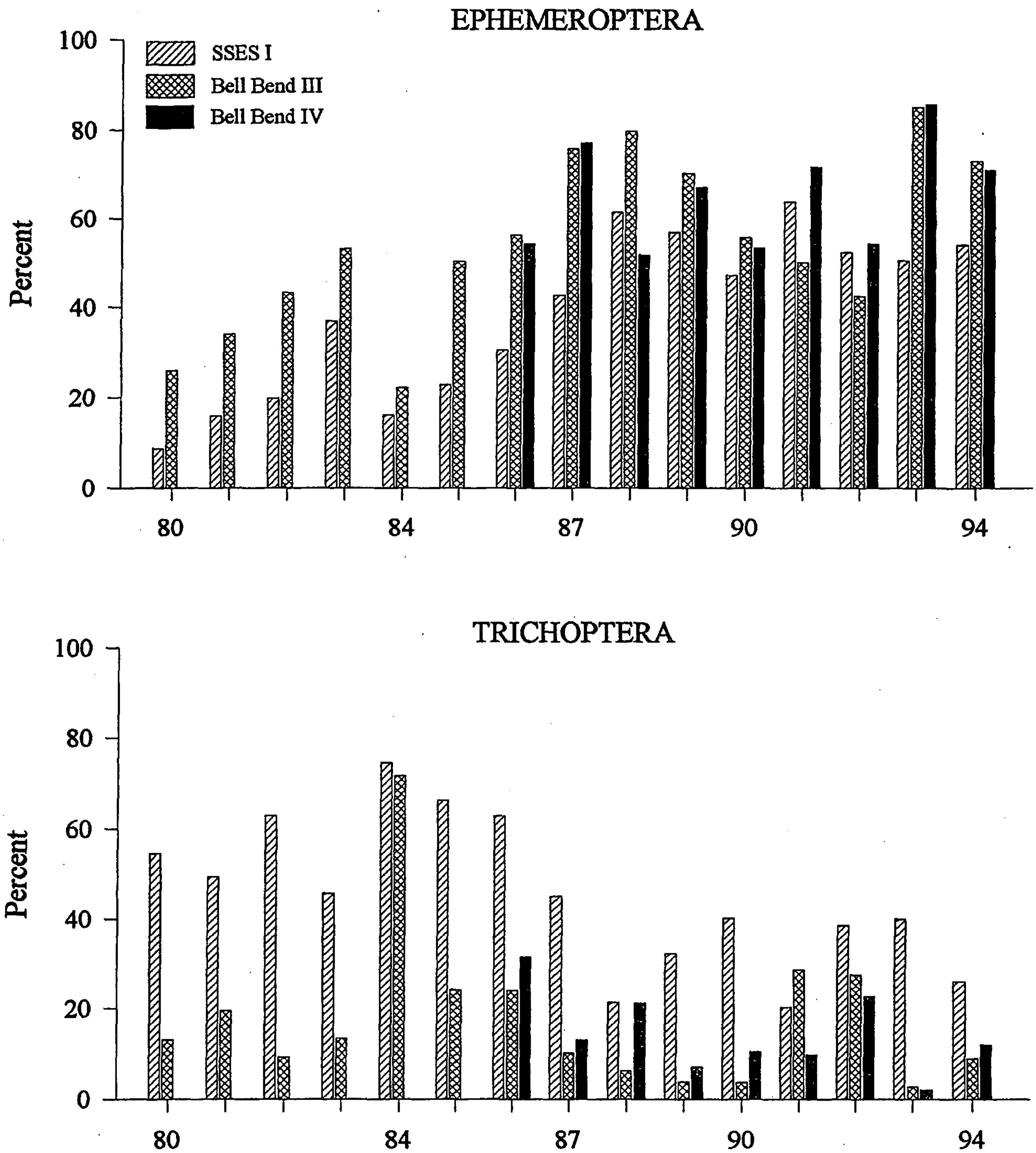

Fig. C-1

Percent annual mean biomass of ephemeroptera and trichoptera in June and October at SSES I, Bell Bend III, and Bell Bend IV on the Susquehanna River during preoperation (1980-82) and operation (1983-94) of the Susquehanna SES. In 1990, high river levels prevented the collection of October samples until 5-7 November.

FISHES

PROCEDURES

Electrofishing

Monthly electrofishing samples were collected from May through August and October at four 1,000-m long sites in 1994. Two sites were sampled at both the SSES and Bell Bend stations (Table D-1; Fig. D-1). All sampling was done at river levels less than 493.1 feet above mean sea level, because electrofishing is ineffective at higher levels due to increased turbidity and current. The sampling runs were usually made within 50 m of the river bank, unless shallow river depths prevented sampling near the shore. Sampling began about one hour after sunset.

The electrofisher, similar to that described by Novotny and Priegel (1974), consisted of a 5-KW generator (direct current) with a variable voltage pulsator mounted in a 6-m-flat-bottomed boat. Two observers stood in the bow of the boat and identified and counted fish during each 1,000-m run. Data were recorded using a cassette tape recorder.

BACI Analysis. A Before-After:Control-Impact (BACI) analysis was applied to 20 species or categories of fish (e.g., bluegill or sunfish spp.) observed during electrofishing at SSES and Bell Bend from 1976 through 1994. These species or categories were chosen based upon frequency of occurrence, using the criterion of a minimum of eight occurrences in the preoperational or operational periods of Susquehanna SES operation. The BACI analysis was applied to two different electrofishing data sets. The first set

included all months sampled by electrofishing at both stations and the second was only June, August and October. Results from each data set are reported.

Habitat Studies. In 1993 fieldwork was begun for an investigation into the relationship between habitat and fish distribution in this area of the river. This investigation is a partial response to the statistical significance reported by the BACI model in past years and received the endorsement of independent reviewers (Smith et al. 1990). This research continued through 1994.

The study involved dividing and labeling each of the traditional 1,000-m electrofishing runs into consecutive 40-m segments, and after electroshocking the runs and identifying the fishes within them, measuring the habitat variables associated with each segment. Because electrofishing was done in the evenings, all of the habitat variables, except substrate, were measured on the next day.

The variables measured were water depth, velocity, substrate size and cover. Depth and velocity were measured concurrently within each 40-m segment at three points along a transect that followed the center of the electrofishing run. Depths were measured to the nearest 0.1 ft with a graduated telescopic stadia. Velocities were measured to the nearest 0.01 m sec^{-1} at 0.6 the depth of the water column using a Marsh-McBirney portable water current meter (Model 201D). Substrate diameters (nearest cm) were measured by scuba diving in the segments. This was done only once in the sample year because substrates were expected to change little during this period.

Electrofishing samples for this study were collected approximately biweekly from June through November in 1993, and in May through November 1994. Consequently, 12

samples were collected in the first year and 15 in the second. Five of these samples also represented the electrofishing efforts in the 1994 fish monitoring program (Tables D-3 and D-4). Some results of preliminary analysis of the fish-habitat data are reported here.

Seining

Shoreline fishes, primarily cyprinids, were collected with a 7.6-m bag seine (6-mm mesh) at four sites in 1994. Two sites were at both the SSES and Bell Bend sampling stations (Table D-1; Fig. D-1). Samples were collected during June, September, and October when river levels were less than 490.2 ft above msl.

To sample, one seine brail was kept stationary on the river bank as the seine was taken about 6 m into the river, if not limited by depth. The seine was then pulled upriver and into shore. Two hauls were made in the same location at each site, and the catches from both hauls were combined and considered one unit of effort. Fishes were placed in 10% formalin in the field and stored in the laboratory for at least two weeks. Next they were soaked in water, and then identified and enumerated before final preservation in 40% isopropanol.

BACI Analysis. BACI analysis was applied to 12 species of fish captured in seine samples from 1977 through 1994. As in electrofishing samples, the species chosen for this analysis were those that occurred frequently enough in samples for Before-After comparisons.

RESULTS AND DISCUSSION

Electrofishing

Electrofishing at SSES and Bell Bend in 1994 resulted in the observation of 855 fish of 21 species (Tables D-2 through D-4). This total is almost half the number of fish observed in 1993, and five fewer species. Smallmouth bass were the most abundant of the 471 fish observed at SSES (73) and of the 384 fish observed at Bell Bend (100). Most of the smallmouths were observed during the June through August samples, and many of these were young-of-the-year (YOY) fish (Tables D-3 and D-4). Smallmouth bass, walleye, quillback and northern hog sucker composed 56% of the fish observed at SSES and 53% of those at Bell Bend.

The mean numbers of fish at SSES and Bell Bend were within the ranges established in preoperational years for those sampled months available for comparison (June, August, October). However, the number at SSES was the second lowest ever recorded, while the number at Bell Bend was the third lowest ever. At both SSES and Bell Bend, the largest numbers of fish were observed in October.

Sixteen species were observed at SSES and 17 species at Bell Bend. Species in the sucker and sunfish families predominated in the overall numbers in most months, and in annual means, at both stations. Unusual fish sightings included a rainbow trout and a brown trout in June and October, respectively, at SSES, and an unidentified member of the herring family in May at Bell Bend.

BACI Results. Of the 20 species of fish for which data were tested using the BACI analysis, 11 species from the data set of all months sampled and 11 species from the June through October data showed marginal or significant effects. Results from the data set of all months sampled were similar to those reported in 1993 (Ecology III, Inc. 1994), while the June through October set revealed that two species were added to the list of affected species when compared to the past five years. However, all of the species that indicated significant changes in their numbers in 1994, had already shown significance at least once within 1989-93.

Species that showed significant changes in their numbers ($P \leq 0.05$) in the data set of all months included muskellunge, fallfish, quillback, white sucker, northern hog sucker, shorthead redhorse, brown bullhead, rock bass, smallmouth bass, and unidentified fish. Sunfish spp. was the only group to show marginal declines ($P \leq 0.10$). Effects on these species were adverse, indicating a relative decline in their numbers at Bell Bend after station start-up, except brown bullhead, which showed an increase in numbers at the Bell Bend sites.

In the June through October data set, significant declines occurred in muskellunge, quillback, white sucker, northern hog sucker, shorthead redhorse, rock bass, smallmouth bass, unidentified fish. Brown bullhead indicated significant increase in numbers. Walleye and sunfish species showed marginally significant declines.

Habitat Studies. A total of 5,662 fish of 22 species was observed during habitat sampling in 1993-94. Walleye, smallmouth bass, rock bass, and quillback composed 72% of the species observed. Most of the 40-m sections, when they contained fish, had only

one or a few individuals. Rarely were more than six fish observed in a section. The same could be said of the number of species per section because most contained one or two species. The maximum number of species observed in 2,700 total sections (100 sections by 27 sampling dates) was seven, and this occurred only once.

River levels on the sampling dates varied considerably between 1993 and 1994. The level ranged from a minimum of 3.2 ft to a maximum of 8.5 ft, with an average of 5.2 ft for both years combined (SD = 1.68). In 1993 the average level was 4.3 ft (SD = 1.37) and 83% of the sampling occurred at levels between 3.2 and 4.4 ft, while in 1994 the average level was 6 ft (SD =1.47) and 87% of the sampling occurred at levels between 4.5 and 8.5 ft. Further, in the summer and early autumn 1994, numerous spates occurred during what is normally a low water period. These two very different years were valuable in that they provide a broad range of levels for comparative habitat use. However, it may have been more beneficial to see the approximate levels from the first year repeated.

The habitat measurements that corresponded with these samples included: 200 plus substrate and cover measurements, and 16,200 measurements of depth and velocity (combined). Depth and velocity were in most cases poorly correlated, which strengthens the assumption that these variables may stand alone in their relationship to fish.

Relatively little natural cover, i.e., aquatic macrophytes, deadfalls, etc., was observed in both years. Though the association between fish and cover remains to be formally analyzed, it seemed that contrary to general expectations, association between adult fish and cover was weak. However, juvenile fish were abundant at certain times in those few areas of the runs that contained macrophytes. The lack of association between

adults and cover may be due to the general paucity of cover in the sampled areas. Further, this may also be an artifact of sampling, because much of the cover, e.g., deadfalls, stuck out of the water and had to be circumnavigated rather than crossed by the electrofishing boat, perhaps preventing the electric field from adequately reaching these areas.

Cover was manipulated in 1994 to try to improve investigation of this variable. Two brush-piles, 1-m high, 1-m wide, and 8-10-m long, were weighted and placed in each of the four electrofishing runs. Unfortunately, these attempts were not very successful, because twice these brush-piles were lost to high water. Further attempts may be made at cover manipulations again in 1995.

Work continues on collation and analysis of these data and the proposed relationship between fish distribution and habitat. A limited amount of fieldwork, such as further attempts at cover manipulations, is planned for 1995. This will be done in conjunction with the traditional fish monitoring studies.

Seining

Seining at SSES and Bell Bend in 1994 resulted in the capture of 890 fish of 17 species (Tables D-2 and D-5). As in the electrofishing data, this number represents half of the total specimens captured in 1993, and five fewer species. Spottail shiner was the most abundant (86) of the 215 fish collected at SSES, and white sucker (316) was the most abundant of the 675 fish at Bell Bend. Spottail shiner, spotfin shiner and white sucker represented 87% and 92% of the total captured at SSES and Bell Bend, respectively. The

mean number of fish captured per unit effort at SSES was the lowest ever for the months of June, September, and October. The mean number collected at Bell Bend was within the range established in preoperational years. Fifteen species were captured at SSES and ten at Bell Bend. These species were primarily of the minnow and sunfish families at both stations.

BACI Results. The results of the 12 seined species tested by the BACI analysis indicated that YOY smallmouth bass marginally declined in numbers below the Susquehanna SES effluent (P = 0.07). This outcome was predicted in the 1993 annual report (Ecology III, Inc. 1994), because smallmouth bass then showed a trend toward decline at the downriver stations. This result is not surprising because smallmouth bass showed significant decrease in numbers in both BACI electrofishing data sets. This species is one of only a few collected regularly by both electrofishing and seining.

Table D-1

Description of electrofishing (EL) and seining (SN) sites at SSES and Bell Bend on the Susquehanna River, 1994.

SITE	LOCATION
	SSES (Control)
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 Environmental Laboratory)
	BELL BEND (Indicator)
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

Fish species that were observed while electrofishing or collected by seining at SSES and Bell Bend on the Susquehanna River, 1994. Names of fishes and order of listing conform to Robins et al. (1991).

COMMON NAME	SCIENTIFIC NAME	COMMON NAME	SCIENTIFIC NAME
Herrings	Clupeidae	Pikes	Esocidae
Herring spp.		Muskellunge	*Esox masquinongy*
Carps and Minnows	Cyprinidae	Trouts	Salmonidae
Spotfin shiner	*Cyprinella spiloptera*	Rainbow trout	*Oncorhynchus mykiss*
Common carp	*Cyprinus carpio*	Brown trout	*Salmo trutta*
Cutlips minnow	*Exoglossum maxillingua*		
Golden shiner	*Notemigonus crysoleucas*	Sunfishes	Centrarchidae
Comely shiner	*Notropis amoenus*	Rock bass	*Ambloplites rupestris*
Spottail shiner	*Notropis hudsonius*	Redbreast sunfish	*Lepomis auritus*
Bluntnose minnow	*Pimephales notatus*	Green sunfish	*Lepomis cyanellus*
Creek chub	*Semotilus atromaculatus*	Bluegill	*Lepomis macrochirus*
Fallfish	*Semotilus corporalis*	Smallmouth bass	*Micropterus dolomieu*
		Largemouth bass	*Micropterus salmoides*
		White crappie	*Pomoxis annularis*
Suckers	Catostomidae		
Quillback	*Carpiodes cyprinus*		
White sucker	*Catostomus commersoni*	Perches	Percidae
Northern hog sucker	*Hypentelium nigricans*	Tessellated darter	*Etheostoma olmstedi*
Shorthead redhorse	*Moxostoma macrolepidotum*	Yellow perch	*Perca flavescens*
		Walleye	*Stizostedion vitreum*
Bullhead Catfishes	Ictaluridae		
Brown bullhead	*Ameiurus nebulosus*		
Channel catfish	*Ictalurus punctatus*		

D-3

›er, mean, and percent total of fish observed while electrofishing at SSES on the Susquehanna River, 1994.

:IES	4 MAY				14 JUN				14 JUL				9 AUG				10 OCT				OVERALL	
	East	West	Mean	% Total	East	West	Mean	% Total	East	West	Mean	% Total	East	West	Mean	% Total	East	West	Mean	% Total	Mean	% Total
aon carp	4	1	2.5	6.2	2	1	1.5	3.7	0	2	1.0	2.3	0	1	0.5	0.9	1	0	0.5	0.9	1.2	2.5
;h	1	0	0.5	1.2	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0.1	0.2
›ack	10	4	7.0	17.3	1	0	0.5	1.2	3	4	3.5	8.0	8	17	12.5	23.6	9	7	8.0	13.9	6.3	13.4
: sucker	4	2	3.0	7.4	3	1	2.0	4.9	0	2	1.0	2.3	7	1	4.0	7.5	3	1	2.0	3.5	2.4	5.1
.ern hog sucker	0	2	1.0	2.5	2	0	1.0	2.5	4	2	3.0	6.8	5	8	6.5	12.3	2	32	17.0	29.6	5.7	12.1
head redhorse	7	6	6.5	16.0	4	2	3.0	7.4	2	1	1.5	3.4	0	1	0.5	0.9	1	1	1.0	1.7	2.5	5.3
r spp.	4	0	2.0	4.9	2	3	2.5	6.2	1	3	2.0	4.5	0	2	1.0	1.9	5	1	3.0	5.2	2.1	4.5
ıel catfish	0	1	0.5	1.2	1	2	1.5	3.7	1	0	0.5	1.1	1	1	1.0	1.9	0	0	0.0	0.0	0.7	1.5
ellunge	1	0	0.5	1.2	0	0	0.0	0.0	1	0	0.5	1.1	0	0	0.0	0.0	1	0	0.5	0.9	0.3	0.6
spp.	1	0	0.5	1.2	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0.1	0.2
›ow trout	0	0	0.0	0.0	0	1	0.5	1.2	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0.1	0.2
ı trout	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	1	0	0.5	0.9	0.1	0.2
bass	1	0	0.5	1.2	2	4	3.0	7.4	1	5	3.0	6.8	10	14	12.0	22.6	2	2	2.0	3.5	4.1	8.7
reast sunfish	0	0	0.0	0.0	0	0	0.0	0.0	1	0	0.5	1.1	1	0	0.5	0.9	0	0	0.0	0.0	0.2	0.4
ı sunfish	0	0	0.0	0.0	0	1	0.5	1.2	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0.1	0.2
mouth bass	3	1	2.0	4.9	9	8	8.5	21.0	18	11	14.5	33.0	9	7	8.0	15.1	7	0	3.5	6.1	7.3	15.5
: crappie	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.5	0.9	0	0	0.0	0.0	0.1	0.2
;h spp.	0	0	0.0	0.0	2	5	3.5	8.6	1	2	1.5	3.4	1	0	0.5	0.9	1	0	0.5	0.9	1.2	2.5
ye	15	2	8.5	21.0	3	10	6.5	16.0	3	6	4.5	10.2	3	0	1.5	2.8	12	15	13.5	23.5	6.9	14.6
(unidentified)	4	7	5.5	13.6	11	1	6.0	14.8	6	8	7.0	15.9	5	3	4.0	7.5	6	5	5.5	9.6	5.6	11.9
ıL	55	26	40.5		42	39	40.5		42	46	44.0		50	56	53.0		51	64	57.5		47.1	

D-4

er, mean, and percent total of fish observed while electrofishing at Bell Bend on the Susquehanna River, 1994.

IES	4 MAY				14 JUN				14 JUL				9 AUG				10 OCT				OVERALL	
	East	West	Mean	% Total	East	West	Mean	% Total	East	West	Mean	% Total	East	West	Mean	% Total	East	West	Mean	% Total	Mean	% Total
ıg spp.	1	0	0.5	1.5	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0.1	0.3
ıon carp	2	2	2.0	5.9	0	1	0.5	1.7	1	0	0.5	1.6	0	0	0.0	0.0	3	0	1.5	2.7	0.9	2.3
h	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	1	3	2.0	3.6	0.4	1.0
ack	10	3	6.5	19.1	1	1	1.0	3.4	3	0	1.5	4.7	1	4	2.5	6.0	12	4	8.0	14.5	3.9	10.2
sucker	2	1	1.5	4.4	0	0	0.0	0.0	3	0	1.5	4.7	2	0	1.0	2.4	7	1	4.0	7.3	1.6	4.2
ern hog sucker	2	2	2.0	5.9	0	1	0.5	1.7	1	1	1.0	3.1	5	0	2.5	6.0	0	2	1.0	1.8	1.4	3.6
ıead redhorse	8	8	8.0	23.5	4	0	2.0	6.9	0	0	0.0	0.0	0	0	0.0	0.0	3	0	1.5	2.7	2.3	6.0
r spp.	0	1	0.5	1.5	0	0	0.0	0.0	1	0	0.5	1.6	0	2	1.0	2.4	3	3	3.0	5.5	1.0	2.6
ı bullhead	0	0	0.0	0.0	0	0	0.0	0.0	1	0	0.5	1.6	1	0	0.5	1.2	0	0	0.0	0.0	0.2	0.5
ıel catfish	1	0	0.5	1.5	0	0	0.0	0.0	0	1	0.5	1.6	1	0	0.5	1.2	0	0	0.0	0.0	0.3	0.8
bass	1	1	1.0	2.9	4	6	5.0	17.2	2	1	1.5	4.7	5	10	7.5	17.9	1	6	3.5	6.4	3.7	9.6
sunfish	0	0	0.0	0.0	1	0	0.5	1.7	0	0	0.0	0.0	0	1	0.5	1.2	0	0	0.0	0.0	0.2	0.5
ll	0	0	0.0	0.0	0	0	0.0	0.0	1	0	0.5	1.6	0	0	0.0	0.0	1	0	0.5	0.9	0.2	0.5
nouth bass	7	1	4.0	11.8	11	9	10.0	34.5	12	18	15.0	46.9	9	14	11.5	27.4	8	11	9.5	17.3	10.0	26.0
nouth bass	0	0	0.0	0.0	0	0	0.0	0.0	2	0	1.0	3.1	0	0	0.0	0.0	0	0	0.0	0.0	0.2	0.5
crappie	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	1	0	0.5	1.2	0	1	0.5	0.9	0.2	0.5
h spp.	0	0	0.0	0.0	1	0	0.5	1.7	0	0	0.0	0.0	6	6	6.0	14.3	0	0	0.0	0.0	1.3	3.4
v perch	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	1	0	0.5	0.9	0.1	0.3
/e	3	1	2.0	5.9	4	6	5.0	17.2	1	3	2.0	6.3	2	1	1.5	3.6	14	17	15.5	28.2	5.2	13.5
unidentified)	8	3	5.5	16.2	4	4	4.0	13.8	7	5	6.0	18.8	6	7	6.5	15.5	6	2	4.0	7.3	5.2	13.5
ıL	45	23	34.0		30	28	29.0		35	29	32.0		39	45	42.0		60	50	55.0		38.4	

Table D-5

Number, mean, and percent total of fish captured by seining at SSES and Bell Bend on the Susquehanna River, 1994.

SPECIES	13 JUN				19 SEP				27 OCT				OVERALL	
	East	West	Mean	% Total	East	West	Mean	% Total	East	West	Mean	% Total	Mean	% Total
SSES														
Spotfin shiner	15	37	26.0	28.3	9	2	5.5	50.0	0	0	0.0	0.0	10.5	29.3
Cutlips minnow	1	0	0.5	0.5	0	0	0.0	0.0	0	0	0.0	0.0	0.2	0.5
Golden shiner	0	1	0.5	0.5	0	0	0.0	0.0	0	0	0.0	0.0	0.2	0.5
Comely shiner	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.5	11.1	0.2	0.5
Spottail shiner	18	62	40.0	43.5	3	1	2.0	18.2	0	2	1.0	22.2	14.3	40.0
Bluntnose minnow	3	0	1.5	1.6	0	0	0.0	0.0	0	0	0.0	0.0	0.5	1.4
Fallfish	0	0	0.0	0.0	2	0	1.0	9.1	0	0	0.0	0.0	0.3	0.9
Quillback	3	1	2.0	2.2	0	0	0.0	0.0	0	0	0.0	0.0	0.7	1.9
White sucker	24	14	19.0	20.7	0	0	0.0	0.0	0	0	0.0	0.0	6.3	17.7
Muskellunge	1	1	1.0	1.1	0	0	0.0	0.0	0	0	0.0	0.0	0.3	0.9
Rock bass	0	3	1.5	1.6	0	0	0.0	0.0	0	5	2.5	55.6	1.3	3.7
Bluegill	0	0	0.0	0.0	0	1	0.5	4.5	0	0	0.0	0.0	0.2	0.5
Smallmouth bass	0	0	0.0	0.0	0	1	0.5	4.5	0	0	0.0	0.0	0.2	0.5
Tessellated darter	0	0	0.0	0.0	2	0	1.0	9.1	1	0	0.5	11.1	0.5	1.4
Yellow perch	0	0	0.0	0.0	0	1	0.5	4.5	0	0	0.0	0.0	0.2	0.5
TOTAL	65	119	92.0		16	6	11.0		1	8	4.5		35.8	
BELL BEND														
Spotfin shiner	87	59	73.0	26.3	3	6	4.5	47.4	3	18	10.5	20.8	29.3	26.1
Spottail shiner	27	23	25.0	9.0	2	4	3.0	31.6	63	9	36.0	71.3	21.3	19.0
Bluntnose minnow	0	1	0.5	0.2	1	0	0.5	5.3	0	0	0.0	0.0	0.3	0.3
Creek chub	1	0	0.5	0.2	0	0	0.0	0.0	0	0	0.0	0.0	0.2	0.1
Fallfish	7	1	4.0	1.4	0	0	0.0	0.0	0	0	0.0	0.0	1.3	1.2
Quillback	26	6	16.0	5.8	0	0	0.0	0.0	0	0	0.0	0.0	5.3	4.7
White sucker	92	223	157.5	56.8	0	1	0.5	5.3	0	0	0.0	0.0	52.7	46.8
Rock bass	0	0	0.0	0.0	0	0	0.0	0.0	0	5	2.5	5.0	0.8	0.7
Tessellated darter	2	0	1.0	0.4	1	1	1.0	10.5	0	2	1.0	2.0	1.0	0.9
Walleye	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.5	1.0	0.2	0.1
TOTAL	242	313	277.5		7	12	9.5		66	35	50.5		112.5	

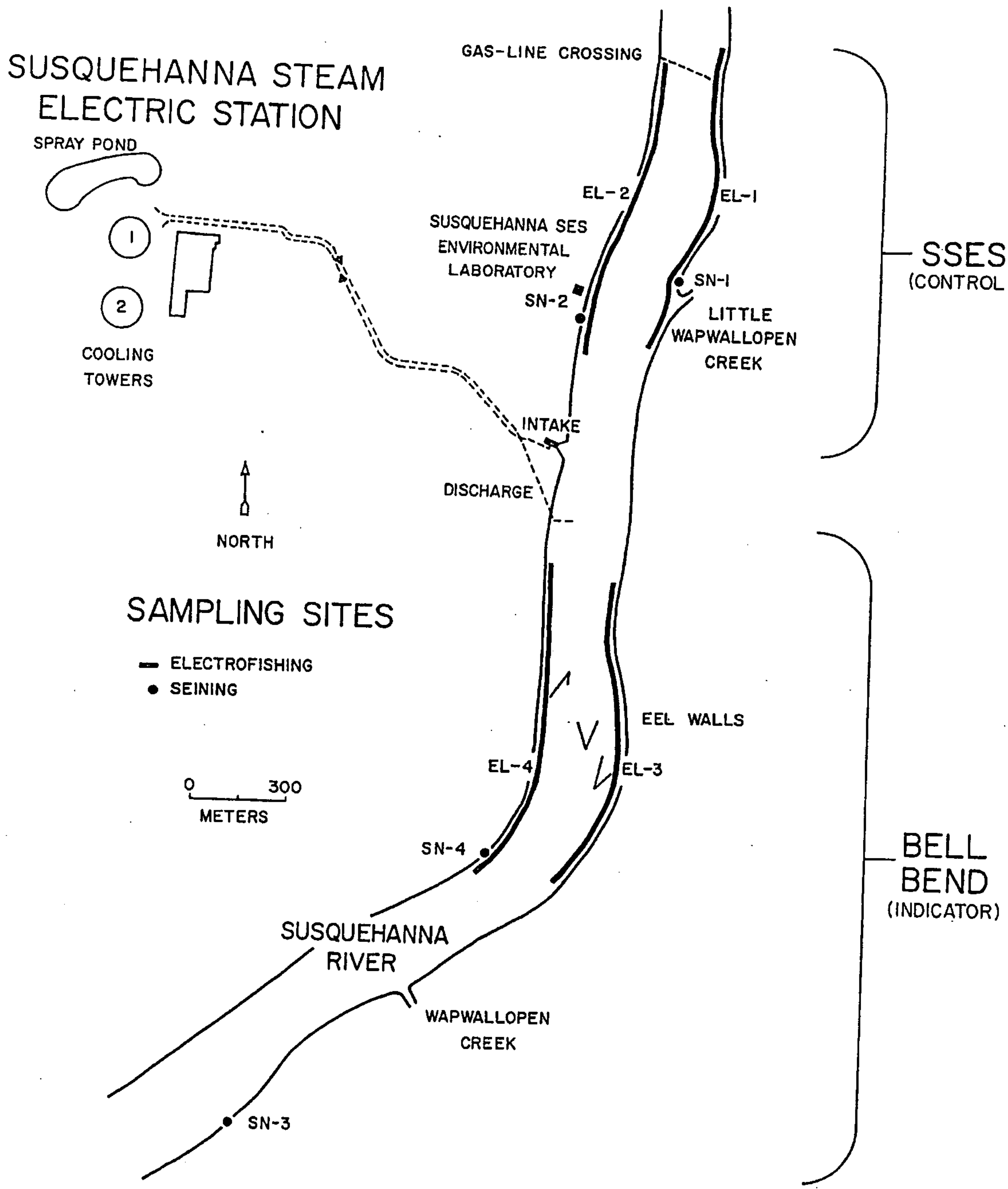

Fig. D-1

Sampling sites for electrofishing (EL) and seining (SN) at SSES and Bell Bend on the Susquehanna River, 1994.

FLORA AND VEGETATION

PROCEDURES

Flora

Floristic studies were conducted from March through October 1994. Transects established in 1977 on both sides of the Susquehanna River in the vicinity of the Susquehanna SES (Fig. E-1) were used from 1977 through 1991 and 1993 (no floristic studies were conducted in 1992). In 1994, five transects were utilized 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. These transects were at varying distances and directions from the Susquehanna SES in mostly forested areas (Table E-1; Fig. E-1). For comparison with the five Susquehanna SES transects, an off-site control transect, established in 1982 at the Elimsport Substation near Elimsport, Lycoming County, Pennsylvania, was also surveyed in 1994.

On each salt drift transect, parasitic plant diseases were recorded according to host species. Frequency and relative effect of the disease on the host were noted and recorded as a coded value (Table E-2). Each transect was surveyed once a month from March through October. Parasitic plant diseases were identified using U. S. Department of Agriculture (1960), Sinclair et al. (1987), and Westcott (1990).

Vegetation

Quantitative vegetation studies at the Susquehanna SES were conducted in two upland forests, Council Cup Forest and Township Road 419 (TR419) Forest (Fig. E-1), and in a control upland forest at Elimsport Substation. Council Cup Forest is located on a moderate east-facing slope. TR419 Forest is located on a steep south-facing hillside. Both are located within 3 km of the Susquehanna SES in Luzerne County, Pennsylvania. The Elimsport Substation Forest (control plot) is located on a moderate south-facing slope, 5.4 km northeast of Elimsport, Lycoming County, Pennsylvania, 72 km northwest of the Susquehanna SES.

The forest plots were sampled in July for trees and saplings using 10x10-m quadrats, and for seedlings, shrubs, herbs, and ground cover using nested 1x1-m quadrats (Cain and Castro 1959). Details of this sampling procedure were discussed in Ichthyological Associates, Inc. (1985). Frequency, relative frequency, density, relative density, dominance, and relative dominance were calculated (Cain and Castro 1959). Importance value was found as the sum of relative frequency + relative density + relative dominance. Density was not used for shrubs, herbs, or ground cover since number of stems was not considered useful for these frequently colonial species.

Comparisons of data collected from 1977 through 1994 (vegetation data were not collected in 1992) were made using a repeated measures analysis of variance with a test for linear trends (Sokal and Rohlf 1969). Quadrat by quadrat tests were made using number of stems per quadrat for each tree, sapling, and seedling species, and percent

cover for shrubs, herbs, and ground cover. Significant changes ($P \leq 0.05$ or $P \leq 0.01$) were tested for linear trends to show increase (+), decrease (-), or no trend.

RESULTS AND DISCUSSION

Flora

Forty parasitic diseases were observed on 56 host species (Table E-2). As in 1977-93, leaf spots were the most frequent diseases encountered, accounting for 19 of the 40 diseases (48%) on 21 host species (38%). Powdery mildew occurred on 18 species (32%); 7 rust diseases occurred on 16 species (29%). Disease frequency ranged from rare to abundant (Table E-2). Disease effect ranged from discoloration only for powdery mildews, to minor leaf necrosis for most other diseases. Numbers of diseases were higher than previously recorded during preoperational and operational studies of forest transects for Council Cup and TR438 and near the upper end of ranges on other transects (Table E-3). Except on TR438, means for operational years are somewhat higher than preoperational means; this appears to be due to higher numbers of diseases on all transects in the last two years. There has been a gradual, irregular increase in the total number of diseases on all transects from 1977 through 1994 (Table E-3); the reason for this is unknown, although observer familiarity with the diseases may be a factor. The number and severity of diseases are also related to weather and host presence on the transect. No effects were observed in 1994 that could be attributed to the operation of the Susquehanna SES, and no evidence of salt drift damage was found.

Vegetation

In the Council Cup Forest in 1994, *Betula lenta* was the most important (highest importance value) tree (Table E-4), *Acer rubrum* was the most important sapling (Table E-5), and most important seedling (Table E-6). These two species have been the most important in these three classes since the study began in 1977, including preoperational (1977-82) and operational (1983-94) periods. Tree density was 640 trees/ha (Table E-4), about the same value as the last several years (Fig. E-2). Sapling density was 1,010/ha (Table E-5), about the same as 1993, but continuing a general decline in sapling density recorded since 1977; this is a successional change as saplings are crowded out or recruited into tree size class. Seedling density was 38,500/ha (Table E-6), near the average value over the last several years (Fig. E-2). *Kalmia latifolia* was the most important shrub in 1994 (Table E-7). *Lycopodium digitatum* was the most important herb and 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 E-8), as in previous years. *Cornus florida* was the most important sapling (Table E-9); this species was the most important sapling before 1991, when it was replaced by *Acer rubrum*. *Cornus florida* has declined in importance due to leaf spot/dieback disease, but may be increasing since the disease has not been as damaging in the last two years. *Acer rubrum* was the most important tree seedling, as in 1993. Tree density was 467/ha (Table E-8), a slight decrease from 1993 (Fig. E-2). Sapling density was 629/ha (Table E-9); sapling density has exhibited an irregular decline from 1977 through 1994 (Fig. E-2). Seedling

density was 43,477/ha (Table E-10), a slight decrease from 1993 (Fig. E-2). *Rubus allegheniensis* was the most important shrub, *Dennstaedtia punctilobula* was the most important herb, and litter was the predominate ground cover (Table E-11). In general, there have been few changes among important species in this plot, and percent cover values are low (<10%) for all species of shrubs and herbs.

In the Elimsport Substation Forest, *Betula lenta* was the most important tree (Table E-12), and most important sapling (Table E-13), and *Acer rubrum* the most important seedling (Table E-14). The same species have been most important trees, saplings, and seedlings in most years since studies began at Elimsport in 1982. Tree density was 1,015/ha (Table E-12), continuing an increase observed each year since 1982 (Fig. E-2). Sapling density was 1,690/ha (Table E-13), continuing a decrease observed since 1982 (Fig. E-2). Seedling density was 90,500/ha (Table E-14), higher than the values reported in most previous years (Fig. E-2). *Smilax rotundifolia* was the most important shrub, *Dennstaedtia punctilobula* was the most important herb, and litter was the predominate ground cover (Table E-15). Each of these has been the most important in previous years.

A total of 82 significant changes was found for the three upland forest plots in trees, saplings, seedlings, shrubs, herbs, and ground cover (Tables E-16 through E-19). Few significant changes occurred among trees (Table E-16). There were more numerous changes among saplings (Table E-17); these were mostly decreases. At Council Cup Forest, the decreases in saplings are successional in nature (Ecology III, Inc. 1994). Sapling changes were less numerous and more variable in the TR419 Forest; however, several early successional species decreased significantly. At Elimsport Substation Forest

there were increases in five species of trees and decreases in nine species of saplings, including all five species that increased in tree class. These changes, first reported in 1989, indicate succession as many saplings are crowded out and some recruited into tree class.

Significant changes and trends were more variable among tree seedlings in the forest plots (Table E-18). Most of these changes have been reported previously, but a detailed analysis has not been made.

Changes in shrubs, herbs, and ground cover have not been analyzed in detail because of time constraints; however, the changes appear to be consistent with findings of previous years (Ecology III, Inc. 1994).

Changes in the forest plots are clearly successional in the case of trees and saplings. Changes in tree seedlings, shrubs, herbs, and ground cover are less clearly successional, although some changes may be related to succession. Details were discussed by Montgomery (Ecology III, Inc.1994). None of the significant changes found in 1994 showed a pattern that could be attributed to the operation of the Susquehanna SES. The Flora and Vegetation Program was discontinued for 1995.

Table E-1

Location of salt drift transects in the vicinity of the Susquehanna SES and at the Elimsport Substation, 1994.

TRANSECT (Abbrev.)	DIRECTION FROM SSES	DISTANCE FROM SSES (km)	HABITAT TYPE	LENGTH (km)	LOCATION
River Forest (RF)	ENE	1.5-2.0	Flood plain hardwood forest	1.2	Adjacent to the Susquehanna River north from Susquehanna SES Environmental Laboratory to southern tip of Gould Island
Twp. Road 419 (TR419)	N	0.5-1.2	Upland hardwood forest	1.5	Along Township Road 419, from U.S. 11 to T. R. 438
Twp. Road 438 (TR438)	WSW	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 forest	2.3	Trail from PA 239 to the transmission line along ridge top down the slope of Little Wapwallopen Valley to a trail past an abandoned spring house, ending at PA 239
Council Cup (CC)	ESE	2.8-3.3	Upland forest	1.4	Council Cup Nature Trail and Overlook
Elimsport Substation (ES)	WNW	72	Upland forest	0.8	Adjacent to and east of Elimsport Substation, 5.4 km NE of Elimsport, Lycoming County, PA

Table E–2

Parasitic plant diseases observed on salt drift transects in the vicinity of the Susquehanna SES and at Elimsport Substation, 1994. Transect names, abbreviations, and locations are given in Table E–1.

HOST SPECIES	DISEASE	TRANSECTS	DISEASE FREQ. *	DISEASE EFFECT **
Acer rubrum	*Phyllosticta minima* leaf spot	TR419, TR438, QSH, CC, ES	2–4	1
Acer rubrum	*Rhytisma acerinum* tar spot	TR438, QSH	3	1
Acer pensylvanicum	*Rhytisma punctatum* tar spot	CC	3	1
Acer saccharinum	*Phyllosticta minima* leaf spot	RF, QSH	3	1
Acer saccharinum	*Rhytisma acerinum* tar spot	RF	3	1
Ambrosia artemisiifolia	*Erysiphe cichoracearum* powdery mildew	TR438, CC	3–4	0
Aster lateriflorus	*Coleosporium asterum* pine–needle rust	TR419	3	1
Aster puniceus	*Erysiphe cichoracearum* powdery mildew	TR438	2	0
Aster simplex	*Coleosporium asterum* pine–needle rust	RF, TR438	2	1
Aster simplex	*Erysiphe cichoracearum* powdery mildew	TR419	3	0
Betula lenta	*Gloeosporium betularum* leaf spot	QSH	3	1
Carya glabra	*Gnomonia caryae* anthracnose	QSH	2	1
Castanea dentata	*Endothia parasitica* chestnut blight	CC	3	4
Catalpa bignonioides	*Phyllosticta catalpae* leaf spot	TR419	4	1
Cornus amomum	*Septoria cornicola* leaf spot	TR438	4	1
Cornus florida	*Discula corni* leaf spot/dieback	TR419, QSH, CC	3	1
Crataegus sp.	*Gymnosporangium globosum* cedar–hawthorn rust	CC	3	1
Eupatorium fistulosum	*Erysiphe cichoracearum* powdery mildew	TR438	2	0
Eupatorium rugosum	*Erysiphe cichoracearum* powdery mildew	RF, TR419, CC	2	0
Fraxinus americana	*Gloeosporium aridum* anthracnose	CC	4	1
Fraxinus pensylvanica	*Gloeosporium aridum* anthracnose	RF	3	1
Helianthus tuberosus	*Coleosporium helianthae* leaf rust	RF	3	1

Table E-2 (cont.)

HOST SPECIES	DISEASE	TRANSECTS	DISEASE FREQ.	DISEASE EFFECT
Kalmia latifolia	*Mycosphaerella colorata* leaf spot	CC	4	1
Lindera benzoin	*Phyllosticta linderae* leaf spot	QSH	3	1
Liriodendron tulipifera	*Mycosphaerella tulipiferae* leaf spot	TR419, TR438, ES	3	1
Panicum lanuginosum	*Balansia strangulans* black ring	QSH	2	1
Parthenocissus quinquefolia	*Guignardia bidwellii* leaf spot	TR419, TR438	3	1
Platanus occidentalis	*Gnomonia platani* anthracnose	RF	3	3
Podophyllum peltatum	*Phyllosticta podophylli* leaf spot	CC	3	1
Podophyllum peltatum	*Puccinia podophylli* rust	RF, TR438, QSH, CC	4–5	1
Populus tremuloides	*Phyllosticta maculans* leaf spot	TR438	3	1
Potentilla simplex	*Phragmidium andersonii* rust	QSH, ES	1–2	1
Prunus serotina	*Coccomyces lutescens* leaf spot	TR438	2	1
Prunus serotina	*Dibotryon morbosum* black knot	CC	3	3
Pycnanthemum incanum	*Erysiphe cichoracearum* powdery mildew	CC	3	0
Pycnanthemum virginianum	*Erysiphe cichoracearum* powdery mildew	CC	3	0
Quercus alba	*Mycosphaera alni* powdery mildew	CC	1	0
Quercus borealis	*Gnomonia quercina* anthracnose	TR419	2	1
Quercus borealis	*Mycosphaera alni* powdery mildew	QSH	1	0
Quercus palustris	*Mycosphaera alni* powdery mildew	TR438	3	0
Quercus prinus	*Gnomonia quercina* anthracnose	CC	3	1
Quercus prinus	*Mycosphaera alni* powdery mildew	CC	1	0
Rhus radicans	*Cercospora rhoina* leaf spot	RF, TR419, TR438, QSH	2–3	1
Rubus allegheniensis	*Gymnoconia peckiana* rust	TR419, ES	2–3	1
Rubus flagellaris	*Elsinoe veneta* leaf spot	TR419, QSH, ES	2–4	1

Table E-2 (cont.)

HOST SPECIES	DISEASE	TRANSECTS	DISEASE FREQ.	DISEASE EFFECT
Rubus flagellaris	*Gymnoconia peckiana* rust	QSH	3	1
Rubus hispidus	*Elsinoe veneta* leaf spot	ES	4	1
Rubus occidentalis	*Gymnoconia peckiana* rust	CC, ES	3-4	1
Sassafras albidum	*Actinothyrium gloeosporioides* leaf spot	TR419, QSH, CC, ES	3	1
Smilax rotundifolia	*Cercospora smilacis* leaf spot	TR419, ES	3-4	1
Solidago arguta	*Coleosporium asterum* pine-needle rust	CC	3	1
Solidago arguta	*Erysiphe cichoracearum* powdery mildew	CC	3	0
Solidago caesia	*Coleosporium asterum* pine-needle rust	TR419, QSH, CC	2-4	1
Solidago caesia	*Erysiphe cichoracearum* powdery mildew	TR419, QSH, CC	2-3	0
Solidago canadensis	*Coleosporium asterum* pine-needle rust	RF, TR419, TR438, QSH, ES	3-4	1
Solidago canadensis	*Erysiphe cichoracearum* powdery mildew	TR419, ES	2-3	0
Solidago flexicaulis	*Coleosporium asterum* pine-needle rust	RF	4	1
Solidago gigantea	*Coleosporium asterum* pine-needle rust	RF, TR438	3-4	1
Solidago gigantea	*Erysiphe cichoracearum* powdery mildew	RF, TR438, QSH	2-3	0
Solidago graminifolia	*Coleosporium delicatulum* pine-needle rust	QSH, ES	2-3	1
Solidago graminifolia	*Placosphaeria haydeni* tar spot	TR438, QSH, ES	3	1
Solidago rugosa	*Coleosporium asterum* pine-needle rust	TR419, TR438, QSH, CC, ES	2-4	1
Solidago rugosa	*Erysiphe cichoracearum* powdery mildew	TR419, QSH	2-3	0
Tilia americana	*Gnomonia tiliae* anthracnose	RF, QSH	2-3	1
Ulmus americana	*Stegophora ulmea* black spot	QSH	3	1
Verbena urticifolia	*Erysiphe cichoracearum* powdery mildew	RF, TR419, QSH	3-4	0
Verbesina alternifolia	*Erysiphe cichoracearum* powdery mildew	RF	3	0
Viola blanda	*Septoria violae* leaf spot	ES	5	1
Vitis aestivalis	*Phyllosticta viticola* leaf spot	CC	3	1

Table E-2 (cont.)

HOST SPECIES	DISEASE	TRANSECTS	DISEASE FREQ.	DISEASE EFFECT
Vitis riparia	*Mycosphaerella personata* 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 E–3

Number of parasitic plant diseases on each salt drift transect, 1978–94. Transect names, abbreviations, and locations are given in Table E–1.

TRANSECT	PREOP.	OPERATION											
	Mean*	1983	1984	1985	1986	1987	1988	1989	1990	1991	1993	1994	Mean
CC	13.2	14	15	15	13	15	18	20	19	17	20	25	17.4
ES	6.0	8	12	8	11	13	7	7	12	12	15	15	10.9
QSH	21.6	23	22	25	22	20	27	22	21	23	27	26	23.5
RF	11.4	10	13	13	13	9	10	12	15	16	15	16	12.9
TR419	12.6	16	17	26	22	21	14	16	23	19	16	22	19.3
TR438	17.2	10	17	18	16	13	9	16	16	17	11	19	14.7
ALL	31.4	35	32	35	36	30	34	37	32	39	40	40	35.5

* Preoperational mean for 1977–82

Table E-4

Vegetation analysis for trees in the Council Cup Forest, 1994.

SPECIES	COMMON NAME	FREQ.	RELATIVE FREQ.	DENSITY (no./ha)	RELATIVE DENSITY	DOMINANCE (ba/ha)	RELATIVE DOMINANCE	IMPORT. VALUE
Betula lenta	sweet birch	0.75	24.2	205	32.0	61552	26.8	83.0
Pinus strobus	white pine	0.30	9.7	45	7.0	44724	19.5	36.2
Quercus borealis	red oak	0.35	11.3	75	11.7	20495	8.9	31.9
Quercus velutina	black oak	0.35	11.3	60	9.4	20122	8.8	29.5
Quercus prinus	chestnut oak	0.30	9.7	75	11.7	17196	7.5	28.9
Acer rubrum	red maple	0.35	11.3	50	7.8	8957	3.9	23.0
Quercus alba	white oak	0.15	4.8	20	3.1	26833	11.7	19.6
Pinus virginiana	virginia pine	0.10	3.2	35	5.5	17208	7.5	16.2
Tsuga canadensis	eastern hemlock	0.05	1.6	25	3.9	3966	1.7	7.2
Prunus pensylvanica	pin cherry	0.10	3.2	10	1.6	958	0.4	5.2
Carya glabra	pignut hickory	0.05	1.6	10	1.6	1748	0.8	4.0
Sassafras albidum	sassafras	0.05	1.6	10	1.6	1276	0.6	3.8
Fraxinus americana	white ash	0.05	1.6	5	0.8	1901	0.8	3.2
Pyrus malus	apple	0.05	1.6	5	0.8	1418	0.6	3.0
Populus tremuloides	quaking aspen	0.05	1.6	5	0.8	884	0.4	2.8
Betula populifolia	gray birch	0.05	1.6	5	0.8	393	0.2	2.6
TOTAL		-	100.0	640	100.0	229631	100.0	300.0

Table E-5

Vegetation analysis for saplings in the Council Cup Forest, 1994.

SPECIES	COMMON NAME	FREQ.	RELATIVE FREQ.	DENSITY (no./ha)	RELATIVE DENSITY	DOMINANCE (ba/ha)	RELATIVE DOMINANCE	IMPORT. VALUE
Acer rubrum	red maple	0.75	19.7	350	34.7	5180	34.3	88.7
Betula lenta	sweet birch	0.55	14.5	105	10.4	2796	18.5	43.4
Pinus strobus	white pine	0.55	14.5	120	11.9	2439	16.1	42.5
Quercus borealis	red oak	0.40	10.5	70	6.9	1237	8.2	25.6
Prunus serotina	black cherry	0.20	5.3	125	12.4	495	3.3	21.0
Quercus prinus	chestnut oak	0.20	5.3	65	6.4	715	4.7	16.4
Carya glabra	pignut hickory	0.20	5.3	30	3.0	306	2.0	10.3
Quercus velutina	black oak	0.15	3.9	20	2.0	353	2.3	8.2
Castanea dentata	american chestnut	0.10	2.6	30	3.0	228	1.5	7.1
Tsuga canadensis	eastern hemlock	0.10	2.6	20	2.0	334	2.2	6.8
Sassafras albidum	sassafras	0.10	2.6	10	1.0	283	1.9	5.5
Quercus alba	white oak	0.10	2.6	15	1.5	102	0.7	4.8
Fagus grandifolia	american beech	0.10	2.6	10	1.0	79	0.5	4.1
Fraxinus americana	white ash	0.10	2.6	10	1.0	71	0.5	4.1
Carya tomentosa	mockernut hickory	0.05	1.3	5	0.5	251	1.7	3.5
Amelanchier arborea	shad-bush	0.05	1.3	10	1.0	134	0.9	3.2
Acer pensylvanicum	striped maple	0.05	1.3	10	1.0	39	0.3	2.6
Betula populifolia	gray birch	0.05	1.3	5	0.5	63	0.4	2.2
TOTAL		-	100.0	1010	100.0	15105	100.0	300.0

Table E-6

Vegetation analysis for tree seedlings in the Council Cup Forest, 1994.

SPECIES	COMMON NAME	FREQ.	RELATIVE FREQ.	DENSITY (no./ha)	RELATIVE DENSITY	DOMINANCE (ba/ha)	RELATIVE DOMINANCE	IMPORT. VALUE
Acer rubrum	red maple	0.53	24.9	16750	43.5	1.73	18.5	86.9
Prunus serotina	black cherry	0.25	11.7	5250	13.6	1.45	15.5	40.8
Quercus borealis	red oak	0.28	13.1	3750	9.7	0.73	7.8	30.6
Acer pensylvanicum	striped maple	0.23	10.8	2750	7.1	0.53	5.7	23.6
Sassafras albidum	sassafras	0.13	6.1	2000	5.2	1.00	10.7	22.0
Quercus alba	white oak	0.08	3.8	2250	5.8	1.00	10.7	20.3
Quercus prinus	chestnut oak	0.18	8.5	2250	5.8	0.33	3.5	17.8
Quercus velutina	black oak	0.13	6.1	1000	2.6	0.55	5.9	14.6
Castanea dentata	american chestnut	0.05	2.3	250	0.6	1.00	10.7	13.6
Betula lenta	sweet birch	0.10	4.7	1000	2.6	0.33	3.5	10.8
Fraxinus americana	white ash	0.05	2.3	500	1.3	0.25	2.7	6.3
Carya glabra	pignut hickory	0.03	1.4	250	0.6	0.23	2.5	4.5
Crataegus sp.	hawthorne	0.03	1.4	250	0.6	0.10	1.1	3.1
Prunus avium	sweet cherry	0.03	1.4	250	0.6	0.08	0.9	2.9
Pinus strobus	white pine	0.03	1.4	0	0.0	0.03	0.3	1.7
TOTAL		-	100.0	38500	100.0	9.34	100.0	300.0

Table E-7

Vegetation analysis for shrubs, herbs, and ground cover in the Council Cup Forest, 1994.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQ.	DOMINANCE (% cover)	RELATIVE DOMINANCE	IMPORTANCE VALUE
SHRUBS						
Kalmia latifolia	mountain laurel	0.25	15.4	5.40	17.9	33.3
Vaccinium vacillans	low-bush blueberry	0.35	21.6	2.40	7.9	29.5
Gaylussacia baccata	black huckleberry	0.23	14.2	4.55	15.1	29.3
Rhus radicans	poison ivy	0.20	12.3	5.05	16.7	29.0
Vaccinium stamineum	deerberry	0.20	12.3	5.00	16.5	28.8
Rubus allegheniensis	blackberry	0.18	11.1	3.08	10.2	21.3
Rhododendron nudiflorum	pinxter-flower	0.10	6.2	3.28	10.9	17.1
Parthenocissus quinquefolia	virginia creeper	0.08	4.9	0.63	2.1	7.0
Viburnum acerifolium	maple-leaf viburnum	0.03	1.9	0.83	2.7	4.6
HERBS						
Lycopodium digitatum	ground pine	0.38	28.4	9.90	35.6	64.0
Maianthemum canadense	wild lily-of-the-valley	0.23	17.2	6.93	24.9	42.1
Dennstaedtia punctilobula	hay-scented fern	0.15	11.2	6.08	21.8	33.0
Aralia nudicaulis	wild sarsaparilla	0.18	13.4	1.93	6.9	20.3
Lysimachia quadrifolia	whorled loosestrife	0.08	6.0	0.33	1.2	7.2
Mitchella repens	partridge-berry	0.03	2.2	1.00	3.6	5.8
Medeola virginiana	indian cucumber	0.03	2.2	0.75	2.7	4.9
Polygala paucifolia	fringed polygala	0.05	3.7	0.18	0.6	4.3
Deschampsia flexuosa	hairgrass	0.03	2.2	0.45	1.6	3.8
Gaultheria procumbens	wintergreen	0.03	2.2	0.08	0.3	2.5
Phytolacca americana	pokeweed	0.03	2.2	0.08	0.3	2.5
Chimaphilia maculata	spotted wintergreen	0.03	2.2	0.03	0.1	2.3
Melampyrum lineare	cow-wheat	0.03	2.2	0.03	0.1	2.3
Prenanthes alba	tall white lettuce	0.03	2.2	0.03	0.1	2.3
Pyrola elliptica	shinleaf	0.03	2.2	0.03	0.1	2.3
GROUND COVER						
Litter	-	0.98	71.5	96.23	96.7	168.2
Moss	-	0.28	20.4	0.63	0.6	21.0
Rock	-	0.08	5.8	0.25	0.3	6.1
Bare soil	-	0.03	2.2	2.40	2.4	4.6

Table E-8

Vegetation analysis for trees in the TR419 Forest, 1994.

SPECIES	COMMON NAME	FREQ.	RELATIVE FREQ.	DENSITY (no./ha)	RELATIVE DENSITY	DOMINANCE (ba/ha)	RELATIVE DOMINANCE	IMPORT. VALUE
Quercus velutina	black oak	0.58	20.6	121	25.9	90694	38.1	84.6
Pinus virginiana	virginia pine	0.29	10.3	58	12.4	35539	14.9	37.6
Cornus florida	flowering dogwood	0.38	13.5	50	10.7	6872	2.9	27.1
Quercus prinus	chestnut oak	0.29	10.3	42	9.0	15220	6.4	25.7
Acer rubrum	red maple	0.29	10.3	38	8.1	12062	5.1	23.5
Pinus strobus	white pine	0.13	4.6	42	9.0	17135	7.2	20.8
Prunus serotina	black cherry	0.17	6.0	25	5.4	17541	7.4	18.8
Carya tomentosa	mockernut hickory	0.25	8.9	33	7.1	6404	2.7	18.7
Fraxinus americana	white ash	0.08	2.8	13	2.8	8394	3.5	9.1
Quercus alba	white oak	0.08	2.8	8	1.7	10724	4.5	9.0
Prunus avium	sweet cherry	0.08	2.8	8	1.7	4991	2.1	6.6
Carya glabra	pignut hickory	0.08	2.8	13	2.8	1119	0.5	6.1
Tsuga canadensis	eastern hemlock	0.04	1.4	8	1.7	5030	2.1	5.2
Liriodendron tulipifera	tulip-tree	0.04	1.4	4	0.9	5773	2.4	4.7
Amelanchier arborea	shad-bush	0.04	1.4	4	0.9	327	0.1	2.4
TOTAL		-	100.0	467	100.0	237825	100.0	300.0

Table E-9

Vegetation analysis for saplings in the TR419 Forest, 1994.

SPECIES	COMMON NAME	FREQ.	RELATIVE FREQ.	DENSITY (no./ha)	RELATIVE DENSITY	DOMINANCE (ba/ha)	RELATIVE DOMINANCE	IMPORT. VALUE
Cornus florida	flowering dogwood	0.50	18.2	142	22.6	3966	32.6	73.4
Acer rubrum	red maple	0.67	24.5	171	27.2	1600	13.2	64.9
Carya tomentosa	mockernut hickory	0.21	7.7	58	9.2	1685	13.9	30.8
Quercus velutina	black oak	0.17	6.2	63	10.0	1417	11.7	27.9
Betula lenta	sweet birch	0.25	9.1	54	8.6	658	5.4	23.1
Crataegus sp.	hawthorne	0.21	7.7	29	4.6	432	3.6	15.9
Carya glabra	pignut hickory	0.13	4.7	29	4.6	697	5.7	15.0
Quercus prinus	chestnut oak	0.08	2.9	13	2.1	213	1.8	6.8
Prunus serotina	black cherry	0.08	2.9	8	1.3	295	2.4	6.6
Quercus alba	white oak	0.08	2.9	8	1.3	295	2.4	6.6
Quercus borealis	red oak	0.08	2.9	8	1.3	190	1.6	5.8
Fraxinus americana	white ash	0.08	2.9	13	2.1	56	0.5	5.5
Fagus grandifolia	american beech	0.04	1.5	8	1.3	295	2.4	5.2
Amelanchier arborea	shad-bush	0.04	1.5	13	2.1	187	1.5	5.1
Pinus strobus	white pine	0.04	1.5	4	0.6	160	1.3	3.4
Prunus avium	sweet cherry	0.04	1.5	4	0.6	13	0.1	2.2
Sassafras albidum	sassafras	0.04	1.5	4	0.6	3	0.0	2.1
TOTAL		-	100.0	629	100.0	12162	100.0	300.0

Table E-10

Vegetation analysis for tree seedlings in the TR419 Forest, 1994.

SPECIES	COMMON NAME	FREQ.	RELATIVE FREQ.	DENSITY (no./ha)	RELATIVE DENSITY	DOMINANCE (ba/ha)	RELATIVE DOMINANCE	IMPORT. VALUE
Acer rubrum	red maple	0.59	23.4	9565	22.0	1.67	12.7	58.1
Prunus serotina	black cherry	0.43	17.1	9565	22.0	1.70	12.9	52.0
Sassafras albidum	sassafras	0.41	16.3	8043	18.5	1.39	10.6	45.4
Fraxinus americana	white ash	0.24	9.5	3696	8.5	2.20	16.7	34.7
Betula lenta	sweet birch	0.11	4.4	3696	8.5	2.20	16.7	29.6
Quercus velutina	black oak	0.22	8.7	2391	5.5	1.41	10.7	24.9
Quercus prinus	chestnut oak	0.07	2.8	652	1.5	1.13	8.6	12.9
Cornus florida	flowering dogwood	0.15	6.0	1957	4.5	0.20	1.5	12.0
Prunus avium	sweet cherry	0.11	4.4	1739	4.0	0.22	1.7	10.1
Amelanchier arborea	shad-bush	0.07	2.8	652	1.5	0.57	4.3	8.6
Crataegus sp.	hawthorne	0.04	1.6	435	1.0	0.24	1.8	4.4
Quercus borealis	red oak	0.04	1.6	652	1.5	0.11	0.8	3.9
Quercus alba	white oak	0.02	0.8	217	0.5	0.09	0.7	2.0
Acer saccharum	sugar maple	0.02	0.8	217	0.5	0.04	0.3	1.6
TOTAL		-	100.0	43477	100.0	13.17	100.0	300.0

Table E-11

Vegetation analysis for shrubs, herbs, and ground cover in the TR419 Forest, 1994.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQ.	DOMINANCE (% cover)	RELATIVE DOMINANCE	IMPORTANCE VALUE
SHRUBS						
Rubus allegheniensis	blackberry	0.41	26.8	9.52	35.0	61.8
Lindera benzoin	spicebush	0.15	9.8	7.67	28.2	38.0
Parthenocissus quinquefolia	virginia creeper	0.33	21.6	2.33	8.6	30.2
Vaccinium stamineum	deerberry	0.11	7.2	2.17	8.0	15.2
Viburnum acerifolium	maple-leaf viburnum	0.07	4.6	2.22	8.2	12.8
Vaccinium vacillans	low-bush blueberry	0.11	7.2	1.04	3.8	11.0
Rubus flagellaris	dewberry	0.13	8.5	0.61	2.2	10.7
Vitis aestivalis	summer grape	0.11	7.2	0.30	1.1	8.3
Rhus radicans	poison ivy	0.07	4.6	0.52	1.9	6.5
Rubus occidentalis	black rasberry	0.02	1.3	0.54	2.0	3.3
Berberis thunbergii	japanese barberry	0.02	1.3	0.26	1.0	2.3
HERBS						
Dennstaedtia punctilobula	hay-scented fern	0.15	8.2	3.61	25.2	33.4
Alliaria officinalis	garlic mustard	0.07	3.8	2.43	17.0	20.8
Carex swannii	sedge	0.20	10.9	1.00	7.0	17.9
Solidago rugosa	rough goldenrod	0.09	4.9	0.65	4.5	9.4
Polygonum virginianum	virginia knotweed	0.09	4.9	0.59	4.1	9.0
Galium circaezans	bedstraw	0.09	4.9	0.48	3.3	8.2
Uvularia sessilifolia	sessile-leaved bellwort	0.11	6.0	0.28	2.0	8.0
Aster divaricatus	white wood aster	0.04	2.2	0.76	5.3	7.5
Geum canadense	avens	0.07	3.8	0.39	2.7	6.5
Maianthemum canadense	wild lily-of-the-valley	0.04	2.2	0.61	4.3	6.5
Circaea quadrisulcata	enchanter nightshade	0.07	3.8	0.35	2.4	6.2
Polystichum acrostichoides	christmas fern	0.04	2.2	0.54	3.8	6.0
Solidago caesia	blue-stemmed goldenrod	0.04	2.2	0.37	2.6	4.8
Panicum lanuginosum	panic-grass	0.07	3.8	0.13	0.9	4.7
Polygonum persicaria	smartweed	0.07	3.8	0.09	0.6	4.4
Arisaema triphyllum	jack-in-the-pulpit	0.04	2.2	0.24	1.7	3.9
Athyrium filix-femina	lady fern	0.04	2.2	0.17	1.2	3.4
Danthonia spicata	poverty oatgrass	0.02	1.1	0.28	2.0	3.1
Panicum boscii	panic-grass	0.04	2.2	0.11	0.8	3.0
Dryopteris carthusiana	spinulose wood fern	0.02	1.1	0.24	1.7	2.8
Phytolacca americana	pokeweed	0.02	1.1	0.13	0.9	2.0
Lysimachia quadrifolia	whorled loosestrife	0.02	1.1	0.11	0.8	1.9
Lysimachia terrestris	yellow loosestrife	0.02	1.1	0.09	0.6	1.7
Carex sp.	sedge	0.02	1.1	0.07	0.5	1.6
Polygonatum biflorum	soloman's seal	0.02	1.1	0.07	0.5	1.6
Smilacina racemosa	false soloman's seal	0.02	1.1	0.07	0.5	1.6
Thelypteris noveboracensis	new york fern	0.02	1.1	0.07	0.5	1.6
Desmodium nudiflorum	tick-trefoil	0.02	1.1	0.04	0.3	1.4
Impatiens biflora	jewelweed	0.02	1.1	0.04	0.3	1.4
Lycopodium digitatum	ground pine	0.02	1.1	0.04	0.3	1.4
Pilea pumila	clearweed	0.02	1.1	0.04	0.3	1.4
Viola papilionacea	common blue violet	0.02	1.1	0.04	0.3	1.4
Asplenium platyneuron	ebony spleenwort	0.02	1.1	0.02	0.1	1.2
Carex laxiflora	sedge	0.02	1.1	0.02	0.1	1.2
Convolvulus sepium	hedge bindweed	0.02	1.1	0.02	0.1	1.2
Deschampsia flexuosa	hairgrass	0.02	1.1	0.02	0.1	1.2
Lycopodium obscurum	tree clubmoss	0.02	1.1	0.02	0.1	1.2
Mitchella repens	partridge-berry	0.02	1.1	0.02	0.1	1.2
Polygonum convolvulus	black bindweed	0.02	1.1	0.02	0.1	1.2
Potentilla simplex	cinquefoil	0.02	1.1	0.02	0.1	1.2
Thalictrum polygamum	tall meadow rue	0.02	1.1	0.02	0.1	1.2
Uvularia perfoliata	perfoliate bellwort	0.02	1.1	0.02	0.1	1.2
GROUND COVER						
Litter	-	0.98	54.1	93.00	93.8	147.9
Moss	-	0.33	18.2	0.74	0.7	18.9
Bare soil	-	0.22	12.2	4.74	4.8	17.0
Rock	-	0.28	15.5	0.72	0.7	16.2

Table E-12

Vegetation analysis for trees in the Elimsport Substation Forest, 1994.

SPECIES	COMMON NAME	FREQ.	RELATIVE FREQ.	DENSITY (no./ha)	RELATIVE DENSITY	DOMINANCE (ba/ha)	RELATIVE DOMINANCE	IMPORT. VALUE
Betula lenta	sweet birch	0.90	22.2	295	29.1	48667	19.0	70.3
Acer rubrum	red maple	0.85	21.0	250	24.6	52107	20.3	65.9
Liriodendron tulipifera	tulip-tree	0.65	16.0	210	20.7	57153	22.3	59.0
Quercus prinus	chestnut oak	0.35	8.6	60	5.9	28588	11.1	25.6
Nyssa sylvatica	black gum	0.40	9.9	60	5.9	17204	6.7	22.5
Sassafras albidum	sassafras	0.35	8.6	75	7.4	12582	4.9	20.9
Quercus borealis	red oak	0.30	7.4	35	3.4	25408	9.9	20.7
Pinus strobus	white pine	0.10	2.5	10	1.0	9931	3.9	7.4
Acer pensylvanicum	striped maple	0.05	1.2	10	1.0	958	0.4	2.6
Tsuga canadensis	eastern hemlock	0.05	1.2	5	0.5	2077	0.8	2.5
Carya glabra	pignut hickory	0.05	1.2	5	0.5	1732	0.7	2.4
TOTAL		-	100.0	1015	100.0	256407	100.0	300.0

Table E-13

Vegetation analysis for saplings in the Elimsport Substation Forest, 1994.

SPECIES	COMMON NAME	FREQ.	RELATIVE FREQ.	DENSITY (no./ha)	RELATIVE DENSITY	DOMINANCE (ba/ha)	RELATIVE DOMINANCE	IMPORT. VALUE
Betula lenta	sweet birch	1.00	23.8	995	58.9	25537	55.2	137.9
Acer rubrum	red maple	0.90	21.4	315	18.6	8906	19.3	59.3
Sassafras albidum	sassafras	0.55	13.1	95	5.6	5030	10.9	29.6
Liriodendron tulipifera	tulip-tree	0.35	8.3	60	3.6	2234	4.8	16.7
Nyssa sylvatica	black gum	0.30	7.1	80	4.7	1641	3.5	15.3
Quercus prinus	chestnut oak	0.25	6.0	35	2.1	1166	2.5	10.6
Quercus borealis	red oak	0.15	3.6	30	1.8	456	1.0	6.4
Pinus strobus	white pine	0.15	3.6	15	0.9	86	0.2	4.7
Quercus velutina	black oak	0.10	2.4	15	0.9	389	0.8	4.1
Tsuga canadensis	eastern hemlock	0.10	2.4	10	0.6	102	0.2	3.2
Betula papyrifera	paper birch	0.05	1.2	5	0.3	251	0.5	2.0
Betula populifolia	gray birch	0.05	1.2	5	0.3	251	0.5	2.0
Fagus grandifolia	american beech	0.05	1.2	10	0.6	98	0.2	2.0
Fraxinus americana	white ash	0.05	1.2	5	0.3	35	0.1	1.6
Amelanchier arborea	shad-bush	0.05	1.2	5	0.3	16	0.0	1.5
Carya glabra	pignut hickory	0.05	1.2	5	0.3	16	0.0	1.5
Quercus alba	white oak	0.05	1.2	5	0.3	16	0.0	1.5
TOTAL		-	100.0	1690	100.0	46230	100.0	300.0

Table E-14

Vegetation analysis for tree seedlings in the Elimsport Substation Forest, 1994.

SPECIES	COMMON NAME	FREQ.	RELATIVE FREQ.	DENSITY (no./ha)	RELATIVE DENSITY	DOMINANCE (ba/ha)	RELATIVE DOMINANCE	IMPORT. VALUE
Acer rubrum	red maple	0.90	38.0	58750	64.9	1.43	35.6	138.5
Sassafras albidum	sassafras	0.43	18.1	6750	7.5	0.88	21.9	47.5
Acer pensylvanicum	striped maple	0.33	13.9	7750	8.6	0.38	9.5	32.0
Betula lenta	sweet birch	0.13	5.5	11750	13.0	0.20	5.0	23.5
Quercus prinus	chestnut oak	0.13	5.5	1500	1.7	0.43	10.7	17.9
Quercus borealis	red oak	0.10	4.2	1000	1.1	0.13	3.2	8.5
Liriodendron tulipifera	tulip-tree	0.10	4.2	1000	1.1	0.10	2.5	7.8
Prunus serotina	black cherry	0.05	2.1	500	0.6	0.10	2.5	5.2
Amelanchier arborea	shad-bush	0.03	1.3	0	0.0	0.13	3.2	4.5
Nyssa sylvatica	black gum	0.05	2.1	500	0.6	0.05	1.2	3.9
Pinus strobus	white pine	0.03	1.3	250	0.3	0.08	2.0	3.6
Carya glabra	pignut hickory	0.03	1.3	250	0.3	0.05	1.2	2.8
Crataegus sp.	hawthorne	0.03	1.3	250	0.3	0.03	0.7	2.3
Quercus velutina	black oak	0.03	1.3	250	0.3	0.03	0.7	2.3
TOTAL		-	100.0	90500	100.0	4.02	100.0	300.0

Table E-15

Vegetation analysis for shrubs, herbs, and ground cover in the Elimsport Substation Forest, 1994.

SPECIES	COMMON NAME	FREQUENCY	RELATIVE FREQ.	DOMINANCE (% cover)	RELATIVE DOMINANCE	IMPORTANCE VALUE
SHRUBS						
Smilax rotundifolia	greenbrier	0.45	50.0	6.93	47.1	97.1
Hamamelis virginiana	witch hazel	0.18	20.0	5.53	37.6	57.6
Lindera benzoin	spicebush	0.08	8.9	0.73	5.0	13.9
Vaccinium vacillans	low-bush blueberry	0.08	8.9	0.35	2.4	11.3
Rubus hispidus	dewberry	0.03	3.3	0.63	4.3	7.6
Vaccinium corymbosum	high-bush blueberry	0.03	3.3	0.45	3.1	6.4
Parthenocissus quinquefolia	virginia creeper	0.05	5.6	0.08	0.5	6.1
HERBS						
Dennstaedtia punctilobula	hay-scented fern	0.43	35.2	5.35	55.5	90.7
Thelypteris noveboracensis	new york fern	0.13	10.7	0.95	9.9	20.6
Osmunda cinnamomea	cinnamon fern	0.08	6.6	1.15	11.9	18.5
Carex swannii	sedge	0.13	10.7	0.25	2.6	13.3
Athyrium filix-femina	lady fern	0.05	4.1	0.50	5.2	9.3
Uvularia sessilifolia	sessile-leaved bellwort	0.08	6.6	0.15	1.6	8.2
Medeola virginiana	indian cucumber	0.05	4.1	0.20	2.1	6.2
Mitchella repens	partridge-berry	0.03	2.5	0.33	3.4	5.9
Osmunda claytoniana	interrupted fern	0.03	2.5	0.23	2.4	4.9
Polygonatum biflorum	soloman's seal	0.03	2.5	0.18	1.9	4.4
Aralia nudicaulis	wild sarsaparilla	0.03	2.5	0.15	1.6	4.1
Pteridium aquilinum	bracken	0.03	2.5	0.08	0.8	3.3
Carex sp.	sedge	0.03	2.5	0.03	0.3	2.8
Goodyera pubescens	rattlesnake plantain	0.03	2.5	0.03	0.3	2.8
Habenaria orbiculata	round-leaved orchid	0.03	2.5	0.03	0.3	2.8
Lysimachia quadrifolia	whorled loosestrife	0.03	2.5	0.03	0.3	2.8
GROUND COVER						
Litter	-	1.00	39.2	86.35	86.9	126.1
Rock	-	0.80	31.4	10.25	10.3	41.7
Moss	-	0.75	29.4	2.80	2.8	32.2

Table E-16

F values and trends for trees in the Council Cup Forest (1977-94), TR419 Forest (1978-94), and Elimsport Substation Forest (1982-94).

SPECIES	COUNCIL CUP		TR419		ELIMSPORT	
	F	Trend	F	Trend	F	Trend
Acer pensylvanicum	--		--		1.00	
Acer rubrum	1.44		1.38		4.84 **	+
Amelanchier arborea	--		1.00		--	
Betula lenta	0.76		--		13.70 **	+
Betula populifolia	0.28		1.28		--	
Carya glabra	1.00		1.56		1.00	
Carya tomentosa	--		0.80		--	
Cornus florida	1.47		1.92		1.00	
Crataegus sp.	--		1.00		--	
Fraxinus americana	1.00		1.06		--	
Liriodendron tulipifera	--		0.00		8.01 **	+
Nyssa sylvatica	--		--		1.57	
Pinus strobus	0.83		2.09 **	—	0.00	
Pinus virginiana	1.36		2.05 *	—	--	
Populus grandidentata	1.39		--		--	
Populus tremuloides	1.00		--		--	
Prunus avium	--		0.00		--	
Prunus pensylvanica	1.18		--		--	
Prunus serotina	--		0.51		--	
Pyrus malus	0.00		0.57		--	
Quercus alba	1.45		1.00		--	
Quercus borealis	2.19 **	+	0.86		0.47	
Quercus prinus	1.11		0.85		2.60 **	+
Quercus velutina	1.71		1.12		1.00	
Sassafras albidum	1.00		1.00		6.60 **	+
Tsuga canadensis	1.00		1.00		0.00	

*Significant at P≤0.05
**Significant at P≤0.01

Table E-17

F values and trends for saplings in the Council Cup Forest (1977-94), TR419 Forest (1978-94), and Elimsport Substation Forest (1982-94).

SPECIES	COUNCIL CUP		TR419		ELIMSPORT	
	F	Trend	F	Trend	F	Trend
Acer negundo	–		–		1.00	
Acer pensylvanicum	1.41		–		0.72	
Acer rubrum	1.69		2.38 **	+	25.00 **	—
Amelanchier arborea	0.63		1.24		1.40	
Betula lenta	9.80 **	—	3.39 **	+	109.44 **	—
Betula papyrifera	–		–		1.00	
Betula populifolia	4.71 **	—	3.39 **	—	1.00	
Carya glabra	1.97		0.82		0.00	
Carya tomentosa	2.48 **	—	2.38 **	—	–	
Castanea dentata	1.67		–		1.00	
Cornus florida	3.02 **	—	21.10 **	—	5.27 **	—
Crataegus sp.	–		1.49		–	
Fagus grandifolia	2.11 **		0.92		1.16	
Fraxinus americana	2.01 *		1.79		1.00	
Liriodendron tulipifera	–		–		11.24 **	—
Nyssa sylvatica	–		–		3.69 **	—
Pinus strobus	1.12		0.89		1.35	
Pinus virginiana	1.74		1.09		–	
Populus grandidentata	1.00		–		–	
Prunus avium	–		1.00		1.00	
Prunus pensylvanica	1.16		–		1.00	
Prunus serotina	1.65		0.91		1.70	
Pyrus malus	–		1.00		–	
Quercus alba	3.19 **	—	1.65		3.37 **	—
Quercus borealis	4.88 **	—	1.36		3.68 **	—
Quercus prinus	5.23 **	—	0.87		11.22 **	—
Quercus velutina	6.51 **	—	4.52 **	—	1.46	
Sassafras albidum	1.19		1.39		31.76 **	—
Tsuga canadensis	0.58		–		1.00	
Ulmus americana	–		1.00		–	

*Significant at $P \leq 0.05$
**Significant at $P \leq 0.01$

Table E-18

F values and trends for tree seedlings (number of stems) in the Council Cup Forest (1978-94), TR419 Forest (1978-94), and Elimsport Substation Forest (1982-94).

SPECIES	COUNCIL CUP		TR419		ELIMSPORT	
	F	Trend	F	Trend	F	Trend
Acer pensylvanicum	4.11 **	+	--		6.62 **	+
Acer rubrum	5.51 **	—	3.03 **		10.78 **	
Acer saccharum	--		1.00		--	
Amelanchier arborea	0.91		1.30		0.00	
Betula lenta	2.82 **	+	3.70 **	+	4.47 **	
Betula populifolia	1.00		1.18		--	
Carya glabra	0.77		1.86		1.69	
Carya tomentosa	0.85		1.11		--	
Castanea dentata	1.96		--		--	
Celtis occidentalis	--		1.96		--	
Cornus florida	--		12.42 **	—	1.37	
Crataegus sp.	1.00		0.79		0.97	
Fagus grandifolia	--		--		1.00	
Fraxinus americana	0.22		8.44 **	—	0.92	
Liriodendron tulipifera	--		--		2.12 *	
Nyssa sylvatica	--		--		5.61 **	—
Pinus strobus	9.60 **	+	2.09 **		0.90	
Pinus virginiana	1.00		2.00 *		--	
Populus grandidentata	0.93		1.46		--	
Populus tremuloides	1.84		0.87		--	
Prunus avium	1.13		1.65		--	
Prunus pensylvanica	1.00		--		--	
Prunus serotina	2.53 **	—	2.27 **	—	2.74 **	—
Prunus virginiana	1.00		--		--	
Pyrus malus	--		1.28		--	
Quercus alba	2.06 *	+	1.00		0.57	
Quercus borealis	2.01 *		1.09		1.45	
Quercus prinus	0.66		0.55		2.53 **	+
Quercus velutina	1.36		2.16 **		0.70	
Sassafras albidum	1.49		1.58		2.09 *	—
Tsuga canadensis	1.46		1.00		0.75	

*Significant at $P \leq 0.05$
**Significant at $P \leq 0.01$

Table E-19

F values and trends for shrubs, herbs, and ground cover (% cover) in the Council Cup Forest (1977-94), TR419 Forest (1978-94), and Elimsport Substation Forest (1982-94).

SPECIES	COUNCIL CUP		TR419		ELIMSPORT	
	F	Trend	F	Trend	F	Trend
Gaylussacia baccata	3.88 **	+	--		--	
Hamamelis virginiana	--		--		0.97	
Kalmia latifolia	1.32		--		--	
Lindera benzoin	--		3.01 **	+	1.11	
Parthenocissus quinquefolia	1.16		1.32		2.10 *	—
Rhododendron nudiflorum	1.94		--		--	
Rhus radicans	2.38 **	+	1.67		--	
Rubus allegheniensis	3.12 **	+	2.14 **	+	2.60 **	—
Rubus flagellaris	--		1.56		--	
Rubus occidentalis	--		0.81		--	
Smilax rotundifolia	--		--		0.48	
Vaccinium stamineum	3.90 **	+	0.77		--	
Vaccinium vacillans	3.59 **	—	1.39		1.38	
Viburnum acerifolium	--		0.52		--	
Vitis aestivalis	--		1.67		0.51	
Alliaria officinalis	--		1.24		--	
Aralia nudicaulis	1.23		--		1.38	
Arisaema triphyllum	--		0.99		--	
Asplenium platyneuron	--		1.01		--	
Aster divaricatus	--		0.70		--	
Carex laxiflora	--		2.20 **		--	
Carex pensylvanica	--		1.12		--	
Carex rosea	--		1.62		--	
Carex swannii	--		5.53 **		2.59 **	+
Carex sp.	--		1.83		1.78	
Chimaphilia maculata	1.31		--		--	
Circaea quadrisulcata	--		0.43		--	
Danthonia spicata	--		1.25		--	
Dennstaedtia punctilobula	2.85 **	+	0.48		0.30	
Desmodium nudiflorum	--		2.17 **	—	--	
Erechtites hieracifolia	--		14.72 **	+	--	
Eupatorium rugosum	--		1.38		--	
Galium aparine	--		0.92		--	
Galium circaezans	--		2.27 **		--	
Geum canadense	--		0.80		--	
Lycopodium digitatum	1.64		1.44		--	
Lysimachia quadrifolia	3.36 **		--		1.16	
Maianthemum canadense	3.82 **	+	1.00		--	
Medeola virginiana	--		--		0.93	
Melampyrum lineare	1.39		--		--	
Monotropa uniflora	1.34		1.97		--	
Osmunda cinnamomea	--		--		1.33	
Panicum boscii	--		2.94 **	+	--	
Panicum lanuginosum	--		2.24 **	+	--	
Panicum spp.	--		1.98		--	
Phytolacca americana	--		1.72		--	
Pilea pumila	--		1.52		--	
Polygala paucifolia	1.10		--		--	
Polygonatum biflorum	--		--		1.58	
Polygonum persicaria	--		1.01		--	
Polygonum virginianum	--		1.93		--	
Potentilla simplex	--		1.33		--	
Solidago caesia	--		0.99		--	
Solidago rugosa	--		0.60		--	
Thelypteris noveboracensis	--		--		0.70	
Uvularia perfoliata	--		2.75 **		--	
Uvularia sessilifolia	--		1.93		2.14 *	
Veronica officinalis	1.73		--		--	
Viola papilionacea	--		1.29		--	
Litter	0.86		0.87		1.46	
Moss	1.44		3.58 **	—	2.21 *	
Rock	3.49 **	—	1.48		2.89 **	+
Bare soil	1.01		1.28		--	

*Significant at P≤0.05
**Significant at P≤0.01

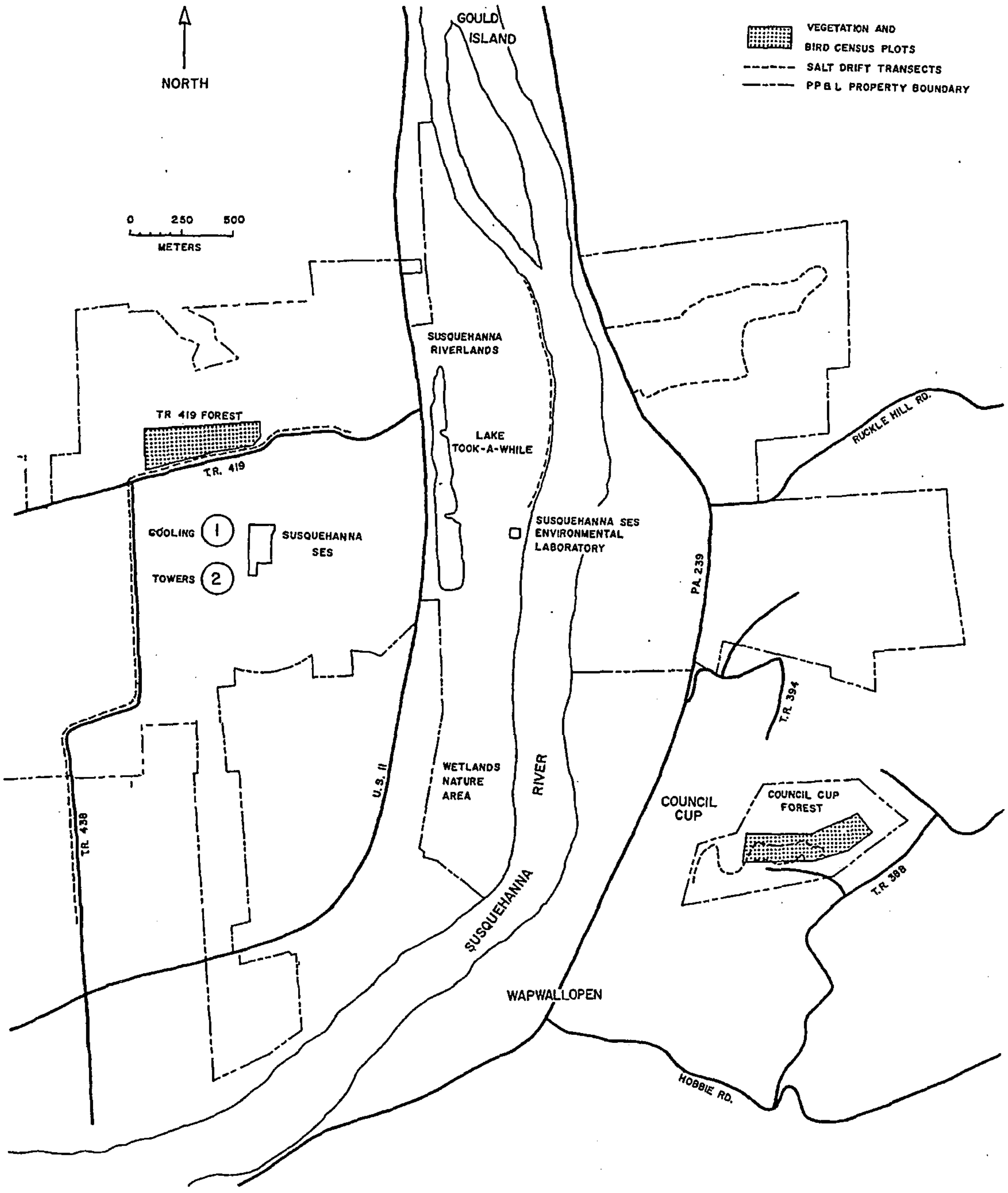

Fig. E-1

Location of vegetation and bird census plots and salt drift transects in the vicinity of the Susquehanna SES site, 1994.

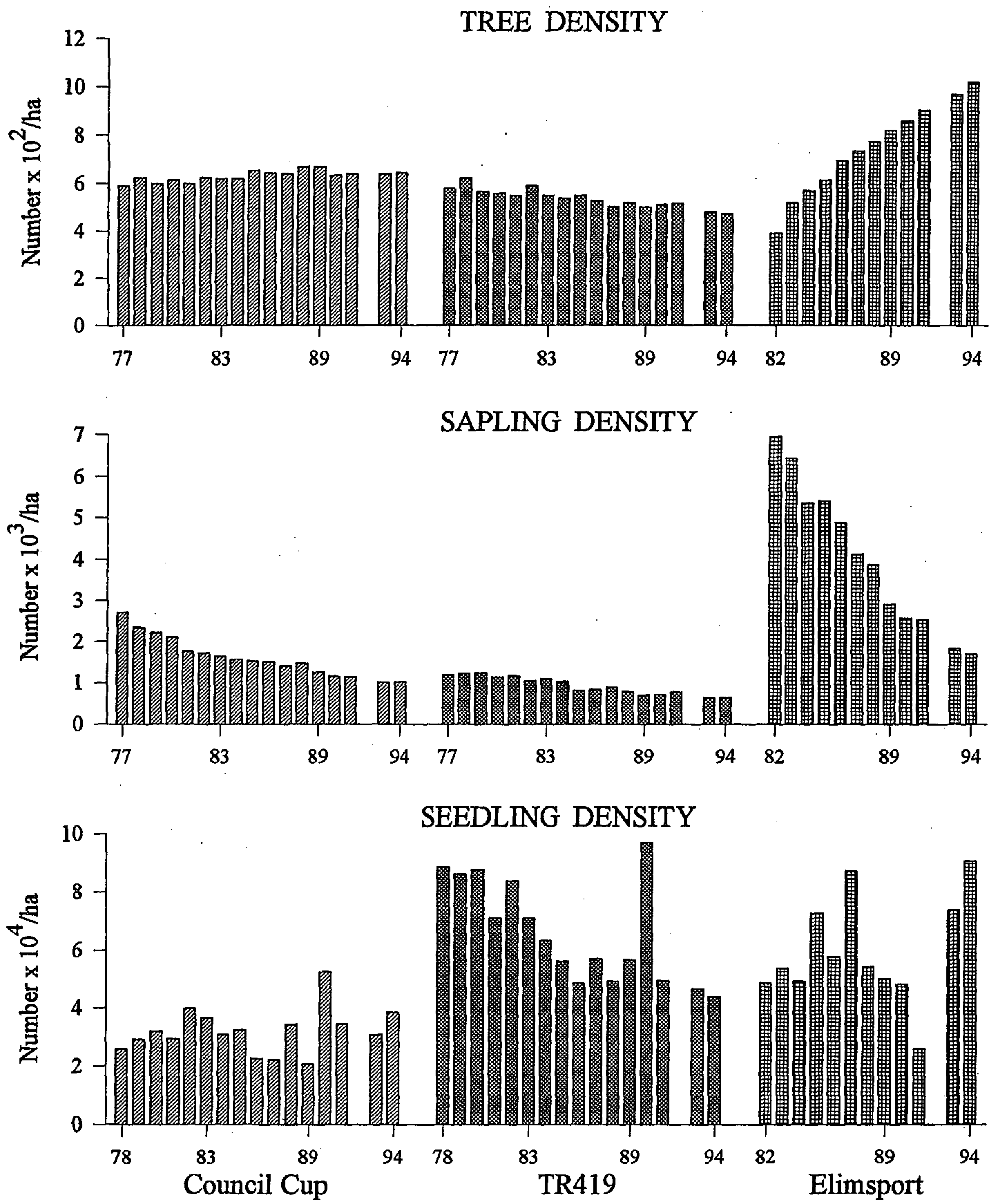

Fig. E-2

Tree, sapling, and seedling density for forest plots during preoperation (1977-82) and operation (1983-94) of the Susquehanna SES. Data were not collected in 1992.

BIRDS

PROCEDURES

Species of Special Concern

The Pennsylvania Species of Special Concern List is divided into the following categories: endangered, threatened, candidate (at risk, rare, and undetermined), and extirpated. It includes birds that are listed as endangered or threatened in the 1988 Endangered Species Act Amendments (U. S. Department of the Interior 1994). The extirpated category is treated by the Pennsylvania Game Commission as a subcategory of endangered (Brauning et al. 1994). The Susquehanna SES program emphasizes endangered and threatened species and candidate species with a history of nesting nearby.

Species of Special Concern surveys were conducted throughout the year. Most surveys occurred on PP&L property within 8 km of the Susquehanna SES, but some observations were made as far away as 15 km. Efforts were concentrated on wetlands, especially the Wetlands Nature Area in the southern part of the Susquehanna Riverlands, riverbank lookouts along the Susquehanna River, and Council Cup Overlook. Advocational birdwatchers and naturalists reported rare bird sightings to the Susquehanna SES Environmental Laboratory and the Susquehanna Energy Information Center. Local birdwatchers conducted a hawkwatch from Council Cup Overlook during autumn migration (Gregory 1995). Hawkwatch data were used to judge the status of some raptors listed as

Species of Special Concern. These sightings were checked for accuracy by assessing observer expertise and by obtaining details of the sighting. Birds were identified in the field using field marks learned from personal experience or these identification guides: Robbins et al. (1966), Peterson (1980), Farrand (1983), Scott (1983), Clark and Wheeler (1987), Dunn et al. (1988), and Kaufman (1990).

Bird Population Studies

The 1994 breeding bird studies were conducted in TR419 Forest (11.05 ha) and Council Cup Forest (6.00 ha) plots (Fig. E-1). Both forest plots are part of large wooded tracts fragmented by roads, farms, and transmission corridors. All birds were identified to species. Time and weather conditions were recorded during each count. Counts and surveys were not conducted during periods of inclement weather, such as heavy rains or high winds, when birds are more difficult to detect. Nomenclature follows the American Ornithologists' Union Check-list (1983, 1987, 1989, 1991, and 1993).

Nine breeding bird counts were conducted from 4 May through 29 July in each plot. 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 behavior (e.g., singing, aggression, nest building) of each bird were noted when applicable. Counts were begun within one hour of sunrise and conducted in early morning when bird activity is greatest.

Daily count map data were transferred to species maps and then analyzed. The number of breeding pairs was usually determined by counting the clusters formed by

registrations of conspicuous territorial males. Consideration was also given to locations of nests and females, and especially to simultaneous observations of territorial birds. The number of breeding pairs was rounded to the nearest half number according to convention (Robbins 1970). When a species was represented by less than 0.5 pair (territory), it was assigned a value of 0.1 for the sake of analysis. For each species, the following were calculated:

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

$$\begin{array}{c}\textit{Relative density}\\ \textit{(\% total)}\end{array} = \frac{\textit{number of breeding pairs of a species}}{\textit{number of breeding pairs of all species}} \times 100$$

Breeding bird densities were tested for change over time with Daniels test for trend (Conover 1971). Densities were paired with years using Spearman's rank correlation coefficient (rho) to test trend over time. Critical values were found in Zar (1974). This approach to trend analysis does not assume normal distribution or linearity of trend (Forbes 1990). Its ranking procedure lessens the influence of unusual values. The null hypothesis is that year and bird densities are independent and the alternative is that bird densities change with time. Trend analysis was performed only on species with at least 0.5 territories for at least five years. Spearman's rank correlations were also conducted between appropriate bird densities in the two plots to evaluate similarities between TR419 and Council Cup Forests.

RESULTS AND DISCUSSION

From 1977 through 1994, 248 species of birds and 2 hybrids were observed within 8 km of Susquehanna SES. No species were added to the site list in 1994.

Species of Special Concern

Thirty-seven species of birds observed near the Susquehanna SES since 1977 are currently listed as Pennsylvania Species of Special Concern (Brauning et al. 1994). A summary of their history and status near the Susquehanna SES is presented in Table F-1. None of the species listed as endangered or threatened were found nesting near the Susquehanna SES, but some listed species were seen more frequently than in past years.

In 1994, four Pennsylvania endangered species were observed near Susquehanna SES: Osprey, Bald Eagle, Peregrine Falcon, and Black Tern. The U. S. Fish and Wildlife Service categorizes the Bald Eagle and Peregrine Falcon as Endangered (U. S. Department of the Interior 1994). The first three endangered species are recovering in northeastern United States, but none of them nest within 15 km of the power station.

Ospreys have become fairly common near the power station, especially near the river. There are no known nesting Ospreys in the immediate vicinity, but pairs nest along the lower Susquehanna River near Harrisburg and in the Poconos. The closest known nest is near Bear Creek in eastern Luzerne County.

Peregrine Falcons have been seen migrating through the area almost every year. There were two Peregrine Falcon sightings at Council Cup despite lower hawk-watch

coverage in October 1994. A state program has helped Peregrines in five Pennsylvania cities and raised public interest in this appealing bird (Brauning 1994a). Peregrine Falcons once nested on Council Cup bluff and several other cliffs along the Susquehanna River (Rice 1969).

There were more reports of Bald Eagles near Susquehanna SES in 1994 than in any previous year. At least two Bald Eagles apparently stayed in the Shickshinny - Berwick area during the winter of 1993-94. One was an adult and at least one immature bird with plumage characteristics of a third-year bird (McCollough 1989). Mid-air fights observed between two eagles near Shickshinny indicated either courtship or territoriality. Bald Eagles have been reestablishing themselves along Pennsylvania rivers and lakes (Leberman 1992). Since the Susquehanna River provides the necessary foraging and nesting locations, Bald Eagles might eventually nest in the area as part of its regional expansion.

Three species listed as Pennsylvania threatened were observed migrating near the Susquehanna SES in 1994, but none of them were observed breeding. Great Egrets were observed on several occasions along the Susquehanna River in late summer. Common Snipes were found in wet areas of the Susquehanna Riverlands during spring and autumn migrations. Two migrating Yellow-bellied Flycatchers were found in the Quarry-Hillside Forest on 13 May.

Few species listed as Pennsylvania candidates regularly nest near Susquehanna SES, so they have not been studied extensively (Table F-1). These species have not been studied thoroughly enough to detect population trends.

The presence, and sometimes increase, of several endangered and threatened species near Susquehanna SES indicate that habitats on PP&L lands near the power station are important to local wildlife. The wetlands, fields, and forests associated with the Susquehanna River provide important feeding and resting areas for several birds listed as Pennsylvania Species of Special Concern.

Bird Population Studies

Forty-eight species demonstrated some evidence of breeding in the 1994 study plots (Table F-2). There were 42 breeding species in TR419 Forest and 34 in Council Cup Forest. Red-eyed Vireo was the most common breeding species (highest density) in TR419 Forest and Ovenbird was the most common species in Council Cup Forest. The Kentucky Warbler was a new breeding species in TR419 Forest and Black-throated Green Warbler was new in Council Cup Forest.

Most birds that nest in these plots travel great distances to Latin America for the winter. These are the long-distance migrants. Residents are the next largest group, followed by the short-distance migrants. Resident species are important monitoring subjects because they nest and overwinter in the same area and thus experience local environmental stresses throughout the year. Many long-distance migrants are forest-obligate or forest interior species, while most residents and short-distance migrants are less sensitive to vegetational disturbances (Brittingham 1989, Freemark and Collins 1992). Forest-obligate species are important monitoring subjects because changes in their populations have the potential to reflect stresses on the forest food web.

Since the start of power station operation, the breeding populations of most species have been as high or higher than during preoperational years (Tables F-3 and F-4). Since the preoperation data set is relatively small and both forests were stressed by gypsy moth infestation in the early 1980's, emphasis is placed on long-term trends rather than before-after comparisons.

Many 1994 breeding bird densities are similar to previous years (Tables F-3 and F-4). It is evident that total bird densities (Fig. F-1) and densities of 20 common species (Figs. F-2 through F-4) have changed since the beginning of this study. Some changes are without an obvious pattern, but 27 species had significant or marginally significant trends in at least one of the study plots (Table F-5).

The TR419 Forest total breeding bird density was 37% higher than the average of 1980-93 and the third highest observed during the study (Table F-3; Fig. F-1). Twenty-seven species had densities that were above the average of previous years, while 28 species were below average or did not occur (Table F-3). Fifteen species had positive significant or marginally significant trends from 1980 to 1994, while five species had negative trends (Table F-5).

In Council Cup Forest, the 1994 total breeding bird density was the highest ever observed in the plot (Fig. F-1). Of the fifty species, half had higher than average breeding densities, while the other 25 were below average or did not occur (Table F-4). From 1980 to 1994, there were 11 species with positive trends that were significant or marginally significant and there was only one species with a significant negative trend (Table F-5).

Residents had fairly similar trends in both plots (Fig. F-1). Tufted Titmouse significantly increased in both forests while other residents seemed to vary without obvious trend. Most Pennsylvania resident species have increased or changed without trend in recent years (Brauning 1992, 1994b). Trends in these plots roughly reflect state-wide patterns.

Most decreases have been experienced by short-distance migrants which are generally considered edge or shrub species (Table F-5; Fig. F-3). The decline of the Rufous-sided Towhee in TR419 Forest is typical of a decline observed throughout the northeastern United States, including Pennsylvania (Gross 1992, Hagan 1993, Brauning 1994b). Forest maturization may be the main contributor to towhee decreases. Blue Jay declined significantly in TR419 Forest, but it seems to have recovered from a 1988 low in Council Cup (Table F-5; Fig. F-3). Cedar Waxwing provides an exception in this group by increasing significantly in both plots. Waxwings eat fruit produced by various shrubs and trees, including cherries (*Prunus* spp.) in and near the plots. In TR419 Forest, cherry trees increased in dominance by 34% from 1980 to 1994 ("Flora and Vegetation" in Ichthyological Associates 1981).

Several long-distance migrant forest birds have significantly increased in at least one of the plots during the study (Table F-5; Fig. F-4). Many long-distance migrants are forest interior birds that forage or nest in the canopy (DeGraff and Rudis 1986, Ehrlich et al. 1988, Brittingham 1989). This includes the Blue-gray Gnatcatcher, Yellow-throated Vireo, Red-eyed Vireo, American Redstart, and Scarlet Tanager. Increases in canopy volume as measured by tree dominance may account for the increases in many canopy-

dwelling birds (see "Flora and Vegetation"). Breeding bird densities can increase with canopy volume because larger trees provide more feeding substrate, nesting locations, and camoflage from nest predators.

Gypsy moth defoliation and subsequent tree mortality may have also influenced forest bird populations. The canopy gaps due to tree mortality create patches of herbaceous plants and woody shrubs including blackberries (*Rubus* spp.) used by several bird species in these plots. Several woody shrubs and herbs have significantly increased in both plots (see "Flora and Vegetation"). Eastern Wood-Pewee, Wood Thrush, Chestnut-sided Warbler, Hooded Warbler, and Indigo Bunting may benefit from the micro-habitat changes due to tree-fall gaps (Blake and Hoppes 1986, Yahner and Smith 1990). The increase in downed woody debris caused by tree mortality is also associated with higher populations of some forest birds, particularly Eastern Wood-Pewee, Worm-eating Warbler, and Ovenbird.

There were mixed results with long-distance migrant significant trends. There were increases in some area-sensitive species such as Ovenbird (both plots) and Worm-eating Warbler (TR419 Forest), but there were also some decreases. Great Crested Flycatcher declined in Council Cup Forest, while Black-and-white Warbler and Rose-breasted Grosbeak declined in TR419 Forest. It is difficult to determine the reasons for these trends, but some might be explained by changes in vegetation and associated food resources. Black-and-white Warbler is associated with higher densities of oaks, but declines as canopy cover increases, a consequence of forest maturization (Yahner and Smith 1990). The decrease of Rose-breasted Grosbeak, a forest edge and mid-story

species (Leberman 1992), might be related to declines in flowering dogwood and sapling density (see "Flora and Vegetation"). Since Ovenbirds and Worm-eating Warblers are area-sensitive forest-obligate species, their populations bear watching (Robbins et al. 1989). The reproductive success and breeding density of Ovenbirds is greater in large forest fragments (Porneluzi et al. 1993, Villard et al. 1993).

There is a widespread concern about declines in migratory forest birds (Terborgh 1989, Hagan and Johnston 1992). Some investigators have found evidence that many long-distance migrants may be declining because of problems on their breeding grounds (Böhning-Gause et al. 1993, Martin 1992). Forest fragmentation may be the chief culprit, indirectly causing nest depredation and a decrease in productivity (Robbins 1979, Temple and Cary 1988, Hoover 1992, Porneluzi et al.1993). Transmission corridor maintenance may be a confounding factor since some intense vegetation control methods have negative effects on many bird species (Chasko and Gates 1982). Except for some maintenance cutting at forest edges, both plots have not been noticeably disturbed by humans during the study period and have been allowed to mature naturally. For this reason, the trends observed in migratory forest birds in these forests run counter to the pattern of decline in similar breeding bird plot data sets in eastern United States, but are similar to trends observed in Pennsylvania generally (Holmes and Sherry 1988, Johnston and Hagan 1992, Brauning 1994b). Like many forests in rural Pennsylvania, TR419 and Council Cup are relatively mature and are not suffering from the severe fragmentation experienced in more heavily developed parts of the Northeast where many similar studies have taken place.

Many patterns of population change in TR419 Forest (within 0.3 km of the Unit 1 Cooling Tower) have been similar to the patterns in Council Cup Forest, which is 3 km from the cooling towers (Figs. F-2 through F-4). The total breeding bird densities of the two plots were significantly correlated through time and several species significantly increased during the study period in both forests (Table F-5). Many of the trends observed in these plots are similar to ones recently observed in Pennsylvania generally (Brauning 1992, 1994b). Since many resident and forest-obligate species have increased in TR419 Forest, the power station probably has not put significant stress on the forest food web.

The patterns and trends found in these bird population data sets suggest that many, but perhaps not all, changes in bird populations are due to factors other than power station operation that are common to both plots. These may include, but are not limited to general forest maturization, gypsy moth infestations, the effects of plant diseases on vegetation (dogwood leaf anthracnose), and weather (droughts). Many species that have declined at other locations in eastern United States have increased or been stable in the two forest plots studied here. Most breeding bird densities during operational years were similar to or higher than preoperational years. This suggests that Susquehanna SES operation has not been a negative factor to most bird species living nearby. There is, however, a lack of data about nesting productivity and survivalship of birds in these forests due to the large amount of resources this kind of research would require. The Bird Program was discontinued for 1995.

Table F-1

Pennsylvania bird Species of Special Concern observed near Susquehanna SES, 1977-94. The following were used to review local and historical status: Warren (1890), Poole (1964), Gill (1985), and Brauning et al. (1994).

CATEGORY* Species	1994 STATUS NEAR SUSQUEHANNA SES
ENDANGERED	
Osprey	A regular and relatively common migrant along the Susquehanna River and along ridges near the power station. Ospreys were observed fishing or resting several times on PP&L property, especially the Susquehanna Riverlands. Over 30 were counted as they flew by Council Cup Overlook and the Susquehanna Riverlands in autumn migration. At least 20 pairs nested in Pennsylvania, primarily in the Poconos. Ospreys nest in eastern Luzerne County and along the Susquehanna River near Harrisburg, but no nests were found within 15 km of the power station.
** Bald Eagle	There were more eagle sightings near the power station than in any previous year. Most eagles were seen along the river or near Council Cup Overlook (7 sightings). At least two Bald Eagles, an adult and an immature, apparently stayed in the Shickshinny-Berwick area during the winter of 1993-94. The Bald Eagle is recovering in Pennsylvania from a status of near extirpation to a breeding population of 18 pairs. Earlier this century, Bald Eagles nested locally along the Susquehanna River, possibly near Wapwallopen.
** Peregrine Falcon	A rare but regular migrant in all seasons, mostly in autumn. Three Peregrines were observed at Council Cup Overlook in 1994. Peregrine Falcons nested on Council Cup bluff as late as 1960, producing fledglings that year.
King Rail	Never observed near Susquehanna SES. No history of nesting nearby.
Black Tern	A juvenile bird was observed flying over the Susquehanna River on 13 June 1994. Black Tern is a rare migrant in Luzerne County. There is no history of nesting nearby. The closest nesting populations are in northwestern Pennsylvania and the Lake Ontario region of New York. A species in decline in northeastern states.
Short-eared Owl	A rare migrant at Susquehanna SES with no history of nesting nearby. None observed in 1994; last observed 30 December 1985.
THREATENED	
American Bittern	A rare but regular migrant in wetlands. None observed in 1994; last observed in the Wetlands Nature Area on 23 April 1992. Historically, American Bittern may have nested in the area, but no nestings have been documented since these studies began.
Least Bittern	A rare but regular migrant in the Wetlands Nature Area. No known local nesting. None observed in 1994; last observed 13 May 1989.
Great Egret	An uncommon but fairly regular migrant. Some were observed along the river in post-breeding dispersal in August and September. Never known to nest locally, but does nest along the lower Susquehanna River.
Yellow-crowned Night-Heron	Never observed near Susquehanna SES, but nests along the lower Susquehanna River.
Upland Sandpiper	None observed in 1994. The only recent record was a single bird seen over the Susquehanna Riverlands, 7 April 1993. Historically, the Upland Sandpiper nested in grasslands of the Susquehanna River valleys, including sites near Montour SES.

Table F-1 (cont.)

CATEGORY* Species	1994 STATUS NEAR SUSQUEHANNA SES
THREATENED (cont.)	
Common Snipe	An uncommon but regular migrant in wetlands near Susquehanna SES. A few were seen in the Susquehanna Riverlands and Wetlands Nature Area in 1994. Small numbers nest in northern Pennsylvania; population is declining in state.
Yellow-bellied Flycatcher	A rare migrant near Susquehanna SES. Two were observed in Quarry-Hillside Forest on 13 May 1994. A rare local nester in some forested wetlands about 80 km north of Susquehanna SES.
Sedge Wren	No observations in 1994. Only observation was in the Wetlands Nature Area, 6 May 1992. No records of nesting nearby.
EXTIRPATED	
Greater Prairie-Chicken	No records for immediate area, but the Heath Hen (Pennsylvania's subspecies) nested in northeastern Pennsylvania, including Luzerne County.
Piping Plover	Never observed in area. Not believed to have nested nearby.
Common Tern	An uncommon migrant along the Susquehanna River. No records of local nesting. Last sighting in spring 1991.
Olive-sided Flycatcher	A rare but regular migrant in wetlands, woods, and fence rows. None observed in 1994, but one visited the Wetlands Nature Area, 23-27 September 1992. This species once nested within 25 km of Berwick.
Bewick's Wren	Never observed near Susquehanna SES. No historical records.
Loggerhead Shrike	A rare migrant. No known local nesting. None observed in 1994; last sighting, 23 April 1983.
Bachman's Sparrow	Never observed near Susquehanna SES. No historical records.
CANDIDATE -- AT RISK	
Snowy Egret	None observed in 1994. A rare migrant in wetlands, especially along the Susquehanna River. No records of nesting nearby.
Northern Harrier	An uncommon migrant throughout the area. Not known to nest in study area, but probably nests within 20 km of Susquehanna SES.
Barn Owl	A rare local nesting species which is reported to nest on farms within 8 km of Susquehanna SES. It has nested in large trees in Beach Haven.
Prothonotary Warbler	None observed in 1994. A rare migrant with no history of nesting near Susquehanna SES. It has been increasing in parts of the state.
CANDIDATE -- RARE	
Green-winged Teal	An uncommon but regular migrant. Regularly seen in the Wetlands Nature Area. This species nests in wetlands 55 km north of Susquehanna SES.
Northern Goshawk	A rare but regular migrant. This species nests in extensive mature forests throughout northern Pennsylvania.
American Coot	An uncommon migrant for which there are no local records of nesting. Regularly seen in the Wetlands Nature Area in spring and autumn.

Table F-1 (cont.)

CATEGORY* Species	1994 STATUS NEAR SUSQUEHANNA SES
CANDIDATE – RARE (cont.)	
Marsh Wren	A rare migrant for which there are no local records of nesting. There were no 1994 records, but two birds were observed in the Wetlands Nature Area, 28 April 1993. Although it has never been documented nesting here, this wren nests in some northeastern Pennsylvania marshes.
Swainson's Thrush	An uncommon but regular migrant in forests near Susquehanna SES. In recent years, some breeding has been documented on the plateau approximately 50 km north of Susquehanna SES.
Summer Tanager	An occasional migrant with only one local observation in 1979. No history of nesting in area.
CANDIDATE – UNDETERMINED	
Cattle Egret	An uncommon migrant with no history of nesting nearby.
Northern Pintail	An uncommon but regular migrant with no history of nesting nearby.
Northern Shoveler	A rare migrant with no history of nesting nearby.
American Wigeon	An uncommon but regular migrant with no history of nesting nearby.
Ruddy Duck	A rare migrant with no record of nesting nearby.
Northern Bobwhite	An uncommon resident which is regularly stocked throughout the area. Local history and status is obscured by these stocking attempts.
Long-eared Owl	A rare migrant and possible nesting species in the area. None were observed in 1994, but a pair nested near Benton, Columbia County, within 32 km of Susquehanna SES.
Northern Saw-whet Owl	A rare migrant which nests in high elevations within 50 km of Susquehanna SES. None observed in 1994.
Common Nighthawk	Common, but perhaps declining, nesting bird in Berwick area. Many migrated through area in August.
Whip-poor-will	Rare nesting species which was once much more common in local woods and farms. None observed in 1994.
Henslow's Sparrow	Never observed at Susquehanna SES. This species has a history of nesting in various northern Luzerne County locations.
Dickcissel	An occasional migrant with no record of nesting nearby. One impacted on a cooling tower in 1979.
Red Crossbill	An erratic and rare migrant, primarily in autumn and winter. None observed in 1994. Historically, this conifer specialist once nested in Luzerne County, but is poorly documented.
EXTINCT	
Passenger Pigeon	An abundant bird in this area in the nineteenth century.

* Breeding status within the state. Extirpated is treated by the Pennsylvania Game Commission as a subcategory of endangered.

** Federal endangered species list.

Table F-2

Number of breeding pairs, density (no./sq km), and relative density (% total) of bird species in TR419 and Council Cup Forests, 1994.

MIGRATORY STATUS	TR419 FOREST			COUNCIL CUP FOREST		
Species	Pairs	Density	% Total	Pairs	Density	% Total
RESIDENTS	**16.4**	**148.2**	**15.3**	**18.5**	**308.4**	**26.5**
Red-tailed Hawk	1.0	9.0	0.9	0.0	0.0	0.0
Ruffed Grouse	0.1	0.9	0.1	0.5	8.3	0.7
Downy Woodpecker	3.0	27.1	2.8	1.5	25.0	2.1
Hairy Woodpecker	0.1	0.9	0.1	1.0	16.7	1.4
Pileated Woodpecker	0.1	0.9	0.1	0.5	8.3	0.7
American Crow	1.0	9.0	0.9	1.0	16.7	1.4
Black-capped Chickadee	4.0	36.2	3.7	7.0	116.7	10.0
Tufted Titmouse	6.0	54.3	5.6	3.0	50.0	4.3
White-breasted Nuthatch	0.1	0.9	0.1	3.0	50.0	4.3
Northern Cardinal	1.0	9.0	0.9	1.0	16.7	1.4
SHORT-DISTANCE MIGRANTS	**10.7**	**96.7**	**10.0**	**12.1**	**201.8**	**17.3**
Northern Flicker	0.5	4.5	0.5	0.1	1.7	0.1
Blue Jay	1.0	9.0	0.9	1.5	25.0	2.1
Fish Crow	0.1	0.9	0.1	0.0	0.0	0.0
Red-breasted Nuthatch	0.0	0.0	0.0	1.0	16.7	1.4
Brown Creeper	0.0	0.0	0.0	0.5	8.3	0.7
American Robin	2.0	18.1	1.9	3.0	50.0	4.3
Cedar Waxwing	2.0	18.1	1.9	1.0	16.7	1.4
Rufous-sided Towhee	0.1	0.9	0.1	0.0	0.0	0.0
Brown-headed Cowbird	4.0	36.2	3.7	4.0	66.7	5.7
American Goldfinch	1.0	9.0	0.9	1.0	16.7	1.4
LONG-DISTANCE MIGRANTS	**80.4**	**727.1**	**74.8**	**39.3**	**655.4**	**56.2**
Yellow-billed Cuckoo	0.0	0.0	0.0	1.0	16.7	1.4
Ruby-throated Hummingbird	1.0	9.0	0.9	0.0	0.0	0.0
Eastern Wood-Pewee	6.5	58.8	6.0	3.0	50.0	4.3
Great Crested Flycatcher	0.1	0.9	0.1	1.0	16.7	1.4
Eastern Kingbird	0.0	0.0	0.0	0.1	1.7	0.1
House Wren	0.1	0.9	0.1	0.0	0.0	0.0
Blue-gray Gnatcatcher	5.0	45.2	4.7	2.0	33.3	2.9
Wood Thrush	8.0	72.4	7.4	2.5	41.7	3.6
Gray Catbird	3.5	31.7	3.3	0.0	0.0	0.0
Solitary Vireo	0.0	0.0	0.0	2.5	41.7	3.6
Yellow-throated Vireo	1.5	13.6	1.4	0.0	0.0	0.0
Red-eyed Vireo	15.0	135.7	14.0	5.5	91.7	7.9
Yellow Warbler	0.1	0.9	0.1	0.0	0.0	0.0
Chestnut-sided Warbler	0.5	4.5	0.5	0.0	0.0	0.0
Black-throated Green Warbler	0.0	0.0	0.0	1.0	16.7	1.4
Blackburnian Warbler	1.0	9.0	0.9	0.0	0.0	0.0
Pine Warbler	1.0	9.0	0.9	0.1	1.7	0.1
Black-and-white Warbler	1.0	9.0	0.9	1.0	16.7	1.4
American Redstart	9.0	81.4	8.4	1.0	16.7	1.4
Worm-eating Warbler	3.0	27.1	2.8	0.0	0.0	0.0
Ovenbird	7.5	67.9	7.0	10.0	166.7	14.3
Kentucky Warbler	0.1	0.9	0.1	0.0	0.0	0.0
Common Yellowthroat	0.5	4.5	0.5	0.0	0.0	0.0
Hooded Warbler	2.5	22.6	2.3	0.0	0.0	0.0
Scarlet Tanager	9.0	81.4	8.4	7.0	116.7	10.0
Rose-breasted Grosbeak	1.5	13.6	1.4	0.5	8.3	0.7
Indigo Bunting	2.0	18.1	1.9	0.1	1.7	0.1
Northern Oriole	1.0	9.0	0.9	1.0	16.7	1.4
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	

Table F-3

Comparison of breeding bird densities observed in TR419 Forest in 1994 with prior study years (1980-93) and during preoperation (1980-82) and operation (1983-94) of the Susquehanna SES.

MIGRATORY STATUS	1994	1980-93		PREOPERATION		OPERATION	
Species		Mean	SD	Mean	SD	Mean	SD
RESIDENTS	**148.2**	**163.3**	**73.9**	**132.4**	**15.8**	**169.8**	**34.0**
Red-tailed Hawk	9.0	2.6	3.5	3.0	4.3	3.1	3.6
Ruffed Grouse	0.9	1.1	2.2	0.3	0.4	1.3	2.4
Wild Turkey	0.0	0.1	0.2	0.0	0.0	0.1	0.2
Eastern Screech-Owl	0.0	0.7	2.3	0.0	0.0	0.8	2.5
Great Horned Owl	0.0	0.8	2.3	0.0	0.0	1.0	2.4
Downy Woodpecker	27.1	22.9	9.1	18.1	0.0	24.5	9.5
Hairy Woodpecker	0.9	6.3	6.8	3.6	3.8	6.5	7.1
Pileated Woodpecker	0.9	1.2	1.4	0.3	0.4	1.4	1.4
American Crow	9.0	2.0	2.6	0.0	0.0	3.1	3.1
Black-capped Chickadee	36.2	44.3	7.7	40.7	9.8	44.5	6.9
Tufted Titmouse	54.3	46.5	15.0	31.7	9.8	50.9	12.9
White-breasted Nuthatch	0.9	8.3	5.2	10.6	5.6	7.1	5.0
Carolina Wren	0.0	3.6	6.4	0.0	0.0	4.2	6.7
Northern Cardinal	9.0	22.9	9.3	24.1	4.2	21.5	10.5
SHORT-DISTANCE MIGRANTS	**96.7**	**121.7**	**23.5**	**137.3**	**10.7**	**115.7**	**23.9**
Sharp-shinned Hawk	0.0	0.1	0.2	0.0	0.0	0.1	0.2
Northern Flicker	4.5	8.9	6.9	13.6	6.4	7.4	6.3
Blue Jay	9.0	25.2	9.5	36.2	3.7	21.1	8.7
Fish Crow	0.9	0.6	2.3	0.0	0.0	0.8	2.5
Brown Creeper	0.0	3.3	4.3	6.0	4.3	2.3	3.9
American Robin	18.1	6.0	6.1	15.1	2.1	4.7	5.7
Cedar Waxwing	18.1	26.2	17.1	6.0	4.3	30.5	14.9
Rufous-sided Towhee	0.9	6.1	8.1	18.1	3.7	2.6	5.2
Chipping Sparrow	0.0	5.8	8.3	0.0	0.0	6.8	8.6
Brown-headed Cowbird	36.2	37.2	7.7	42.2	4.3	35.8	7.5
American Goldfinch	9.0	2.3	5.0	0.0	0.0	3.5	5.5
LONG-DISTANCE MIGRANTS	**727.1**	**426.0**	**117.8**	**292.8**	**25.2**	**501.1**	**125.3**
Broad-winged Hawk	0.0	0.1	0.2	0.0	0.0	0.1	0.2
Yellow-billed Cuckoo	0.0	2.2	4.2	4.8	6.2	1.1	2.7
Ruby-throated Hummingbird	9.0	0.8	2.4	0.0	0.0	1.6	3.3
Eastern Wood-Pewee	58.8	35.1	16.2	19.6	9.3	42.6	14.9
Great Crested Flycatcher	0.9	4.5	3.8	6.3	3.8	4.1	3.7
Eastern Kingbird	0.0	0.5	1.2	0.0	0.0	0.5	1.2
House Wren	0.9	5.5	5.3	0.6	0.4	6.3	5.1
Blue-gray Gnatcatcher	45.2	20.3	17.6	4.8	6.2	29.8	19.6
Veery	0.0	0.8	2.4	3.3	4.1	0.1	0.3
Wood Thrush	72.4	47.3	11.0	42.2	8.5	51.3	12.2
Gray Catbird	31.7	10.9	8.1	16.6	7.7	11.4	9.2
Solitary Vireo	0.0	0.7	2.4	0.0	0.0	0.8	2.5
Yellow-throated Vireo	13.6	5.9	7.0	0.0	0.0	8.3	6.6
Red-eyed Vireo	135.7	73.8	36.2	33.2	2.1	91.2	32.8
Yellow Warbler	0.9	0.1	0.3	0.0	0.0	0.2	0.4
Chestnut-sided Warbler	4.5	1.6	2.7	4.5	3.7	1.7	2.7
Blackburnian Warbler	9.0	2.4	3.8	0.0	0.0	3.5	4.1
Pine Warbler	9.0	4.2	4.5	3.0	4.3	4.5	4.5
Black-and-white Warbler	9.0	12.4	11.2	10.9	7.3	11.4	11.6
American Redstart	81.4	28.7	26.7	6.3	5.3	41.2	28.2
Worm-eating Warbler	27.1	12.5	8.3	3.0	4.3	16.6	7.2
Ovenbird	67.9	34.1	14.8	19.6	4.3	42.6	15.9
Kentucky Warbler	0.9	0.0	0.0	0.0	0.0	0.1	0.2
Mourning Warbler	0.0	0.1	0.2	0.0	0.0	0.1	0.2
Common Yellowthroat	4.5	1.2	2.3	3.3	4.1	0.9	1.2
Hooded Warbler	22.6	17.4	7.7	13.6	3.7	21.1	10.5
Scarlet Tanager	81.4	62.3	13.3	42.2	9.3	69.4	7.2
Rose-breasted Grosbeak	13.6	27.1	10.2	39.2	2.1	23.0	8.5
Indigo Bunting	18.1	7.3	10.1	3.6	3.8	10.4	11.1
Northern Oriole	9.0	6.3	6.0	12.0	7.7	5.3	4.0

Table F-4

Comparison of breeding bird densities observed in Council Cup Forest in 1994 with prior study years (1980-93) and during preoperation (1980-82) and operation (1983-94) of the Susquehanna SES.

MIGRATORY STATUS	1994	1980-93		PREOPERATION		OPERATION	
Species		Mean	SD	Mean	SD	Mean	SD
RESIDENTS	**308.4**	**211.5**	**58.2**	**145.6**	**20.1**	**236.0**	**54.3**
Red-tailed Hawk	0.0	0.4	0.7	0.0	0.0	0.4	0.7
Ruffed Grouse	8.3	4.3	8.5	1.7	0.0	5.3	9.1
Wild Turkey	0.0	0.1	0.4	0.0	0.0	0.1	0.5
Eastern Screech-Owl	0.0	0.7	2.2	0.0	0.0	0.8	2.3
Great Horned Owl	0.0	1.8	4.2	0.6	0.8	1.9	4.5
Downy Woodpecker	25.0	23.8	9.9	13.9	3.9	26.4	8.9
Hairy Woodpecker	16.7	13.8	9.6	13.9	0.0	14.0	10.2
Pileated Woodpecker	8.3	3.6	3.0	3.9	3.1	3.9	3.1
American Crow	16.7	3.0	3.4	2.8	3.9	4.2	4.9
Black-capped Chickadee	116.7	87.5	19.6	69.4	14.2	94.5	18.4
Tufted Titmouse	50.0	45.8	18.6	25.0	11.8	51.4	15.2
White-breasted Nuthatch	50.0	21.6	14.2	11.7	7.1	26.4	15.5
Northern Cardinal	16.7	5.1	6.6	2.8	3.9	6.7	7.4
SHORT-DISTANCE MIGRANTS	**201.8**	**179.7**	**41.2**	**156.7**	**19.6**	**187.2**	**41.6**
Cooper's Hawk	0.0	0.1	0.4	0.0	0.0	0.1	0.5
Northern Flicker	1.7	8.7	9.2	17.2	12.9	6.0	5.9
Blue Jay	25.0	35.1	10.5	38.9	3.9	33.3	11.3
Red-breasted Nuthatch	16.7	1.2	2.9	2.8	3.9	2.1	5.0
Brown Creeper	8.3	8.6	10.3	0.0	0.0	10.7	10.0
Hermit Thrush	0.0	1.1	2.1	0.6	0.8	1.1	2.3
American Robin	50.0	16.4	11.1	22.2	7.9	17.8	14.5
Cedar Waxwing	16.7	39.9	17.9	19.4	14.2	43.1	15.9
Rufous-sided Towhee	0.0	3.2	4.6	1.7	0.0	3.3	5.0
Chipping Sparrow	0.0	11.7	11.3	3.3	3.6	12.8	11.7
Brown-headed Cowbird	66.7	53.6	15.3	50.0	13.6	55.6	15.3
American Goldfinch	16.7	0.1	0.4	0.6	0.8	1.4	4.6
LONG-DISTANCE MIGRANTS	**655.4**	**448.2**	**62.5**	**405.0**	**73.6**	**476.3**	**74.3**
Broad-winged Hawk	0.0	2.6	5.8	11.7	7.1	0.1	0.5
Black-billed Cuckoo	0.0	0.7	2.1	0.6	0.8	0.7	2.3
Yellow-billed Cuckoo	16.7	6.8	8.9	19.4	3.9	4.5	7.1
Ruby-throated Hummingbird	0.0	0.8	2.2	2.8	3.9	0.3	0.6
Eastern Wood-Pewee	50.0	49.4	20.0	27.8	10.4	54.9	17.2
Great Crested Flycatcher	16.7	28.0	8.7	33.3	0.0	25.7	9.3
Eastern Kingbird	1.7	0.1	0.4	0.0	0.0	0.3	0.6
Blue-gray Gnatcatcher	33.3	10.0	10.9	20.0	13.4	9.4	10.7
Veery	0.0	0.1	0.4	0.0	0.0	0.1	0.5
Wood Thrush	41.7	44.1	15.9	44.4	15.7	43.8	15.3
Solitary Vireo	41.7	4.3	6.8	2.8	3.9	7.8	12.4
Red-eyed Vireo	91.7	86.3	18.5	61.1	7.9	93.1	13.5
Black-throated Blue Warbler	0.0	0.1	0.4	0.0	0.0	0.1	0.5
Black-throated Green Warbler	16.7	0.0	0.0	0.0	0.0	1.4	4.6
Blackburnian Warbler	0.0	2.5	5.8	0.0	0.0	2.9	6.2
Pine Warbler	1.7	0.0	0.0	0.0	0.0	0.1	0.5
Black-and-white Warbler	16.7	22.4	13.4	30.6	10.4	19.9	12.7
American Redstart	16.7	0.6	2.1	0.0	0.0	2.1	5.0
Worm-eating Warbler	0.0	3.3	4.9	8.3	6.8	1.8	3.0
Ovenbird	166.7	92.9	29.7	61.1	21.9	106.9	30.2
Canada Warbler	0.0	0.1	0.4	0.0	0.0	0.1	0.5
Scarlet Tanager	116.7	60.7	14.6	61.1	7.9	65.3	21.7
Rose-breasted Grosbeak	8.3	25.1	13.5	17.2	17.5	25.7	12.0
Indigo Bunting	1.7	2.4	2.5	1.7	0.0	2.5	2.7
Northern Oriole	16.7	4.9	4.7	1.1	0.8	6.8	5.5
TOTAL	**1165.6**	**839.4**	**116.6**	**707.2**	**107.2**	**899.6**	**117.7**

Table F-5

Daniels' test for trend over time (1980-94) in breeding bird densities of common species and correlations between these densities in TR419 and Council Cup Forest plots. Trend test was Spearman's rank correlation coefficient (rho). Analysis was limited to species with at least 0.5 territory in at least five years of the study period.

MIGRATORY STATUS	TR419 FOREST		COUNCIL CUP FOREST		CORRELATION BETWEEN PLOTS	
Species	rho	P	rho	P	rho	P
RESIDENTS	**0.589**	**0.020 ****	**0.780**	**0.000 ****	**0.604**	**0.017 ****
Red-tailed Hawk	0.291	0.281				
Downy Woodpecker	0.342	0.204	0.586	0.021 **	0.242	0.374
Hairy Woodpecker	-0.006	0.974	0.117	0.667	0.340	0.209
Pileated Woodpecker			0.262	0.339		
American Crow	0.800	0.000 **	0.711	0.003 **	0.601	0.018 **
Black-capped Chickadee	-0.396	0.138	0.476	0.071 *	0.209	0.441
Tufted Titmouse	0.800	0.000 **	0.595	0.018 **	0.743	0.001 **
White-breasted Nuthatch	-0.188	0.489	0.492	0.060 *	-0.071	0.792
Northern Cardinal	-0.029	0.913	0.720	0.002 **	0.346	0.199
SHORT-DISTANCE MIGRANTS	**-0.345**	**0.199**	**0.497**	**0.058 ***	**-0.072**	**0.792**
Northern Flicker	-0.268	0.325	-0.092	0.734	-0.262	0.339
Blue Jay	-0.705	0.003 **	-0.317	0.240	0.540	0.037 **
Brown Creeper	-0.359	0.185	0.520	0.046 **	0.256	0.346
American Robin	-0.382	0.154	0.267	0.325	0.291	0.281
Cedar Waxwing	0.705	0.003 **	0.334	0.214	0.527	0.043 **
Rufous-sided Towhee	-0.736	0.001 **				
Chipping Sparrow	0.401	0.134	-0.167	0.540	0.303	0.263
Brown-headed Cowbird	-0.442	0.095 *	0.344	0.204	-0.132	0.629
LONG-DISTANCE MIGRANTS	**0.940**	**0.000 ****	**0.509**	**0.050 ****	**0.416**	**0.117**
Yellow-billed Cuckoo			-0.290	0.287		
Eastern Wood-Pewee	0.780	0.000 **	0.623	0.012 **	0.619	0.014 **
Great Crested Flycatcher	0.096	0.724	-0.661	0.007 **	0.277	0.306
House Wren	0.281	0.300				
Blue-gray Gnatcatcher	0.780	0.000 **	-0.354	0.189	-0.448	0.089 *
Wood Thrush	0.535	0.038 **	-0.261	0.339	-0.400	0.134
Gray Catbird	-0.029	0.913				
Solitary Vireo			0.397	0.138		
Yellow-throated Vireo	0.760	0.000 **				
Red-eyed Vireo	0.910	0.000 **	0.553	0.031 **	0.721	0.002 **
Chestnut-sided Warbler	0.196	0.473				
Blackburnian Warbler	0.830	0.000 **				
Pine Warbler	0.217	0.426				
Black-and-white Warbler	-0.579	0.023 **	-0.295	0.275	0.238	0.381
American Redstart	0.860	0.000 **				
Worm-eating Warbler	0.840	0.000 **				
Ovenbird	0.750	0.000 **	0.681	0.005 **	0.780	0.000 **
Hooded Warbler	0.820	0.000 **				
Scarlet Tanager	0.647	0.009 **	0.429	0.107	0.364	0.176
Rose-breasted Grosbeak	-0.656	0.007 **	0.305	0.257	-0.188	0.489
Indigo Bunting	0.662	0.007 **				
Northern Oriole	-0.190	0.489	0.720	0.002 **	0.024	0.923
TOTAL	**0.900**	**0.000 ****	**0.870**	**0.000 ****	**0.800**	**0.000 ****

* Marginally significant at $P \leq 0.10$

** Significant at $P < 0.05$

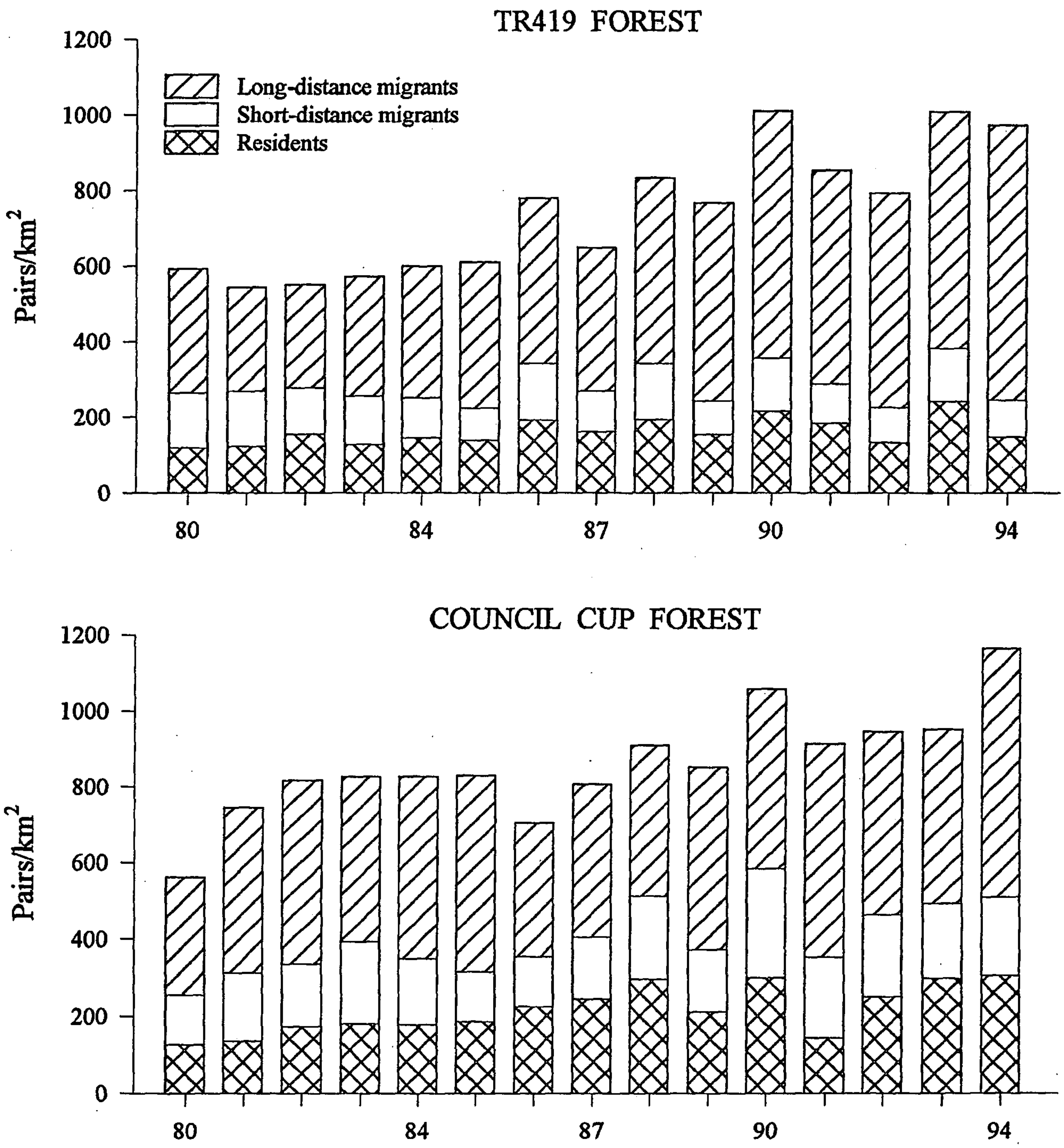

Fig. F-1

Total breeding bird densities in TR419 and Council Cup Forests during preoperation (1980-82) and operation (1983-94) of the Susquehanna SES .

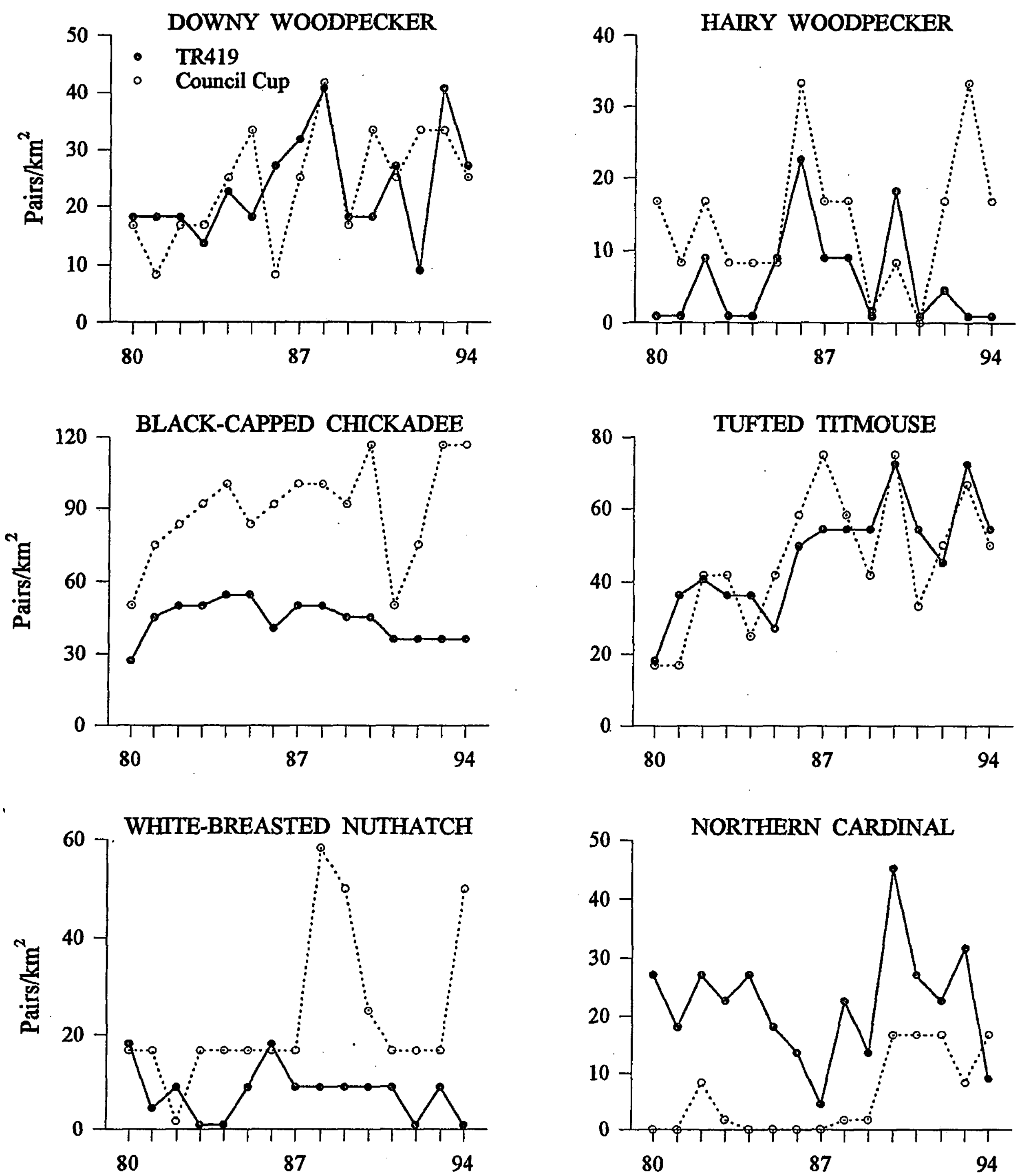

Fig. F-2

Breeding densities of six common resident species in TR419 and Council Cup Forests during preoperation (1980-82) and operation (1983-94) of the Susquehanna SES.

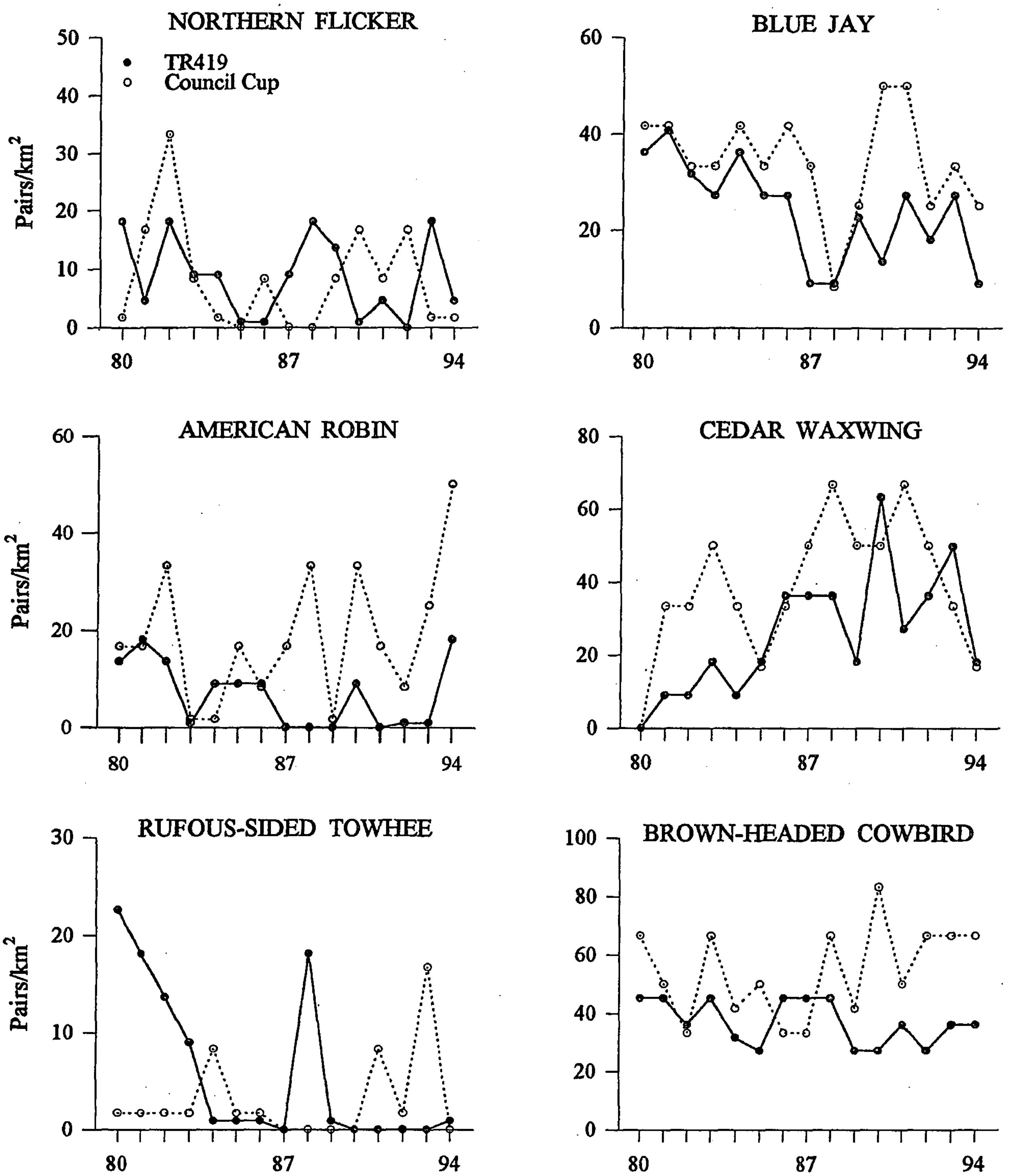

Fig. F-3

Breeding densities of six common short-distance migrant species in TR419 and Council Cup Forests during preoperation (1980-82) and operation (1983-94) of the Susquehanna SES.

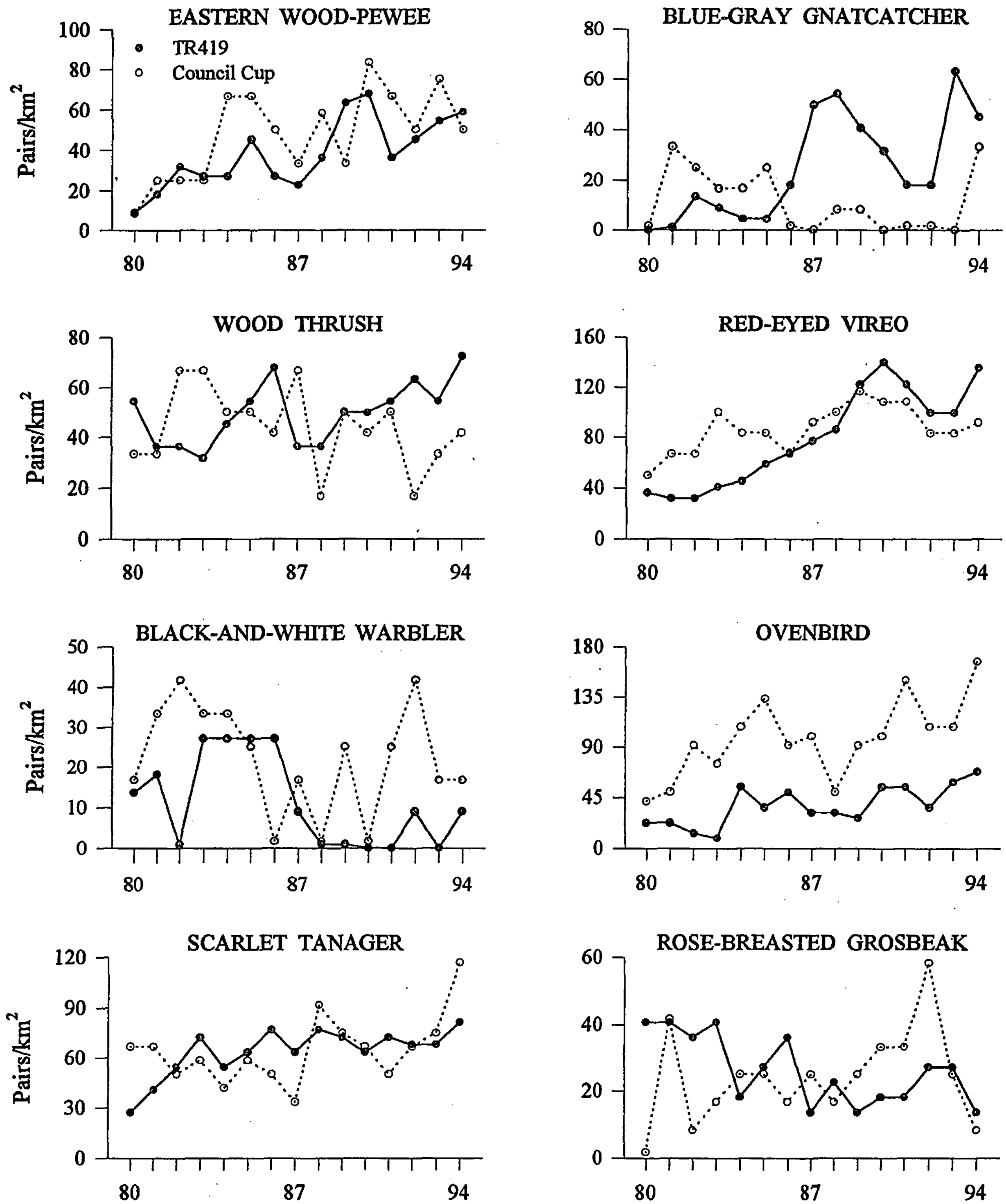

Fig. F-4

Breeding densities of eight common long-distance migrant species in TR419 and Council Cup Forests during preoperation (1980-82) and operation (1983-94) of the Susquehanna SES.

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TECHNICAL REPORTS AND PUBLICATIONS ISSUED BY ECOLOGY III AT THE SUSQUEHANNA SES ENVIRONMENTAL LABORATORY DURING 1994

Environmental Studies In The Vicinity Of The Susquehanna Steam Electric Station, Monthly Progress Reports (January-December 1994)

Quality Assurance Program for the Radiological Environmental Monitoring Program, 1993 Summary Report (March 1994)

Collection of American Shad Eggs from the Delaware River, 1994 (June 1994)

Susquehanna Steam Electric Station 1994 Discharge Diffuser Pipe Inspection Report (June 1994)

Environmental Studies in the Vicinity of the Susquehanna Steam Electric Station, 1993 Annual Report (July 1994)

Environmental Studies in the Vicinity of the Susquehanna Steam Electric Station, 1993 Summary Report (August 1994)

A Survey of Sediment on the Bottom of the Susquehanna Steam Electric Station Emergency Service Water Spray Pond (October 1994)

Susquehanna Steam Electric Station 1994 Land Use Census (Nov 1994)

Wetland Evaluation South of the Susquehanna Steam Electric Station Intake Structure (Nov 1994)

Pennsylvania Breeding Birds of Special Concern: A Listing Rationale and Status Update by D. W. Brauning, M. C. Brittingham, D. A. Gross, R. C. Leberman, T. L. Master, and R. S. Mulvihill. Journal of the Pennsylvania Academy of Science, 68(1): 3-28.

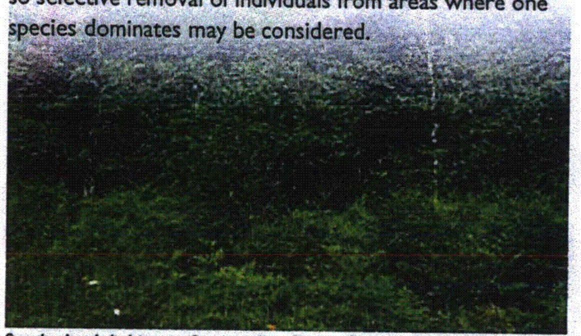
Pupation Ecology of the Dobsonfly *Corydalus cornutus* (Corydalidae: Megaloptera) along a Large River by B. P. Mangan. Journal of Freshwater Ecology, Vol. 9(1): 57-62.

Enclosure 7

TE-09 - Collected Attachments

Planting and Managing Scrub-Shrub Habitat

Typically scrub-shrub habitat is only a temporary condition before conversion to forest. In areas near power lines, however, it is necessary to keep vegetation height low in perpetuity. This can be accomplished by planting compatible species and selectively removing saplings of large trees. Removing invasive plants like multiflora rose and honeysuckle will allow native shrubs (see compatible list below), which provide nutritious berries and seeds, to flourish. Habitat that includes a variety of species and heights will produce the best habitat for many bird species, so selective removal of individuals from areas where one species dominates may be considered.



Scrub-shrub habitat at forest edge. Photo ©Laurie Smaglick Johnson

Compatible Plant Species

The following list of native plants are appropriate for planting in Border Zones and provide cover and food to desirable birds and native plants noted above.

Small trees
Flowering dogwood
Redbud
Hawthorn
American Hornbeam
Serviceberry
Eastern Red Cedar
American Chestnut
Dwarf Willow
Winterberry Holly

Large shrubs
Alder
Witch-hazel
Spicebush
Common Chokecherry
Elderberry
Rhododendron
Viburnum
Dogwood
Sumac species
Chokeberry

Small shrubs
Mountain laurel
American Yew
Sweetfern
Trumpet Honeysuckle
Huckleberries
Blueberries
Viburnums
Meadowsweet (Spirea)
Wintergreen
Trailing Arbutus
Blackberry (Allegheny)
Raspberry
Hazelnut
Scrub Oak species

All native grasses, ferns, herbaceous plants

For more information, go to http://pa.audubon.org/habitat

An award-winning program

PPL Electric Utilities is a proud recipient of the Tree Line USA® award from the Arbor Day Foundation and the National Association of State Foresters. The groups seek to promote proper utility arboriculture and public education through annual worker training, quality tree care, tree planting and public education, energy conservation and collaboration with community groups. For information about planting the right tree in the right place, visit www.arborday.org.

PPL Electric Utilities works with state and local conservation, land management and environmental groups to advance common goals of electric reliability and environmental stewardship.

TREE LINE USA.
Arbor Day Foundation

Vegetation management is critical to electric reliability

Our customers depend on reliable power, and vegetation management is a critical part of maintaining the reliability of our delivery system.

PPL Electric Utilities operates thousands of miles of transmission lines. Transmission lines are interconnected regionally, so power can move long distances from power plants to local communities. It is vital that trees are kept well clear of transmission lines. Tree contact with high-voltage lines can result in widespread power outages.

For more information, call 1-877-528-2889, email us at PPLVegetationManagement@pplweb.com or visit www.pplweb.com/vegetation.

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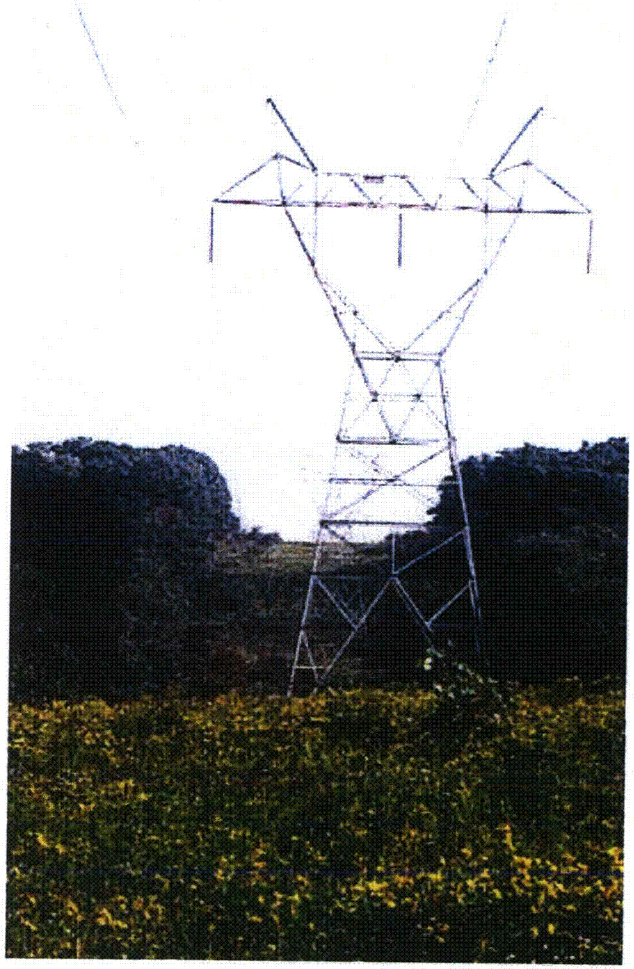
Transmission Line Vegetation Management

Keeping your electric service reliable



High-voltage transmission lines are the backbone of the regional electric grid. They are vital to our economic health and our nation's security.

The Northeast blackout of 2003 demonstrated how important it is to keep trees away from these power lines. About 55 million people in eight U.S. states and Canada were left without power after a tree touched a transmission line.

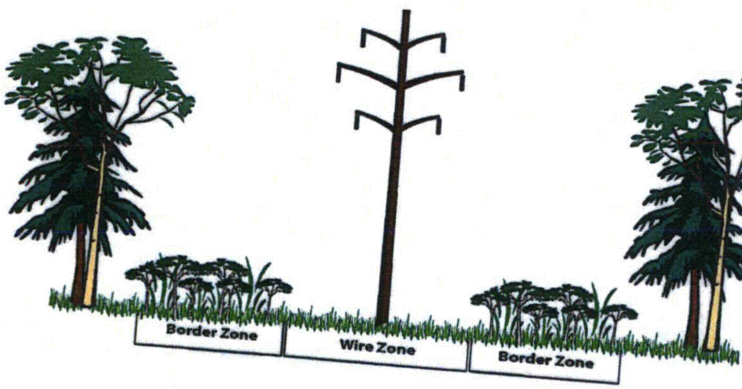
After the blackout, the federal government adopted strict new reliability standards for electric utilities. We are required to meet these standards. And we have an obligation to keep your electric service reliable.

PPL Electric Utilities takes a proactive approach to keeping trees away from power lines. This means that we are now removing trees in areas where in the past we permitted them to grow. We know this isn't always popular with landowners, but it is the right thing to do.

This brochure contains more information about our approach to transmission line vegetation management. Our program is based on industry best practices. It is carried out by trained professionals who are focused on preventing damage to the power grid so that you will have the electricity you need when you need it the most.

Our commitment to you

We have a longstanding respect for the environment. We respect the rights of property owners. We will keep customers informed about any planned work. The work we perform is intended to keep your electric service reliable.



Compliance with federal reliability standards

Under federal reliability standards, certain clearances must be maintained between overhead power lines and any vegetation. To comply with these standards – and to meet our obligation to customers to keep their power supply reliable – PPL Electric Utilities follows an industry best practice referred to as Wire Zone-Border Zone.

What is Wire Zone-Border Zone?

The wire zone is the area directly under the transmission lines and extending out an additional 10 feet on each side. Trees are removed from the wire zone because they are incompatible with high-voltage wires. Low-growing grasses and other compatible species are permitted in this zone.

The border zone extends from the edge of the wire zone to the edge of the right of way. Certain trees and shrubs are allowed in this area if they do not pose a reliability risk.

PPL Electric Utilities does not remove or dispose of any vegetation from transmission rights of way after cutting. These materials belong to the property owner. In some areas, like hillsides, leaving cut vegetation can protect against erosion.

In some areas, we use herbicides to effectively manage undesirable vegetation conditions along our power lines. We only use products that have been approved for use by the U.S. Environmental Protection Agency. Some of the materials our contractors will use are the same as those commonly used by homeowners.

*The **wire zone** is the area beneath the wires plus an additional 10 feet on each side. Vegetation is cleared from this zone. Grasses and other low-growing plants will be permitted to grow back.*

*The **border zone** extends from the edge of the wire zone to the edge of our right of way. Depending on conditions, we will either clear this zone of all vegetation, allowing certain small trees and shrubs to grow back if they do not pose a reliability risk, or we will selectively remove*

Audubon PENNSYLVANIA

PPL Rights-of-way as Bird Habitat

Golden-winged Warbler. Photo ©Laurie Smaglick Johnson

To ensure compliance with federal electric reliability standards, many utilities like PPL Electric Utilities are clearing the areas under high-voltage power lines along utility rights-of-way (referred to as the "wire zones"). The area bordering the wire zone extending to the edge of the utility rights-of-way (called the "border zone") can have low-growing plant species that are consistent with the utility's program to comply with the federal requirements. Such plant species also can provide critical habitat to birds and other wildlife.

Scrub-Shrub Habitat

When an old field is left unmanaged, woody shrubs become established, which eventually give way to small trees and, ultimately, forest. Scrub-shrub or "successional" habitat refers to the middle time period when shrubs and small trees dominate. A host of bird species, including ruffed grouse, brown

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Keeping your electric service reliable

Our customers want reliable power – in good weather and bad. Trees are generally the most common cause of power outages, and vegetation management is critical to keeping the electric power grid reliable.

To make sure our customers have reliable electric service, PPL Electric Utilities has developed a comprehensive program to manage vegetation around power lines. We maintain about 35,000 miles of transmission and distribution lines. Keeping trees and other vegetation away from these lines is very important.

Why do we trim trees?

Trees are generally the most common cause of power outages. We work very hard to keep them away from power lines so you will have reliable electric service. We spend millions of dollars each year as an investment in safe, reliable operation of the electric delivery system.

Transmission lines deliver large amounts of power from power plants to local communities. Transmission lines are vital to our region and to our nation's security and economic well-being. It is imperative that trees are kept clear of these transmission lines.

Tree contact with higher-voltage lines can result in widespread power outages to many thousands of homes and businesses. Because these lines are so vital to deliver electricity, we clear trees and other vegetation beneath or near transmission lines.

Distribution lines typically run down local streets and highways to deliver electricity to customers. We generally prune or trim trees away from these lines every few years. Tree trimming varies based on the type of facilities, tree species and density, growth rates, proximity of the trees to the power lines, and recent power outages on the line.

Federal and state requirements – Vegetation management is required to meet federal and state reliability standards.

After the 2003 Northeast blackout, federal standards mandated that utilities have a vegetation management program to prevent widespread outages on the transmission system.

The North American Electric Reliability Corporation strictly enforces the standards. Utility companies who fail to comply with the standards can be fined up to $1 million per day for each violation.

The Pennsylvania Public Utility Commission also requires PPL Electric Utilities to adequately maintain its facilities to provide safe, reliable electric service to customers. Service reliability is monitored each year to ensure that we meet our state obligations.

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How do we trim trees?

PPL Electric Utilities' professional foresters work directly with qualified line clearance tree trimming companies, who are trained to safely work around energized power lines and perform the work properly.

On the distribution system that delivers power to your neighborhood, our contractors use a technique known as directional pruning, which is widely accepted in the industry as the best practice. This technique removes only those branches growing toward the power lines. With directional pruning, entire branches under, over or beside power lines will be pruned back to the main stem of the tree or to another large branch.

Remaining branches are left to grow naturally, providing more of the tree's natural shape. By only removing those braches that are growing toward the power lines, less stress is placed on each tree. The Arbor Day Foundation strongly endorses directional pruning techniques as being better for tree health. This method of pruning also follows the nationally recognized Standards for Tree Care Operations.

We look to make the fewest cuts possible to clear tree limbs from the power lines. Some customers may want an arborist or landscaper to perform additional pruning for aesthetic purposes since the utility trims mainly for safety and reliability.

On the transmission system, which is like a highway for electricity, we take a more proactive approach toward maintaining utility rights of way where transmission lines are located. In the past we selectively trimmed to keep tall-growing trees away from the lines.

Now in most cases all vegetation under these critical transmission lines is cleared. Tree species that may in the past have been allowed in certain locations now must be cleared.

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Why has PPL Electric Utilities changed its approach on transmission line vegetation maintenance?

After the Northeast blackout in 2003, the federal government adopted strict new reliability standards for electric utilities because a tree was the primary cause of the blackout.

The reliability standards assumed a "zero tolerance" policy when it comes to tree-related power outages on transmission lines since they can leave large areas without power.

Additionally, the federal government can impose stiff financial penalties if utilities fail to comply. Under the new standards, certain clearances must be maintained between the

overhead lines and any vegetation.

The clearances recognize that lines can sag under heavier loads and trees can sway in the wind. Subsequently, PPL Electric Utilities and companies across the U.S. began taking a more proactive approach to ensure that we meet these higher expectations to maintain the reliability of the electric grid.

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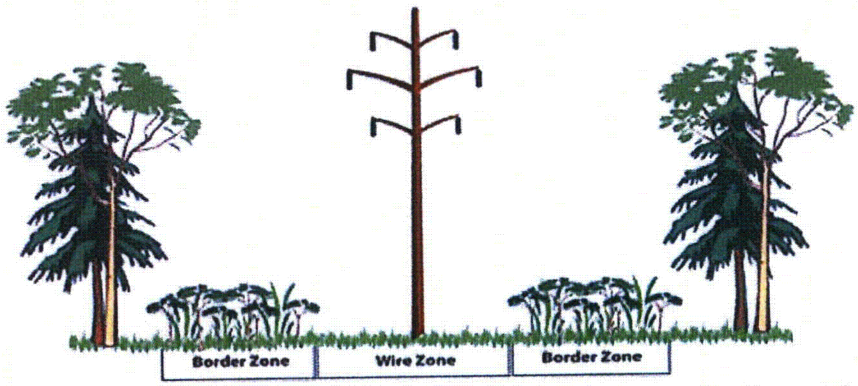
What is "Wire Zone/Border Zone"?

Our vegetation management program is responsible for reliability of 4,500 miles of transmission power lines. On certain rights of way, PPL Electric Utilities now uses industry best practices, known as "Wire Zone-Border Zone." The new approach, which now applies to transmission lines of 115 kilovolts and higher, means most trees and shrubs that we have allowed to remain directly under the lines in the past are no longer are permitted.



The **Wire Zone** is considered the area directly under the transmission lines and extending out 10 feet. Trees are typically removed from the wire zone as they are incompatible with high-voltage wires. Over time, low-growing grasses and other species native to the area will be permitted to grow back.

The **Border Zone** extends from the edge of the wire zone to the edge of the PPL Electric Utilities right of way. Small trees and certain shrubs will be allowed to grow back over time if they do not pose a reliability risk. According to Audubon Pennsylvania, border zones can become and remain early successional scrubland (scrub-shrub), a habitat that is important to several bird species of conservation concern in Pennsylvania and other parts of the northeast.

The **Danger Tree Zone** is located outside of the utility right of way. Because some trees could pose a risk of falling onto transmission lines, our right-of-way agreements allow us to remove any tree from this area.

We will perform only the work that we believe is necessary to meet reliability standards and keep electric service reliable.

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Helicopter patrols improve reliability

PPL Electric Utilities uses high-tech solutions to ensure we maintain compliance with the federal reliability standards. A technology called LIDAR (Light Detection and Ranging) makes the task of monitoring potential tree interference with transmission lines faster and more accurate.

The technology uses laser beams from a helicopter to accurately measure distances from a wire to any potential obstructions including trees. It creates a map that displays the relative heights and positions of towers, power lines, and trees. LIDAR inspections each year verify clearances around high voltage transmission lines and help us prioritize where clearance work is needed to meet the reliability standards.

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What is integrated vegetation management?

PPL Electric Utilities is proud to be a Tree Line USA® award recipient from the National Arbor Day Foundation. The Arbor Day Foundation, in cooperation with the National Association of State Foresters, promotes the dual goals of safe, reliable electric service and abundant, healthy trees across utility service areas.

The program seeks to promote best practices in utility arboriculture and public education through five core standards: annual worker training, quality tree care, tree planting and public education, energy conservation, and collaboration with community groups.

Ongoing and well-documented research has shown that integrated vegetation management programs that use herbicides provide significant wildlife benefits to reptiles, amphibians, song birds and mammals by increasing habitat diversity.

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Cleanup and wood chips

PPL Electric Utilities does not remove or dispose of any vegetation from transmission rights of way after cutting. One reason is that materials belong to the property owner. Also, in some areas, like hillsides, leaving cut vegetation can protect against erosion. When work is done on local distribution facilities, tree crews typically chip and remove smaller limbs and branches.

Larger wood is generally cut into handling lengths and left at the base of the tree for property owner use. In more rural areas where possible, tree crews will pile pruning debris to create cover for wildlife. Larger limb wood will be separated and left for property owner use.

If you'd like wood chips, please see the foreman of the tree crew doing the work. The foreman will do his or her best to grant your request. If you do request chips, be mindful that contractors will deliver full loads – 5 to 7 cubic yards – and will not remove unused chips once delivered.

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Why do we use herbicides?

PPL Electric Utilities uses herbicides to effectively manage vegetation conditions along our power lines. Research has shown that herbicide use on rights of way can greatly enhance wildlife habitat diversity, while promoting low-growing plant communities.

By promoting low-growing plant communities and increased habitat for wildlife that feed on many of the undesirable vegetation species, less herbicide use will be required to ensure safe and reliable electric service.

We are committed to managing vegetation in ways that will have a minimal impact on our environment. We will only apply herbicide products that have been approved for use on utility rights of way by the U.S. Environmental Protection Agency. These products have undergone significant testing. In fact, some of the materials our contractors will use are the same as those commonly used by homeowners.

All herbicides used on our right of way are applied by state certified applicators. Within the rights of way, vegetation that is acceptable is generally left untreated, while vegetation that has potential to grow too close to power lines is treated. Herbicides provide the most effective means to reducing re-sprouting by effectively treating the entire plant system.

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Don't try to prune or remove trees around live wires

Do not attempt to prune or remove trees near power lines. Contact with a power line can cause serious injury or death. Electricity can "flash over" if someone comes too close to a high-voltage line.

Our qualified line clearance tree trimmers have specialized training to work around our power lines. If you or a private arborist working for you plans to remove a tree growing within 10 feet of a power line wire, call PPL Electric Utilities. We will have one of our tree trimmers prune the tree to provide a safe working distance.

We do not prune or remove trees around the service wire between your house and the utility pole. We will be happy to de-energize your service wire and lower it to the ground so you can do the work safely. Both of these services are provided at no cost. We do require at least three business days' notice, and additional time may be required to schedule a crew. Please call 1-800-342-5775.

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Our commitment to you

Our easements grant PPL Electric Utilities the right to operate and maintain electric facilities on property owned by others. We will do our best to notify residents or property owners in advance of any vegetation management work. We want our customers to understand what line clearance work PPL Electric Utilities must perform, the reasons for the work and the timing.

If you have any questions about our approach, you can call our vegetation management hotline at 1-877-528-2889 or email us at PPLVegetationManagement@pplweb.com.

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Planting near power lines

Transmission line corridors can be cultivated with native grasses that can be visually appealing, provide food to birds and wildlife, and are more compatible with high-voltage power lines.

If you plan to plant a new tree, or replace an existing tree, please pay close attention to what type of tree you plant and where. When choosing a spot to plant your tree, make sure it will have plenty of room to grow to full maturity.

Speak with the nursery where you plan to purchase the tree and tell them about any power lines so they can help you select the right tree. Selecting the right tree for the right place will make your property safer, more attractive and reduce the likelihood for power outages.

PPL Electric Utilities' professional foresters can also advise you to select the proper tree for the location you have chosen. For more information, call our vegetation

management hotline at 1-877-528-2889 or email us at PPLVegetationManagement@pplweb.com.

Learn more about planting the right tree in the right place.

Compatible species

Tree care tips

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For more information

- North American Electric Reliability Corporation
  www.nerc.com
- Edison Electric Institute on Vegetation Management
  http://www.eei.org/ourissues/TheEnvironment/Land/Pages/VegManagement.aspx
- Utility Arborist Association
  www.utilityarborist.org
- Tree Care Industry Association
  www.treecareindustry.org
- National Arbor Day Foundation
  www.arborday.org
- International Society of Arboriculture
  www.isa-arbor.org
- National Association of State Foresters
  www.stateforesters.org
- Articles in Transmission & Distribution World
  http://tdworld.com/veg-management
- FERC Vegetation Management Report
  http://www.ferc.gov/industries/electric/indus-act/reliability/veg-mgmt-rpt-final.pdf
- Tree Line USA Program
  http://www.arborday.org/programs/treeLineUSA/standards.cfm

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Useful links:

- Compatible Species
- Frequently asked questions about PPL Electric Utilities' vegetation program along transmission lines.
- Brochure on PPL transmission vegetation management
  This brochure summarizes PPL's vegetation management program and philosophy, and includes much of the information on this Web page.
- From Pennsylvania Audubon: PPL Rights-of-way as Bird Habitat
- PPL Electric Utilities' vegetation management program
  for smaller transmission and distribution lines.

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May 4, 2007,

S.A. Bogle – SUSSC
G.R. Hahn – HONSC
G.J. Owens – LEHSC

PPL Vegetation Management Program response to the protection of the Indiana Bat along transmission rights-of-ways extending from the PPL Susquehanna, LLC operating station.

As part of the PPL Susquehanna, LLC re-licensing of the Susquehanna SES, the Nuclear Regulatory Commission (NRC) has requested applicants to contact various regulatory agencies to determine if any adverse environmental impacts of such re-licensing could affect endangered species.

The U.S. Fish and Wildlife Agency (USFWS) has identified that the Indiana bat, a federally protected species, as having two hibernaculums (winter hibernating areas) within close proximity of the Susquehanna plant. These hibernaculums have been identified as being near the towns of Glen Lyon and Dogtown, Pennsylvania.

According to the USFWS, tree cutting activities within a five (5) mile radius of the identified hibernaculums during the period of April 1st through November 15th on trees larger than five (5) inches DBH (diameter at breast height) could adversely affect Indiana bat populations. The USFWS is requesting PPL to limit tree cutting activities along the identified areas to only the period of November 16th through March 31st of any calendar year.

Affected Susquehanna SES Bulk Power transmission corridors, within the five (5) mile radiuses of the towns Glen Lyon and Dogtown, Pennsylvania are listed on the attached spreadsheet. Total affected area is approximately sixty-seven (62) line miles.

In response to this request, PPL Electric Utilities will limit transmission corridor tree cutting activities on trees larger than five (5) inches DBH, within the identified areas (see attached spreadsheet) to the period of November 16th to March 31st of each calendar year, with the following reservations:

- PPL reserves the right to remove danger trees at any time of the year, as provided under Section 7 of the Endangered Species Act.
- PPL reserves the right to conduct other vegetation management activities within these areas that do not require tree removals.

As required, PPL Electric Utilities Field Services will maintain all records of vegetation management activities, routine and emergency, on these lines for a period of five (5) years.

As part of Section 7 of the Endangered Species Act, PPL will notify appropriate Regulatory Agencies (NRC, FERC, FEMA, etc.) with information regarding any emergency cutting operations on trees larger than five (5) inched DBH.

Earl Burnside
PPL System Forester
610-774-3946
ETN 220-3946
GENN5

Attachments: - Spreadsheet identifying PPL Lines and restricted activity zone.
Indiana Bat Affected Lines.xls
Section 7 of the Endangered Species Act
..\Sect 7 ESA.pdf
PNDI Form..\PNDI Form_formatted.doc

CC:
Phil Weber – GENN5
Bill Taylor – GENN5
Dave Bonenberger – GENTW19
Al Kosydar – SCRSC
Mike McGinley - HARSC
Jerome Fields – GENPL5
Curtis Saxton – NUCSA3
Tinku Khanwalkar – GENTW13
Mike Detamore – GENPL5
Mike Crowthers – GENPL4
Duane Filchner – GENPL4
John Fridman – SSO
Kevin Drewencki – MPR
Jeff Luzenski – GENTW17

Specification For
Initial Clearing and Control Maintenance
Of Vegetation on Or
Adjacent To Electric Line
Right-of-Way through Use Of
Herbicides, Mechanical,
And Hand-clearing Techniques

LA-79827-8

PPL ELECTRIC UTILITIES CORPORATION
Allentown, Pennsylvania

Prepared: Earl V. Burnside – System Forester — 12/29/10 **Date**

Approved: Philip J. Walnock – Manager – Vegetation Management — 12/29/10 **Date**

- Special care shall be taken in clearing near ornamentals or any type of cultivated tree, shrub, or vine.

- If areas are encountered that have already been cut over, any tree stubs of an excessive height shall be re-cut to the heights specified above.

- Danger trees shall be pruned or removed, as previously described under "Clearing Requirements".

IV. DISPOSAL OF CLEARED VEGETATION

In accordance with state and federal environmental regulations and policies, it shall be the policy of PPL Electric that no vegetation disposal (e.g.. piling, drop and lop, chipping, burning, etc.) shall occur in known or suspected wetland areas.

Wetlands are defined as areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

A. Specific Procedures for Each Disposal Method

1. Piling

(a) Timber (6" or larger in diameter).

- All timber shall be placed in neat piles along the edge of the right-of-way, away from areas of preserved compatible vegetation. Under normal conditions timber piles will be interspersed with slash piles.

- Timber shall be stacked in tree length piles unless otherwise specified, in piles not greater in length than the longest tree length. A separation of at least 10' shall be provided on either side of each pile.

- Herbicides shall not be applied during inclement weather, preventing the need for reapplication and reducing the chance of runoff into non-target areas. If rain does occur, application shall not begin until one hour after runoff has stopped. Early morning dew, when foliage is extremely wet, will be allowed to dry before application.

- Herbicides shall not be applied in the following areas (with the exceptions as noted):

  (1) Pasture areas.

  (2) Within 50' of any water body, except stump treatments and herbicides approved for watershed/aquatic use.

  (3) Within any actively maintained orchard or cultivated planting.

  (4) Near susceptible crops or other non-target vegetation, where drift, runoff, or vapors can cause injury. Exact safety distances shall be determined based on wind conditions, topography, soil type, vegetation (crop) type, and label instructions.

  (5) In cases where weather conditions create excessive drift, applications will be temporarily suspended until improved conditions warrant the continuation of the application.

  (6) On rights-of-way under jurisdiction of the Pennsylvania Department of Conservation and Natural Resources, Pennsylvania Game Commission, Pennsylvania Fish and Boat Commission, and the U.S. Park Service unless prior approval is granted by the Department or Commission.

  (7) On watershed properties, or in the vicinity of springs, irrigation ditches, or other potable water sources, unless prior approval is granted by the property owner for use of a watershed/aquatic approved herbicide.

Enclosure 8

TE-26 – Leaf-on Noise Survey, 2008

Hessler Associates, Inc.
Consultants in Engineering Acoustics

3862 Clifton Manor Place
Suite B
Haymarket, Virginia 20169 USA
Phone: 703-753-1602
Fax: 703-753-1522
Website: www.hesslernoise.com

Report Number 062608-1
Baseline Environmental Noise Survey
Leaf-on Season

Bell Bend Nuclear Power Plant (BBNPP) Project
June 2008

Prepared For:

AREVA NP Inc.
400 Donald Blvd.
Marlborough, MA 01752

Prepared By:
Hessler Associates, Inc.
Consultants in Engineering Acoustics

Principal Consultant:
George F. Hessler Jr., P.E., Bd. Cert. INCE

1.0_Introduction

Hessler Associates has been retained by AREVA NP, Inc. to conduct a baseline environmental noise level measurement survey in the surrounding environs at the Bell Bend Nuclear Power Plant project located near the town of Berwick, Pennsylvania. The site contains two existing PPL nuclear power units, rated at nominal capacities of 1105 and 1111 Mw just to the east of the planned Bell Bend project. An aerial map with topography shading is given on **Figure 1.0.1** that shows the planed Bell Bend expansion area and the selected community noise survey locations 1 through 5.

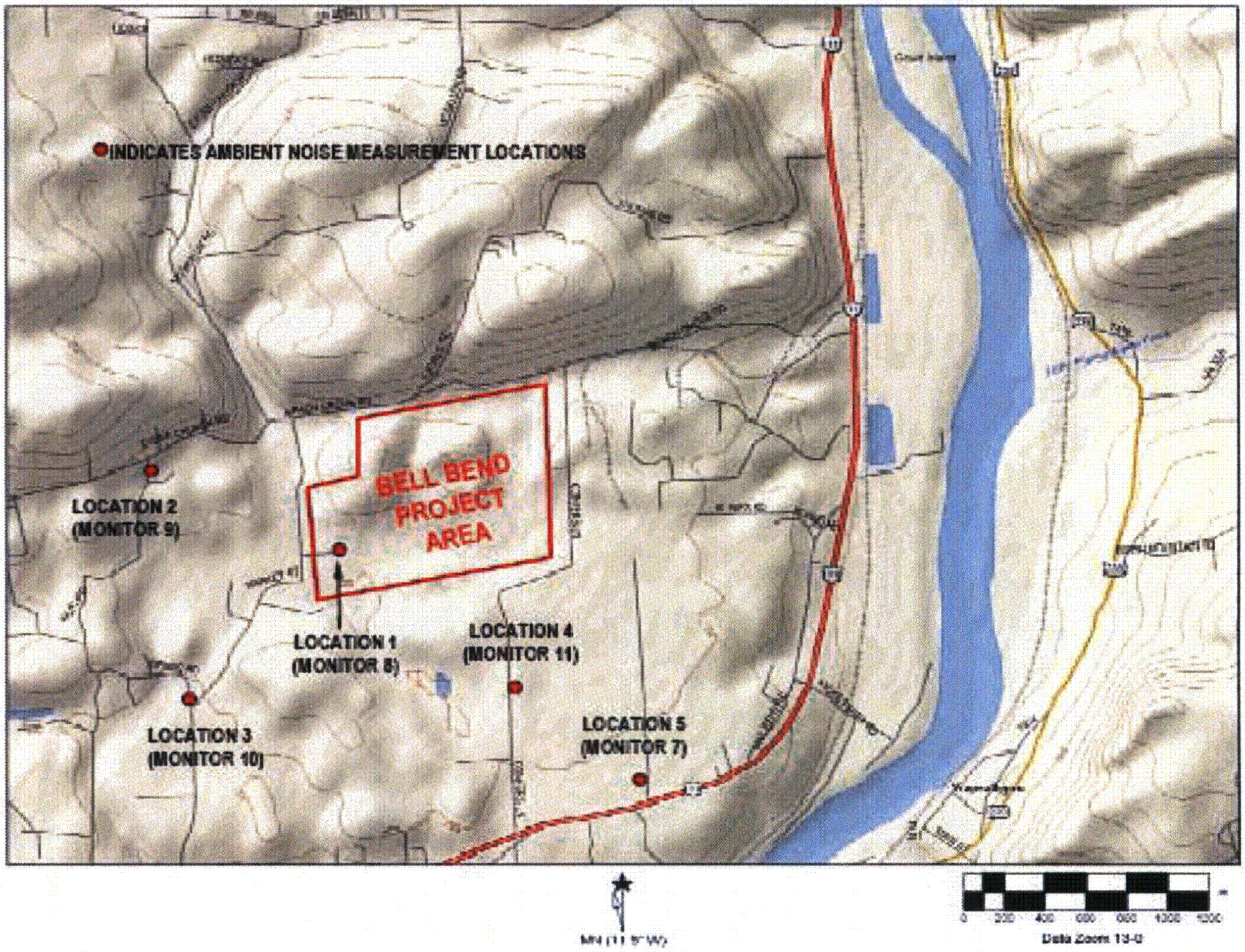

***Figure 1.0.1:** Site Map of Bell Bend Project Showing Sound Measurement Locations.*

A *leaf-off* ambient noise survey was completed over a 13 day interval-in March[1] for this site and this report promulgates the results of an identical survey conducted during *leaf-on* seasonal conditions during late May and early June. Measurements are made during leaf-off and leaf-on conditions to detect any contribution from the existing generating facilities, since the excess noise attenuation from dense trees between the plant and community would be different during the two seasons. In addition, potential adverse impact from noise (unwanted sound) is more likely during warmer leaf-on conditions when neighbors are outdoors.

Ambient or existing environmental community noise levels during leaf-on conditions were measured continuously over an 18-day period and are reported as complete days from midnight May 24th through June 10, 2008.

The results of the two surveys covering a combined 31-day measurement period provide a reliable long-term ambient sound level baseline for assessing any noise impact from the planned Bell Bend project.

There are no identified state or local noise ordinances for this project.

2.0_ Executive Summary and Results

Subjectively, existing facility noise emissions from the operating PP&L facilities were not noticeable at any of the five measurement locations during installation and removal of the noise monitors and while conducting manual measurements during these periods.
The data presented below are the minimum measured hourly levels for each of the eighteen complete measurement days. It is customary in three states (NY, MA and CA) with codified ambient-based procedures to use the minimum ambient level present during facility operational hours. For the proposed project with planned 24/7 operation at this rural environment, the minimum value may occur in any hour of the 24-hour day.

Table 2.0.1 below forms the key finding for this leaf-on study with the minimum daily levels measured by the three most common metrics. The average daily weather conditions for each day is plotted for reference, and conditions were not extreme (such as heavy rain or thunder, etc.) to exclude data for any of the measurement time.

Both PPL units 1 and 2 were fully operational during the survey period.

LOCATION	5/24 SAT	5/25 SUN	5/26 MON	5/27 TUE	5/28 WEB	5/29 THU	5/30 FRI	5/31 SAT	6/1 SUN	6/2 MON	6/3 TUE	6/4 WEB	6/5 THU	6/6 FRI	6/7 SAT	6/8 SUN	6/9 MON	6/10 TUE	AVERAGE DAILY MINIMUM HOURLY LEVEL
	LA50 METRIC MINIMUM HOUR MEASUREMENT																		
1	29	38	37	40	36	37	37	40	38	36	39	41	38	40	37	38	39	38	**38**
2	23	27	26	30	29	31	33	39	36	38	33	41	35	38	37	40	40	36	**34**
3	31	30	32	32	30	35	35	36	34	31	34	35	34	38	37	39	37	37	**34**
4	28	32	33	38	36	33	32	29	29	--	--	--	--	--	--	--	--	--	**31**
5	31	36	35	32	37	35	38	36	37	32	40	41	39	37	34	38	41	39	**37**
	LA90 METRIC MINIMUM HOUR MEASUREMENT																		
1	27	33	34	36	33	33	33	36	35	35	35	36	34	35	32	34	33	33	**34**
2	22	25	24	29	27	28	31	35	31	31	31	36	34	37	35	36	36	35	**31**
3	29	29	30	30	29	32	33	34	32	32	32	32	32	34	33	34	34	34	**32**
4	25	30	29	26	33	31	30	27	26	--	--	--	--	--	--	--	--	--	**29**
5	27	33	33	28	35	33	35	33	35	35	35	38	36	33	31	33	35	33	**33**
	LAeq METRIC MINIMUM HOUR MEASUREMENT																		
1	29	39	38	42	38	37	38	45	42	37	39	42	46	44	43	44	44	41	**40**
2	27	33	28	33	32	33	37	41	40	39	33	42	36	39	38	40	42	38	**36**
3	32	37	33	36	34	36	38	38	41	33	36	41	37	44	42	42	41	42	**38**
4	29	33	35	29	39	41	40	37	33	--	--	--	--	--	--	--	--	--	**35**
5	39	41	39	40	39	41	44	41	42	41	44	45	42	41	38	42	43	44	**41**

AVG. WIND, MPH	7	3	4	6	8	3	2	4	5	3	3	2	2	3	3	4	4	3
DIRECTION	NNW	NW	SW	NNW	N	NNW	ESE	SSW	NNW	NNW	SSW	SE	SSE	S	WNW	NW	WNW	W
PERCIPITATION, IN.	0	0	0	0	0	0	0	0.33	0	0	0.12	0.75	0.08	0	0	0	0	0.31

Table 2.0.1: *Tabulation of daily minimum A-weighted sound levels measured over an 18-day sampling period under leaf-on warm weather conditions.*

3.0_Conclusions

Based on observations during this survey and the leaf-off survey it can be concluded that the existing PPL facilities have no discernable noise impact at the five surrounding measurement locations representing the closest residential land use.

Ambient noise in a residential community varies greatly with time of day and day to day. The levels measured and presented above for this survey are representative for daily minimum baseline sound levels during leaf-on warm weather conditions over an extended time period. The measured sound levels are those typically found in a "Very Quiet Suburban or Rural Area", see Table 4.0.2 on page 8.

The combined results for the leaf-on and off surveys provide long-term baseline ambient sound levels for noise assessment analysis.

4.0_ Definitions and Background Information

Units and Discussion of Sound Levels

The universal measure of sound in decibels used throughout the world is the A-weighted sound level, abbreviated dB(A) or dBA. The overall sound level is defined as the summed level in decibels over the entire *audible* frequency range (for young adults) of approximately 20 to 20,000 cycles/second (Hertz). The A-weighted sound level is a convenient single number to quantify the entire spectrum of a sound. A-weighting is an electronic filter applied to the spectrum that reshapes the spectrum to simulate human hearing response to frequency content. Lower frequency sound is subtracted by the A-weighting filter since humans perceive higher frequencies easier than lower notes. The reshaped or weighted new spectrum is summed over the same audible frequency span and is called the overall A-weighted level. Thus, the A-weighted sound level becomes an excellent single number descriptor for audible sounds.

Reference [2] is an informative and a more detailed reference source for definitions and units used in this report.

Table 4.0.1 below is a scale of common sound levels that have similar character to the sounds created by a well designed power plant and many industrial facilities. These data come from the author's files over many years. All of the sounds are broadband, meaning the spectrum is smooth without sharp peaks or tonal noise. Examples of broadband noise are slow speed airflow from HVAC ducting, rushing water, tree leaf rustling and traffic noise without truck diesel tones. More irritating non-broadband tonal noise examples are an alarm clock, siren, diesel engine or construction noise back-up bells or buzzers.

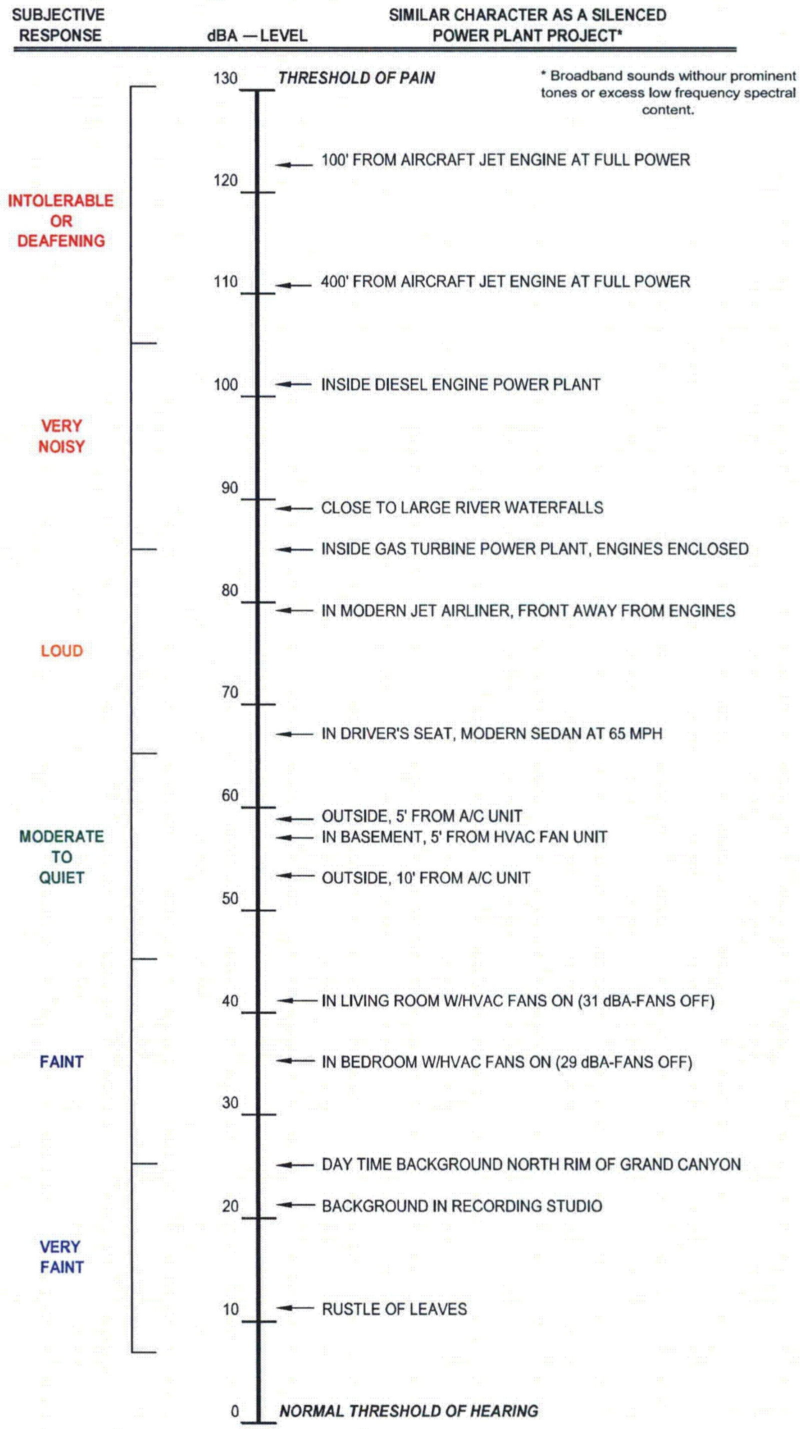

Table 4.0.1: *Table of Common Sounds in A-weighted dBA Units*

The *instantaneous* A-weighted sound level in any residential community varies over any sampling period as sporadic noise events occur. Such events may be passing vehicles, aircraft or rail events, dog barking, tree leaf rustle, song birds, etc. **Figure 4.0.1** below shows the instantaneous level for a 10-minute daytime sample in a quiet rural environment.

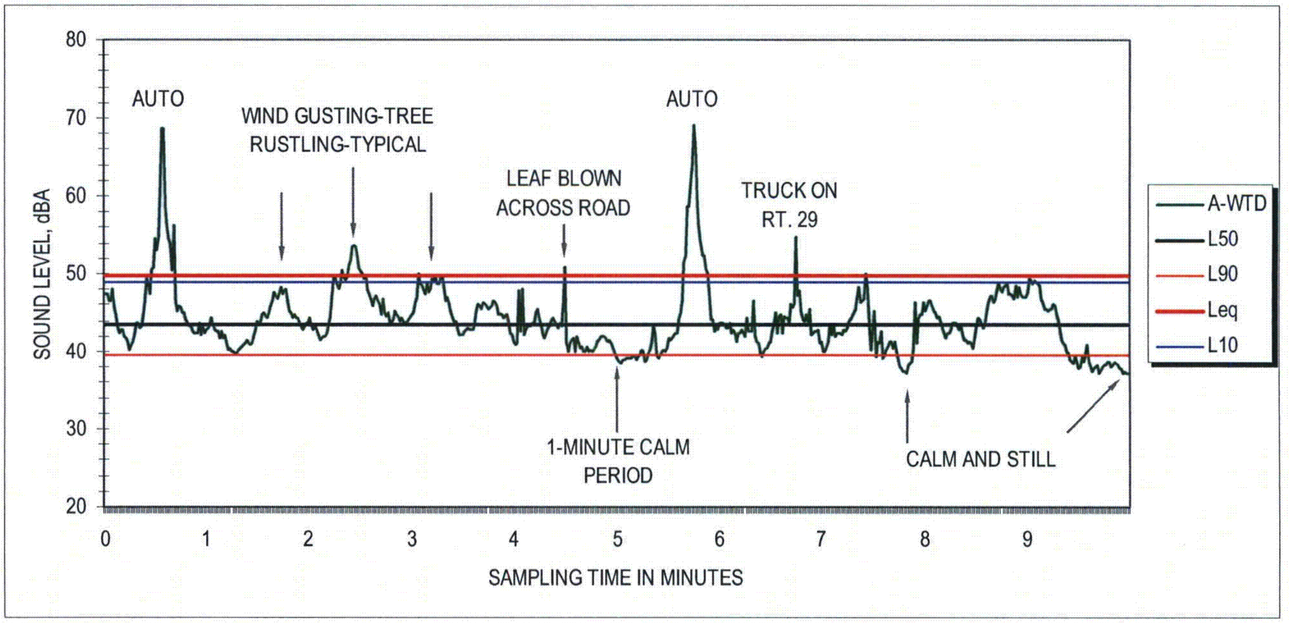

***Figure 4.0.1:** Instantaneous sound level plot for a quiet residential environment remote from highways and airports.*

To condense this widely varying data to a more usable form, standard measurement metrics are defined in reference 2. The obvious ones are the minimum, maximum and average levels that occur over the interval. The max and min are the highest and lowest measured instantaneous level during the sampling period. The average, designated Leq is the *equivalent* steady sound level that has the same or equivalent acoustic energy as the actual time varying signal. It can be thought of as the true energy or true pressure average, and is not simply the arithmetic average over the period.

Percentile levels or exceedence levels, designated L_1, L_{10}, L_{50} and L_{90} are statistically derived units over the sampling period. They are the levels exceeded for 1, 10, 50 and 90% of the sampling time. L50 is the mean level where half the time the sound level is higher or lower. Of course, all of these units would be identical if the sound were perfectly steady without any variance with time, i.e., L_{min} would equal L_{max} would equal L_{eq}. etc.

The L_{90} percentile level is often used for evaluating community noise in residential environments. L_{90} is defined in reference 3, pages 5-6 as the "residual" sound level, which is the quasi-steady level that occurs in the absence of all identifiable sporadic sound levels occurring over the interval. The vast majority of all residual sound levels found in communities come from far-away unidentifiable steady levels from traffic and/or industrial sources.

Typical residual daytime levels[3] found throughout the U.S. under calm and still wind conditions are shown in **Table 4.0.2** below:

Typical Residential Area Sound Levels
Daytime Residual Level, dBA, Level Exceeded 90% of the Time, L90

Description	Typical Range	Average
Very Quiet Rural or Remote Area	26 to 30 inclusive	28
Very Quiet Suburban or Rural Area	31 to 35 inclusive	33
Quiet Suburban Residential	36 to 40 inclusive	38
Normal Suburban Residential	41 to 45 inclusive	43
Urban Residential	46 to 50 inclusive	48
Noisy Urban Residential	51 to 55 inclusive	53
Very Noisy Urban Residential	56 to 60 Inclusive	58

***Table 4.0.2:** Typical Residual Sound levels in Residential Communities.*

5.0_ Methodology

5.1_Instrumentation for Continuous and Manual Measurements

The instantaneous sound level was measured on a continuous and simultaneous basis over the 312-hour period using type 2 precision data loggers programmed to record the metrics discussed in Section 4 above. The meters report the data in hourly intervals. A typical continuous data logger is shown in **Figure 5.0.1** below:

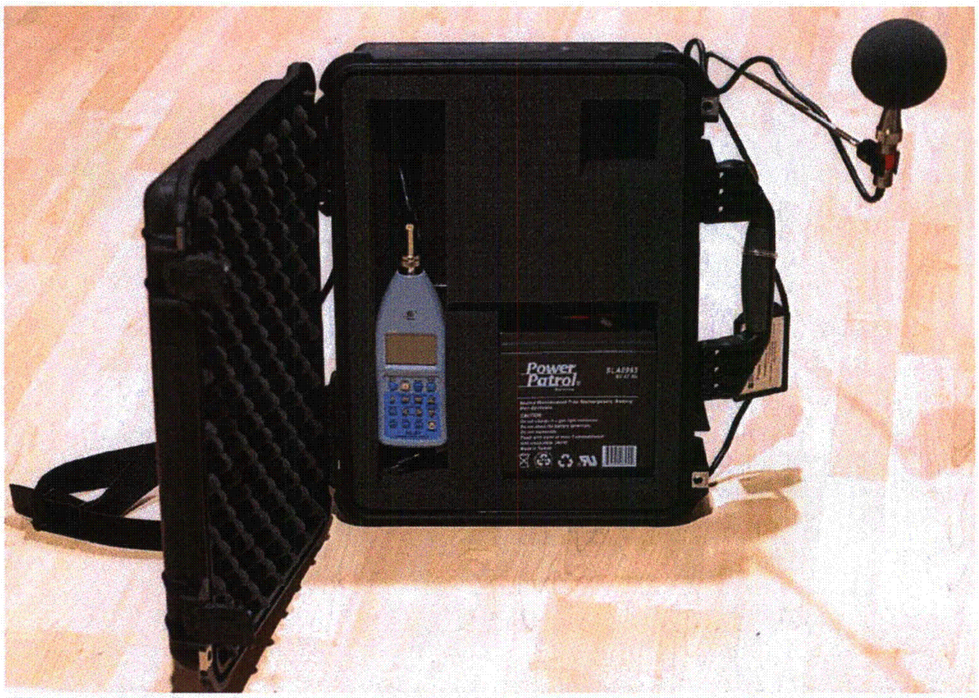

***Figure 5.1.1:** Data logger shown in weatherproof case with power supply and remote microphone.*

The loggers were checked for calibration by inserting two independent type 1 precision portable calibrators onto the microphone when each meter was setup and taken down. This calibrates the entire system of microphone, preamplifier and sound level meter (SLM) electronics. The reason for using separate calibrators is to insure accuracy even though each calibrator is checked for accuracy yearly at a NIST certified laboratory. The chance of one being out of calibration is low, but would show up immediately if the proper sensitivity of each did not agree. The start and finish calibrations for this survey are tabulated below:

	START		FINISH	
LOCATION	B&K 4230	Rion NC-73	B&K 4230	Rion NC-73
1	94.0	94.0	93.6	93.8
2	↓	↓	93.6	94.0
3	↓	↓	93.6	94.0
4	↓	↓	93.5	93.6
5	↓	↓	93.5	93.9

Table 5.1.1: *Calibration at start and finish of monitoring period.*

The calibration change was insignificant (<0.5 dBA) at all locations 1 through 5.

In addition to the continuous data loggers, manual measurements were carried out at each location during day time periods with a Rion model NA27 type 1 precision sound level meter (SLM) and 1/3 octave band frequency analyzer. The meters were programmed to run for ten-minute intervals to calculate the average and other statistical metrics described in Section 4 above. Attended measurements allow observations of weather effects and identification of environmental noise sources.

5.2_Monitor Locations

Five monitor locations were chosen after review of the site to visually locate potentially sensitive receptors in all directions around the site. Each location is shown on **Figure 1.0.1.** These residences are the closest to the plant and represent the surrounding residential and farming community.

One monitor was placed in the planned Bell Bend plant area and reasonably close to the existing PPL plant.

All of the remaining monitors were located near residential locations. The monitors were mounted to trees or utility poles at a height of approximately 6 feet above grade.

Locations 2, 3 and 4 are the closest residential receptors to the planned expansion area. Location 5 is on the power line right of way approximately 250 feet from route 11.

The GPS coordinates for each location are given below:

LOCATION	DEGREES	MINUTES	DEGREES	MINUTES
1	N38	58.956	W81	55.717
2	N38	59.372	W81	56.878
3	N38	59.270	W81	56.884
4	N38	59.447	W81	56.055
5	N38	58.828	W81	56.678

6.0_Discussion of Results

6.1_Monitor Measurement Results

Appendix A-1 and A-2 contain graphic plots of the measured hourly data at each location for the entire sampling program. All metrics are plotted for each hour including the minimum and maximum levels, Leq and the statistical metrics of L10, L50 and L90. The maximum levels in each hour represent passing traffic.

To illustrate, **Figure 6.1.1** below is a plot showing the residual LA90 sound level at all locations. The trends are consistent in the five community locations but note the variability from hour to hour. This is expected since the residual sound level in a quiet rural setting is dependent on wind and insect and other natural sources. The cable connecting the processor to microphone became disconnected (raccoons suspected) for monitor 4 on June 2nd resulting in data loss.

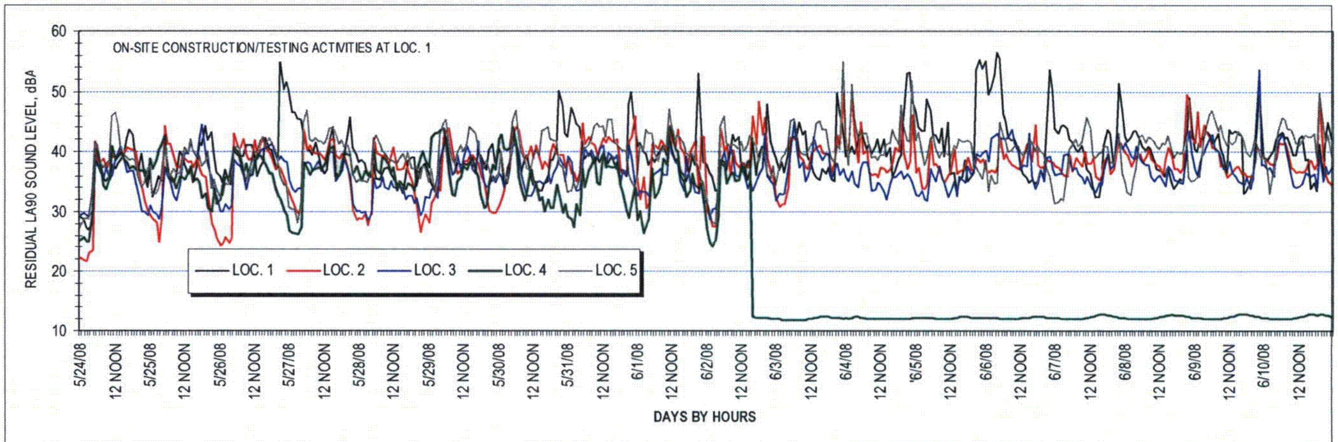

***Figure 6.1.1:** Plot of residual LA90 sound level at locations 1 through 5 over the entire sampling period.*

6.2_Attended Measurement Results

Attended 10-minute sampling measurements were carried out to observe sources of environmental sounds and to record the frequency spectrum of the level. **Figure 6.2.1** below shows the measured spectra at all five locations at the start and finish of the monitoring period. Measurement conditions were good during both surveys with mild wind and mostly sunny sky.

Plant noise was essentially absent during both surveys at all locations. Although some very faint plant sound was discernable on the set-up survey only at location 4. High line "crackle" sound was audible at location 5 under the high line.

Figure 6.2.1 below plots the measured spectra at all locations for both surveys.

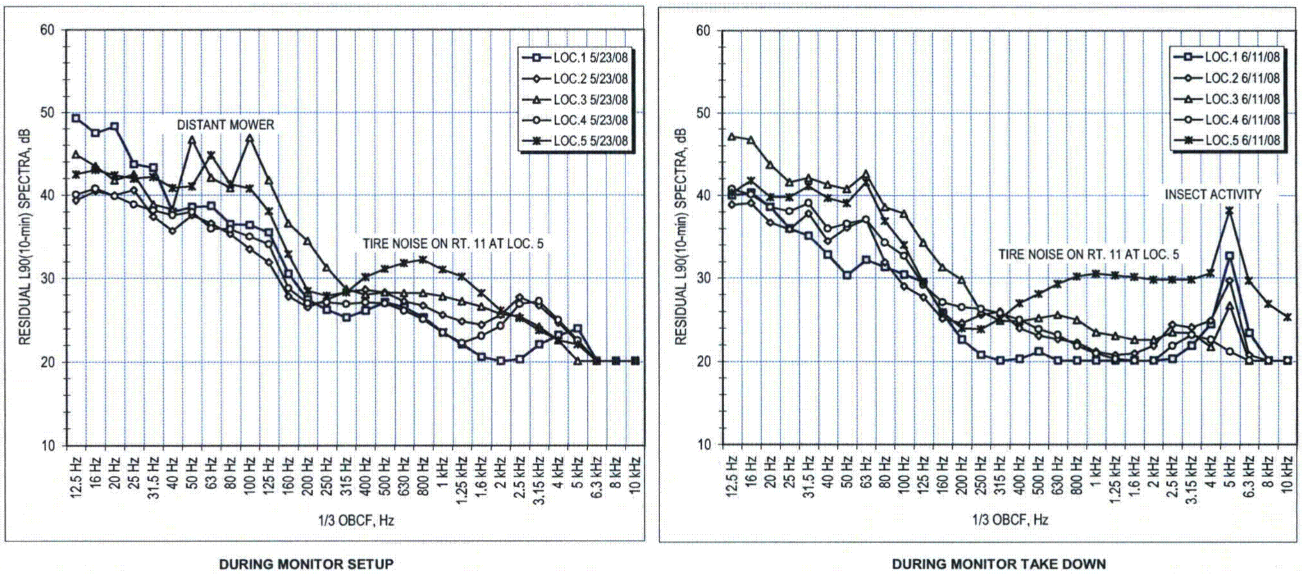

***Figure 6.2.1:** One third octave band spectra at five sampling locations on two days at the start and finish of the survey.*

7.0_ Noise Assessment Guidelines

A web search did not turn up any local or county noise ordinances for this site area.

End of Text

8.0_References

[1] Hessler Associates Inc. Report Number 041808-1, *Baseline Environmental Noise Survey – Leaf-off Season*, April 2008

[2] "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety", US EPA Report PB-239 429, March 1974

[3] "Community Noise", US EPA Report NTID300.3, Dec. 1971.

TECHNICAL MEMO

Title:	**ADDENDUM 1 TO HAI REPORT 062608-1:** Baseline Environmental Noise Survey, Leaf-on Season
Project:	**BELL BEND NUCLEAR POWER PLANT**
Location:	**Berwick, PA**
Prepared For:	**AREVA NP, Inc.**
Prepared By:	**George F. Hessler, P.E.**
Revision:	**0**
Issue Date:	**August 14, 2008**
Reference No:	**TM-062608-1**
Attachments:	**None**

Attn. Mr. J. Snooks

Introduction

This addendum adds additional requested measured data to the subject report and forms an integral part of the report. The measured daily 24-hour day/night sound level metric, abbreviated both as DNL and Ldn, was computed from the measured Leq hourly data given in the primary report. DNL must be calculated from 24 hours of measured hourly Leq data because a weighting or penalty factor of 10 dBA must be added for the hours from 10 p.m. to 7 a.m. This accounts for the greater sensitivity to nighttime noise experienced at potentially sensitive receptors.

Results

The following Table summarizes the developed DNL results. The arithmetic average and standard deviation are given for the sampling period at each sampling location. The "log average" is the true pressure average and is calculated by averaging the anti-log of each measured decibel value and converting back into decibels as opposed to directly averaging the decibel quantities. Summations or averaging of Leq based data is usually log averaged. For example, the FAA uses the yearly average DNL to assess aircraft noise in communities.

BBNPP LEAF ON	24-HOUR DAILY DAY/NIGHT SOUND LEVEL (DNL OR Ldn), dBA				
	LOCATION				
DATE	1 (ON-SITE)	2	3	4	5
5/24/2008	54	53	56	51	54
5/25/2008	52	53	57	53	54
5/26/2008	57	57	60	51	53
5/27/2008	57	53	52	52	63
5/28/2008	50	54	58	54	53
5/29/2008	54	54	57	55	56
5/30/2008	55	55	56	56	56
5/31/2008	58	55	55	57	54
6/1/2008	56	56	55	51	56
6/2/2008	54	59	57	57	56
6/3/2008	56	56	63		56
6/4/2008	58	59	60		59
6/5/2008	63	56	58		54
6/6/2008	66	59	64		59
6/7/2008	58	63	63		58
6/8/2008	59	60	63		58
6/9/2008	58	58	65		59
6/10/2008	64	63	66		63
ARITH. AVERAGE	N/A	57	59	54	57
LOG AVERAGE	N/A	56	58	53	57
STD DEV	N/A	2.1	2.7	2.5	2.8

Table 1: *24-hour Day/Night Sound Levels for a 18 Day Sampling Period during Leaf-on Seasonal Conditions at the Proposed Bell Bend Project*

Let me know if I can assist in any other way or answer any questions.

George F. Hessler Jr., Bd. Cert. INCE

George F. Hessler Jr.

Enclosure 9

TE-26 – Leaf-off Noise Survey, 2008

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Report Number 041808-1
Baseline Environmental Noise Survey
Leaf-off Season

Bell Bend Nuclear Power Plant (BBNPP) Project
April 2008

Prepared For:

AREVA NP Inc.
400 Donald Blvd.
Marlborough, MA 01752

Prepared By:
Hessler Associates, Inc.
Consultants in Engineering Acoustics

Principal Consultant:
George F. Hessler Jr., P.E., Bd. Cert. INCE

1.0_Introduction

Hessler Associates has been retained by AREVA NP, Inc. to conduct a baseline environmental noise level measurement survey in the surrounding environs at the proposed Bell Bend Nuclear Power Plant (BBNPP) project located near the town of Berwick, Pennsylvania. The site contains two existing PPL nuclear power units, rated at nominal capacities of 1105 and 1111 Mw, located just to the east of the planned Bell Bend project. An aerial map with topography shading is given on **Figure 1.0.1** that shows the planed Bell Bend expansion area and the selected community noise survey locations 1 through 5.

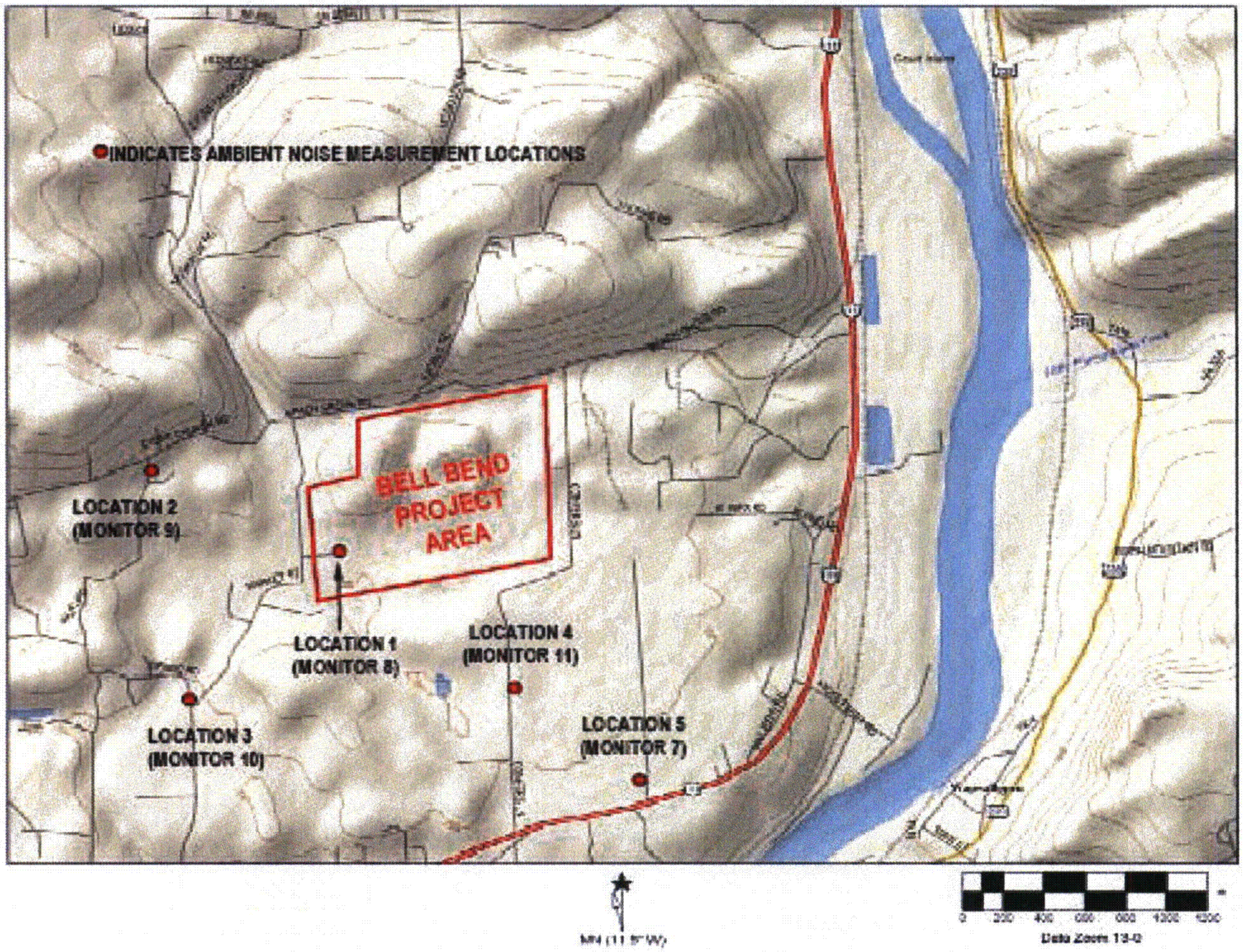


***Figure 1.0.1:** Site Map of Bell Bend Project Showing Sound Measurement Locations.*

Noise level survey results are required environmental information to define existing noise conditions. Measured levels at the closest potentially sensitive receptors are used to assess any potential noise impact from the planned project. Typical receptors of concern are residential units, hospitals, parks and houses of worship. In this case, all potentially sensitive locations were the closest residential land uses.

Ambient or existing environmental community noise levels during leaf-off conditions were measured continuously over a 13 day period and are reported as complete days from midnight March 1st through March 13th, 2008. Monitors were installed on February 29th and removed on March 14th. Measurements are made during leaf-off conditions to detect any contribution from the existing generating facilities, since the excess attenuation from dense trees between the plant and community would be minimal. Measurements are repeated during leaf-on warmer weather conditions when use of the outdoor environment for enjoyment by the community is normal. Potential adverse impact is more likely during warmer leaf-on conditions.

Ideally, environmental levels should be measured during quiescent or calm and still weather conditions when minimum levels occur to provide the most conservative baseline[1]. Surveying over a 13-day period provides the ambient under many weather and time conditions. Baseline levels measured under these conditions provide always-present masking noise levels for evaluation of any new predicted emissions.

2.0_ Executive Summary and Results

Subjectively, existing facility noise emissions were not detectable at any location during normal operation of both PPL units on February 29th while installing the noise monitors and conducting manual measurements. Unit 1 was shut down March 3rd for a planned outage. Construction or maintenance noise was detectable on March 14th during manual measurements while removing the continuous monitors.

There are no identified state or local noise ordinances for the project. Compliance with applicable noise regulations is usually deemed an adequate assessment. When there is no ordinance, noise assessment is typically done by comparing the noise emissions from the planned facilities to measured baseline ambient sound levels and is called an ambient-based assessment. Impact, or lack of, is quantified by the incremental change or increase to the measured ambient sound level. If the increase to the residual ambient level is small, i.e. 0 to 3 dBA, little noise impact is expected. The threshold for potential impact from noise is typically a 5 dBA increase above existing conditions. Adverse impact would be predictable with large increases in level caused by the new source.

This study documents measured ambient levels in the surrounding environs of the planned Bell Bend project for assessing noise impact. The final baseline ambient level cannot be established until completion of the leaf-on warmer-weather survey. The data presented below are the minimum measured hourly levels in three metrics for each of the thirteen complete measurement days. It is customary in three states (NY, MA and CA) with codified ambient-based procedures to use the minimum ambient level present during facility operational hours. For the proposed project with planned 24/7 operation at this rural environment, the minimum value may occur in any hour of the 24-hour day.

Table 2.0.1 below forms the key finding for this leaf-off study with the minimum daily levels measured by the three most common metrics. The average daily weather conditions for each day is plotted for reference, and conditions were not extreme (such as thunder, etc.) to exclude data for any of the measurement time. Note that minimum ambient levels generally occur on calm and still days. Both units 1 and 2 were fully operational at the start of monitoring but unit 1 was shut down for a planned outage on the night of March 3rd.

LOCATION	3/1 SAT	3/2 SUN	3/3 MON	3/4 TUE	3/5 WED	3/6 THU	3/7 FRI	3/8 SAT	3/9 SUN	3/10 MON	3/11 TUE	3/12 WED	3/13 THU	AVERAGE DAILY MINIMUM HOURLY LEVEL
	DATE AND DAY OF WEEK													
	LA50 METRIC MINIMUM HOUR MEASUREMENT													
1	28	27	34	32	33	32	36	36	28	28	32	28	31	**31**
2*	30	27	35	34	37	34	36	35	29	29	34	30	32	**33**
3	32	28	34	36	38	37	34	32	32	32	34	30	31	**33**
4	31	27	37	34	39	33	38	37	27	26	36	33	35	**33**
5	39	34	36	52	43	36	48	46	32	28	40	39	34	**39**
	LA90 METRIC MINIMUM HOUR MEASUREMENT													
1	27	25	32	31	32	30	34	33	27	27	29	26	28	**29**
2*	29	26	33	33	35	32	34	32	27	28	31	28	30	**31**
3	30	27	33	36	38	34	33	31	30	31	32	29	30	**32**
4	29	26	33	32	36	31	36	33	25	25	33	30	32	**31**
5	33	31	34	39	35	33	39	42	27	26	36	33	29	**34**
	LAeq METRIC MINIMUM HOUR MEASUREMENT													
1	31	28	35	32	34	33	38	37	28	28	34	30	32	**32**
2*	35	28	37	35	40	38	38	36	32	29	36	35	34	**35**
3	40	29	37	37	40	37	37	33	38	32	35	38	32	**36**
4	33	28	39	36	46	44	38	38	30	28	38	37	37	**36**
5	51	47	51	55	56	55	54	53	53	51	53	53	52	**53**

AVERAGE WIND SPEED, MPH	8	6	5	7	8	3	6	8	10	5	3	8	5
AVERAGE WIND DIRECTION	NW	NNW	S	ESE	WNW	WNW	SE	WSW	NW	NW	NNW	NW	SSE
PRECIPITATION, INCHES	0	0	0	1.2	0.9	0	0.6	0.4	0	0	0	0	0

* EST FROM MACRO DATA RESULTS AT LOCATIONS 1, 3 & 4

WEATHER DATA FROM TOP OF SHICKSHINNY MOUNTAIN, APPROX. 7 MILES NORTH OF SITE

Table 2.0.1: *Tabulation of daily minimum A-weighted sound levels measured over a 13-day sampling period under leaf-off cold weather conditions.*

3.0_Conclusions

Ambient noise in a residential community varies greatly with time of day and day to day. The levels measured in this survey are representative for daily minimum levels during leaf-off conditions over an extended time period. Any industrial or power plant noise or far-off road system noise would be at maximum levels under leaf off conditions since there is no foliage attenuation in the path between the plant and receptors. A leaf-on survey is planned for two reasons; ambient levels could be lower due to the excess sound attenuation provided by dense tree cover and soft ground, and potentially sensitivity would be higher when receptors are outdoors enjoying the milder environment.

4.0_ Definitions and Background Information

Units and Discussion of Sound Levels

The universal measure of sound in decibels used throughout the world is the A-weighted sound level, abbreviated dB(A) or dBA. The overall sound level is defined as the summed level in decibels over the entire *audible* frequency range (for young adults) of approximately 20 to 20,000 cycles/second (Hertz). The A-weighted sound level is a convenient single number to quantify the entire spectrum of a sound. A-weighting is an electronic filter applied to the spectrum that reshapes the spectrum to simulate human hearing response to frequency content. Lower frequency sound is subtracted by the A-weighting filter since humans perceive higher frequencies easier than lower notes. The reshaped or weighted new spectrum is summed over the same audible frequency span and is called the overall A-weighted level. Thus, the A-weighted sound level becomes an excellent single number descriptor for audible sounds.

Reference [2] is an informative and a more detailed reference source for definitions and units used in this report.

Table 4.0.1 below is a scale of common sound levels that have similar character to the sounds created by a well designed power plant and many industrial facilities. These data come from the author's files over many years. All of the sounds are broadband, meaning the spectrum is smooth without sharp peaks or tonal noise. Examples of broadband noise are slow speed airflow from HVAC ducting, rushing water, tree leaf rustling and traffic noise without truck diesel tones. More irritating non-broadband tonal noise examples are an alarm clock, siren, diesel engine or construction equipment back-up bells or buzzers.

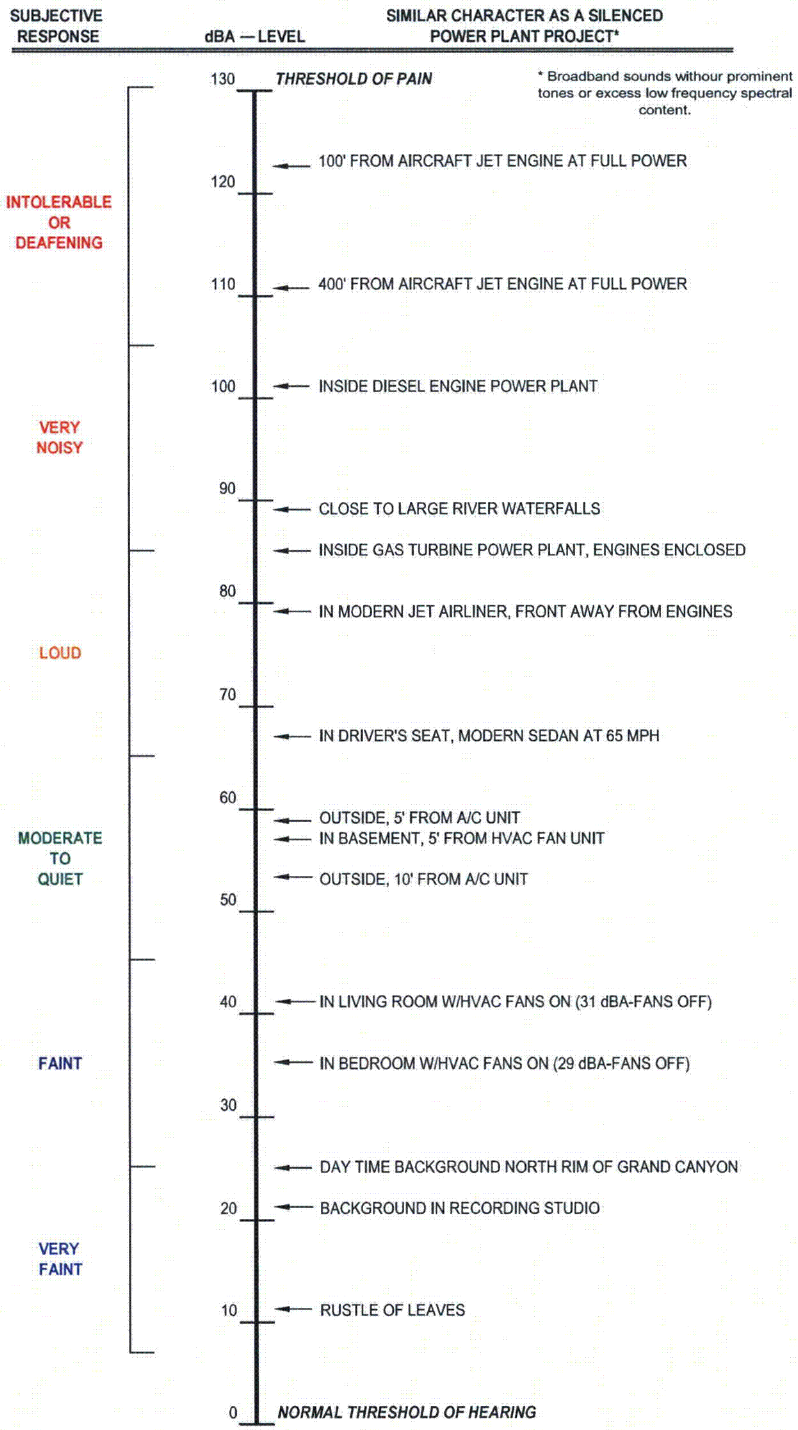


***Table 4.0.1:** Table of Common Sounds in A-weighted dBA Units*

The *instantaneous* A-weighted sound level in any residential community varies over any sampling period as sporadic noise events occur. Such events may be passing vehicles, aircraft or rail events, dog barking, tree leaf rustle, song birds, etc. **Figure 4.0.1** below shows the instantaneous level for a 10-minute daytime sample in a quiet rural environment.

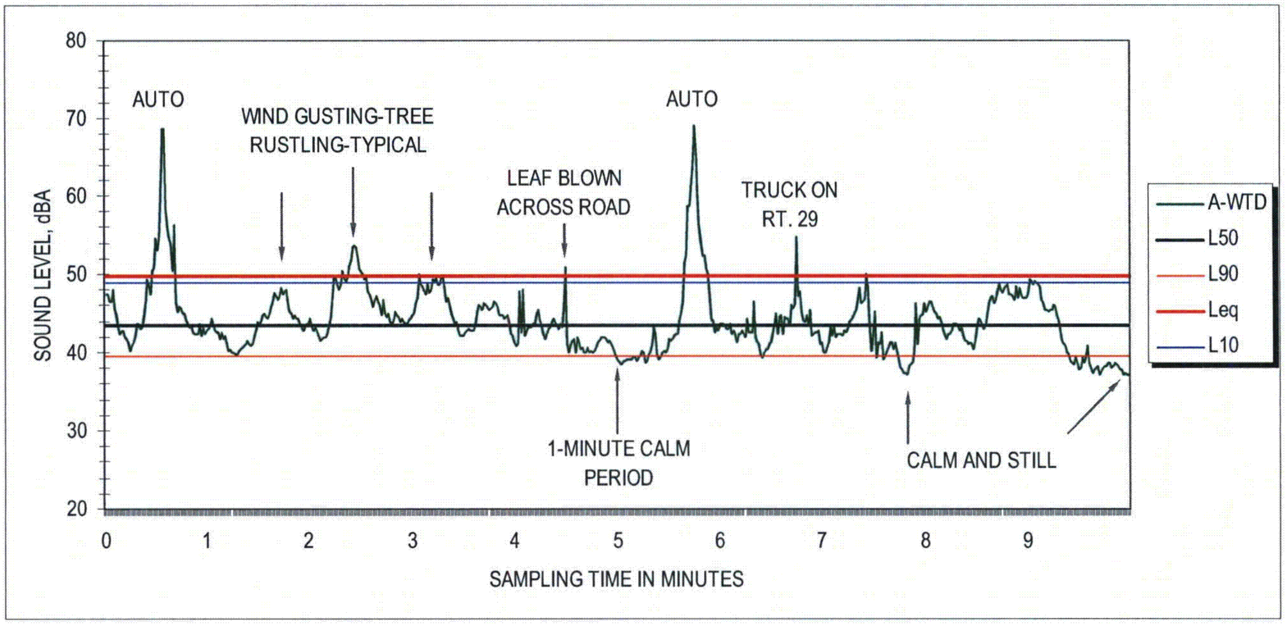


Figure 4.0.1: *Instantaneous sound level plot for a quiet residential environment remote from highways and airports.*

To condense this widely varying data to a more usable form, standard measurement metrics are defined in reference 2. The obvious ones are the minimum, maximum and average levels that occur over the interval. The max and min are the highest and lowest measured instantaneous level during the sampling period. The average, designated Leq is the *equivalent* steady sound level that has the same or equivalent acoustic energy as the actual time varying signal. It can be thought of as the true energy or true pressure average, and is not simply the arithmetic average over the period.

Percentile levels or exceedence levels, designated L_1, L_{10}, L_{50} and L_{90} are statistically derived units over the sampling period. They are the levels exceeded for 1, 10, 50 and 90% of the sampling time. L50 is the mean level where half the time the sound level is higher or lower. Of course, all of these units would be identical if the sound were perfectly steady without any variance with time, i.e., L_{min} would equal L_{max} would equal L_{eq}. etc.

The L_{90} percentile level is often used for evaluating community noise in residential environments. L_{90} is defined in reference 3, pages 5-6 as the "residual" sound level, which is the quasi-steady level that occurs in the absence of all identifiable sporadic sound levels occurring over the interval. The vast majority of all residual sound levels found in communities come from far-away unidentifiable steady levels from traffic and/or industrial sources.

Typical residual daytime levels[3] found throughout the U.S. under calm and still wind conditions are shown in **Table 4.0.2** below:

Typical Residential Area Sound Levels
Daytime Residual Level, dBA, Level Exceeded 90% of the Time, L90

Description	Typical Range	Average
Very Quiet Rural or Remote Area	26 to 30 inclusive	28
Very Quiet Suburban or Rural Area	31 to 35 inclusive	33
Quiet Suburban Residential	36 to 40 inclusive	38
Normal Suburban Residential	41 to 45 inclusive	43
Urban Residential	46 to 50 inclusive	48
Noisy Urban Residential	51 to 55 inclusive	53
Very Noisy Urban Residential	56 to 60 Inclusive	58

***Table 4.0.2:** Typical Residual Sound levels in Residential Communities.*

5.0_ Methodology

5.1_Instrumentation for Continuous and Manual Measurements

The instantaneous sound level was measured on a continuous and simultaneous basis over the 13-day period using type 2 precision data loggers programmed to record the metrics discussed in Section 4 above. The meters report the data in hourly intervals. A typical continuous data logger is shown in **Figure 5.0.1** below:

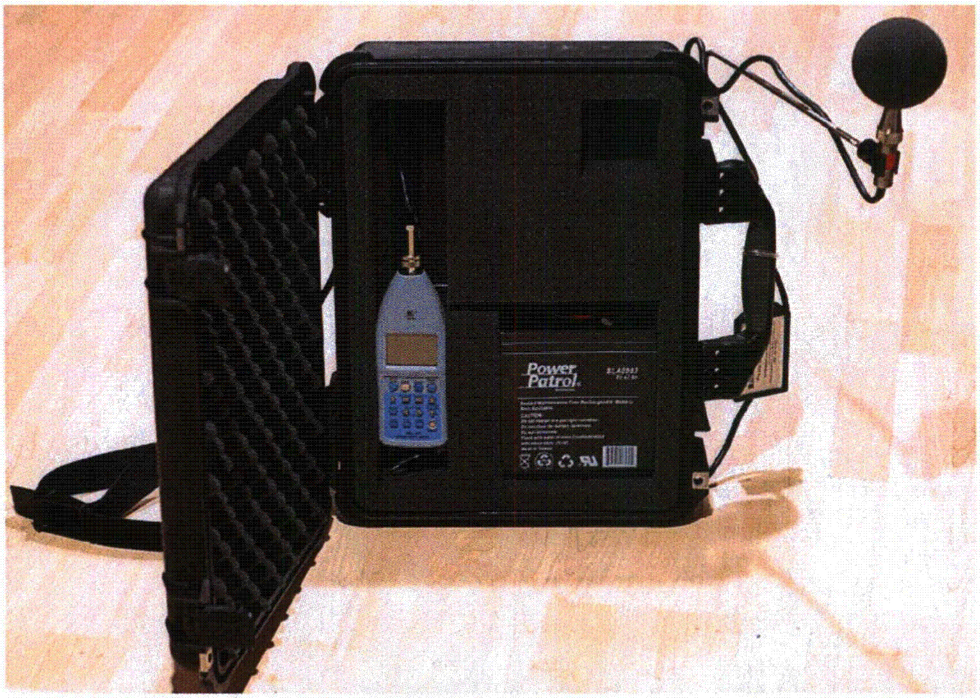


***Figure 5.1.1:** Data logger shown in weatherproof case with power supply and remote microphone.*

The loggers were checked for calibration by inserting two independent type 1 precision portable calibrators onto the microphone when each meter was setup and taken down. This calibrates the entire system of microphone, preamplifier and sound level meter (SLM) electronics. The reason for using separate calibrators, each with a different sensitivity (94 and 114 dB at 1000 Hz), is to ensure accuracy even though each calibrator is checked for accuracy yearly at a NIST certified laboratory. The chance of one being out of calibration is low, but would show up immediately if the proper sensitivity of each did not agree. The start and finish calibrations for this survey are tabulated below:

	START		FINISH	
LOCATION	B&K 4230	NOR 1251	B&K 4230	NOR 1251
1	94.0	114.0	93.7	114.2
2	↓	114.0	93.9	113.9
3		113.9	93.9	113.8
4		114.0	94.3	114.3
5		114.0	94.2	114.1

Table 5.1.1: *Calibration at start and finish of monitoring period.*

The calibration change was insignificant (<0.5 dBA) at all locations 1 through 5.

In addition to the continuous data loggers, manual measurements were carried out at each location during day time periods with a Rion model NA27 type 1 precision sound level meter (SLM) and 1/3 octave band frequency analyzer. The meters were programmed to run for ten-minute intervals to calculate the average and other statistical metrics described in Section 4 above. Attended measurements allow observations of weather effects and identification of environmental noise sources.

5.2_Noise Monitor Locations

Five monitor locations were chosen after review of the site to locate potentially sensitive receptors in all directions around the site as shown on **Figure 1.0.1**. The monitors were mounted to trees or utility poles at a height of approximately 6 feet above grade.

Monitor location 1 was placed in the planned Bell Bend plant area and reasonably close to the existing PPL plant. Locations 2 through 4 are near residences that are closest to the new plant. Monitor location 5 is on the power line right-of-way approximately 200 feet from busy route 11.

The GPS coordinates for each location are given below:

LOCATION	DEGREES	MINUTES	DEGREES	MINUTES
1	N38	58.956	W81	55.717
2	N38	59.372	W81	56.878
3	N38	59.270	W81	56.884
4	N38	59.447	W81	56.055
5	N38	58.828	W81	56.678

6.0_Discussion of Results

6.1_Monitor Measurement Results

Appendix A contains graphic plots of the measured hourly data at four locations for the entire sampling program. All metrics are plotted for each hour including the minimum and maximum levels, Leq and the statistical metrics of L10, L50 and L90. The maximum levels in each hour represent passing traffic. Note maximum levels at location 5 are nearly constant over the 13 day period averaging about 75 dBA, while at all other locations, the traffic subsides at night and the early morning hours. Note also that the hourly temporal trend is the same at all locations but differs substantially at location 5.

Monitor 9 at location 2 ran for the entire period but did not download or write the data to the compact flash card within the meter. It is the first instance and inexplicable at present why the measurement parameters were written to the card but the data file was empty? Fortunately, the environment at all of the sampled residences is a "macro" area ambient and the levels at location 2 can be easily estimated from the remaining data. The residual ambient in a macro area is essentially constant for all practical purposes at any of the three locations 1, 3 and 4. This occurs in areas where the environmental sound sources are far off in distance relative to the distance between monitoring points, and natural sources are similar at all locations. The major source of environmental noise in the project area is from far-off unidentifiable traffic.

To illustrate, **Figure 6.1.1** below is a plot showing the residual hourly LA90 sound level at the five locations. The trends are consistent in the five community locations except at location 5 (dotted line) that contains nearly constant noise from the route 11 only 200 feet away. The levels for location 2 are calculated from the average of results at locations 1, 3 and 4.

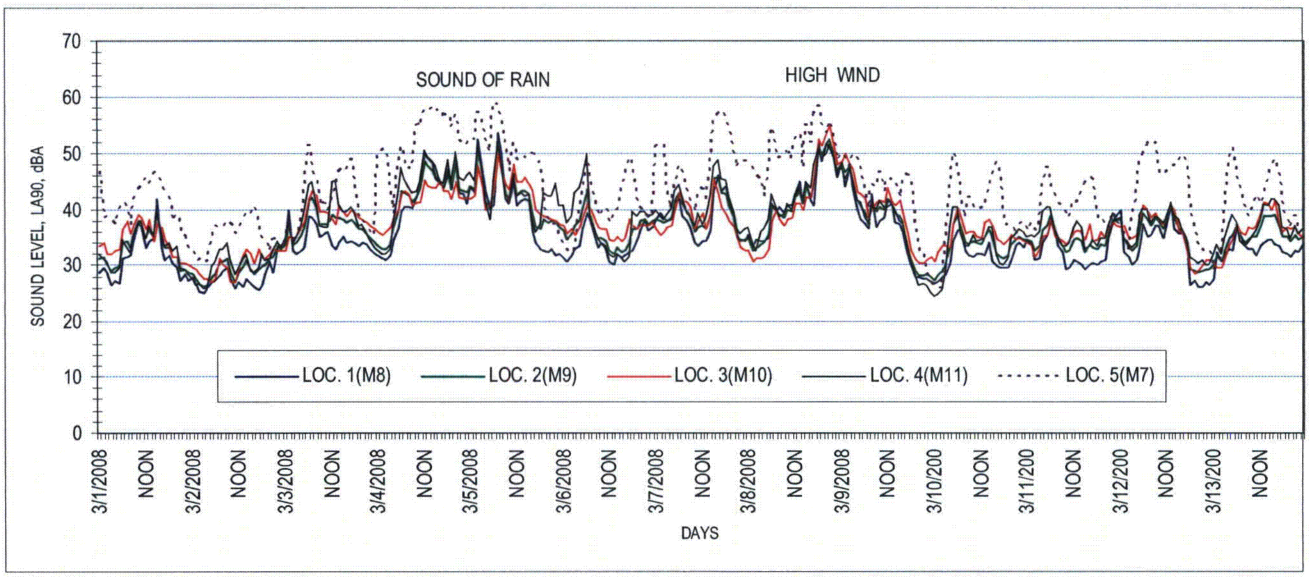
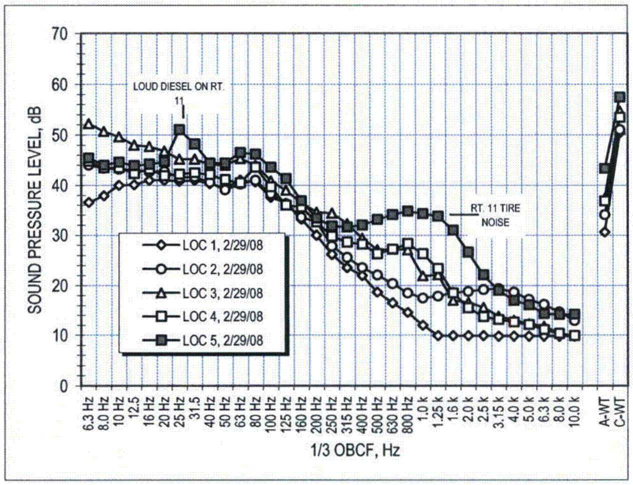


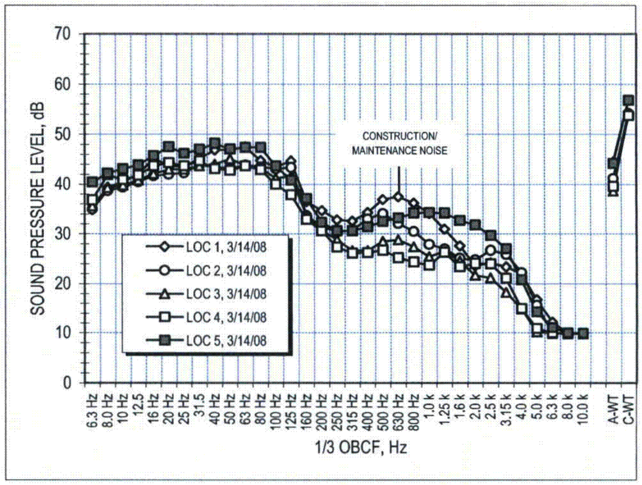
Figure 6.1.1: *Plot of residual LA90 sound level at locations 1, 2, 3, 4 and 5 over the entire sampling period.*

6.2_Attended Measurement Results

Attended 10-minute sampling measurements were carried out to observe sources of environmental sounds and to record the frequency spectrum of the level. **Figure 6.2.1** below shows the measured spectra at all five locations at the start and finish of the monitoring period. It was a little breezy on 2/29 and the very low frequency data below 20 Hz shows wind induced microphone noise even with protective wind screens. This effect has no impact on the A-weighted sound level results due the electronic weighting at these low frequencies. Measurement conditions were absolutely perfect on 3/14 with quiescent calm and still wind.

As noted above, unit 1 was shut down on March 3rd. Absolutely no sounds from the plant were detectable for normal full operation on 2/29. Noise from the plant presumed to be construction or maintenance sources was readily audible during the 3/14 survey.





a) NO NOISE DETECTABLE FROM PPL PLANT AT ANY LOCATION   b) CONSTRUCTION/MAINTENANCE NOISE CLEARLY OBSERVABLE FROM PPL PLANT

Figure 6.2.1: *One third octave band spectra at five sampling locations on two days at the start and finish of the survey.*

7.0_ Noise Assessment Guidelines

A web search did not turn up any local or county noise ordinances for this site area. An ambient-based noise assessment methodology[4] is proposed for use that is based on years of successful application in three states, NY, MA and CA.

End of Text

8.0_References

[1] Hessler, G. F., "Controlling Noise Impact in the Community from Power Plant Operations – Recommendations for Ambient Noise Measurements", *Noise Control Engineering Journal*, Volume 48, Number 5, 2000 Sept-Oct

[2] "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety", US EPA Report PB-239 429, March 1974

[3] "Community Noise", US EPA Report NTID300.3, Dec. 1971.

[4] Hessler, G. F., "The Noise Perception Index (NPI) for Assessing Noise Impact from Major Industrial Facilities and Power Plants in the U.S.", *Noise Control Engineering Journal,* Draft Publication dated 4/17/08 currently undergoing peer review process for publication.

TECHNICAL MEMO

Title:	**ADDENDUM 1 TO HAI REPORT 041808-1:** Baseline Environmental Noise Survey, Leaf-off Season
Project:	**BELL BEND NUCLEAR POWER PLANT**
Location:	**Berwick, PA**
Prepared For:	**AREVA NP, Inc.**
Prepared By:	**George F. Hessler, P.E.**
Revision:	**0**
Issue Date:	**August 14, 2008**
Reference No:	**TM-081408-1**
Attachments:	**None**

Attn. Mr. J. Snooks

Introduction

This addendum adds additional requested measured data to the subject report and forms an integral part of the report. The measured daily 24-hour day/night sound level metric, abbreviated both as DNL and Ldn, was computed from the measured Leq hourly data given in the primary report. DNL must be calculated from 24 hours of measured hourly Leq data because a weighting or penalty factor of 10 dBA must be added for the hours from 10 p.m. to 7 a.m. This accounts for the greater sensitivity to nighttime noise experienced at potentially sensitive receptors.

Results

The following Table summarizes the developed DNL results. The arithmetic average and standard deviation are given for the sampling period at each sampling location. The "log average" is the true pressure average and is calculated by averaging the anti-log of each measured decibel value and converting back into decibels as opposed to directly averaging the decibel quantities. Summations or averaging of Leq based data is usually log averaged. For example, the FAA uses the yearly average DNL to assess aircraft noise in communities.

BBNPP LEAF OFF	24-HOUR DAILY DAY/NIGHT SOUND LEVEL (DNL OR Ldn), dBA				
			LOCATION		
DATE	1 (ON-SITE)	2	3	4	5
3/1/2008	66	55	60	57	62
3/2/2008	42	46	52	49	60
3/3/2008	48	52	58	61	64
3/4/2008	53	55	57	62	66
3/5/2008	61	60	60	63	68
3/6/2008	50	53	57	61	67
3/7/2008	54	55	58	59	66
3/8/2008	61	61	62	59	66
3/9/2008	61	62	63	58	65
3/10/2008	45	51	59	57	66
3/11/2008	55	55	58	58	65
3/12/2008	52	53	56	58	65
3/13/2008	52	55	60	58	66
ARITH. AVERAGE	N/A	55	58	58	65
LOG AVERAGE	N/A	57	59	59	65
STD DEV	N/A	4.3	2.8	3.4	2.1

Table 1: *24-hour Day/Night Sound Levels for a 13 Day Sampling Period during Leaf-off Seasonal Conditions at the Proposed Bell Bend Project*

Let me know if I can assist in any other way or answer any questions.

George F. Hessler Jr., Bd. Cert. INCE

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Enclosure 10

TE-26 – Estimated Cooling Tower Sound Emissions, 2008

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Report Number 080108-1
Estimated Cooling Tower Sound Emissions
For the
Bell Bend Nuclear Power (BBNPP) Expansion Project
August 2008

Prepared For:

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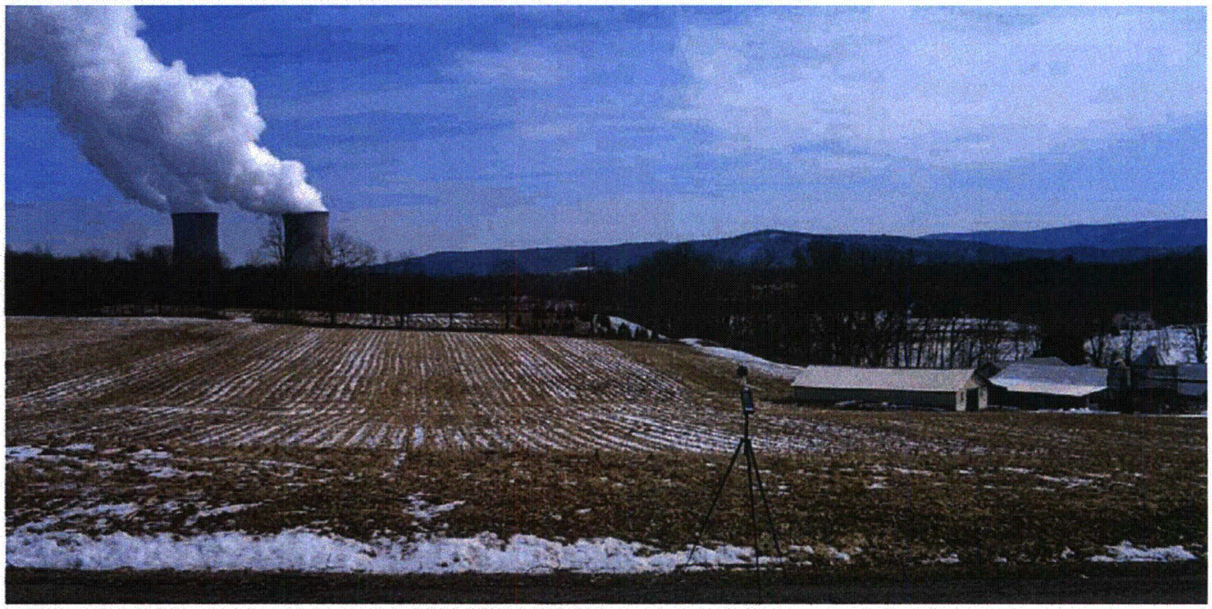

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Appendix

1.0_Introduction

Hessler Associates has been contracted by AREVA NP, Inc. to develop a noise model for the hyperbolic natural draft cooling towers planned for use at the Bell Bend NPP Expansion project. The circulating water system cooling tower could be a significant source of environmental noise leaving the site. As a result, the modeled noise emissions from the tower are to be compared to baseline ambient sound level measurement results at discreet points of interest measured in previous leaf-on and off ambient surveys. This comparison permits an estimate of subjective response to cooling tower noise at the closest potentially sensitive off-site locations.

It is still early in the project and comprehensive noise design data is not available for the bulk of the plant. Sound emissions from existing natural draft cooling towers have been cataloged from in-situ nuclear plant measurements and prediction algorithms have been developed for source sound power levels for the cooling towers.

2.0_ Executive Summary and Conclusions

Cooling tower noise emissions were estimated at four off-site community locations and one on-site location. The large buffer distances between the towers and potentially sensitive receptors are mostly flat farm fields with the exception of a high ridge to the north that runs east and west. There is no major dense forest coverage between the planned facilities and the closest residential receptors to the west. The estimated cooling tower noise level contours, therefore would be essentially the same during leaf-on and off seasons.

The estimated levels from the cooling towers are tabulated and compared to baseline ambient measurements made during leaf on and off seasons. It is concluded that noise emissions from the planned hyperbolic cooling towers, exclusive of the tower recirculation pumps and all other plant sources, will be imperceptible at most sensitive locations surrounding the plant except for location 4 to the south that is the closest off-site residential location to the planned facility. The tower noise emissions will be perceptible at this location on calm and still days when the ambient sound levels reach minimum levels, but imperceptible at other times of the day and night.

3.0_ Noise Modeling Methodology

Equal level noise contour plots for the site were calculated using the "CADNA", ver. 3.5.115 noise modeling program developed by DataKustik, GmbH (Munich). This software enables the project and its surroundings, including terrain features, to be realistically modeled in three-dimensions. Sound propagation is calculated in the model in strict accordance with ISO 9613 Part 2[1]. There is no comparable standard in the U.S. This computer model with standard ISO algorithms essentially predicts long term noise emissions under slight downwind conditions at all locations around the facility.

In general, a three dimensional drawing of the source emitters and the topography of the surrounding area of interest are drawn, and acoustic source strength in sound power level is assigned to each component. In this case the sound power model input was acquired from reference [2]. This information includes the sound power emitted from the low elevation air inlet faces called 'rim noise' and from the high stack top exit termed 'stack noise'. There was no information provided for the water recirculation pumps and lines so the estimated contours exclude any such sources that are considered relatively minor at this stage.

4.0_ Noise Modeling Results

Figure 4-1 below depicts the estimated total cooling tower noise levels (rim and stack noise) for two towers operating at a water flow rate of 720,000 gallons per minute each at every location in the vicinity of the Bell Bend and PPL facilities. The contours are cut-off at a level of 30 dBA. This value is the approximate measured residual ambient level from both leaf-on and leaf-off surveys. When an introduced new broadband source, such as cooling tower noise, is equal to the minimum ambient level, cooling tower noise becomes imperceptible. Hence, the 30 dBA contour is the limit of perception or audibility at the site.

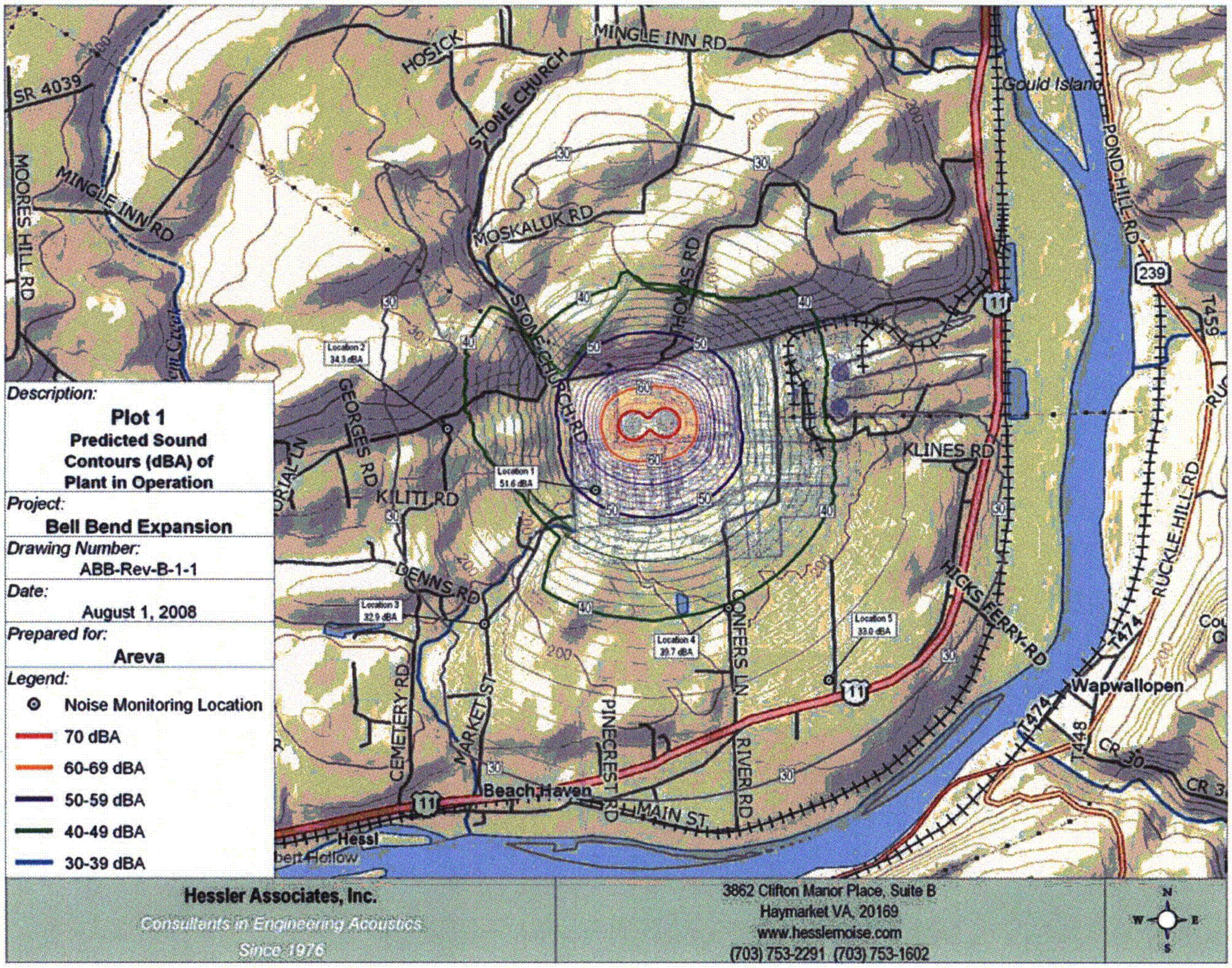

Figure 4.1: Noise contour plots attributable to natural draft cooling towers.

The labeled receptors 1 through 5 correspond to the ambient sound survey locations reported in references[3] [4]. The A-weighted sound levels estimated for the cooling towers at each location are tabulated below on **Table 4.1** and compared to the ambient survey results reported in the references.

The ambient values shown in the table are the arithmetic average of the daily-minimum hour measured levels over approximately one and one-half week periods. A comparison of the estimated cooling tower noise to the minimum ambient levels show that cooling tower levels are approximately equal or less than the ambient at most locations. The exception is location 4, which is the closest residence to the towers, where cooling tower noise exceeds the minimum ambient.

Subjectively, cooling tower noise would be essentially imperceptible at the off-site receivers except at location 4. Cooling tower noise would be perceptible at this location during quiet periods of the day or night and imperceptible at other times.

LOCATION	ESTIMATED COOLING TOWER LAeq	LEAF-OFF AMBIENT LA50	LEAF-ON AMBIENT LA50	LEAF-OFF AMBIENT LAeq	LEAF-ON AMBIENT LAeq
1 (ON-SITE)	52	N/A	N/A	N/A	N/A
2	34	33	34	35	36
3	33	33	34	36	38
4	40	33	31	36	35
5	33	39	37	53	41

***Table 4.1:** Estimated cooling tower noise in A-weighted levels a tfour community receptors.*

The estimated sound spectra attributable to the cooling towers at the on and off-site locations are plotted below in **Figure 4.2**. Natural draft cooling towers have little low frequency noise, and the peak frequency is shown to be in the 2000 Hz octave band. The source is created by falling water splashing into the basin. Such high frequency noise decays rapidly with distance from the tower.

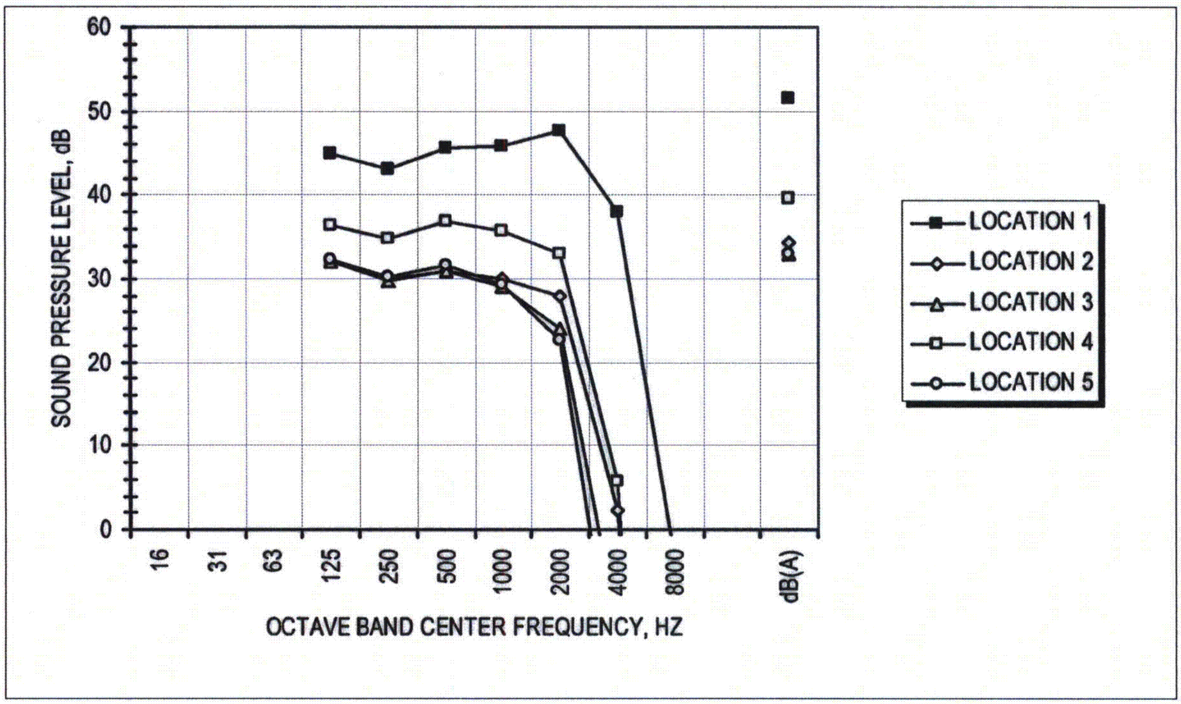

***Figure 4.2**: Estimated sound spectra at five locations.*

End of Text

References:

[1] ISO 9613, "Acoustics-Attenuation of sound during propagation outdoors-Part 2: General method of calculation (ISO 9613-2:1996), ISO International Organization for Standardization, Switzerland.
[2] Electric Power Plant Environmental Noise Guide, Edison Electric Institute, 2nd Edition, Section 4.4.2 Natural Draft Cooling Towers, Table 4.17, Rev. 1984.
[3] Hessler Associates Report Number 041808-1, "Baseline Environmental Noise Survey- Leaf off Season, Bell Bend Nuclear Power Plant (BBNPP)", April 2008
[4] Hessler Associates Report Number 062608-1, "Baseline Environmental Noise Survey- Leaf on Season, Bell Bend Nuclear Power Plant (BBNPP)", June 2008