ENVIRONMENTAL STUDIES IN THE VICINITY OF THE SUSQUEHANNA STEAM ELECTRIC STATION

2009
WATER QUALITY
FISHES

Prepared by

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INTRODUCTION

PPL Susquehanna, LLC (PPL) contracted Ecology III, Inc. to conduct nonradiological monitoring of the Susquehanna River in the vicinity of the Susquehanna Steam Electric Station (Susquehanna SES) in 2009. The Susquehanna SES is a nuclear power station with two boiling water reactors, each with a net electrical generating capacity of approximately 1,230 megawatts. It is located on about 1,700 acres on the west side of the Susquehanna River in Salem Township, Luzerne County, 5 miles northeast of Berwick, Pennsylvania. In addition, approximately 700 acres of mostly undeveloped and recreational lands owned by PPL are located on the east side of the Susquehanna River in Conyngham and Hollenback Townships. PPL owns 90 percent of the station and the Allegheny Electric Cooperative, Inc. 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 water quality and relative abundance of fishes. This was accomplished in 2009 by comparing data at control and indicator stations and by evaluating results of preoperational (1971-1982) and operational (1983-2008) studies (Ichthyological Associates 1972, Ichthyological Associates, Inc. 1973-1985, Ecology III, Inc. 1986-2009). Monitoring was done at sites within a control station (SSES) upriver from the Susquehanna SES river intake structure and indicator station (Bell Bend) downriver from the discharge diffuser.

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 fishes monitoring data.

This report presents results of water quality and fishes studies.

WATER QUALITY

PROCEDURES

Water quality of the Susquehanna River relative to operation of the Susquehanna SES was monitored throughout 2009 at four locations (Table 1, Fig. 1). Susquehanna River water samples were collected quarterly at SSES (control) and Bell Bend (indicator). In addition, water samples were also collected quarterly from the cooling tower blowdown of the Susquehanna SES. River flow and temperature were monitored continuously at the Environmental Laboratory (Table 2).

Most of the water sample parameters were analyzed by the Chemical Laboratory personnel at the PPL System Facilities Center, Hazleton, Pennsylvania. This laboratory has state accreditation with the Pennsylvania Department of Environmental Protection (PADEP; Commonwealth of PA 2006), identified as Lab #40-00568 (www.dep.state.pa.us). Water temperature and dissolved oxygen were measured by Ecology III personnel and river level was recorded with the SSES data (Table 2). PPL Susquehanna, LLC personnel provided data for Susquehanna River water withdrawal and blowdown discharge.

RESULTS AND DISCUSSION

River Flow, River Water Withdrawal, and River Temperature

In 2009, Susquehanna River flow was above the 48-year average for June, July, August, and October, and below average for the remaining months (Fig. 2). The annual

precipitation at Avoca, PA (about 30 miles upriver from the Susquehanna SES) was 35.46 inches (www.erh.noaa.gov/bgm/climate/avp.shtml, accessed 1 February 2010).

Daily mean river flow ranged from 1,940 to 85,500 cubic feet per second (cfs; Table 3). The Susquehanna River Basin Commission designated Luzerne County as abnormally dry from March through May 2009. However, there were no drought watches issued by PADEP since 11 January 2009 (www.srbc.net/hydrologic/drought_center.htm link: Pennsylvania Department of Environmental Protection Drought Center, accessed 18 February 2010). Cumulatively, an estimated 410 billion cubic feet of water flowed through this section of the Susquehanna River during 2009 (Fig. 3). This flow was within the 35th percentile of the last 49 years.

Susquehanna SES river water withdrawal of river flow ranged from 0.08% on 10 and 11 March to 3.90% on 26 September (Fig. 4). Daily river water withdrawal of the plant was ≤2% of river flow for most of 2009. River water withdrawal exceeded 2% of river flow on 29 days last year.

Daily mean river temperature ranged from 0.4 C on 31 December to 26.5 C on 18 August (Table 4). The hourly minimum river temperature of 0.2 C occurred at 0300 h on 15 January. The hourly maximum river temperature of 27.3 C occurred at 1300 and 1400 h on 18 August. November had the second warmest (exceeded by 0.2 C in 1982) monthly mean river temperature on record since 1974 and April was the fourth warmest in 36 years. River temperature was above average every month except January, June, July, August, and October. However, these temperature comparisons did not take into account variations in river flow among the months.

River Water Quality at the Susquehanna SES

Control and indicator data were compared to PADEP specific water quality criteria (Commonwealth of PA 2009; Table 5). The parameters with published specific water quality criteria include alkalinity, ammonia nitrogen, chloride, dissolved oxygen, fluoride, total and dissolved iron, manganese, nitrogen (nitrate), pH, sulfate, and temperature. In 2009, Susquehanna River water did not meet the published criteria for total alkalinity in March at both the control and indicator sampling sites (Table 6). The total alkalinity concentration in March was below the minimum criteria of 20 mg/L. While the total iron concentrations in March and October exceeded 1.5 mg/L, these did not technically violate the criterion because the criterion is based on a 30-day average. The March sample was collected when the river was in a high flow stage, 80,300 cfs, just one day after the highest crest of the year. The October sample was collected when the river was in a condition of increasing flow (3,960 to 21,800 cfs in five days), following an extended period of low flow (<10,000 cfs for 52 days). These concentrations were not a result of power plant operation since they occurred at both the control and indicator sites. Still, this relatively high iron concentration is reflective of the legacy of anthracite coal mining upstream from the power plant in the Wyoming Valley and Mocanaqua regions.

A new minimum for sulfate was established for the database in 2009. The sulfate concentration at SSES on 12 March (9.8 mg/L) was 1.5 mg/L lower than the previous minimum of 11.3 mg/L. There have been significant decreases over time in certain indicators of abandoned mine discharge such as total iron and sulfate concentrations (Table 7, Fig. 5), and Ecology III, Inc. has long reported the biotic recovery in the river associated with these improvements.

Blowdown

Blowdown is river water used in the nuclear power plant cooling cycle that is discharged back to the river. It has elevated conductivity and dissolved solids concentrations because of evaporative loss from the cooling towers (14.3-40.9 million gallons/day during 2009 operation). In 2009, the daily average blowdown discharge rate to the river ranged from 2.4-17.3 million gallons/day (MGD; Fig. 6). This resulted in the blowdown being 0.02-0.95% of the Susquehanna River flow (1,250-55,500 MGD).

Control and Indicator Site Comparisons

Control and indicator water quality data were similar on most of the sampling dates during 2009 (Table 6). Higher concentrations of total suspended solids and some metals at the control site were the exception in the March sample. This sample was collected during a high flow period. Of the 209 samples collected since 1983, the flow was exceptionally high on this date.

Since most of the water taken from the river for plant operation is evaporated in the cooling process, the remaining cooling water returned to the river subsequently contains concentrated mineral solids. Mineral solids concentrations in the blowdown sample were 3.2 to 6.6 times greater than those of the river control (Table 6). However, the dilutive effect of high river flow tends to equalize values at the control and indicator sites. This is evident when TMS values of the blowdown are compared to the control and indicator TMS results (Tables 8 and 9). It has been previously demonstrated that TMS concentrations at SSES are the best predictor of TMS concentrations at Bell Bend at most river flows. In addition, if operation of the Susquehanna SES is to influence the water quality at the

indicator site, then the probability of that occurring should be greatest at low river flows (Ecology III, Inc. 2008).

Conclusion

Susquehanna River flow exceeded the 48-year average during four months in 2009 and was below average for the remaining months. The maximum river water withdrawal of river flow by Susquehanna SES was 3.9% on 26 September. On most days during 2009, however, river water withdrawal was ≤2% of river flow. Exceptionally warm river temperatures were recorded for April and November.

Other than the March total alkalinity concentration, water quality data demonstrated that river samples met the published specific water quality criteria for 12 common parameters. A new minimum for sulfate was established for the database in March. Overall, water quality of this section of the Susquehanna River continues to improve.

Our data analyses demonstrate that effects of the operation of Susquehanna SES on water quality of the Susquehanna River will likely occur at the lowest range of river flows. This is reasonable because the dilutive power of the river against plant discharge would then be minimized.

FISHES

PROCEDURES

Electrofishing

Electrofishing samples were collected once each month in May, June, July, August and October in 2009. Sampling was done at four sites, and each site was approximately 1,100-yards long and parallel to the river shoreline. These sites have been consistently sampled by boat electrofishing since 1976. Two sites were located upriver from the Susquehanna SES river intake structure along each bank of the river, and two sites were downriver from the intake (referred to as SSES and Bell Bend locations, respectively; Table 10, Fig. 1).

The 18-foot electrofishing boat was outfitted with a 5-KW generator (direct current). Electrical output was controlled by a variable-voltage pulsator, with a target of 5-6 amps delivered to the water.

During sampling the boat was driven downstream parallel to the shoreline, usually within 30 feet of the riverbank. For both safety purposes and sampling efficiency electrofishing was done at river levels less than 493.1 feet above mean sea level (msl; equivalent to 10.1 feet) as measured at the Environmental Laboratory. Sampling was done in the evening and began about one hour after sunset. Two observers stood in the bow of the boat and identified and counted fish during each sample. Data were recorded using a cassette tape recorder.

Seining

Shoreline fishes were collected by seine during August and October. Sampling was done when river levels were less than 490.2 feet above msl (equivalent to 7.2 feet at the Environmental Lab). Similar to the electrofishing sampling sites, two shoreline seine sites were above the Susquehanna SES river intake structure and two were below (Table 10, Fig. 1). High water prevented seining in June.

To seine, one end of the 25-foot bag seine (0.25-inch mesh) was kept stationary on the riverbank while the other end was extended about 20 feet into the river or as far as depth of the water allowed. The seine was then pulled upriver and onto 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. Captured fish were placed in 10% formalin in the field and returned to the laboratory. After at least two weeks in the formalin, the fish were rinsed with water, identified, and enumerated before final preservation in 40% isopropyl alcohol.

Statistical Analysis

A statistical analysis known as the Before-After:Control-Impact (BACI), was applied to the electrofishing (1976-2009) and seining data (1978-2009; Ecology III, Inc. 1990). Twenty species or categories of fish were analyzed from the electrofishing data, as were 12 species from the seining data. These species or groups were chosen based on their abundance during the years before Susquehanna SES operation.

Two different electrofishing data sets were analyzed. The first set included all months sampled by electrofishing through the years, and is referred to as the All Data set.

The second set, named Summer Data set, included only the months from June through October to reflect the reduced monitoring effort in place since1986. The seining data set analyzed by the BACI represents all of the months sampled by this method through the years.

RESULTS AND DISCUSSION

Electrofishing

Electrofishing at the SSES and Bell Bend locations in 2009 resulted in the observation of 969 fish of 18 species (Tables 11 through 13). The total numbers of fish collected above and below the SSES intake and discharge for the year were generally similar. Differences in monthly totals between upriver versus downriver sites ranged from as few as 6 fish in August to as many as 104 fish in July; most months sampled had a difference of 11 fish or less between the sampling sites. Comparatively, the range of monthly sample sizes (maxima minus minima) between the east and west banks was 34 fish at SSES and 19 at Bell Bend. Maximum monthly sample sizes occurred during July at SSES (192) and October at Bell Bend (165).

Smallmouth bass was the most abundant species overall observed at SSES and Bell Bend in 2009 (27% and 32% of the totals, respectively). Smallmouth bass and rock bass together represented 44% of the fish observed at SSES and 43% of those at Bell Bend. Smallmouth bass was also the most abundant species during most months at both SSES and Bell Bend, with the exceptions at SSES of northern hog sucker in June and August, and rock bass in July. Overall, there were considerable numbers of fish placed in

the unidentified fish category at both sites during 2009. This likely reflects the high river conditions during sampling throughout the summer.

Sixteen species were observed at SSES as were 18 at Bell Bend. Species richness in monthly samples ranged from 6 to 15 species at SSES and 8 to 15 at Bell Bend. Sucker and sunfish species dominated richness in all months during 2009.

Seining

Seining at the SSES and Bell Bend locations in 2009 resulted in the capture of 566 fish of 12 species (Tables 11 and 14). Spotfin shiner was the most abundant species captured at both SSES and Bell Bend, representing 51% and 59% of the total collections, respectively. Spotfin shiner, spottail shiner, and bluntnose minnow comprised 74% of the fishes collected at SSES and 95% of those collected at Bell Bend.

Similar to previous years, the number of fishes captured at SSES was a fraction (53%) of those collected at Bell Bend. This disparity between the upriver and downriver locations was similarly evident in both monthly samples. This may reflect increasing habitat differences between the sites. Moreover, this location is also the deepest of the four sites.

Eight species were collected at SSES and 9 species were captured at Bell Bend. At both stations, species in the minnow and sunfish families predominated.

BACI Results: Electrofishing

Of the 20 species or categories of fish that were tested with the BACI analysis, nine species from the All Data set and eight species from the Summer Data set showed

significant differences in the numbers of fishes above versus below the power plant discharge (P≤0.05, Table 15). Species in the All Data set that indicated decreases in abundance below the power plant discharge included quillback, white sucker, northern hog sucker, shorthead redhorse, muskellunge, rock bass, smallmouth bass, and unidentified fish. Brown bullhead was also significantly different; however, its numbers significantly increased at Bell Bend compared to the upriver sites. The Summer Data set demonstrated decline or increase in all of the same species except white sucker.

BACI Results: Seining

The results of the 12 seined species tested by BACI analysis indicated marginally significant differences in the numbers of spotfin shiner (P=0.082) and rock bass (P=0.093) above versus below the plant discharge. The point estimates for these species indicated that more spotfins were collected at the downriver sites versus upriver, while fewer rock bass were collected at the downriver locations.

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Table 1

Descriptions of water quality sampling sites in the vicinity of the Susquehanna SES, 2009.

SITE	LOCATION
Susquehanna SES Environmental Laboratory	West bank of the Susquehanna River: 1,620 feet (ft) upriver from the Susquehanna SES intake structure, sensors for river depth and temperature are located on river bottom within 100 ft of the bank
SSES (control)	Susquehanna River: 750 ft upriver from the center of the Susquehanna SES intake structure, 130 ft from the west bank
Blowdown	Since November 1996: Susquehanna SES Cooling Tower Blowdown Discharge Line 2S7 automatic composite sampler (ACS) about 750 feet downstream from the cooling tower basin, 0.1 air miles NNE from the stand-by gas treatment vent at 44200/N34117 (PA Grid System)
	December 1990-October 1996: 6S7 ACS at the Susquehanna SES sewage treatment plant about 2,880 feet downstream from the cooling tower basin
Bell Bend (indicator)	Susquehanna River: 2,260 ft downriver from the Susquehanna SES discharge diffuser, 130 ft from the west bank

Table 2

Water quality parameters and methods of analyses utilized by the Susquehanna SES Environmental Laboratory, 2009.

PARAMETER	METHOD	REFERENCE [a]
River depth (ft)	Seven-day continuous recording from an Acco Bristol, Model No. G500-15 bubbler-type water level gauge.	ACCO (1971)
River level (ft above msl)	$Level = Depth + 482.96$	Soya (1991)
River flow (cfs)	Insert river level into the appropriate regression equation. At level <486.0 ft, $\log flow = -0.05251(level)^2 + 51.478501(level) - 12612.85672$ At level ≥486.0 ft, $flow = 319.96989(level)^2 - 309316.24395(level) + 74753300$	Soya (1991)
Temperature (°F)	Constant monitor of river temperature: Seven-day continuous recording from an Omega RD-MV106-3-2-1D temperature recorder.	Omega (2001)
(°C)	River and blowdown temperature of samples collected: Calibrated, mercury-filled thermometer. Method 2550 B. Convert Fahrenheit to Celsius for tabulation: $^{\circ}C = (^{\circ}F - 32) \div 1.8$ or $\frac{^{\circ}C}{^{\circ}F - 32} = 5/9$	APHA (1995) [b] Internet site
Dissolved oxygen (mg/L)	Membrane electrode. Method 4500-O G.	APHA (1995)

[a] Listed in references cited.
[b] http://mathforum.org/library/drmath/view/58393.html. Accessed: 19 February 2009.

Table 3

Daily mean flow (cfs) of the Susquehanna River at the Susquehanna SES Environmental Laboratory, 2009.

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	40200	5590	18700	17200	6490	17700	14000	25200	14900	5590	32600	11100
2	28100	5300	24000	17700	6490	14000	15300	20700	12700	6180	25200	11100
3	22900	6180	19700	15300	6490	11900	16700	19700	9180	5880	20700	11900
4	20200	5880	15800	17700	7120	9910	16700	17200	7120	5300	18200	12700
5	18200	5880	12300	28100	7780	8470	14900	14400	5880	5300	15300	12700
6	17200	5020	11500	32600	7450	7450	14000	12700	5300	5590	13500	13100
7	16200	4480	11100	31300	7780	6800	11900	9180	4740	5590	11900	12700
8	16700	4210	11900	29400	8120	6180	10700	7450	4210	4740	11100	11100
9	17200	5590	23500	26900	9180	5880	9180	6490	4210	4210	10700	11100
10	16200	7120	77300	22900	11500	6180	8820	6800	3460	4480	9910	12700
11	15300	9540	85500	19700 [a]	10300	6180	8120	7450	3230	4740	9180	14400
12	11900	19200	80300	18700	9540	6490	8120	22900	3710	5300	8470	14900
13	10300	52600	63000	17200	8820	6800	7450	23500	4210	4740	7780	12700
14	10700	56000	48500	15800	8120	11500	6490	16700	3710	4480	7120	13500
15	9910	41600	38700	14000	8470	11100	6490	13500	3230	4480	6800	14900
16	9910	31900	31300	13100	8470	9910	6180	10700	3000	4210	6490	20200
17	8120	24600	27500	12300	14000	8470	5300	8470	3000	4210	6180	23500
18	5300	19200	24600	11100	28100	8470	4740	6800	3000	4480	5880	20700
19	5300	16700	22300	10300	26300	11100	4480	5880	2770	4480	5880	16700
20	7120	14900	24600	9540	21300	12700	4480	6490	2770	4740	6180	14000
21	7120	13500	29400	9910	15800	15800	4210	6800	2770	4480	8820	12300
22	7450	13100	28100	11100	12700	40200	4210	8120	2560	4480	11900	12300
23	7120	11500	23500	11900	9910	33900	3960	7780	2350	3960	13100	11500
24	6800	10300	20200	11100	8820	26300	3460	7780	2140	4740	11500	10300
25	7450	9540	17200	9910	8470	19200	3230	7450	2140	17200	10300	8820
26	6490	9180	14900	9540	8120	14900	3230	6490	1940	21300	9180	8820
27	5880	8470	14000	8820	8120	14900	3230	6180	2140	22300	9180	10300
28	5300	10300	14000	8120	8820	16200	3000	5590	2770	21800	9180	20700
29	6180		14000	7450	12700	16700	3000	5020	3460	33200	10300	24000
30	5590		14000	6800	17200	14400	8470	6180	3960	48500	10700	18200
31	5590		14400		21300		13100	10700		42400		16200
MEAN	12200	15300	28300	15800	11400	13300	7970	11000	4350	10400	11400	14200

[a] Calculated 11-16 April flows using USGS data.

Table 4

Daily mean temperature (C) of the Susquehanna River at the Susquehanna SES Environmental Laboratory, 2009.

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1.5	0.6	3.3	8.8	17.4	18.6	22.4	21.7	21.7	15.6	11.9	6.8
2	0.8	0.6	1.9	9.2	17.0	18.4	22.3	22.1	21.0	14.7	11.2	6.3
3	0.5	0.7	0.6	10.0	16.6	17.9	21.8	23.1	21.2	15.2	10.7	6.7
4	0.5	0.6	0.5	9.8	16.1	17.8	21.8	23.4	21.8	15.4	10.0	6.7
5	0.5	0.5	0.7	9.2	15.5	18.0	22.0	23.8	22.2	15.3	9.6	6.2
6	0.5	0.5	1.6	9.0	15.1	18.4	22.4	23.7	22.5	14.8	8.8	5.1
7	0.7	0.7	2.9	8.4	15.6	19.9	22.5	23.6	22.4	14.9	7.9	4.4
8	0.9	1.2	4.3	7.7	16.4	21.4	22.2	23.4	22.5	14.7	7.6	4.0
9	0.7	1.0	5.1	7.3	17.2	22.4	22.3	23.1	22.3	14.5	7.9	3.7
10	0.5	1.0	3.3	7.2	17.3	23.0	23.2	23.4	21.8	14.6	8.4	3.1
11	0.5	1.3	3.1	7.5	16.6	22.7	23.2	24.5	20.6	14.1	8.6	1.7
12	0.5	1.1	3.4	7.5	16.5	22.7	23.0	24.6	20.0	13.3	8.4	1.1
13	0.5	0.6	3.5	8.2	16.6	22.9	23.1	23.9	20.4	12.8	8.2	0.9
14	0.5	0.8	3.4	8.7	16.3	23.0	23.0	23.8	20.8	12.1	8.8	1.5
15	0.5	1.0	3.9	9.0	16.8	23.1	23.3	24.5	21.2	11.2	9.2	2.4
16	0.5	0.9	4.3	10.1	17.9	22.2	23.9	25.3	20.7	10.3	9.4	2.4
17	0.5	1.0	5.1	11.1	17.4	21.4	24.1	26.2	20.2	9.9	9.6	1.9
18	0.5	0.8	6.2	12.2	15.9	20.5	24.0	26.5	20.1	9.7	9.2	1.2
19	0.5	1.1	7.2	13.0	15.3	20.0	24.1	26.4	19.9	9.6	9.4	0.8
20	0.5	0.7	7.3	12.9	16.0	19.5	24.0	26.1	19.7	10.1	9.6	0.5
21	0.5	0.7	6.9	12.4	17.0	19.6	23.5	25.6	19.7	10.8	9.2	0.5
22	0.5	1.1	6.3	13.0	18.4	19.3	23.5	25.4	19.6	11.4	8.7	0.6
23	0.6	0.8	5.7	12.4	19.3	19.2	23.8	25.1	20.5	11.8	8.3	0.5
24	0.5	0.8	5.3	12.5	19.8	20.2	24.1	24.5	21.1	12.6	8.6	0.5
25	0.5	1.2	5.4	13.6	20.8	21.3	24.4	24.5	20.4	12.8	8.8	0.5
26	0.5	1.9	5.6	15.4	20.4	22.2	24.6	24.6	18.8	12.3	8.9	1.0
27	0.5	2.8	6.4	17.3	19.1	22.2	25.2	24.4	18.7	11.6	8.9	1.8
28	0.5	3.7	7.7	18.7	18.5	22.0	25.7	23.8	18.1	11.4	8.2	1.9
29	0.5		8.7	19.0	18.2	22.3	25.4	23.3	17.2	11.7	7.6	0.9
30	0.6		8.9	18.2	18.7	22.4	25.3	23.1	16.5	11.6	7.5	0.5
31	0.5		8.9		19.2		22.9	22.3		15.6		0.4
MEAN	0.6	1.1	4.8	11.3	17.4	20.8	23.5	24.2	20.5	12.8	9.0	2.5

Table 5

Pennsylvania Department of Environmental Protection specific water quality criteria for the Susquehanna River in the vicinity of the Susquehanna SES, 2009.

PARAMETER	UNIT	PERIOD	CRITERIA		AVERAGE
			Minimum	Maximum	
Alkalinity as CaCO3	mg/L		20		
Ammonia Nitrogen	mg/L			4.56	
Chloride	mg/L			250	
Dissolved Oxygen	mg/L		4.0		
		Daily Average	5.0		
Fluoride	mg/L	Daily			2.0
Iron Total	mg/L	30-Day			1.5
Dissolved	mg/L			0.3	
Manganese	mg/L			1.0	
	ug/L			1000	
Nitrite plus Nitrate as N	mg/L			10	
pH			6.0	9.0	
Sulfate	mg/L			250	
Temperature	C	January 1-31		4.4	
		February 1-29		4.4	
		March 1-31		7.8	
		April 1-15		11.1	
		April 16-30		14.4	
		May 1-15		17.8	
		May 16-31		22.2	
		June 1-15		26.7	
		June 16-30		28.9	
		July 1-31		30.6	
		August 1-15		30.6	
		August 16-31		30.6	
		September 1-15		28.9	
		September16-30		25.6	
		October 1-15		22.2	
		October 16-31		18.9	
		November 1-15		14.4	
		November 16-30		10.0	
		December 1-31		5.6	

Table 6

Water quality data collected quarterly from the Susquehanna River and the Susquehanna SES blowdown, 2009. River sites were SSES (control) and Bell Bend (indicator). Analyses were performed at the PPL Chemical Laboratory, Hazleton, PA. N.D. = Not Detected

PARAMETER	UNITS	SSES	BLOW DOWN	BELL BEND	SSES	BLOW DOWN	BELL BEND
Date		3/12/2009	3/12/2009	3/12/2009	5/21/2009	5/21/2009	5/21/2009
Time		810	714	817	748	816	740
River level	ft	499.5			490.8		
Temperature	C	2.5	14.2	2.5	15.9	21.4	15.9
Dissolved oxygen	mg/L	14.1	11.34	14.3	11.6	11.1	11.5
pH, lab		7.48	8.59	7.43	7.58	8.64	7.64
Conductivity, lab	µmho	143	764	149	184	609	186
Total alkalinity	mg/L	13.5	162	5.2	42.5	146	43
Phenolphthalein alkalinity	mg/L	0	7.4	0	0	5	0
Total suspended solids	mg/L	141	280	76	22	65	21.6
Ammonia as N	mg/L	<0.200	<0.200	<0.200	<0.20	<0.20	<0.20
Silicon dioxide	mg/L	3.58	14.76	3.53	3.42	9.51	3.41
Bicarbonate as CaCO3	mg/L	13.5	147	5.25	42.5	136	43
Carbonate as CO3	mg/L	0	14.8	0	0	10	0
Chloride	mg/L	17.8	110	19.4	18.8	75.6	21
Fluoride	mg/L	0.05	0.27	<0.100	0.071	0.229	<0.100
Nitrate as NO3	mg/L	2.19	12.3	2.33	1.33	5.27	1.49
Nitrate ion as N	mg/L	0.5	2.8	0.5	0.3	1.19	0.34
Phosphorus as PO4	mg/L	0.414	6.055	0.196	0.153	3.439	0.212
Sulfate	mg/L	9.8	56.4	11.3	16	51.3	16.4
Aluminum, dissolved	ug/L	<100	<100	<100	N.D.	<100	<100
Aluminum, total	ug/L	3740	7740	1900	440	1640	418
Barium, total	ug/L	58	172	37	30	104	30
Calcium, dissolved	mg/L	12.2	77.6	12.4	17.3	59.5	17.4
Calcium, total	mg/L	13.5	76.3	13.1	17.4	61.3	17.5
Copper, dissolved	ug/L	<20.0	<20.0	N.D.	N.D.	<20.0	N.D.
Copper, total	ug/L	<20.0	21.2	N.D.	N.D.	<20.0	N.D.
Iron, dissolved	mg/L	0.068	0.272	0.084	0.134	0.265	0.136
Iron, total	mg/L	7.66	15.9	3.76	1.17	4.24	1.14
Magnesium, dissolved	mg/L	2.31	13.9	2.33	3.82	12.4	3.82
Magnesium, total	mg/L	3.6	16.9	2.98	3.95	13.1	3.93
Manganese, dissolved	ug/L	15.1	31.3	13.7	44.3	27.1	45.1
Manganese, total	ug/L	381	814	167	116	467	116
Nickel, total	ug/L	<10.0	17.4	<10.0	<10.0	<10.0	<10.0
Potassium, dissolved	mg/L	1.21	5.24	1.19	1.18	4.06	1.21
Potassium, total	mg/L	1.61	6.12	1.46	1.28	4.3	1.28
Silver, total	ug/L	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sodium, dissolved	mg/L	10.1	58.7	10.3	11.4	44.7	11.4
Sodium, total	mg/L	9.94	60.3	10.1	11.2	45	11.2
Strontium, total	ug/L	38.9	246	37.4	61.9	219	61.6
Vanadium, total	ug/L	<10.0	11	<10.0	N.D.	<10.0	N.D.
Zinc, dissolved	ug/L	27	25.7	22.5	<20.0	<20.0	<20.0
Zinc, total	ug/L	35.2	76.2	<20.0	<20.0	25.1	<20.0
Beryllium, total	ug/L	<1.00	<1.00	N.D.	N.D.	N.D.	N.D.
Cadmium, total	ug/L	N.D.	<1.00	N.D.	N.D.	N.D.	N.D.
Chromium, total	ug/L	<10.0	11.2	<10.0	<10.0	<10.0	N.D.
Lead, total	ug/L	7.18	13.9	<5.00	N.D.	<5.00	N.D.
Thallium, total	ug/L	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Arsenic, total	ug/L	2.35	5.72	1.11	<1.00	2.96	<1.00
Selenium, total	ug/L	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Antimony, total	ug/L	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Total mineral solids	mg/L	67.25	446.09	65.88	98.82	349.67	101.92
Calcium hardness (C)	mg/L	30.5	194	31	43.2	149	43.4
Total hardness (C)	mg/L	48.5	260	45	59.7	207	59.9

Table 6 (cont.)

PARAMETER	UNITS	SSES	BLOW DOWN	BELL BEND	SSES	BLOW DOWN	BELL BEND
Date		8/19/2009	8/19/2009	8/19/2009	10/28/2009	10/28/2009	10/28/2009
Time		657	723	650	604	744	611
River level	ft	488.1			491.7		
Temperature	C	25.2	25.9	25.3	10.5	18.7	10.5
Dissolved oxygen	mg/L	8	7.3	8	11.8	9.7	11.5
pH, lab		7.72	8.92	7.7	7.56	8.8	7.58
Conductivity, lab	µmho	238	708	237	194	623	196
Total alkalinity	mg/L	60	182	58.2	53	177	52
Phenolphthalein alkalinity	mg/L	0	19.5	0	0	11.1	0
Total suspended solids	mg/L	14.5	52	13	36.7	92	42
Ammonia as N	mg/L	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Silicon dioxide	mg/L	2.68	9.56	3.68	5.11	12.7	5.35
Bicarbonate as CaCO3	mg/L	60	143	58.2	53	154	52
Carbonate as CO3	mg/L	0	39	0	0	22.2	0
Chloride	mg/L	23.2	80.8	22.6	18	65.9	17.7
Fluoride	mg/L	0.079	0.261	0.078	0.058	<0.200	0.056
Nitrate as NO3	mg/L	1.4	6.9	1.43	1.38	4.98	1.36
Nitrate ion as N	mg/L	0.32	1.56	0.32	0.31	1.13	0.31
Phosphorus as PO4	mg/L	0.061	3.138	0.071	0.239	4.724	0.328
Sulfate	mg/L	22.3	69.9	22.3	12	45.4	11.7
Aluminum, dissolved	ug/L	<100	<100	N.D.	N.D.	<100	<100
Aluminum, total	ug/L	304	1070	276	831	1940	929
Barium, total	ug/L	29.3	96.2	28.9	36.6	94.9	38.2
Calcium, dissolved	mg/L	22.9	73.4	23.2	18.9	66.3	19.1
Calcium, total	mg/L	23.3	75.5	23.1	19.8	68.7	19.7
Copper, dissolved	ug/L	N.D.	<20.0	N.D.	N.D.	<20.0	N.D.
Copper, total	ug/L	N.D.	<20.0	N.D.	N.D.	<20.0	N.D.
Iron, dissolved	mg/L	0.162	0.195	0.163	0.12	0.258	0.122
Iron, total	mg/L	1.01	3.13	0.956	2.06	4.99	2.32
Magnesium, dissolved	mg/L	5.38	16.4	5.47	3.81	13.2	3.77
Magnesium, total	mg/L	5.55	17	5.5	4.1	14.1	4.12
Manganese, dissolved	ug/L	25.7	17.1	21.4	11.9	22	9.05
Manganese, total	ug/L	118	307	111	108	380	126
Nickel, total	ug/L	<10.0	<10.0	N.D.	N.D.	<10.0	N.D.
Potassium, dissolved	mg/L	1.78	5.25	1.77	2.12	6.37	2.03
Potassium, total	mg/L	1.86	5.57	1.86	2.19	6.72	2.18
Silver, total	ug/L	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sodium, dissolved	mg/L	13.9	47.9	14.2	11	39.4	11.2
Sodium, total	mg/L	14	47.7	13.9	11	39.8	11
Strontium, total	ug/L	93.4	278	92.4	65.5	260	65.2
Vanadium, total	ug/L	N.D.	N.D.	N.D.	N.D.	<10.0	N.D.
Zinc, dissolved	ug/L	22.7	<20.0	<20.0	<20.0	55	<20.0
Zinc, total	ug/L	N.D.	<20.0	N.D.	<20.0	22.3	<20.0
Beryllium, total	ug/L	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Cadmium, total	ug/L	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Chromium, total	ug/L	N.D.	<10.0	N.D.	N.D.	<10.0	N.D.
Lead, total	ug/L	N.D.	<5.00	N.D.	<5.00	<5.00	<5.00
Thallium, total	ug/L	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Arsenic, total	ug/L	<2.00	3.71	<2.00	<2.00	3.26	<2.00
Selenium, total	ug/L	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Antimony, total	ug/L	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Total mineral solids	mg/L	129.53	419.32	129.48	104.13	360.16	103.47
Calcium hardness (C)	mg/L	57.2	183	57.9	47.2	166	47.7
Total hardness (C)	mg/L	81	259	80.3	66.3	230	66.2

Table 7

Total iron concentrations from the Susquehanna River at the SSES sampling site, 1975-2009. Samples were collected monthly from 1975 through 1996 and quarterly from 1997 through 2009. Analyses were performed by the PPL Chemical Laboratory, Hazleton, PA.

YEAR	NO. SAMPLES Collected	NO. SAMPLES <1.50 mg/L	% SAMPLES <1.50 mg/L	ANNUAL MEAN
1975	12	2	16.7	3.55
1976	12	3	25.0	3.08
1977	11	5	45.5	1.71
1978	12	5	41.7	1.48
1979	12	5	41.7	3.13
1980	12	5	41.7	1.74
1981	12	9	75.0	1.31
1982	12	7	58.3	2.37
1983	11	6	54.5	1.41
1984	12	4	33.3	1.71
1985	12	5	41.7	1.61
1986	12	7	58.3	1.82
1987	12	8	66.7	1.96
1988	12	7	58.3	1.28
1989	12	9	75.0	1.45
1990	12	10	83.3	1.41
1991	12	10	83.3	0.98
1992	12	12	100.0	0.92
1993	12	8	66.7	1.55
1994	11	8	72.7	1.46
1995	12	12	100.0	0.89
1996	12	9	75.0	1.42
1997	4	4	100.0	0.55
1998	4	4	100.0	0.65
1999	4	4	100.0	0.60
2000	4	4	100.0	0.70
2001	4	4	100.0	0.74
2002	4	4	100.0	0.62
2003	4	3	75.0	1.43
2004	4	3	75.0	0.94
2005	4	4	100.0	0.57
2006	4	4	100.0	0.62
2007	4	3	75.0	2.00
2008	4	3	75.0	0.98
2009	4	2	50.0	2.98

Table 8

Comparison of total mineral solids (TMS) concentrations from the Susquehanna River and the Susquehanna SES blowdown, 2009. River sites were SSES (control) and Bell Bend (indicator).

DATE	SSES		BLOWDOWN		BELL BEND	DIFFERENCE
	Flow (cfs)	TMS (mg/L)	Flow (cfs)	TMS (mg/L)	TMS (mg/L)	BELL BEND - SSES TMS (mg/L)
12 Mar	80300	67.3	19.3	446.1	65.9	-1.4
21 May	15800	98.8	17.1	349.7	101.9	3.1
19 Aug	5880	129.5	26.7	419.3	129.5	0.0
28 Oct	21800	104.1	26.6	360.2	103.5	-0.6

Table 9

Comparison of annual average total mineral solids (TMS) concentrations from the Susquehanna River and the Susquehanna SES blowdown, 1991-2009. River sites were SSES (control) and Bell Bend (indicator).

YEAR	SSES		BLOWDOWN		BELL BEND	DIFFERENCE
	Flow (cfs)	TMS (mg/L)	Flow (cfs)	TMS (mg/L)	TMS (mg/L)	BELL BEND - SSES TMS (mg/L)
1991	12600	197.3	14.6	711.8	203.7	6.4
1992	13400	155.3	7.5	600.3	156.4	1.1
1993	23700	202.8	13.1	636.2	204.4	1.6
1994	19200	174.9	13.9	660.9	175.3	0.4
1995	10200	196.7	12.9	643.9	198.8	2.1
1996	24000	151.8	19.5	438.4	152.6	0.8
1997	6490	239.0	16.9	787.7	248.6	9.6
1998	11200	242.2	19.2	649.3	247.9	5.7
1999	9120	204.1	11.2	585.1	212.0	7.9
2000	21200	160.4	12.6	449.5	163.5	3.1
2001	7190	180.2	20.8	572.5	183.9	3.7
2002	12200	136.2	17.7	523.4	142.5	6.3
2003	26900	131.3	18.7	459.0	132.5	1.2
2004	12200	134.1	18.3	446.6	136.3	2.2
2005	13500	157.1	16.2	584.0	165.4	8.3
2006	14400	137.6	17.9	522.8	138.0	0.4
2007	20810	145.7	20.4	455.1	147.9	2.2
2008	10700	164.1	23.2	505.0	165.1	1.0
2009	30900	99.9	22.4	393.8	100.2	0.3
MEAN	15800	169.0	16.7	559.2	172.4	3.4

Table 10

Descriptions of electrofishing (EL) and seining (SN) sites at SSES and Bell Bend on the Susquehanna River, 2009.

SITE	LOCATION
	SSES (Control)
EL-1	East bank, 426 feet upriver from gas-line crossing to 1,082 feet upriver from a point opposite the center of the Susquehanna SES intake structure
EL-2	West bank from gas-line crossing to a point 820 feet upriver from the center of the Susquehanna SES intake structure
SN-1	East bank, 1,837 feet upriver from a point opposite the center of the Susquehanna SES intake structure (33 feet upriver from the mouth of Little Wapwallopen Creek)
SN-2	West bank, 1,312 feet upriver from the center of the Susquehanna SES intake structure (328 feet downriver from the boat ramp at the Susquehanna SES Environmental Laboratory)
	BELL BEND (Indicator)
EL-3	East bank, 1,279 feet downriver from a point opposite the center of the Susquehanna SES intake structure to a point 1,640 feet upriver from the mouth of Wapwallopen Creek
EL-4	West bank, 1,246 feet downriver from the center of the Susquehanna SES intake structure (558 feet downriver from the discharge diffuser) to a point near the southeastern boundary of PPL's Wetlands Nature Area
SN-3	East bank, 8,528 feet (1.6 miles) downriver from a point opposite the center of the Susquehanna SES intake structure, at the launching ramp of the Berwick Boat Club
SN-4	West bank, 4,264 feet (0.8 miles) downriver from the center of the Susquehanna SES intake structure, near the southeastern boundary of PPL's Wetlands Nature Area

Table 11

Fish species that were observed while electrofishing or collected by seining at SSES and Bell Bend on the Susquehanna River, 2009. Names of fishes and order of listing conform to Nelson et al. (2004).

COMMON NAME	SCIENTIFIC NAME
Carps and Minnows	Cyprinidae
Spotfin shiner	*Cyprinella spiloptera*
Common carp	*Cyprinus carpio*
Spottail shiner	*Notropis hudsonius*
Rosyface shiner	*Notropis rubellus*
Bluntnose minnow	*Pimephales notatus*
Fallfish	*Semotilus corporalis*
Suckers	Catostomidae
Quillback	*Carpiodes cyprinus*
White sucker	*Catostomus commersonii*
Northern hog sucker	*Hypentelium nigricans*
Shorthead redhorse	*Moxostoma macrolepidotum*
North American Catfishes	Ictaluridae
Channel catfish	*Ictalurus punctatus*
Pikes	Esocidae
Northern pike	*Esox lucius*
Muskellunge	*Esox masquinongy*
Chain pickerel	*Esox niger*
Sunfishes	Centrarchidae
Rock bass	*Ambloplites rupestris*
Redbreast sunfish	*Lepomis auritus*
Green sunfish	*Lepomis cyanellus*
Pumpkinseed	*Lepomis gibbosus*
Bluegill	*Lepomis macrochirus*
Smallmouth bass	*Micropterus dolomieu*
Perches	Percidae
Tessellated darter	*Etheostoma olmstedi*
Yellow perch	*Perca flavescens*
Walleye	*Sander vitreus*

Table 12

Number, mean, and percent total of fish observed while electrofishing at SSES on the Susquehanna River, 2009.

SPECIES	27 May				25 Jun				21 Jul				25 Aug				21 Oct				OVERALL	
	East	West	Mean	% Total	East	West	Mean	% Total	East	West	Mean	% Total	East	West	Mean	% Total	East	West	Mean	% Total	Mean	% Total
Common carp	0	0	0.0	0.0	0	0	0.0	0.0	1	0	0.5	0.5	1	0	0.5	1.4	3	0	1.5	1.9	0.5	0.9
Fallfish	0	1	0.5	1.4	0	0	0.0	0.0	0	2	1.0	1.0	0	1	0.5	1.4	0	4	2.0	2.6	0.8	1.5
Quillback	0	8	4.0	11.0	3	2	2.5	12.2	4	3	3.5	3.6	1	0	0.5	1.4	10	2	6.0	7.8	3.3	6.2
White sucker	0	0	0.0	0.0	0	0	0.0	0.0	1	1	1.0	1.0	0	0	0.0	0.0	0	0	0.0	0.0	0.2	0.4
Northern hog sucker	4	0	2.0	5.5	9	1	5.0	24.4	13	32	22.5	23.4	22	6	14.0	37.8	7	11	9.0	11.7	10.5	19.7
Shorthead redhorse	1	0	0.5	1.4	1	0	0.5	2.4	1	2	1.5	1.6	1	0	0.5	1.4	0	0	0.0	0.0	0.6	1.1
Channel catfish	2	1	1.5	4.1	0	0	0.0	0.0	5	1	3.0	3.1	1	0	0.5	1.4	3	3	3.0	3.9	1.6	3.0
Muskellunge	0	0	0.0	0.0	0	0	0.0	0.0	3	0	1.5	1.6	1	0	0.5	1.4	0	0	0.0	0.0	0.4	0.7
Chain pickerel	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	0.6	0.1	0.2
Pike spp.	1	0	0.5	1.4	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
Rock bass	2	4	3.0	8.2	0	1	0.5	2.4	20	29	24.5	25.5	1	0	0.5	1.4	18	12	15.0	19.5	8.7	16.3
Redbreast sunfish	0	0	0.0	0.0	0	0	0.0	0.0	1	0	0.5	0.5	0	0	0.0	0.0	0	1	0.5	0.6	0.2	0.4
Green sunfish	0	0	0.0	0.0	0	0	0.0	0.0	1	0	0.5	0.5	0	0	0.0	0.0	0	0	0.0	0.0	0.1	0.2
Bluegill	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.5	0.5	0	0	0.0	0.0	0	0	0.0	0.0	0.1	0.2
Smallmouth bass	12	13	12.5	34.2	5	5	5.0	24.4	24	16	20.0	20.8	14	7	10.5	28.4	35	15	25.0	32.5	14.6	27.3
Sunfish spp.	1	2	1.5	4.1	0	0	0.0	0.0	2	4	3.0	3.1	0	0	0.0	0.0	0	0	0.0	0.0	0.9	1.7
Yellow perch	0	1	0.5	1.4	0	0	0.0	0.0	1	3	2.0	2.1	2	0	1.0	2.7	1	2	1.5	1.9	1.0	1.9
Walleye	0	7	3.5	9.6	0	1	0.5	2.4	3	6	4.5	4.7	0	6	3.0	8.1	15	10	12.5	16.2	4.8	9.0
Fish (unidentified)	8	5	6.5	17.8	7	6	6.5	31.7	4	8	6.0	6.3	8	2	5.0	13.5	1	0	0.5	0.6	4.9	9.2
TOTAL	31	42	36.5		25	16	20.5		84	108	96.0		52	22	37.0		94	60	77.0		53.4	

Table 13

Number, mean, and percent total of fish observed while electrofishing at Bell Bend on the Susquehanna River, 2009.

SPECIES	27 May				25 Jun				21 Jul				25 Aug				21 Oct				OVERALL	
	East	West	Mean	% Total	East	West	Mean	% Total	East	West	Mean	% Total	East	West	Mean	% Total	East	West	Mean	% Total	Mean	% Total
Common carp	3	3	3.0	9.1	1	1	1.0	4.2	0	2	1.0	2.3	1	1	1.0	2.9	6	3	4.5	5.5	2.1	4.8
Fallfish	0	2	1.0	3.0	1	0	0.5	2.1	0	0	0.0	0.0	1	0	0.5	1.5	4	3	3.5	4.2	1.1	2.5
Quillback	2	1	1.5	4.5	1	5	3.0	12.5	0	1	0.5	1.1	0	1	0.5	1.5	3	1	2.0	2.4	1.5	3.4
White sucker	0	0	0.0	0.0	0	0	0.0	0.0	1	0	0.5	1.1	1	0	0.5	1.5	1	0	0.5	0.6	0.3	0.7
Northern hog sucker	0	0	0.0	0.0	0	0	0.0	0.0	2	0	1.0	2.3	1	1	1.0	2.9	1	9	5.0	6.1	1.4	3.2
Shorthead redhorse	0	0	0.0	0.0	0	0	0.0	0.0	1	2	1.5	3.4	0	0	0.0	0.0	0	2	1.0	1.2	0.5	1.1
Sucker spp.	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.5	1.5	0	1	0.5	0.6	0.2	0.5
Channel catfish	4	1	2.5	7.6	1	0	0.5	2.1	0	2	1.0	2.3	0	0	0.0	0.0	7	0	3.5	4.2	1.5	3.4
Northern pike	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	1	0	0.5	1.5	0	0	0.0	0.0	0.1	0.2
Muskellunge	0	1	0.5	1.5	0	0	0.0	0.0	0	0	0.0	0.0	0	2	1.0	2.9	0	0	0.0	0.0	0.3	0.7
Chain pickerel	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.5	1.5	0	0	0.0	0.0	0.1	0.2
Pike spp.	0	1	0.5	1.5	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	1	2	1.5	1.8	0.4	0.9
Rock bass	5	0	2.5	7.6	0	1	0.5	2.1	8	6	7.0	15.9	3	0	1.5	4.4	9	14	11.5	13.9	4.6	10.6
Redbreast sunfish	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.5	1.1	0	0	0.0	0.0	0	0	0.0	0.0	0.1	0.2
Green sunfish	0	1	0.5	1.5	0	0	0.0	0.0	1	3	2.0	4.5	0	1	0.5	1.5	0	0	0.0	0.0	0.6	1.4
Pumpkinseed	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	1	0	0.5	1.5	1	0	0.5	0.6	0.2	0.5
Bluegill	0	1	0.5	1.5	0	0	0.0	0.0	1	0	0.5	1.1	1	0	0.5	1.5	0	0	0.0	0.0	0.3	0.7
Smallmouth bass	10	5	7.5	22.7	8	8	8.0	33.3	14	14	14.0	31.8	20	8	14.0	41.2	11	41	26.0	31.5	13.9	32.0
Sunfish spp.	0	1	0.5	1.5	0	0	0.0	0.0	3	3	3.0	6.8	1	3	2.0	5.9	2	1	1.5	1.8	1.4	3.2
Yellow perch	0	0	0.0	0.0	1	0	0.5	2.1	2	0	1.0	2.3	1	0	0.5	1.5	4	0	2.0	2.4	0.8	1.8
Walleye	4	11	7.5	22.7	3	4	3.5	14.6	4	6	5.0	11.4	5	0	2.5	7.4	19	7	13.0	15.8	6.3	14.5
Fish (unidentified)	6	4	5.0	15.2	6	7	6.5	27.1	7	4	5.5	12.5	6	6	6.0	17.6	4	8	6.0	7.3	5.8	13.3
TOTAL	34	32	33.0		22	26	24.0		44	44	44.0		43	25	34.0		73	92	82.5		43.5	

Table 14

Number, mean, and percent total of fish captured by seining at SSES and Bell Bend on the Susquehanna River, 2009.

SPECIES	24 Aug				14 Oct				OVERALL	
	East	West	Mean	% Total	East	West	Mean	% Total	Mean	% Total
SSES										
Spotfin shiner	60	7	33.5	60.9	28	5	16.5	38.8	25.0	51.3
Spottail shiner	6	11	8.5	15.5	4	1	2.5	5.9	5.5	11.3
Bluntnose minnow	1	8	4.5	8.2	13	1	7.0	16.5	5.8	11.8
Shorthead redhorse	1	0	0.5	0.9	0	0	0.0	0.0	0.3	0.5
Muskellunge	0	0	0.0	0.0	0	1	0.5	1.2	0.3	0.5
Rock bass	2	4	3.0	5.5	1	0	0.5	1.2	1.8	3.6
Bluegill	1	2	1.5	2.7	8	0	4.0	9.4	2.8	5.6
Tessellated darter	4	3	3.5	6.4	23	0	11.5	27.1	7.5	15.4
TOTAL	75	35	55.0		77	8	42.5		48.8	
BELL BEND										
Spotfin shiner	129	27	78.0	74.3	11	53	32.0	39.8	55.0	59.3
Spottail shiner	21	13	17.0	16.2	79	3	41.0	50.9	29.0	31.3
Rosyface shiner	0	0	0.0	0.0	0	1	0.5	0.6	0.3	0.3
Bluntnose minnow	3	3	3.0	2.9	1	8	4.5	5.6	3.8	4.0
Fallfish	0	1	0.5	0.5	0	2	1.0	1.2	0.8	0.8
Rock bass	0	3	1.5	1.4	1	0	0.5	0.6	1.0	1.1
Smallmouth bass	0	1	0.5	0.5	0	1	0.5	0.6	0.5	0.5
Tessellated darter	4	3	3.5	3.3	1	0	0.5	0.6	2.0	2.2
Walleye	1	1	1.0	1.0	0	0	0.0	0.0	0.5	0.5
TOTAL	158	52	105.0		93	68	80.5		92.8	

Table 15

P-values for fish species deemed significant by the BACI analysis, 1976-2009 ($\alpha = 0.05$). Species listed decreased in number at the downriver locations, except for brown bullheads which increased at the downriver sites. Columns depict the p-values associated with the two temporal categories of data analyzed; All Data represents all months sampled, Summer Data denotes samples collected from June through October, *ns* indicates that a species was not significant in that data set.

SPECIES	ALL DATA	SUMMER DATA
Quillback	0.009	0.002
White sucker	0.042	*Ns*
Northern hog sucker	0.001	0.013
Shorthead redhorse	<0.001	<0.001
Brown bullhead	0.005	0.047
Muskellunge	<0.001	0.003
Rock bass	0.001	0.006
Smallmouth bass	0.041	0.002
Unidentified fish	0.017	<0.001

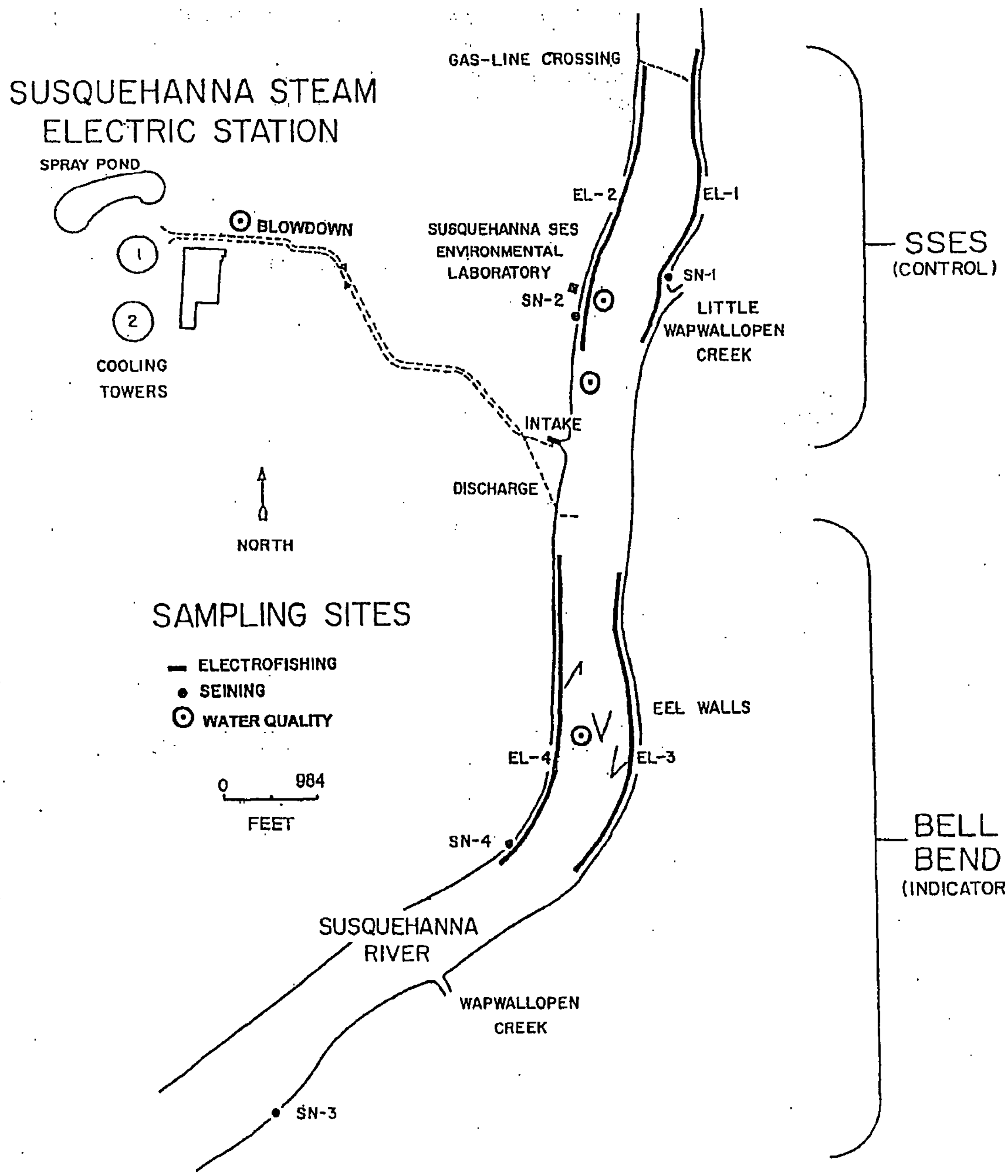

Fig. 1

Sampling sites for water quality, electrofishing (EL), and seining (SN) at SSES and Bell Bend on the Susquehanna River, 2009.

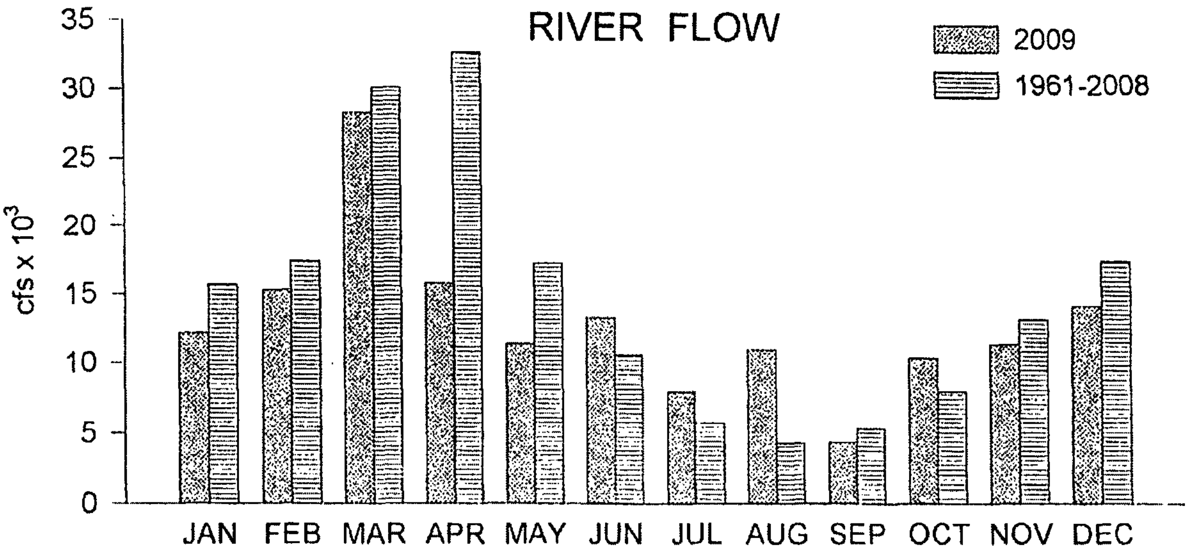

Fig. 2

The 2009 monthly mean flow of the Susquehanna River at the Susquehanna SES Environmental Laboratory compared to the 48-year (1961-2008) mean. The means were calculated from U.S. Geological Survey and Environmental Laboratory data.

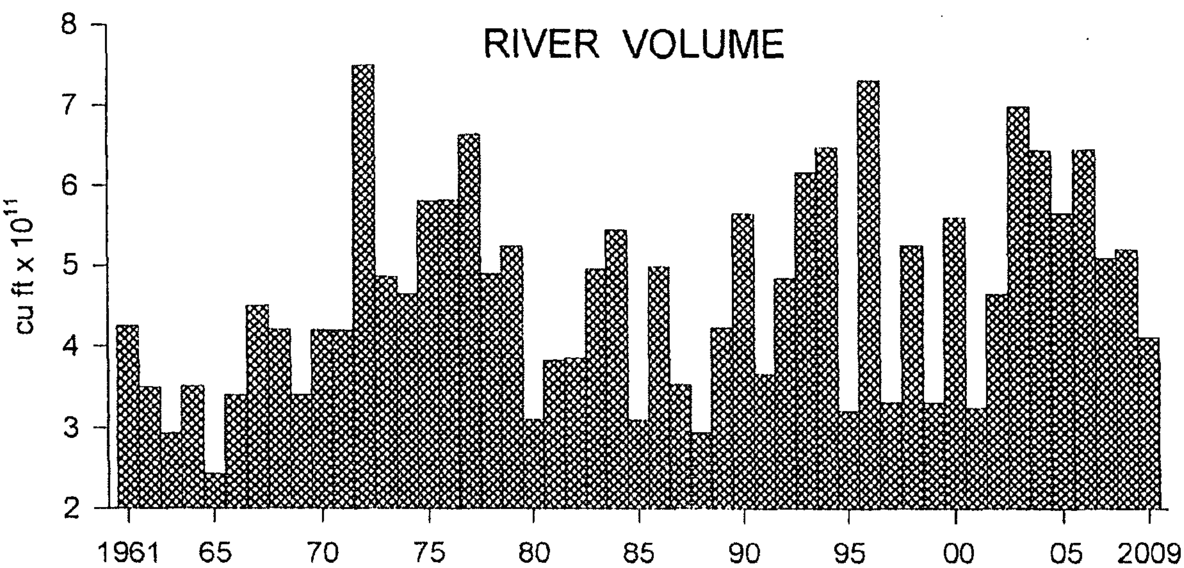

Fig. 3

Volume of Susquehanna River flow at the Susquehanna SES Environmental Laboratory, 1961-2009. The volumes were calculated from U.S. Geological Survey and Environmental Laboratory data.

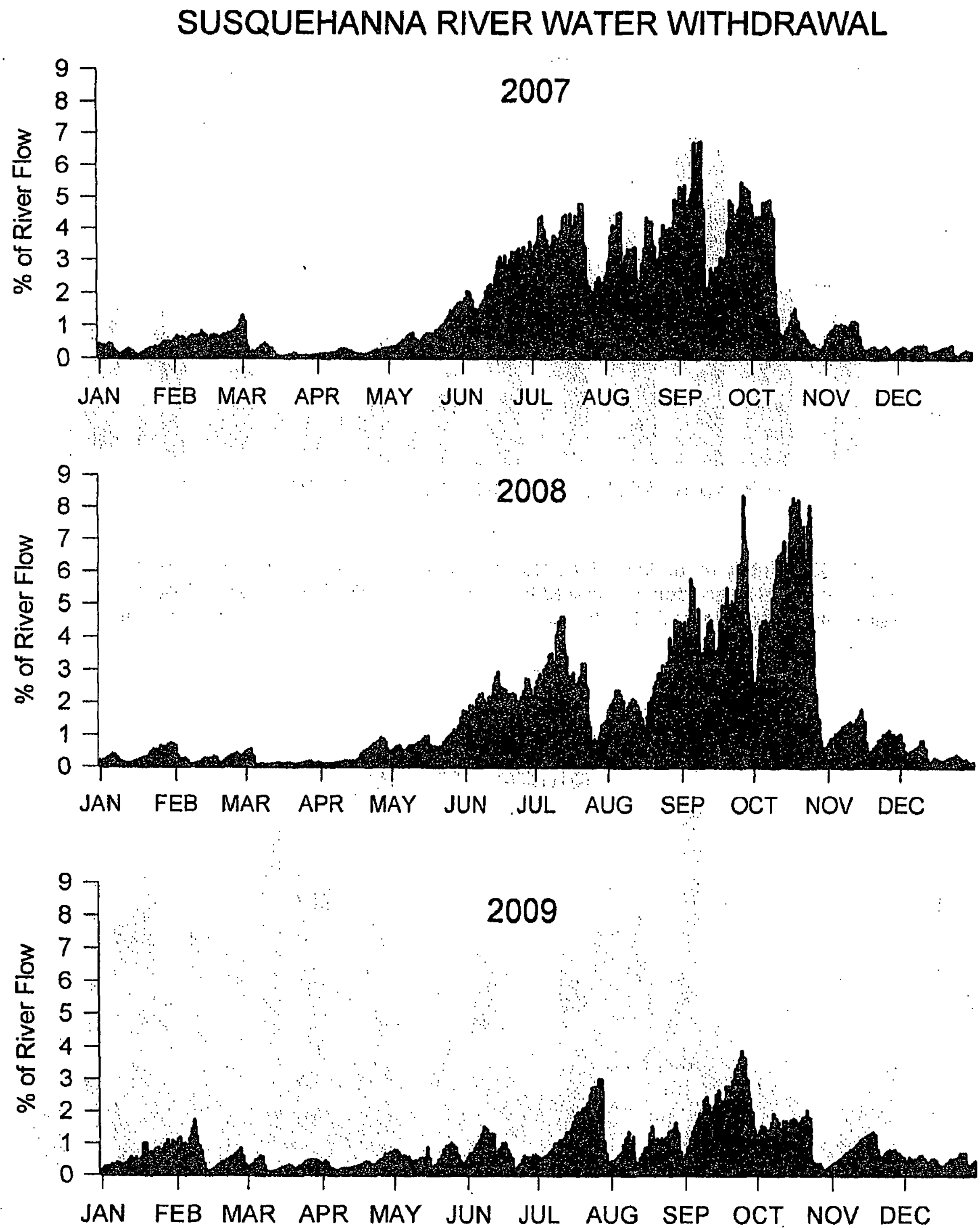

Fig. 4

Daily Susquehanna River water withdrawal by Susquehanna SES, 2007-2009.

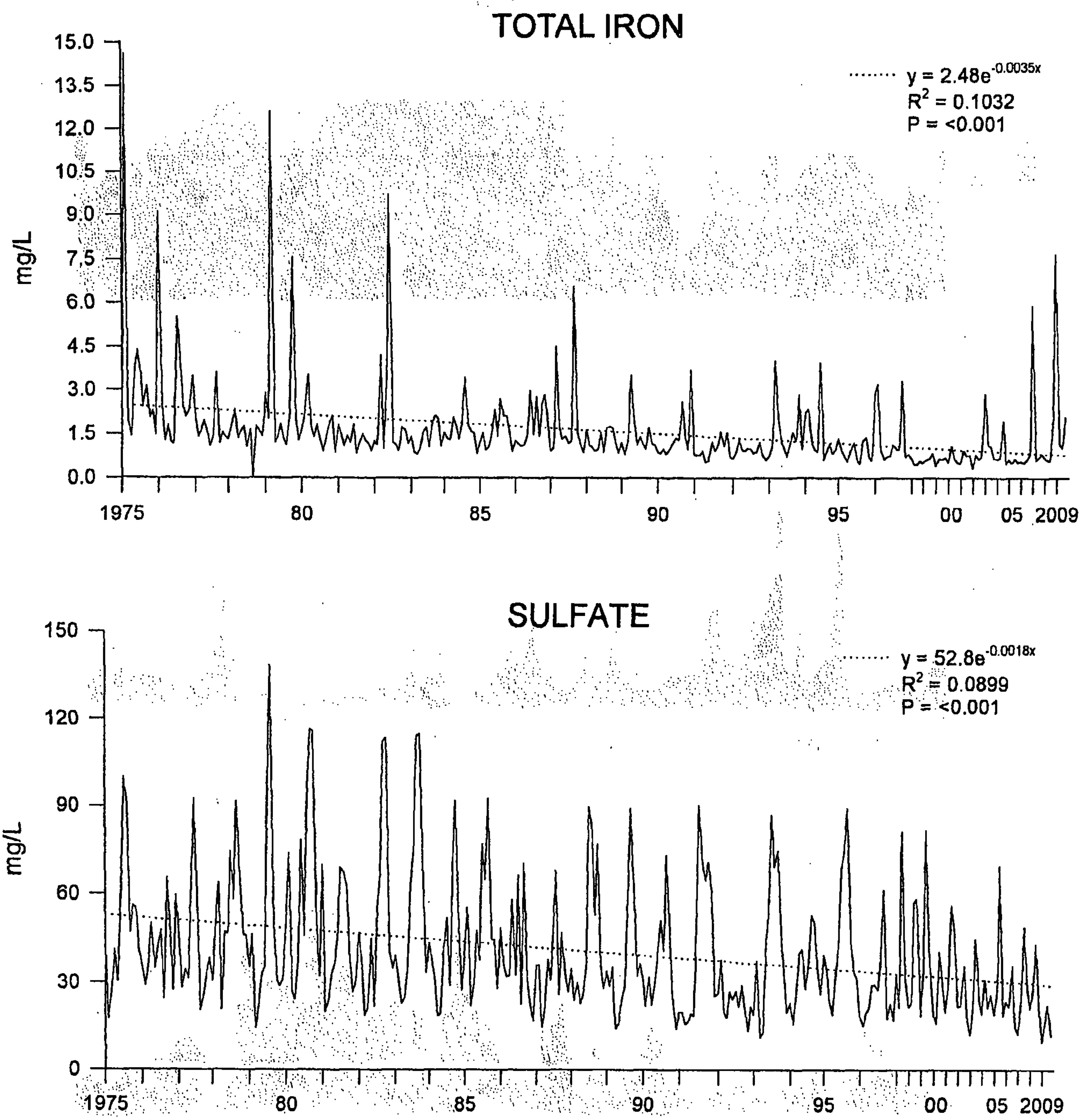

Fig. 5

Total iron and sulfate of the Susquehanna River at the SSES sampling site, 1975-2008. Samples were collected monthly 1975-1996 and quarterly 1997-2009. Analyses were performed by the PPL Chemical Laboratory, Hazleton, PA.

2009

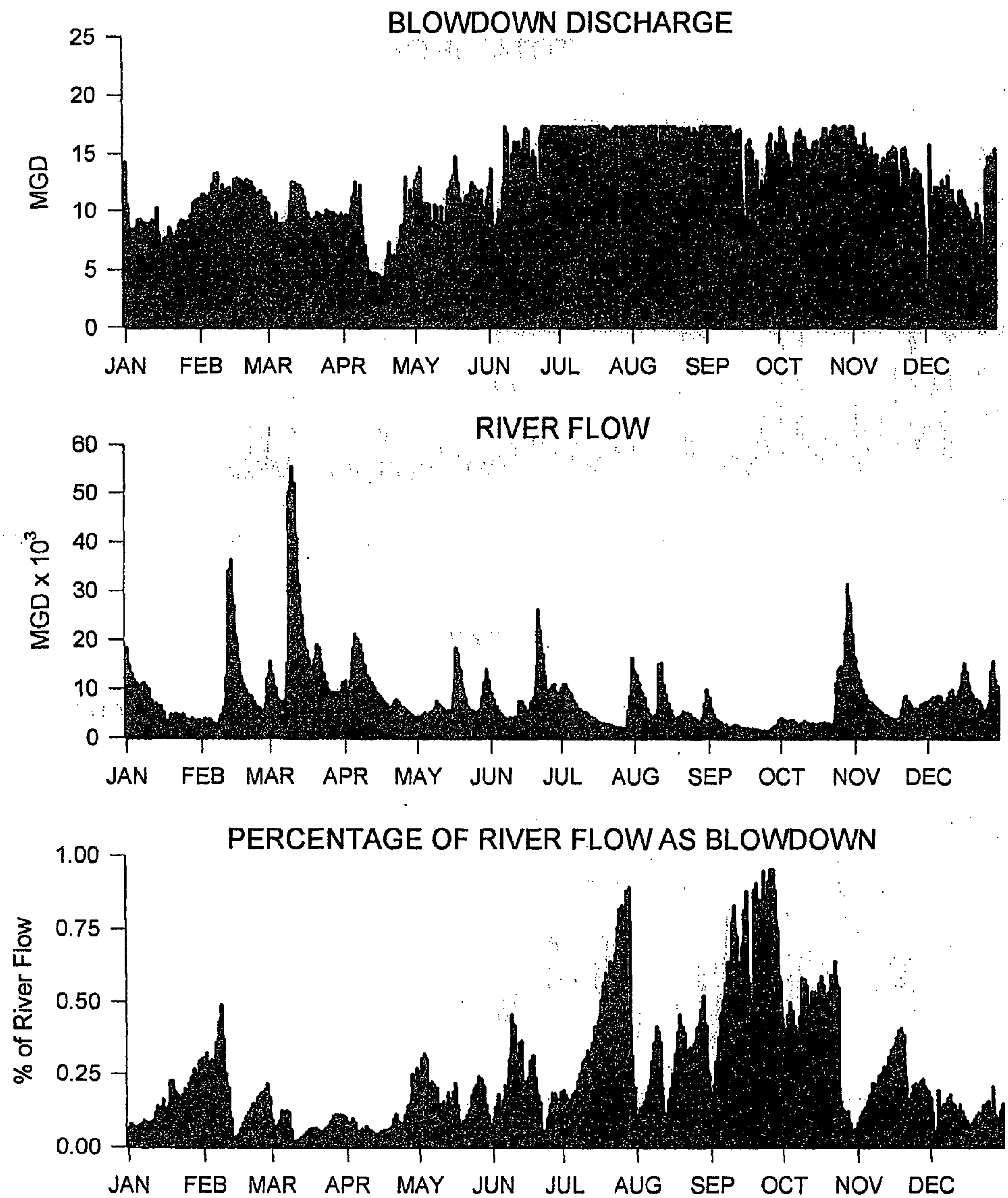

Fig. 6

Daily Susquehanna SES blowdown discharge, Susquehanna River flow and percentage of Susquehanna River flow as Susquehanna SES blowdown, 2009.