METHODS

Data collection

From September 16 through October 21, 2008, SRBC staff collected macroinvertebrate samples using D-frame nets on the mainstem Susquehanna River from Great Bend to Marietta, Pa., and at the mouths of the Juniata and West Branch Susquehanna Rivers. Field chemistry measurements were taken at each site, and chemical water quality samples also were collected for laboratory analysis. Macroinvertebrate samples were labeled with the site number, the date, and the number of bottles used.

Chemical water quality

Water samples were collected at each sampling site, with a depth integrated sampler, to measure nutrient and metal concentrations in the river. Field water quality measurements included water temperature, dissolved oxygen, conductivity, and pH. Temperature was measured with a field thermometer in degrees Celsius. Dissolved oxygen was measured with a YSI 55 meter that was calibrated at the beginning of every day when samples were collected. Conductivity was measured with a Cole-Parmer Model 1481 meter. A Cole-Parmer Model 5996 meter that was calibrated at the beginning of each sampling day and randomly checked throughout the day was used to measure pH.

A list of laboratory parameters is located in Table 2. Laboratory samples consisted of one 500-ml bottle of raw water, one 250-ml bottle preserved with nitric acid for metal analyses, and one 250-ml bottle was preserved with H_2SO_4 for nutrient analyses. Samples were iced and shipped to the Pennsylvania Department of Environmental Protection, Bureau of Laboratories, Harrisburg, Pa., for analysis.

Macroinvertebrates

Benthic macroinvertebrates (organisms that live on the stream bottom, including aquatic insects, crayfish, clams, snails, and worms) were collected for analysis during this survey. Staff collected benthic macroinvertebrate samples using a D-frame kick net with 500 µm mesh.

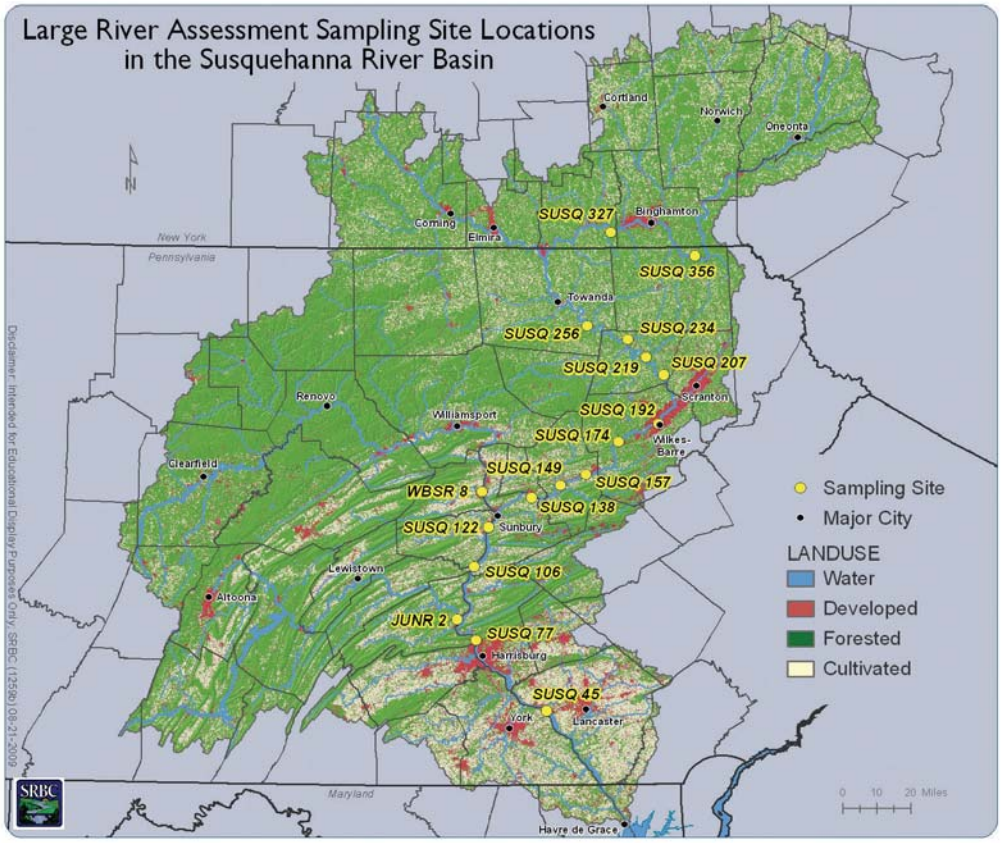

Figure 1. *Large River Assessment Sampling Site Locations*

Station Number	County/State	USGS Quad	Latitude	Longitude	Site Description
SUSQ 356	Susquehanna/Pa.	Great Bend, Pa.	41.9612	-75.6620	Susquehanna River near Oakland, Pa.
SUSQ 327	Tioga/N.Y.	Apalachin, N.Y.	42.0653	-76.1426	Susquehanna River near Apalachin, N.Y.
SUSQ 256	Bradford/Pa.	Wyalusing, Pa.	41.6705	-76.2786	Susquehanna River near Wyalusing, Pa.
SUSQ 234	Wyoming/Pa.	Meshoppen, Pa.	41.6099	-76.0509	Susquehanna River near Meshoppen, Pa.
SUSQ 219	Wyoming/Pa.	Tunkhannock, Pa.	41.5351	-75.9502	Susquehanna River near Tunkhannock, Pa.
SUSQ 207	Wyoming/Pa.	Ransom, Pa.	41.4594	-75.8524	Susquehanna River near West Falls, Pa.
SUSQ 192	Luzerne/Pa.	Kingston, Pa.	41.2500	-75.8845	Susquehanna River near Wilkes-Barre, Pa.
SUSQ 174	Luzerne/Pa.	Nanticoke, Pa.	41.1774	-76.1085	Susquehanna River near Shickshinny, Pa.
SUSQ 157	Columbia/Pa.	Mifflinville, Pa.	41.0405	-76.2945	Susquehanna River near Berwick, Pa.
SUSQ 149	Columbia/Pa.	Catawissa, Pa.	40.9935	-76.4369	Susquehanna River near Bloomsburg, Pa.
SUSQ 138	Northumberland/ Pa.	Danville, Pa.	40.9422	-76.6011	Susquehanna River near Danville, Pa.
SUSQ 122	Snyder/Pa.	Sunbury, Pa.	40.8182	-76.8420	Susquehanna River at Hummels Wharf, Pa.
SUSQ 106	Snyder/Pa.	Dalmatia, Pa.	40.6517	-76.9226	Susquehanna River at McKees Half Falls, Pa.
SUSQ 77	Dauphin/Pa.	Harrisburg West, Pa.	40.3358	-76.9125	Susquehanna River at Fort Hunter, Pa.
SUSQ 45	Lancaster/Pa.	Columbia West, Pa.	40.0365	-76.5239	Susquehanna River at Marietta, Pa.
JUNR 2	Perry/Pa.	Duncannon, Pa.	40.4258	-77.0159	Juniata River at Amity Hall, Pa.
WBSR 8	Northumberland/ Pa.	Lewisburg, Pa.	40.9679	-76.8797	West Branch Susquehanna River at Lewisburg, Pa.

Table 1. *Susquehanna River Station Locations*

SRBC staff collected various aquatic species for analysis, including clams and crayfish.

A three-kick composite sample, collected from representative habitat locations, was collected at each of ten equidistant transects along a one-kilometer sampling reach.

Alternating banks were utilized for transect sampling. For example, transects two, four, six, eight, and ten were sampled on the right bank, while transects one, three, five, seven, and nine were sampled on the left bank. Multiple habitats, including bottom substrate, woody debris, undercut banks, and macrophytes, were included in sample collection. Sampling was conducted in a 10 meter area surrounding each transect, to a depth of 0.5 meters.

Each sample was preserved in the field in 95 percent denatured ethyl alcohol. After sampling was completed at a given site, all equipment that came in contact with the sample was rinsed thoroughly, sprayed with 10 percent bleach solution, examined carefully, and picked free of algae or debris before sampling at the next site. Additional organisms that were found on examination were placed into the sample containers.

Subsampling and sorting procedures were based on the 1999 RBP document (Barbour and others, 1999). In the laboratory, composite samples were sorted into 300-organism subsamples, when possible, using a gridded pan and a random numbers table. The organisms contained in the subsamples were identified to genus (except Chironomidae and Oligochaeta), when possible, and enumerated.

Data Analysis

Chemical water quality

Chemical water quality was assessed by examining field and laboratory parameters. Limit values were obtained for each parameter based on current state and federal regulations or references for aquatic life tolerances (Table 3, Buda, 2008).

Macroinvertebrate analysis

A series of macroinvertebrate metrics was calculated for each sample, and assessments of the sites were performed. Benthic macroinvertebrate samples were assessed using procedures described by Barbour and others (1999), Klemm and others (1990), and Plafkin and others (1989). Using these methods, staff calculated a series of biological indexes at each station. The metrics used in this survey are summarized in Table 4. Metric 2 (Shannon-Wiener Diversity Index) followed the methods described in Klemm and others (1990), and all other metrics were derived from Barbour and others (1999).

A reference condition approach was used to determine impairment levels for each sample. This protocol entails determining the best score for each metric. The 300-organism sub-sample data were used to generate scores for each of the seven metrics. Scores for metrics 1-4 were converted to a biological condition score, based on the percent similarity of the metric score, relative to the best possible metric score. Scores for metrics 5-7 were based on set scoring criteria developed for the percentages (Plafkin and others, 1989; Ohio Environmental Protection Agency, 1987). The sum of the biological condition scores constituted the total biological score for the sample, and total biological scores were used to assign each sample to a biological condition category (Table 5).

RESULTS

Water Quality

In late summer and early fall 2008, water quality at most of the sampling sites met water quality standards. Only 6.9 percent (28 of 408) of water quality values exceeded their respective limits. The majority of these exceedances were for total sodium, total phosphorus,

Table 2. *Parameters for Laboratory Analysis*

Parameter	
Alkalinity, mg/l[a]	Total Suspended Solids, mg/l
Total Nitrogen, mg/l	Total Sodium, mg/l
Total Nitrite, mg/l	Total Chloride, mg/l
Total Nitrate, mg/l	Total Sulfate, mg/l
Total Phosphorus, mg/l	Total Iron, µg/l[b]
Total Orthophosphate, mg/l	Total Manganese, µg/l
Total Organic Carbon, mg/l	Total Aluminum, µg/l
Total Hardness, mg/l	Turbidity, NTU[c]
Total Magnesium, mg/l	Total Calcium, mg/l

[a] mg/l = milligrams per liter
[b] µg/l = micrograms per liter
[c] nephelometric turbidity units

Table 3. *Water Quality Limits and References*

Parameter	Limit	Reference Code
Temperature	> 25 °C	a,f
Dissolved oxygen	< 4 mg/l	a,g,i
Conductivity	>800 µmhos/cm	d
pH	<6.0	i
Alkalinity	< 20 mg/l	a,g
Nitrogen*	>1.0 mg/l	j
Nitrite	> 0.06 mg/l	f,i
Nitrate	> 1.0 mg/l	e,j
Phosphorus	> 0.1 mg/l	e,k
Orthophosphate	> 0.05 mg/l	l,f,j,k
TOC	> 10 mg/l	b
Hardness	> 300 mg/l	e
Magnesium	> 35 mg/l	i,l
Calcium	> 100 mg/l	m
TSS	> 25 mg/l	h
Sodium	> 20 mg/l	i
Chloride	> 250 mg/l	a,i
Sulfate	> 250 mg/l	a,i
Iron	>1,500 µg/l	a
Manganese	>1,000 µg/l	a
Aluminum	> 750 µg/l	n
Turbidity	> 150 NTU	h

Reference Codes and References

a: http://www.pacode.com/secure/data/025/chapter93/s93.7.html
b: Hem (1970) - http://water.usgs.gov/pubs/wsp/wsp2254/
c: Gagen and Sharpe (1987) and Baker and Schofield (1982)
d: http://www.uky.edu/WaterResources/Watershed/KRB_AR/wq_standards.htm
e: http://www.uky.edu/WaterResources/Watershed/KRB_AR/krww_parameters.htm
f: http://www.hach.com/h2ou/h2wtrqual.htm
g: http://sites.state.pa.us/PA_Exec/Fish_Boat/education/catalog/pondstream.pdf
h: http://www.epa.gov/waterscience/criteria/sediment/appendix3.pdf
i: http://www.dec.ny.gov/regs/4590.html
j:* http://water.usgs.gov/pubs/circ/circ1225/images/table.html
k: http://water.usgs.gov/nawqa/circ-1136/h6.html#NIT
l: http://www.epa.gov/waterscience/criteria/goldbook.pdf
m: based on archived data at SRBC
n: http://www.epa.gov/waterscience/criteria/wqctable

* *Background levels for natural streams*

total orthophosphate, and total nitrogen. Exceedances are summarized in Table 6 and Figure 2.

Biological Communities

Biological conditions are summarized in Figure 3. Nonimpaired biological communities were found at two of the 17 stations (12 percent), slightly impaired conditions were found at 10 sites (59 percent), and moderately impaired conditions were found at five sites (29 percent). No sites were rated as severely impaired.

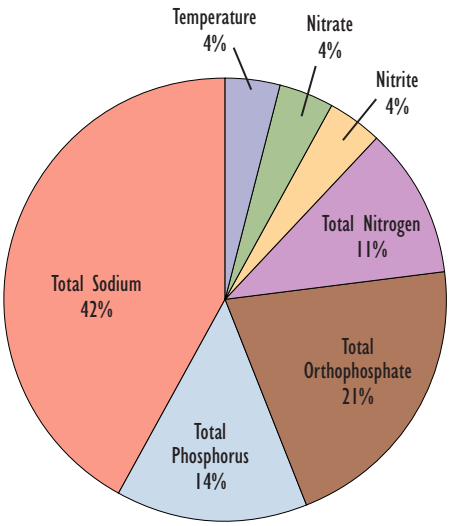

Figure 2. *Parameters Exceeding Water Quality Standards*

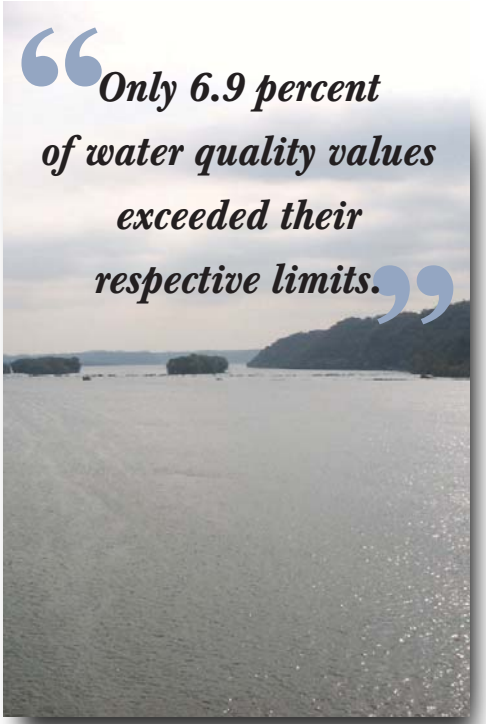

Table 4. *Summary of Metrics Used to Evaluate the Overall Biological Integrity of River Benthic Macroinvertebrate Communities*

Metric	Description
1. Taxonomic Richness (a)	The total number of taxa present in the 300-organism subsample. Number decreases with increasing disturbance or stress.
2. Shannon-Wiener Diversity Index (b)	A measure of biological community complexity based on number of equally or nearly equally abundant taxa in the community. Index value decreases with increasing stress.
3. Hilsenhoff Biotic Index (a)	A measure of the organic pollution tolerance of a benthic macro-invertebrate community. Index value increases with increasing stress.
4. EPT Index (a)	The total number of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) taxa present in the 300-organism subsample. The index decreases with increasing stress.
5. Percent Ephemeroptera (a)	The percentage of Ephemeroptera in a 300-organism subsample. Percentage decreases with increasing stress.
6. Percent Dominant Taxa (a)	A measure of community balance at the lowest positive taxonomic level. Percentage increases with increasing stress.
7. Percent Chironomidae (a)	The percentage of Chironomidae in a 300-organism subsample. Percentage increases with increasing stress.

Sources: (a) Barbour and others, 1999 (b) Klemm and others, 1990

Table 5. *Summary of Criteria Used to Classify the Biological Conditions of Sample Sites*

SAMPLING AND ANALYSIS

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TOTAL BIOLOGICAL SCORE DETERMINATION

	Biological Condition Scoring Criteria			
Metric	**6**	**4**	**2**	**0**
1. Taxonomic Richness (a)	> 80%	79-60%	59-40%	<40%
2. Shannon-Wiener Diversity Index (a)	> 75%	74-50%	49-25%	<25%
3. Hilsenhoff Biotic Index (b)	> 85%	84-70%	69-50%	<50%
4. EPT Index (a)	> 90%	89-80%	79-70%	< 70%
5. Percent Ephemeroptera (c)	> 25%	10-25%	1-9%	< 1%
6. Percent Dominant Taxa (c)	< 20%	20-30%	31-40%	>40%
7. Percent Chironomidae (c)	< 5%	5-20%	21-35%	>35%
Total Biological Score (d)				

↓

BIOASSESSMENT

Percent Comparability of Study and Reference Condition Total Biological Scores (e)	Biological Condition Category
>83%	Nonimpaired
79-54	Slightly Impaired
50-21	Moderately Impaired
<17%	Severely Impaired

(a) Score is study site value/reference condition value X 100
(b) Score is reference condition value/study site value X 100
(c) Scoring Criteria evaluate actual percentage contribution, not percent comparability to the reference station
(d) Total Biological Score = the sum of Biological Condition Scores assigned to each metric
(e) Values obtained that are intermediate to the indicated ranges will require subjective judgment as to the correct placement into a biological condition category

Table 6. *Number of Exceeds per Parameter*

Parameter	Limit Concentration	# of Exceedances
Total Sodium	>20 mg/l	12
Total Orthophosphate	>0.05 mg/l	6
Total Phosphorus	>0.1 mg/l	4
Total Nitrogen	>1.0 mg/l	3
Total Nitrate	>1.0 mg/l	1
Total Nitrite	>0.06 mg/l	1
Water Temperature	>25 °C	1

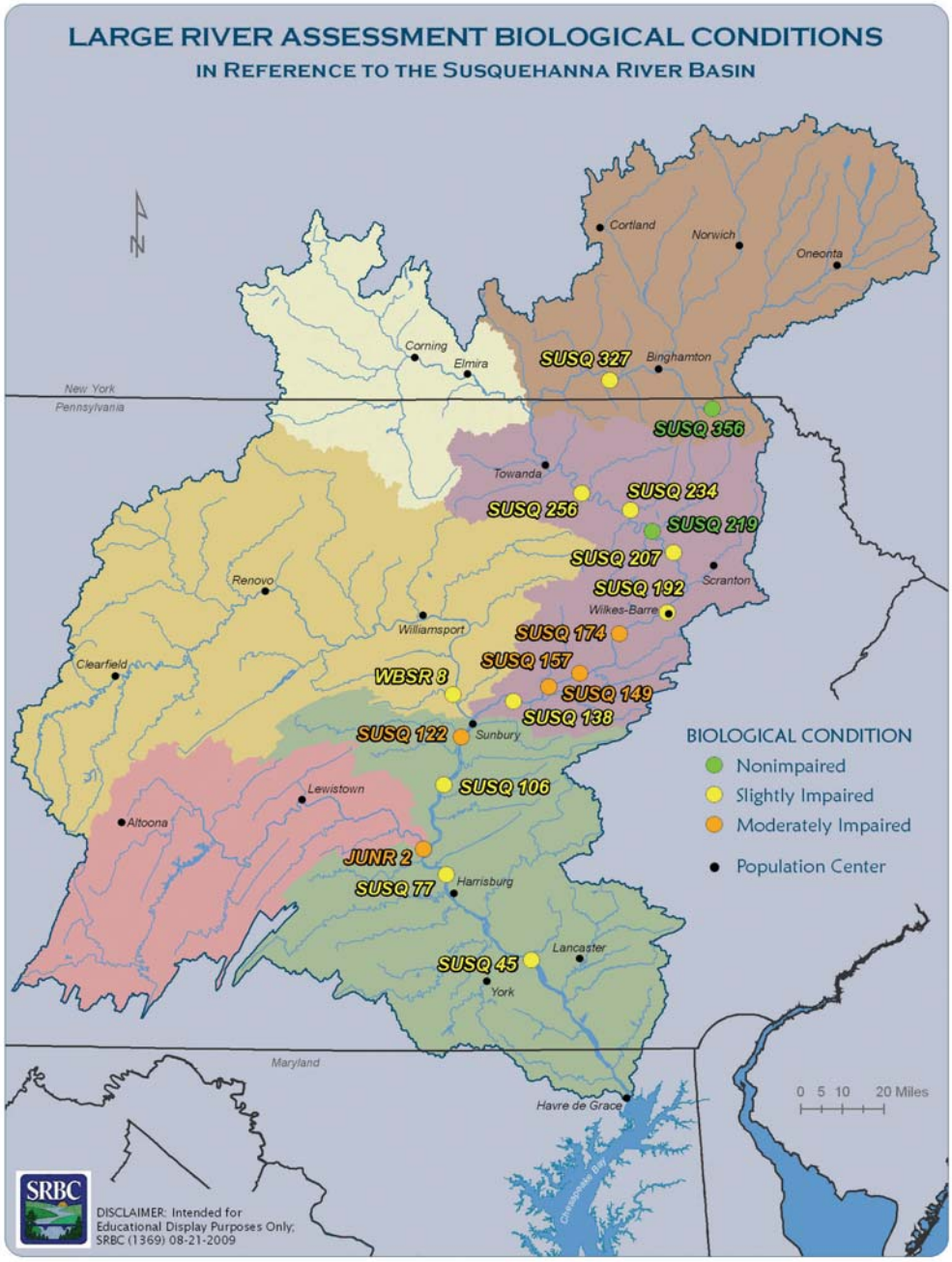

Figure 3. *Biological Conditions in 2008*

DISCUSSION

Water Quality

A comparison of water quality samples from the present large river assessment project (August-September 2007) to water quality samples collected for the most recent interstate streams survey (Steffy, 2007), Upper Susquehanna Subbasin Survey (Buda, 2008), Chemung Subbasin Survey (Buda, 2007), Middle Susquehanna Subbasin Survey (LeFevre, 2002), West Branch Subbasin Survey (LeFevre, 2003), Juniata River Subbasin Survey (LeFevre, 2005), and Lower Susquehanna Subbasin Survey (LeFevre, 2006) indicates that water quality conditions on the Susquehanna River between Sidney, N.Y., and Marietta, Pa., and at the mouths of its major tributaries, are stable and generally below limits, although temperatures were greater than 25 degrees Celsius at several stations and total sodium exceeded the level of concern in many samples. From the data analysis, it appears that the Susquehanna River, in the stretch encompassed by this study, contains fairly good water quality, with some slightly elevated parameters.

Macroinvertebrate Communities

Upper Susquehanna River

The upper Susquehanna River starts at Otsego Lake in Cooperstown, N.Y., and continues to the confluence with the Chemung River in Sayre, Pa. This is a fairly rural area that mostly consists of forest and agricultural land, with the exception of one large population center, Binghamton, N.Y. Only two sites were sampled this year in the upper Susquehanna due to weather and high flows. The most upstream site in the survey was at Great Bend, Pa. (SUSQ356), where the river flows south into Pennsylvania before turning north and back into New York. Great Bend was rated as nonimpaired, with the highest number of EPT taxa (16) and diversity of taxa (31) in the entire river; a condition that continued from the studies of 2005 and 2007. The site at Apalachin, N.Y. (SUSQ327), is located downstream of Binghamton, N.Y., and may show the effects of the population center. The site received a slightly impaired rating; due to a significant reduction in EPT taxa (9) and lower ratings for percent dominant taxa and taxonomic richness.

> ***"Great Bend was rated as nonimpaired, with the highest number of EPT taxa (16) and diversity of taxa (31) in the entire river; a condition that continued from the studies of 2005 and 2007."***

Middle Susquehanna River and the West Branch Susquehanna River

The middle Susquehanna River stretches from Sayre, Pa., to the confluence with the West Branch Susquehanna River at Sunbury, Pa. The northern part of the middle Susquehanna River is heavily forested with plots of agricultural land, which continues to the largely urbanized Scranton/Wilkes-Barre, Pa. This area was heavily mined in the past and