Susquehanna River Basin Commission

Susquehanna Large River Assessment Project

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Abstract

In 2002, the Susquehanna River Basin Commission (SRBC) conducted a pilot study to determine appropriate methods for biologically assessing the large rivers of the Susquehanna River Basin (basin). Based on the results of that survey, SRBC determined that a combination of rock basket samplers and traditional Rapid Bioassessment Protocol (RBP) methods was the most efficient and consistent collection method to sample the Susquehanna River. These methods were implemented in the 2005 Susquehanna Large River Assessment Project (Hoffman, 2006) at 25 stations on the mainstem Susquehanna River and at the mouths of its major tributaries: the West Branch Susquehanna River, the Juniata River, and the Chemung River.

The U.S. Environmental Protection Agency (USEPA) has developed a field operations manual for the National Rivers and Streams Assessment (NRSA), detailing data collection methods for both wadeable and nonwadeable streams (USEPA, 2008). In 2007, SRBC adapted this protocol for the 25 stations previously sampled (Hoffman, 2008). In late summer 2008, SRBC staff collected data at 17 of the same 25 original stations following the NRSA protocols. In 2009, high flows greatly limited SRBC's sampling opportunities. Given the high-flow restrictions, SRBC staff chose to collect data only at the eight stations that were not sampled in 2008, ensuring that all 25 original stations would be covered over the 2008 to 2009 period. The 2009 sampling at the eight stations took place in late summer.

Composite benthic macroinvertebrate samples were collected at each station from three D-frame net sweeps at each of ten transects. Field and laboratory water quality samples and overall observations of the site also were collected at each site.

Four of the sites were designated as nonimpaired, three sites were slightly impaired, and one site was moderately impaired. Only 4.5 percent (9 of 200) of the water quality values exceeded their respective limits, indicating fairly good water quality in the Susquehanna River.

SRBC plans to continue to use the adapted NRSA nonwadeable river protocols in future assessments. Fish collection may be added to the protocol in subsequent years, and SRBC plans to develop protocols to properly assess the reservoirs near the mouth of the Susquehanna River.

Introduction

SRBC has been performing biological assessments throughout the basin since the late 1970s. When USEPA introduced the first version of the RBP manual (Plafkin and others, 1989), SRBC adopted those methods for use in its interstate stream monitoring program and its rotating subbasin surveys. However, neither the previous nor current RBP methods (Barbour and others, 1999) used by SRBC in the aforementioned surveys accurately depict the biological integrity of the basin's large rivers: the mainstem Susquehanna, Chemung, West Branch Susquehanna, and Juniata Rivers. Thus, in 2002, SRBC initiated a pilot project to determine proper methods of biologically assessing the large rivers in the basin. From this pilot project, staff determined that a combination of rock-filled basket samplers and traditional RBP methods was the most effective and consistent collection method for sampling the Susquehanna River (Hoffman, 2003).

In summer 2005, SRBC staff collected biological and water quality data at 25 stations on the mainstem Susquehanna River and at the mouth of its major tributaries using the methodology described above. In 2007, staff changed the methodology to mimic the methods drafted by USEPA for NRSA (USEPA, 2008). These methods have been used for the past three years.

Although the NRSA data collection includes fish, physical habitat, toxicology, and other parameters in addition to benthic macroinvertebrates, SRBC staff chose to focus efforts on benthic macroinvertebrate sampling. Benthic macroinvertebrates were used to assess biological conditions for several reasons. Benthic macroinvertebrates are sensitive to a wide range of stressors, have a wide range of documented pollution tolerances, and are found in a wide variety of habitats throughout lotic systems (Flotemersch and others, 2001a). Additionally, SRBC has background macroinvertebrate data from various sites on the large rivers of the basin from subbasin surveys and interstate streams monitoring, as well as the previous river assessment studies.

Geography

The Susquehanna River Basin is the largest river basin on the east coast of the United States, draining 27,510 square miles. The Susquehanna River originates at Otsego Lake, N.Y., and flows 444 miles through New York, Pennsylvania, and Maryland to the Chesapeake Bay at Havre de Grace, Md.

This year's Large River Assessment stretched from Sidney, N.Y., to Towanda, Pa., and encompassed a total of eight stations: six in the Upper Susquehanna Subbasin; one in the Middle Susquehanna Subbasin, and one on the Chemung River (Figure 1 and Table 1). Downstream of Marietta, Pa., the river flows through a series of dams and reservoirs, which this protocol is not designed to assess.

Methods

Data collection

From September 21 through September 23, 2009, SRBC staff collected macroinvertebrate samples using D-frame nets on the mainstem Susquehanna River from Sidney, N.Y., to Towanda, Pa., and at the mouth of the Chemung River. 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.

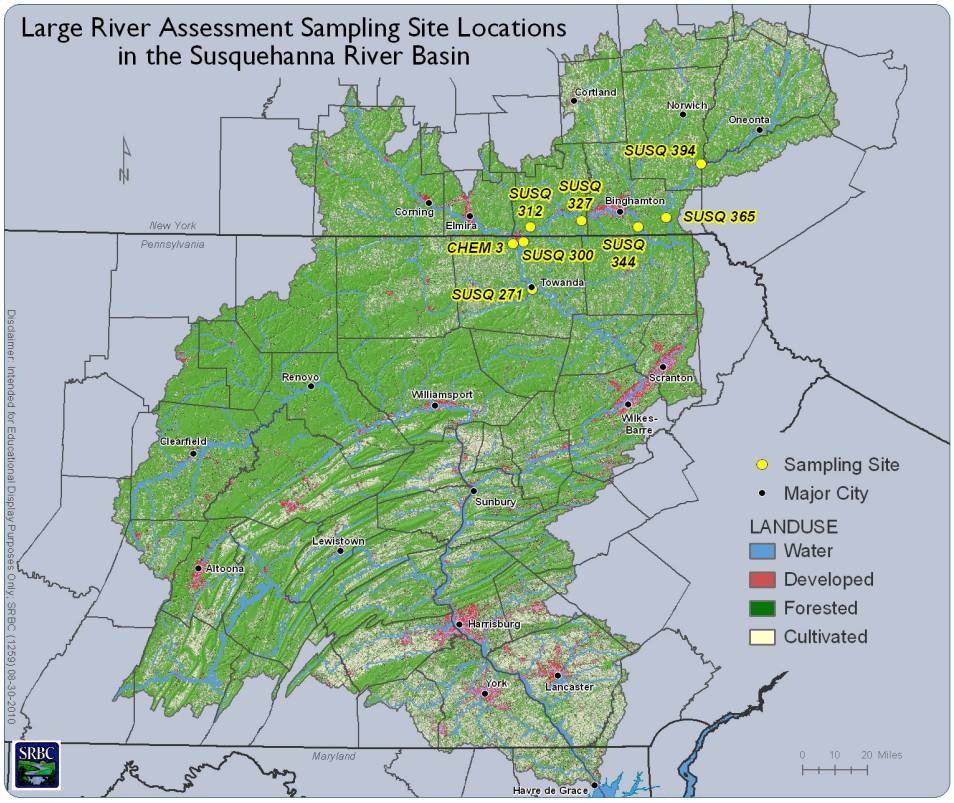

Figure 1. Susquehanna River Site Locations

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 analysis, and one 250-ml bottle preserved with H_2SO_4 for nutrient analysis. Samples were iced and shipped to the Pennsylvania Department of Environmental Protection, Bureau of Laboratories, Harrisburg, Pa., for analysis.

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 1. Susquehanna River Station Locations

Station Number	County/State	USGS Quad	Latitude	Longitude	Site Description
SUSQ 394	Chenango/N.Y.	Sidney, N.Y.	42.3113	-75.4199	Susquehanna River at Sidney, N.Y.
SUSQ 365	Broome/N.Y.	Windsor, Pa.	42.0747	-75.6351	Susquehanna River at Windsor, N.Y.
SUSQ 344	Broome/N.Y.	Binghamton East, N.Y.	42.0347	-75.8017	Susquehanna River at Kirkwood, N.Y.
SUSQ 327	Tioga/N.Y.	Apalachin, N.Y.	42.0653	-76.1426	Susquehanna River at Apalachin, N.Y.
SUSQ 312	Tioga/N.Y.	Barton, N.Y.	42.0400	-76.4464	Susquehanna River at Nichols, N.Y.
SUSQ 300	Bradford/Pa.	Sayre, Pa.	41.9819	-76.5065	Susquehanna River at Sayre, Pa.
SUSQ 271	Bradford/Pa.	Towanda, Pa.	41.7627	-76.4393	Susquehanna River at Towanda, Pa.
CHEM 3	Bradford/Pa.	Sayre, Pa.	41.9607	-76.5324	Chemung River at Athens, Pa.

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

SRBC staff member collects benthic macroinvertebrates at Great Bend, Pa.

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 examined carefully, picked free of algae or debris, rinsed thoroughly and sprayed with 10 percent bleach solution 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 for 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).

Table 3. Water Quality Limits and References

Parameter	Limit	Reference Code
Temperature	> 25 degrees	a,f
Dissolved Oxygen	< 4 mg/l	a,g
Conductivity	> 800 µmhos/cm	d
pH	< 5	c,f
Alkalinity	< 20 mg/l	a,g
Total Dissolved Solids		
Total Nitrogen	> 1.0 mg/l	j,k,l
Total Nitrite	> 1.0 mg/l	f
Total Nitrate	> 1.0 mg/l	e
Total Ammonia	based on pH & temperature	a
Total Phosphorus	> 0.1 mg/l	e
Total Organic Carbon	> 10 mg/l	b
Total Hardness	> 300 mg/l	e
Total Magnesium	> 35 mg/l	i
Total Sodium	> 20 mg/l	i
Total Chloride	> 150 mg/l	a
Total Sulfate	> 250 mg/l	a
Total Iron	> 1,500 g/l	a
Total Manganese	> 1,000 g/l	a
Total Aluminum	> 200 g/l	c
Total Orthophosphate	> 0.05 mg/l	l

Reference Code & References

a. http://www.pacode.com/secure/data/025/chapter93/s93.7.html
b. Hem (1970)
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.deq.virginia.gov/vpdes/pdf/vpdesregulationfeb02.pdf
i. http://www.dec.state.ny.us/web site/regs/part703.html
j. http://water.usgs.gov/pubs/circ/circ1225/images/table.html
k. http://www.crc.govt.nz/Land/pdf%20files sheet13.pdf
l. http://www.water.ncsu.edu/watersheds

Table 4. 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 macroinvertebrate 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

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 subsample 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).


Susquehanna at Sayre, Pa.

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

Sampling Analysis

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 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 site value X 100
(b) Score is reference site 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

RESULTS

Water Quality

In late September 2009, the water quality at most of the sampling sites met water quality standards. Only 4.5 percent (9 of 200) of water quality values exceeded their respective limits. The majority of the exceedances were for total orthophosphate and total sodium. Exceedances are summarized in Table 6 and Figure 2.

Table 6. Number of Exceeds per Parameter

Parameter	Limit	# of Exceedences
Total Orthophosphate	>0.05 mg/l	3
Total Sodium	>20mg/l	2
Total Organic Carbon	>10 mg/l	1
Total Phosphorus	>1.0 mg/l	1
Chloride	>250mg/l	1
Total Nitrite	>0.06 mg/l	1

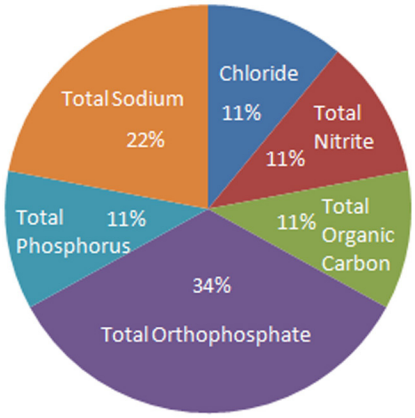

Figure 2. Parameters Exceeding Water Quality Standards

Biological Conditions

Biological conditions are summarized in Figure 3. Nonimpaired biological conditions were found at four of the eight sites (50 percent), slightly impaired conditions were found at three sites (37.5 percent), and moderately impaired conditions were found at one site (12.5 percent). No sites were rated as severely impaired.

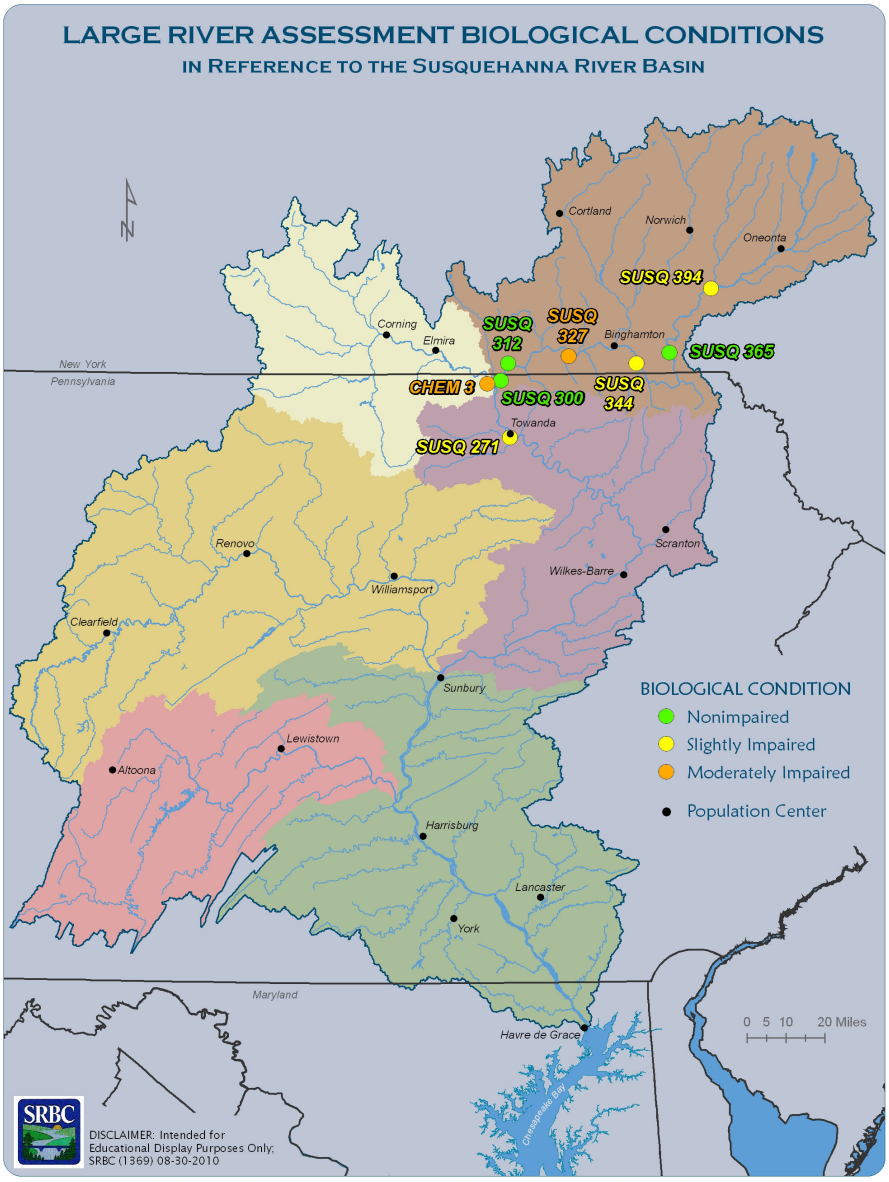

Figure 3. Biological Conditions in 2009

Windsor, N.Y.

Discussion

Water Quality

The assessments conducted during the 2009 Large River Project, when compared to the results of the 2008 Large River Assessment Project (Shenk, 2009), 2007 Large River Assessment Project (Hoffman, 2008), Upper Susquehanna Subbasin Survey (Buda, 2008), and Middle Susquehanna Subbasin Survey (Buda, 2009), show that most of the water quality parameters in the mainstem of the Susquehanna River and the mouths of most of its larger tributaries are below water quality limits. Total orthophosphate is the parameter that exceeded its limit most often. Total sodium, total phosphorus, chloride, nitrite, and total organic carbon each exceeded their respective limits at least at one site. Even with these exceedances, the data analysis shows that the river from Sidney, N.Y., to Towanda, Pa., has fairly good water quality.

Macroinvertebrate Communities

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. Six of the eight sites that were sampled in 2009 were in the Upper Susquehanna River area. Due to higher seasonal flows during the sampling time frame, staff focused on these sites because they were not sampled during 2008. Also, the river system is smaller in this area and thus easier to effectively sample during higher flow conditions.

The most upstream site sampled was at Sidney, N.Y. (SUSQ 394), approximately 50 miles downstream of Otsego Lake. This site was rated slightly impaired with one of the highest diversity of taxa and high number of EPT taxa when compared to all the sites sampled in 2009. The site at Windsor, N.Y. (SUSQ 365), was rated nonimpaired due to its highest rating in both percent of dominant taxa and Shannon-Wiener Diversity index. After the river flows briefly into Pennsylvania, it turns north and flows back into New York upstream of the site in Kirkwood, N.Y. (SUSQ344). As found in the 2007 survey, this site is slightly impaired with highest ratings for Hilsenhoff Biotic Index, percent Ephemeroptera, and percent Chironomidae, but a very low rating for diversity of taxa.

The first site after the river flows through Binghamton, N.Y., is the station in Apalachin, N.Y. (SUSQ327). In the 2007 and 2008 surveys, this site was moderately impaired; however, in the 2009 survey, it was nonimpaired. This could be attributed to the smaller number of sites for comparison in 2009 but the nonimpaired rating held even when compared to all site data for the past three years. There are significant increases in diversity of taxa, number of EPT taxa, and percent Ephemeroptera from the 2008 and 2007 surveys. The site at Nichols, N.Y. (SUSQ 312), was nonimpaired with high ratings in all categories. The first site after the river heads south into Pennsylvania is at Sayre, Pa. (SUSQ 300), which is also nonimpaired, with the highest overall rating among the 2009 sites.

The Chemung River confluence is just downstream of SUSQ 300 and upstream of the site at Towanda, Pa. (SUSQ 271). This site was slightly impaired in 2009 with two very low ratings for diversity of taxa and number of EPT taxa. Some of the observed degradation in the macroinvertebrate community could be contributed to the Chemung River. The site on the Chemung River at Athens, Pa. (CHEM 3), was moderately impaired with the lowest ratings for Hilsenhoff Biotic Index, percent Ephemeroptera, percent dominant taxa, percent Chironomidae, and Shannon-Wiener Diversity for all of the 2009 sites. Two of the biggest decreases in ratings from the 2007 survey were in percent Chironomidae and diversity of taxa.

Future Goals

The assessments at the Susquehanna River sites are fairly consistent between this study and past studies, not withstanding the reduced number of sampling points in 2009 due to the high flows. The 2007, 2008, and 2009 Large River Assessment projects used the same protocol with very similar end results, while staff used different protocols in 2005 with very similar results. Future studies will continue, conditions permitting, and expansion of the project will be investigated. SRBC is interested in adapting lake and reservoir protocols to help assess the last 45 miles of reservoirs, as well as collecting fish community data at the current stations.

Towanda, Pa.

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