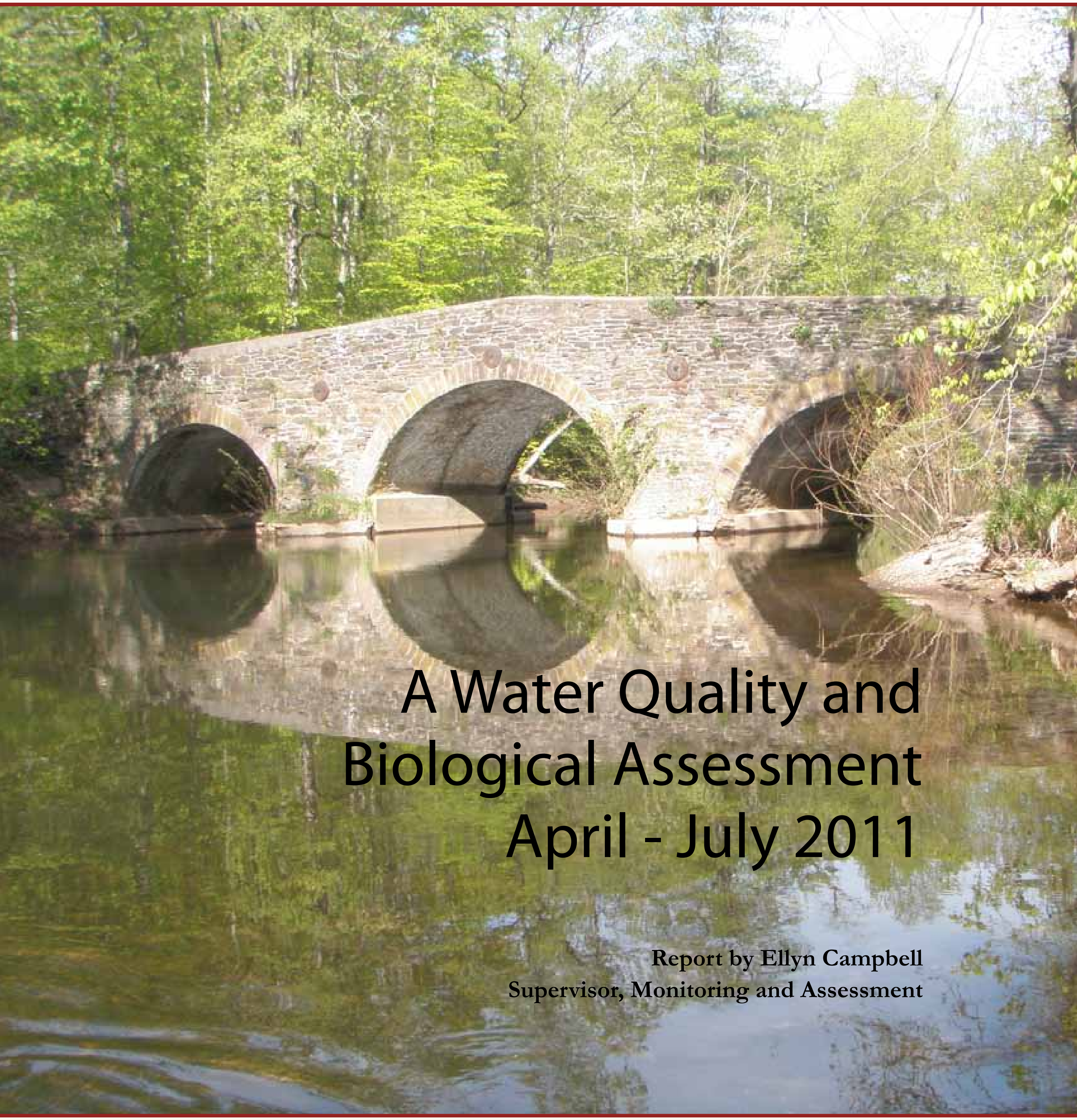
SUSQUEHANNA RIVER BASIN COMMISSION

Lower Susquehanna River Subbasin Year-1 Survey

Publication 282
September 2012



A Water Quality and Biological Assessment April - July 2011

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Introduction

The Susquehanna River Basin Commission (SRBC) conducted a survey of the Lower Susquehanna River Subbasin from April through July 2011. This survey was conducted through SRBC's Subbasin Survey Program, which is funded in part through the United States Environmental Protection Agency (USEPA). This program consists of two-year assessments in each of the six major subbasins (Figure 1) on a rotating schedule. The goals of this Year-1 survey were to collect one-time samples of the macroinvertebrate community, habitat, and water quality at 104 sites in the major tributaries and areas of interest throughout the Lower Susquehanna River Subbasin. The Year-2 survey, which is a more focused, in-depth study of a select area, will follow in late 2013 and be focused on the three major reservoirs comprising the last 45 miles of the Susquehanna River—Lake Clarke, Lake Aldred, and Conowingo Pond. Previous surveys of the Lower Susquehanna River Subbasin were conducted in 1985 (McMorran, 1986), 1996 (Traver, 1997), and 2005 (Buda, 2006). A comparison of the 1996 and 2005 data along with the 2011 results is included in this report.

Subbasin survey information is used by SRBC staff and others to:

- evaluate the chemical, biological, and habitat conditions of streams in the basin;
- identify major sources of pollution and lengths of stream impacted;
- identify high quality sections of streams that need to be protected;
- maintain a database that can be used to document changes in stream quality over time;
- review projects affecting water quality in the basin; and
- identify areas for more intensive study.

Description of the Lower Susquehanna River Subbasin

The Lower Susquehanna River Subbasin is a diverse watershed that drains approximately 5,913 square miles of sandstone ridges, shale/limestone/dolomite valleys, urban areas, and rural landscape from Sunbury, Pa., to where the Susquehanna River empties into the Chesapeake Bay in Havre de Grace, Md. Counties that are located entirely or partially in this subbasin include Adams, Berks, Centre, Chester, Columbia, Cumberland, Dauphin, Franklin, Juniata, Lancaster, Lebanon, Mifflin, Northumberland, Perry, Schuylkill, Snyder, Union, and York in Pennsylvania and Baltimore, Carroll, Cecil, and Harford Counties in Maryland (Figure 2). Four different ecoregions, divided into 11 different subecoregions, are found within this area (Omernik, 1987):

Figure 1. Six Major Subbasins of the Susquehanna River

Northern Piedmont (Ecoregion 64)
- 64a: Triassic Lowlands
- 64b: Trap Rock and Conglomerate Uplands
- 64c: Piedmont Uplands
- 64d: Piedmont Limestone/Dolomite Lowlands

Blue Ridge (Ecoregion 66)
- 66b: Northern Sedimentary and Metasedimentary Ridges

Ridge and Valley (Ecoregion 67)
- 67a: Northern Limestone/Dolomite Valleys
- 67b: Northern Shale Valleys
- 67c: Northern Sandstone Ridges
- 67d: Northern Dissected Ridges and Knobs
- 67e: Anthracite Subregion

Central Appalachians (Ecoregion 69)
- 69a: Northern Igneous Ridges

The mixed land use in the Lower Susquehanna Subbasin is connected to the geology of the region (Figures 2 and 3). Ecoregion 66 (Blue Ridge) occurs in the Lower Susquehanna Subbasin and has varying terrain comprised of ridges, hills, and mountains and is mostly forested with freestone streams draining a mix of metamorphic, igneous, and sedimentary rock. Ecoregion 69 (Central Appalachians) is mainly a plateau formation that is predominantly sandstone, shale, conglomerate, and coal. Since the soils are not conducive to agriculture, this ecoregion is mostly forested. Only very small portions of the subbasin are found in Ecoregions 66 and 69.

Ecoregion 64 (Northern Piedmont) is renowned for agriculture and consequently is dominated by cultivated as well as developed land. The low hills, irregular plains, and open valleys are comprised of metamorphic, igneous, and sedimentary rocks. Prominent watersheds in Ecoregion 64 include Codorus, Muddy, Octoraro, Pequea, Chiques, Deer, West Conewago, and Swatara Creeks as well as the Conestoga River. The largest urban centers in the Lower Susquehanna River Subbasin—the cities

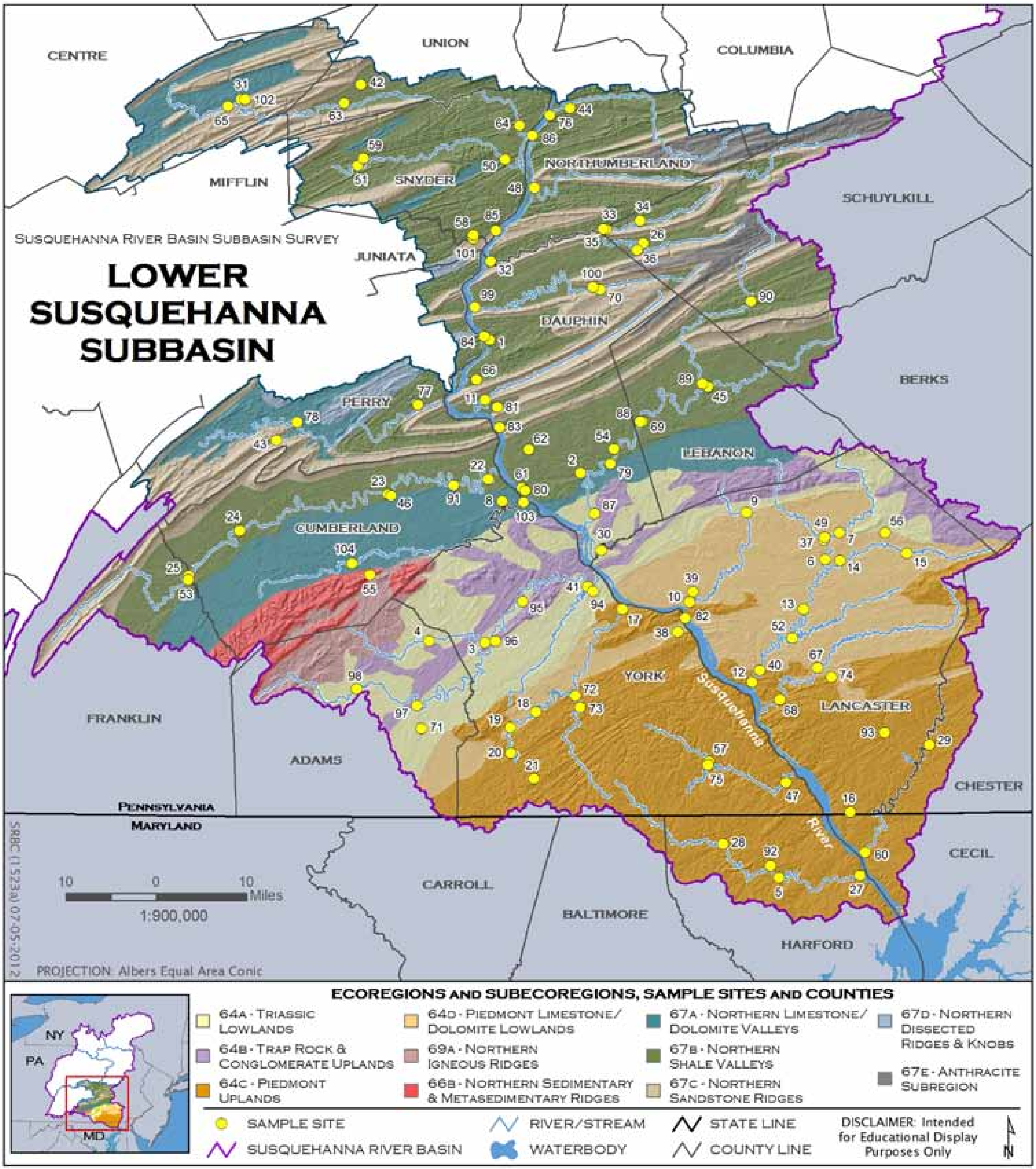


Figure 2. Lower Susquehanna River Subbasin Ecoregions and Sample Sites

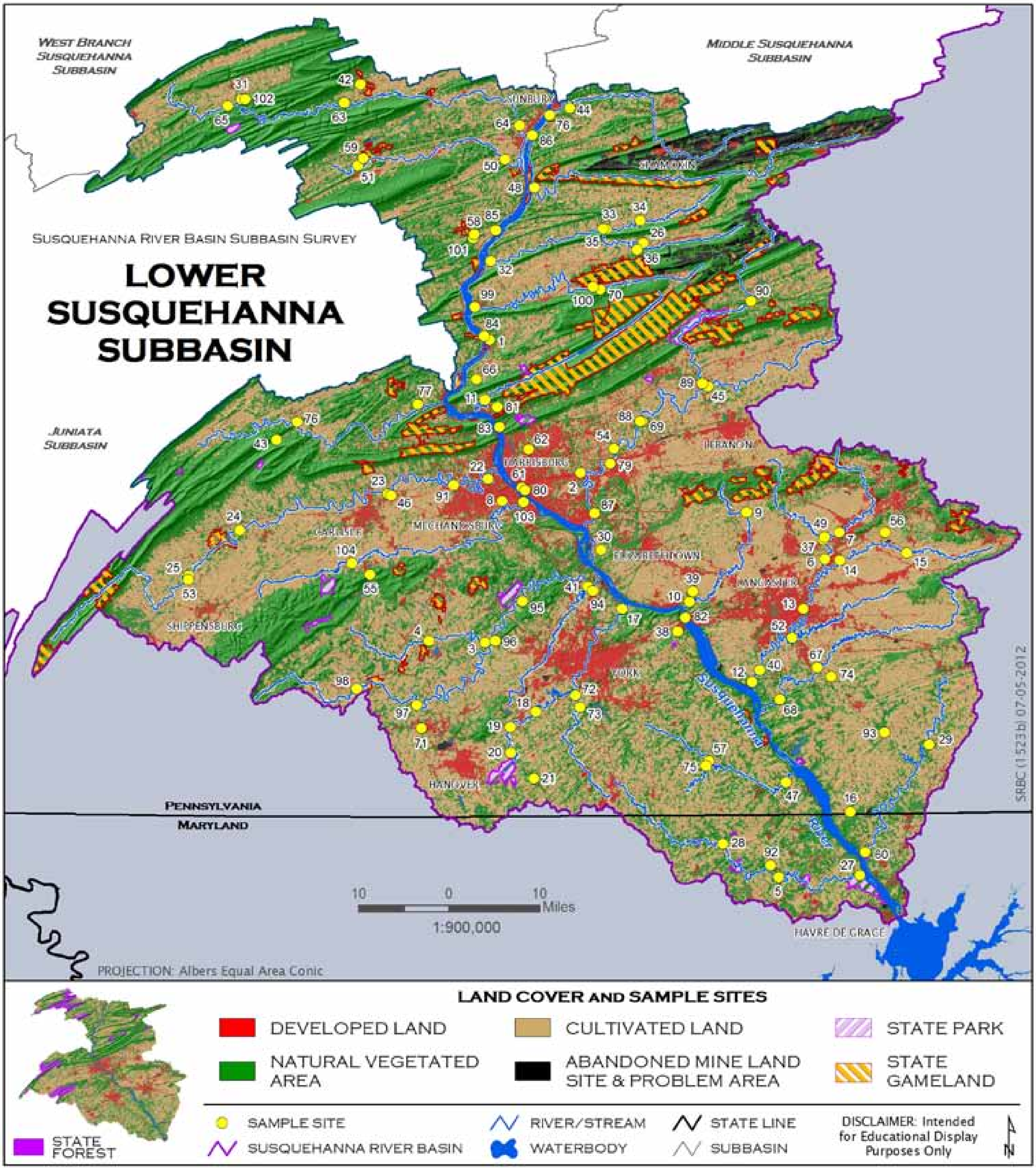


Figure 3. Lower Susquehanna River Subbasin Land Cover and Sample Sites

of Harrisburg, Lancaster, and York, Pa.—are all located within Ecoregion 64.

Ecoregion 67 (Ridge and Valley) is characterized by nearly parallel ridges and valleys formed by folding and faulting events. The predominant geologic materials include sandstone, shale, limestone, dolomite, siltstone, chert, mudstone, and marble. Springs and caves are common in this ecoregion. The ridges are mostly forested, and the limestone/dolomite and shale valleys are predominantly agricultural. There is little urban development in this portion of the basin, probably due to the steep, folded nature of the ridges. In the Anthracite Subregion (67e), there are abandoned mine land sites and problem areas, depicted in black (Figure 3). Prominent watersheds in Ecoregion 67 include Sherman, Conodoguinet, Penns, Middle, Shamokin, Mahanoy, Mahantango, Wiconisco, Swatara, and Yellow Breeches Creeks. The city of Sunbury, Pa., is also located within Ecoregion 67.

Many agencies and environmental organizations throughout the Lower Susquehanna River Subbasin are working to restore and protect local and regional watersheds, including SRBC. Other local entities, such as county conservation districts, land conservation groups, and volunteer groups, protect and conserve land and water resources in the subbasin.

Methods

Data Collection

Sampling of Year-1 sites provides a point-in-time picture of stream characteristics throughout the whole Lower Susquehanna Subbasin. Samples were collected using a slightly modified version of USEPA's Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (RBP III) (Barbour and others, 1999).

From April to July 2011, SRBC staff sampled 99 of the 104 sites throughout the Lower Susquehanna Subbasin slated for study. Appendix A contains a list with the sample site number, the station name (designated by approximate stream mile), the latitude and longitude, a description of the sampling location, the drainage size, and the reference category. Seven new sites were added for the 2011 survey: CABB 0.1 on Cabbage Run Branch, CODO 15.5 on Codorus Creek, EMAH 23.5 on Mahantango Creek, RATT 1.0 on Rattling Creek, SPRG 4.4 on Spring Creek, UNTD 0.5 on an unnamed tributary to Deer Creek, and WICO 27.0 on Wiconisco Creek. The reference category designation was based on subecoregions and grouped according to similarities between subecoregions as described in Traver (1997). Macroinvertebrate samples were collected at 96 sites. In a year marked by record precipitation, no macroinvertebrate samples were collected on Codorus Creek at CODO 25.5, Conestoga River at CNTG 0.9, or Swatara Creek at SWAT 21.7 because of high water. Likewise, no macroinvertebrate or water quality sampling was conducted on the mainstem sites because of perpetual high water conditions caused by a continuous succession of rain events, including Hurricane Irene and Tropical Storm Lee. A physical habitat assessment was conducted at the sites where a macroinvertebrate sample was collected.

Water Quality

Field chemistry analysis was done at the time of sampling, and water samples from each sampling site were also collected for laboratory analysis. A list of the field and laboratory parameters and their units is found in Table 1. A multi-meter YSI sonde was used to collect all field chemistry parameters (temperature, conductivity, pH, and dissolved oxygen) simultaneously. The probes of all meters were rinsed with distilled water and sample water prior to collection of water quality data, and calibrations were conducted as detailed in the Quality Assurance Project Plan (QAPP). At stations with no USGS gage, flow measurements were made by field personnel using a FlowTracker and standard USGS procedures (Buchanan and Somers, 1969). Water samples were collected using depth-integrated water sampling methods (Guy and Norman, 1969) and were iced and delivered to ALS Environmental in Middletown, Pa.

Macroinvertebrates

Benthic macroinvertebrates (organisms that live on the stream bottom, including aquatic insects, crayfish, clams, snails, and worms) were collected using a slightly modified version of RBP III (Barbour and others, 1999).

Table 1. Water Quality Parameters Sampled in the Lower Susquehanna Subbasin

Field Parameters	
Flow (instantaneous cfs[a])	Conductivity (µmhos/cm[c])
Temperature (°C)	Dissolved Oxygen (mg/l[b])
pH	
Laboratory Analysis	
Alkalinity (mg/l)	Total Magnesium (mg/l)
Total Dissolved Solids (mg/l)	Total Sodium (mg/l)
Total Suspended Solids (mg/l)	Chloride (mg/l)
Total Nitrogen (mg/l)	Sulfate (mg/l)
Nitrite-N (mg/l)	Total Iron (mg/l)
Nitrate-N (mg/l)	Total Manganese (mg/l)
Turbidity (NTU[d])	Total Aluminum (mg/l)
Total Organic Carbon (mg/l)	Total Phosphorus (mg/l)
Total Hardness (mg/l)	Total Orthophosphate (mg/l)
Total Calcium (mg/l)	Hot Acidity (mg/l)

[a] cfs = cubic feet per second
[b] mg/l = milligram per liter
[c] µmhos/cm = micromhos per centimeter
[d] NTU = nephelometric turbidity units

In Pennsylvania, macroinvertebrate sampling was conducted using PADEP's Semi-Quantitative (PADEP-RBP) Method (PADEP, 2009a). Forty-four targeted sites were sampled prior to May 1, 2011, because of possible limestone influence (PADEP, 2009b) in order to collect *Ephemerella* nymphs (mayflies) before they emerge as adults in May and June. *Ephemerella* mayflies are sensitive ecological indicator taxa that tend to be found in healthy limestone streams.

SRBC staff processing a macroinvertebrate sample in the field.

Remaining Pennsylvania streams were sampled from May through July 2011. Six D-frame (500-micron mesh) samples were obtained at each 100-meter station reach by collecting the dislodged material loosened through disturbance of the substrate of six representative riffle/run areas. The six D-frame samples were composited into one sample, which was preserved in 95-percent denatured ethyl alcohol and returned to SRBC's lab for processing. Each sample was then subsampled, with approximately 200 (± 20 percent) organisms picked.

In Maryland, macroinvertebrate sampling was conducted using Maryland Department of Natural Resource's (MDNR's) Maryland Biological Stream Survey (MBSS) protocol (MDNR, 2010) for the spring index period. Twenty D-frame (540-micron mesh) samples were obtained from a proportionate variety of habitat representative of a 75-meter reach. The twenty D-frame samples were composited into one sample, which was preserved in 95-percent denatured ethyl alcohol and returned to SRBC's lab for processing. Each sample was then subsampled, with approximately 120 organisms picked.

For all samples, organisms were identified to genus when possible, except for midges, which were identified to family, and worms, which were identified to class.

Habitat

Habitat conditions were also evaluated using a modified version of RBP III (Plafkin and others, 1989; Barbour and others, 1999). Physical stream characteristics relating to substrate, pool, and riffle composition, shape of the channel, conditions of the banks, and the riparian zone were rated on a scale of 0-20, with 20 being optimal. Other observations were noted regarding recent precipitation events, substrate material composition, surrounding land use, and any other relevant features in the watershed.

Data Analysis

Water quality was assessed by examining field and laboratory parameters that included nutrients, major ions, and metals (Table 1). The data were compared to water quality levels of concern based on current state and federal regulations, background levels for uninfluenced streams, or references for approximate tolerances of aquatic life (Table 2). The difference between each value and the level of concern value from Table 2 was calculated for each site. If the measured value exceeded the level of concern value, the difference between the two was listed. If the measured value did not exceed the level of concern value, the difference was listed as zero. An average of all the differences for each site was calculated. All sites that received a score of zero (no parameters exceeded the limits) were classified as higher quality. Sites that had a percentage value between zero and one were classified as middle quality, and sites that had a percentage value greater than one were classified as lower quality.

Seven reference categories were created for macroinvertebrate and habitat data analysis. All the sites were divided into small (<100 square miles), medium (100 to 500 square miles), and large (>500 square miles) drainage areas. The sites were grouped again according to ecoregions and subecoregions (Omernik, 1987; Omernik, 1992). Those sites less than 100 square miles were grouped by subecoregion due to the smaller size of the watersheds. Sites that represented drainage areas greater than 100 square miles were grouped by ecoregion since they often covered an area with more than one subecoregion and were designated with a letter "L" (Appendix A). Some of the subecoregions were combined due to similarity of the subecoregions and limited number of sites for ease of analysis. Based on the location of the sampling sites, the seven reference categories used were: 64ac, 64d, 64L, 67a, 67b, 67cd, and 67L. Mainstem sites were placed in a separate River reference category, but since no River sites were sampled during 2011 because of high flows, this reference category was not analyzed in this survey. The site on Mountain Creek (MNTN 3.0) was grouped with 67cd since no other sites were located within subecoregion 66b. One reference site was chosen in each of the seven reference categories, primarily based on the results of the macroinvertebrate metrics, and secondarily based on habitat and water quality scores, to represent the best combination of conditions within each category.

Benthic macroinvertebrate samples were analyzed using seven metrics mainly derived from RBP III: (1) taxonomic richness; (2) modified Hilsenhoff Biotic Index; (3) percent Ephemeroptera; (4) percent contribution of dominant taxon; (5) number of Ephemeroptera/Plecoptera/Trichoptera (EPT) taxa;

Table 2. Water Quality Standards and Levels of Concern			
Parameters	**Limits**	**Reference Codes**	**References**
Based on state water quality standards:			
Temperature	≤ 30.5 ºC	a	a. http://www.pacode.com/secure/data/025/chapter93/s93.7.html b. http://www.pacode.com/secure/data/025/chapter93/s93.8c.html c. http://www.dec.ny.gov/regs/4590.html#16132 d. http://www.dsd.state.md.us/comar/comarhtml/26/26.08.02.03-3.htm
Dissolved Oxygen	≥ 4 mg/l	a	
pH	≥ 6.0 and ≤ 9.0	a	
Alkalinity	≥ 20 mg/l	a	
Total Chloride	≤ 250 mg/l	a	
Total Dissolved Solids	≤ 500 mg/l	c	
Total Sulfate	≤ 250 mg/l	a	
Total Iron	≤ 1500 µg/l	a	
Total Manganese	≤ 1000 µg/l	a	
Total Aluminum	≤ 750 µg/l	b	
Total Magnesium	≤ 35 mg/l	c	
Total Sodium	≤ 20 mg/l	c	
Total Suspended Solids	≤ 25 mg/l	a	
Turbidity	≤ 50 NTU	d	
Based on background levels or aquatic life tolerances:			
Conductivity	≤ 800 µmhos/cm	e	e. http://www.uky.edu/WaterResources/Watershed/KRB_AR/wq_standards.htm f. http://water.usgs.gov/pubs/circ/circ1225/images/table.html g. http://www.uky.edu/WaterResources/Watershed/KRB_AR/krww_parameters.htm h. Hem (1970) i. Based on archived data at SRBC
Total Nitrogen	≤ 1 mg/l	f	
Total Nitrate	≤ 0.6 mg/l	f	
Total Nitrite	≤ 1 mg/l	c	
Total Phosphorus	≤ 0.1 mg/l	g	
Total Orthophosphate	≤ 0.02 mg/l	f	
Total Organic Carbon	≤ 10 mg/l	h	
Total Hardness	≤ 300 mg/l	g	
Acidity	≤ 20 mg/l	i	
Calcium	≤ 100 mg/l	i	

(6) percent Chironomidae; and (7) Shannon-Wiener Diversity Index. Each site's metric scores were compared to the scores at its corresponding reference site, and a biological condition category of nonimpaired, slightly impaired, moderately impaired, or severely impaired was assigned based on RBP III methods. The same reference sites were used in the analysis for the habitat scores. The ratings for each habitat condition were totaled, and a percentage score of the reference site was calculated. The percentages were used to assign a habitat condition category of excellent, supporting, partially supporting, or nonsupporting to each site.

Ephemerella mayflies are a sensitive ecological indicator taxa that tend to be found in healthy limestone streams. *Photo credit: Robert Henricks*

Results/Discussion

Water quality, macroinvertebrate, and habitat conditions for each sampling site in the Lower Susquehanna Subbasin in 2011 are depicted in Figure 4. Five of the 104 sites were located on the mainstem Susquehanna River and were not sampled due to high flows. The remaining 99 sites were sampled in the subbasin for water quality and habitat, and 96 of those sites were also sampled for benthic macroinvertebrates. Twenty-seven percent of the sampled sites had nonimpaired macroinvertebrate communities, 46 percent had slightly impaired communities, 25 percent had moderately impaired communities, and 2 percent had severely impaired communities (Figure 5).

Forty-eight percent of the evaluated sites had excellent habitat, 32 percent had supporting habitat, 15 percent had partially supporting habitat, and 5 percent had nonsupporting habitat (Figure 6).

The vast majority of sampled sites had at least one parameter that exceeded levels of concern, with 90 percent of sites receiving a middle water quality designation and 8 percent receiving a lower water quality designation (Figure 7). Only 2 percent of sampled sites had no parameters exceed levels of concern and received a higher water quality designation. Twenty-three percent of sampled sites had three or more parameters exceed levels of concern. Five sites, one each on the Conestoga River (CNTG 0.9), Mahanoy Creek (MHNY 0.3), Mill Creek (MILL 0.3), Pequea Creek (PQEA 15.2), and Yellow Breeches (YLBR 0.1) had five or six parameters exceed levels of concern.

Only two sites, one on Clarks Creek (CLRK 3.8) and the other on Laurel Run (LRSL 0.5), had the ideal combination of nonimpaired macroinvertebrate communities, excellent habitat, and higher water quality designations. Eight percent of sampled sites had nonimpaired macroinvertebrate communities, excellent habitat, and middle water quality designations. An additional 11 percent of sampled sites had nonimpaired macroinvertebrate sites, supporting habitat, and middle water quality.

Elevated total nitrate concentrations were found at 90 percent of sampled sites, followed closely by total nitrogen at 82 percent of sampled sites (Table 3). Since numeric nutrient standards have not yet been developed for Pennsylvania, the threshold values set for total nitrate (0.6 mg/l) and total nitrogen (1 mg/l) are based on natural background concentrations (Table 2) published by the USGS (1999). Values higher than these background levels indicate the potential presence of nitrate and nitrogen sources such as agriculture or urbanization in the watershed. The highest levels of nitrate (11.2 mg/l) occurred at sites on Cedar Run (CEDR 0.1), Swatara Creek (SWAT 2.3 at 10.4 mg/l), and Conowingo Creek (CNWG 1.8) and Little Chiques Creek (LCHQ 0.4) (both at 9.9 mg/l). The highest levels of total nitrogen occurred at Pequea Creek (PQEA 15.2 at 11.9 mg/l), Cedar Run (CEDR 0.1 at 11.2 mg/l), Chiques Creek (CHIQ 3.0 at 10.5 mg/l), and Conowingo Creek (CNWG 1.8) and Little Chiques Creek (LCHQ 0.4) (both at 9.9 mg/l). Based on these results, it appears that Cedar Run, Conowingo Creek, and Little Chiques Creek are prominent sources of nitrate and total nitrogen in the Lower Susquehanna Subbasin.

Low total alkalinity was measured at 12 percent of sampled sites, with the lowest level occurring at a site on Laurel Run (LRLN 0.8 at 6 mg/l), followed by sites on Shamokin Creek (SHAM 2.7) and Stony Creek (STON 0.4) (both 7 mg/l) as well as Powell Creek (POWL 0.1) at 8 mg/l. Low total alkalinity can be an indicator of abandoned mine drainage (AMD) or acid deposition. Streams with low alkalinity have less capacity to buffer the harmful effects of drops in pH, which can be caused by anthropogenic sources. Elevated total sodium, which

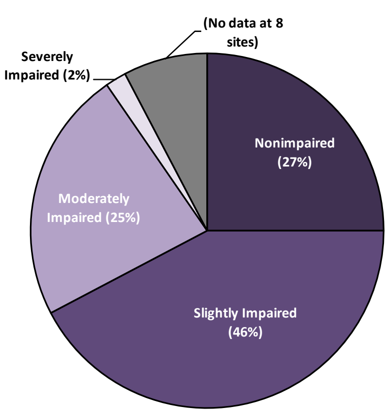


Figure 5. 2011 Biological Condition Categories for Sampled Lower Susquehanna Subbasin Sites

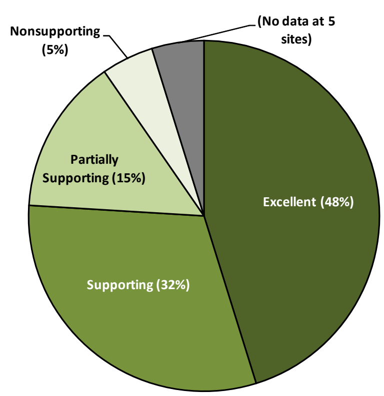


Figure 6. 2011 Habitat Condition Categories for Sampled Lower Susquehanna Subbasin Sites

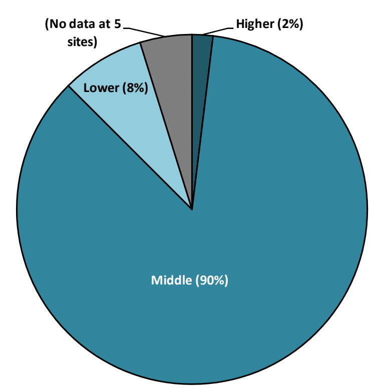


Figure 7. 2011 Water Quality Condition Categories for Sampled Lower Susquehanna Subbasin Sites

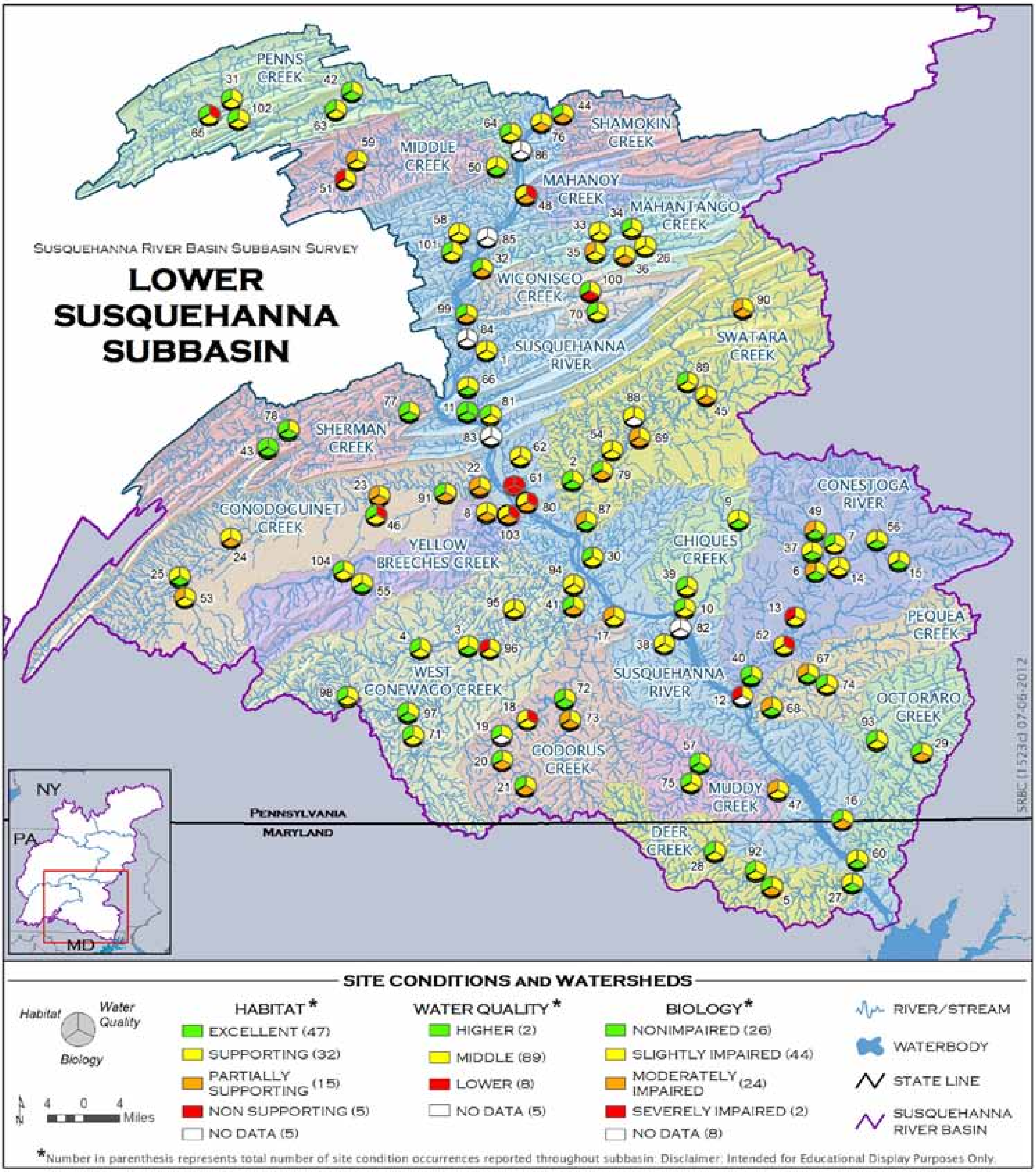


Figure 4. Lower Susquehanna Subbasin Site Conditions and Watersheds

is an indicator of urbanization, was observed at 11 percent of sampled sites, with the highest level occurring at 75.7 mg/l on the most downstream Yellow Breeches Creek site (YLBR 0.1).

Orthophosphate and hardness were elevated at 7 and 5 percent of sampled sites, respectively. Total dissolved solids, total suspended solids, total phosphorus, total calcium, total manganese, total aluminum, total magnesium, and total sulfate were all elevated in 1 to 4 percent of the sampled sites. Acidity, total nitrite, total organic carbon, turbidity, dissolved oxygen (DO), pH, and specific conductance did not exceed levels of concern at any of the sites.

(continued on page 12)

Table 3. Lower Susquehanna River Subbasin Sites with Water Quality Values Exceeding Levels of Concern (all in mg/l)

Site	T Nitrate	T Nitrogen	T Alkalinity	T Na	Ortho-P	Hardness	TDS	T Fe	T P	T Ca	T Mn	TSS	T Al	T Mg	T S04	TOTAL
ARMS 0.1	2.5	2.5	15													3
BEAV 0.6	1.8	1.8		21.4												3
BERM 1.2	1.4	1.4														2
BERM 11.0	1.6	1.6														2
CABB 0.1	4.4	4.4														2
CCLC 0.4	6.4	6.4			0.044											3
CCLC 12.2	6.1	6.1			0.027											3
CEDR 0.1	**11.2**	11.2														2
CHIQ 20.0	3.9	3.9														2
CHIQ 3.0	9.1	10.5														2
CLRK 3.8																0
CNTG 0.9	7.3	7.3		21.3	**0.12**				**0.24**			29				6
CNTG 22.6	7.3	7.3			0.038											3
CNTG 32.7	6.9	6.9														2
CNTG 43.9	5.9	5.9														2
CNWG 1.8	9.9	9.9														2
CODO 0.6	3.9	3.9		28.2												3
CODO 22.4	2.6	3.6		53.4												3
CODO 25.5	3.2	3.2														2
CODO 33.0	2.1	2.1										**37**				3
CODO 36.8	4.3	4.3														2
CONO 1.3	3.7	3.7														2
CONO 28.8	4.1	4.1														2
CONO 51.8	3.7	3.9														2
CONO 66.0	2.3	4.5														2
DEEP 1.2	0.94		15													2
DEER 1.2	3.3	3.3														2
DEER 30.1	4	4														2
EBOC 5.3	7.4	7.4														2
ECON 0.0	3.1	3.1														2
ELKN 0.1	3.6	6.9														2
EMAH 0.2	2.1	2.1														2
EMAH 17.1	4.1	4.1						1.7								3
EMAH 23.5	3.8	3.8														2
EPIN 0.1	0.74		16													2
EPIN 12.7			14													1
HAMM 0.2	6.1	6.1														2
KRTZ 1.5	4.5	5.6														2
LCHQ 0.4	9.9	9.9														2
LCNT 1.7	8.4	8.4		22.5		303										4
LCON 1.5	3.3	3.3														2
LRLN 0.8		3.8	**6**													2
LRLS 0.5																0
LSHM 0.8	3.1	3.1														2
LSWT 0.6	5.3	5.3														2
LTRT 0.1	5.3	5.3				321				102						4
MDDY 3.3	5.1	5.1														2
MHNY 0.3	0.72					**371**	527				2			**46.1**	**325**	6
MIDD 0.2	6.7	6.7														2
MIDL 0.7	1.4	1.4														2
MIDL 24.7		1.5														1

Site	T Nitrate	T Nitrogen	T Alkalinity	T Na	Ortho-P	Hardness	TDS	T Fe	T P	T Ca	T Mn	TSS	T Al	T Mg	T S04	TOTAL
MILL 0.3	9.4	9.4		29.9	0.079	319										5
MISP 0.5	5.8	6.04														2
MNDA 0.1	0.92															1
MNTN 3.0			14													1
MUDD 0.2	3.3	3.3														2
NBMY 0.0	6	6	15													3
NMHT 0.0	2.1	2.1														2
NMID 0.7	1.3	2.8														2
OCTO 1.0	6.4	6.4														2
PAXT 0.5	1.8			41.4												2
PAXT 8.4	1.7	1.7		38												3
PENN 30.0	1.3	4.1														2
PENN 5.0	1.4	1.4														2
PENN 50.6	2.1	5.8					537									3
POWL 0.1	1.3	1.3	8													3
PQEA 15.2	8.6	**11.9**			0.06				0.12				**0.86**			5
PQEA 3.3	7.8	7.8														2
QUIT 0.3	7.9	7.8			0.095				0.12							4
RATT 1.0		1.6														1
SBCC 1.2	4	4														2
SBCD 0.4	4.3	4.3														2
SBCD 3.6	5	5														2
SBEV 2.5	6.4	6.4														2
SBMY 0.0	4.9	4.9														2
SHAM 2.7			7					**2.4**			**2.2**					3
SHRM 2.0	1.2	1.2														2
SHRM 27.5	1.6	1.6														2
SPRG 0.0	5.4			26.2												2
SPRG 0.4	2.5	2.5		65.6			501									4
STON 0.4			7													1
SWAT 2.3	**10.4**															1
SWAT 21.7	2.4	2.4														2
SWAT 39.0	0.96		13													2
SWAT 56.0	0.84		10													2
TRDL 0.0	4.7	4.7														2
UNTD 0.5	4	4														2
WBOC 4.3	8.4	8.4														2
WCON 2.9	1.6	1.6														2
WCON 20.4	1.6	1.6														2
WCON 35.5	1.7	1.7														2
WCON 56.3	0.8															1
WCON 66.5	0.86															1
WICO 0.3	2.4	2.4														2
WICO 27.0								1.9								1
WMHT 2.2	1.6	1.6														2
WPIN 0.8	1.3	3.4														2
YLBR 0.1	3.8	3.8		**75.7**		345	**567**			**111**						6
YLBR 35.7	1.5	1.5														2
TOTAL	**89**	**81**	**12**	**11**	**7**	**5**	**4**	**3**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	
% of sites	**90%**	**82%**	**12%**	**11%**	**7%**	**5%**	**4%**	**3%**	**3%**	**2%**	**2%**	**2%**	**1%**	**1%**	**1%**	

Red bolded values were the most extreme values for that parameter measured during this study.

Elevated total nitrate concentrations were found at 90 percent of sampled sites, followed closely by total nitrogen at 82 percent of sampled sites.

Total Maximum Daily Loads

Section 303(d) of the Clean Water Act requires a Total Maximum Daily Load (TMDL) to be developed for any waterbody designated as impaired or not meeting the state water quality standards or its designated use. Streams in Pennsylvania are being assessed as part of the State Surface Waters Assessment Program, and if they are found to be impaired, they are listed as requiring a TMDL, which would eventually be established for the watershed. Some of the watersheds in the Lower Susquehanna River Subbasin have been designated as impaired for different uses and subsequently will require a TMDL to be established.

Since the 2006 subbasin report was published, approximately 380 river miles in segments along 83 streams were listed as being impaired and requiring the establishment of a TMDL in the Lower Susquehanna River Subbasin (PADEP, 2010). The vast majority of these listings were for aquatic life impairment caused by siltation, sometimes in combination with nutrients. By far, primary sources of the siltation include agriculture (general, crop-related, and grazing-related), but some other sources of siltation noted include golf courses, flow regulation/modification, land development, surface mining, and urban runoff/storm sewers. Other causes of aquatic life impairment include excessive algal growth caused by hydromodification and municipal point sources, organic enrichment and low dissolved oxygen caused by agriculture, and low pH caused by atmospheric deposition. Some of these stream segments have potable water supply impairment caused by nutrients and/or siltation from agriculture and recreational use impairment caused by pathogens from agriculture, on-site wastewater treatment, and unknown sources. A segment of Conewago Creek was listed for fish consumption impairment caused by mercury from an unknown source.

Ten of the streams that are part of the Year-1 survey have stream segments that were listed since the 2006 subbasin report as impaired, requiring TMDLs to be established. East Branch Octoraro Creek, Mill Creek, Conestoga River, North Branch Muddy Creek, and Yellow Breeches were all listed for aquatic life impairment from siltation and/or nutrients with an agricultural source. The Yellow Breeches was listed for recreational use impairment with pathogens caused by agriculture. Octoraro Creek was listed for potable water supply impairment resulting from nutrients caused by agriculture. Both Sherman Creek and Elk Creek were listed for recreational use impairment caused by pathogens derived from agriculture and on-site wastewater treatment (Sherman) or an unknown source (Elk). Bermudian Creek was listed for aquatic life impairment due to organic enrichment and low DO caused by an industrial point source. Beaver Creek was listed for aquatic life impairment caused by siltation resulting from a flow regulation/modification.

Since the 2006 subbasin report was published, TMDLs were established for approximately 165 miles along sections of 27 streams in the Lower Susquehanna River Subbasin. The vast majority of these stream segments (57 percent) had TMDLs developed to address metals and/or low pH caused by AMD. Approximately 34 percent of these stream segments have TMDLs addressing a combination of nutrients and siltation caused by agriculture and small residential runoff. Approximately 22 percent had TMDLs developed to address siltation alone caused by various agricultural practices as well as urban runoff, storm sewers, and construction.

Numerous streams where TMDLs are in place are in watersheds sampled as part of the Year-1 survey, including those of Mahanoy Creek, Wiconisco Creek, and Paxton Creek. TMDLs were established for the Mahanoy Creek Watershed to address metals and pH issues caused by AMD and acid precipitation. The Wiconisco Creek Watershed had TMDLs established to address metals, pH, and siltation issues with sources of AMD and various agricultural practices. Paxton Creek suffers from siltation issues and had TMDLs developed to address urban runoff, storm sewer, and construction sources.

Upstream view of Mahantango Creek, Dauphin Co., Pa.

Ridge and Valley Ecoregion

Penns Creek Watershed

The site on Laurel Run (LRLN 0.8), a tributary to Penns Creek, had a nonimpaired macroinvertebrate community, excellent habitat, middle water quality, and functioned as a 2011 reference site for the 67b subecoregion. Elk Creek (ELKN 0.1) and Pine Creek (WPIN 0.8), two other tributaries, have slightly impaired macroinvertebrate communities, excellent habitat, and middle water quality. The three tributary sites had elevated nitrate and total nitrogen, except for LRLN 0.8, which had elevated total nitrogen and low total alkalinity.

The three Penns Creek sites had slightly impaired communities and excellent habitat, while having elevated nitrate and total nitrogen levels. The two downstream sites (PENN 5.0 and PENN 30.0) had middle water quality ratings as a result, while the upstream site (PENN 50.6) had lower water quality from the addition of elevated total dissolved solids.

Middle Creek Watershed

The North Branch Middle Creek site (NMID 0.7) had a slightly impaired biological community and partially supporting habitat. The two sites on Middle Creek (MIDL 0.7 and MIDL 24.7) had either nonimpaired or slightly impaired communities and supporting or nonsupporting habitat. All three sites were rated as having middle water quality from elevated nitrate and total nitrogen.

Upstream view of Middle Creek, Snyder Co., Pa.

East Mahantango Creek Watershed (East of Susquehanna)

The two sites on Pine Creek (EPIN 0.1 and EPIN 12.7) and one site on Deep Creek (DEEP 1.2), both tributaries to East Mahantango Creek, had either slightly impaired or moderately impaired macroinvertebrate communities and either supporting or partially supporting habitat and middle water quality from low total alkalinity and elevated nitrates. Pine Creek was previously listed as being impaired for agriculture, grazing-related agriculture, AMD, and unknown sources. Deep Creek was identified in 1998 as impaired, requiring a TMDL for siltation caused by agriculture and unknown sources.

The three sites on East Mahantango Creek had either slightly or moderately impaired communities, excellent or supporting habitat, and middle water quality from elevated nitrate and total nitrogen, with EMAH 17.1 also having elevated total iron concentrations resulting from AMD influence.

North and West Branches of Mahantango Creek (West of Susquehanna River)

The sites on both the North and West Branches of Mahantango Creek (NMHT 0.0 and WMHT 2.2, respectively) had slightly impaired communities, supporting or excellent habitat, and middle water quality from elevated nitrate and total nitrogen. North Branch Mahantango Creek was identified in 1998 as impaired, requiring a TMDL for siltation caused by agriculture.

Shamokin Creek Watershed

Both sites in the Shamokin Creek Watershed had moderately impaired macroinvertebrate communities, with either supporting or excellent habitat, and middle water quality. Little Shamokin Creek (LSHM 0.8) had issues with elevated nitrate and total nitrogen. Little Shamokin Creek was identified in 2002 as impaired, requiring a TMDL for siltation and to address low dissolved oxygen caused by organic enrichment derived from agriculture and grazing-related agriculture.

Shamokin Creek (SHAM 2.7), however, had different issues involving low total alkalinity, total iron, and total manganese resulting from AMD influence. Shamokin Creek was identified in 1996 and 2004 as impaired, requiring a TMDL for metals, siltation, and low pH caused by AMD, urban runoff, and/or road runoff.

Mahanoy Creek Watershed

Mahanoy Creek (MHNY 0.3) had a moderately impaired benthic community, supporting habitat, and lower water quality from elevated hardness, total manganese, total sulfate, and total dissolved solids resulting from AMD influence. Mahanoy Creek was identified in 1996 and 2002 as impaired and requiring a TMDL for metals, low pH, and siltation caused by AMD, atmospheric deposition, and/or crop-related agriculture.

Wiconisco Creek Watershed

Rattling Run (RATT 0.1), a tributary to Wiconisco Creek, had a slightly impaired macroinvertebrate community, excellent

Downstream view of Rattling Creek, Dauphin Co., Pa.

habitat, and middle water quality from elevated total nitrogen. The two Wiconisco Creek sites had excellent habitat and middle water quality. The upstream Wiconisco site (WICO 27.0) had a severely impaired community low in organism abundance and diversity and devoid of pollution sensitive taxa and had elevated iron concentrations resulting from AMD influence. Similar macroinvertebrate community traits were observed in the downstream site (WICO 0.3), which had a moderately impaired community and elevated nitrate and total nitrogen concentrations.

Wiconisco Creek was identified at various times between 1998 and 2004 as impaired, requiring a TMDL for metals, pH, siltation, and nutrients caused by AMD, crop-related agriculture, grazing-related agriculture, removal of vegetation, small residential development runoff, and/or unknown sources.

Armstrong Creek Watershed

One site on Armstrong Creek near its mouth (ARMS 0.1) had a slightly impaired community, supporting habitat, and middle water quality from elevated nitrate and total nitrogen as well as low total alkalinity. Armstrong Creek was identified in 1998 as impaired, requiring a TMDL for siltation problems caused by agriculture and removal of vegetation.

Powell Creek Watershed

The site on Powell Creek near its mouth (POWL 0.1) had a nonimpaired community, supporting habitat, and middle water quality from elevated nitrate and total nitrogen as well as low total alkalinity. Powell Creek had been previously listed as impaired, requiring a TMDL for siltation caused by agriculture and removal of vegetation.

Clarks Creek Watershed

One site was studied on Clarks Creek (CLRK 3.8) and had a nonimpaired community, excellent habitat, and higher water quality.

Stony Creek Watershed

One site was located on Stony Creek near its mouth (STON 0.4) and had a slightly impaired community, excellent habitat, and middle water quality from low total alkalinity.

Sherman Creek Watershed

One site on Laurel Run (LRSL 0.5), a tributary to Sherman Creek, had a nonimpaired benthic community rich in diversity and pollution-sensitive organisms, excellent habitat, and higher water quality and served as a 2011 reference site for the 67cd subecoregion. Both sites on Sherman Creek also had nonimpaired communities and excellent habitat but had middle water quality as a result of elevated nitrate and total nitrogen. Both sites on Sherman Creek served as 2011 reference sites for the 67a (SHRM 27.5) and 67L (SHRM 2.0) subecoregions. Sherman Creek had been previously listed in 2002 as impaired, requiring a TMDL for nutrients and siltation caused by grazing-related and crop-related agriculture as well as removal of vegetation.

Upstream view of Laurel Run, Union Co., Pa.

Conodoguinet Creek Watershed

Three tributaries to the Conodoguinet were sampled. The site on Letort Spring Run (LTRT 0.1) had a slightly impaired community and lower water quality from elevated nitrate and total nitrogen, as well as total calcium and hardness likely resulting from natural groundwater sources. One site on Middle Spring Run (MISP 0.5) had a slightly impaired community and partially supporting habitat, and a site located on Trindle Spring Run (TRDL 0.0) harbored a moderately impaired community. The sites on both Middle Spring and Trindle Spring Runs had middle lower quality from elevated nitrate and total nitrogen.

The lower three of the four Conodoguinet sites (CONO 1.3, CONO 28.1, and CONO 51.8) had moderately impaired macroinvertebrate communities, partially supporting or supporting habitat, and middle water quality. The most upstream site (CONO 66.0) had a nonimpaired community, supporting habitat, and middle water quality. All Conodoguinet sites had elevated nitrate and total nitrogen levels.

Half of the sites sampled in the Conodoguinet Creek Watershed had high alkalinity concentrations (greater than 140 mg/l) and water temperatures (50 to 55º F) that can be indicative of limestone streams (PADEP, 2009b). In addition, limestone streams also tend to harbor communities that are dominated by a few specific taxa such as *Ephemerella* mayflies, *Optioservus* beetles, midges (Chironomidae), and freshwater crustaceans such as scuds (Amphipoda) and sowbugs (Isopoda). Consequently, healthy macroinvertebrate communities in limestone streams tend to be rich in abundance but poor in diversity, appearing impaired compared to healthy communities in non-limestone streams. As previously discussed, MISP 0.5 harbors a slightly impaired macroinvertebrate community but has typical limestone characteristics. The other three sites (CONO 1.3, CONO 28.1, and TRDL 0.0) had moderately impaired communities, but TRDL 0.0 was the only site that appeared to have a community that is typically seen in limestone streams. Impairment of the other two sites can be attributed to other unknown causes, but it is probable that development stress in the watershed is affecting these sites.

Conodoguinet Creek was identified from 1998 through 2004 as impaired, requiring a TMDL for siltation, organic enrichment and low dissolved oxygen, nutrients, and suspended solids caused by various agricultural practices, urban runoff, and unknown sources.

Yellow Breeches Creek Watershed

The site on Mountain Creek (MNTN 3.0), a tributary to the Yellow Breeches, had a nonimpaired macroinvertebrate community, supporting habitat, and middle water quality from low total alkalinity. Mountain Creek was identified in 1998 as impaired, requiring a TMDL for low pH caused by atmospheric deposition.

The site on the other tributary in this watershed that was sampled, Cedar Run (CEDR 0.1), had a moderately impaired macroinvertebrate community, supporting habitat, and middle water quality from elevated nitrate and total nitrogen. Cedar Run was identified in 1998 as impaired, requiring a TMDL for siltation and nutrients caused by urban runoff, agriculture, and natural and unknown sources. Currently, SRBC is in the early stages of collecting data to develop the Cedar Run TMDL.

The upstream Yellow Breeches site (YLBR 35.7) had a slightly impaired community, excellent habitat, and middle water quality from elevated nitrate and total nitrogen. The downstream Yellow Breeches site (YLBR 0.1) had a moderately impaired community, supporting habitat, and lower water quality with the same nutrient issues as the upstream site in addition to elevated total calcium, hardness, total sodium, and total dissolved solids. YLBR 0.1 also had the limestone stream characteristics of elevated alkalinity and lower water temperature, but its community structure, which is ranked as moderately impaired, is not typical of that seen in limestone streams. The impairment of its community is likely due to other causes such as accumulated effects from agriculture and urbanization. Yellow Breeches Creek was identified from 1998 through 2004 as impaired for PCBs (polychlorinated biphenyls), organic enrichment, low dissolved oxygen, siltation, and nutrients caused by industrial point sources, urban runoff, agriculture, construction, and unknown sources.

Paxton Creek Watershed

The upstream Paxton Creek site (PAXT 8.4) had a slightly impaired macroinvertebrate community, supporting habitat, and middle water quality with elevated nitrate, total nitrogen, and total sodium. The downstream Paxton Creek site (PAXT 0.5) had a severely impaired macroinvertebrate community low in organism abundance and diversity and devoid of pollution sensitive taxa, nonsupporting habitat, and lower water quality from elevated nitrogen and total sodium. Severely impaired conditions at PAXT 0.5 are not surprising since the site is located in a concrete-lined channel in highly urbanized Harrisburg, Pa., and receives strong stormwater pulses and combined sewer overflows. Paxton Creek was identified from 1996 through 2004 as impaired, requiring a TMDL for nutrients, siltation, organic enrichment, low dissolved oxygen, and suspended solids caused by agriculture, combined sewer overflows, urban runoff, storm sewers, construction, and unknown causes.

Downstream view of Paxton Creek, Dauphin Co., Pa.

Swatara Creek Watershed

Six sites were sampled on five tributaries to Swatara Creek. The site on Beaver Creek (BEAV 0.6) had a nonimpaired macroinvertebrate community, excellent habitat, and middle water quality from elevated nitrate, total nitrogen, and total sodium. One site on Manada Creek (MNDA 0.1) had a slightly impaired community, supporting habitat, and middle water quality from elevated nitrate. Manada Creek was identified in 2002 and 2004 as impaired, requiring a TMDL for pathogens,

Chrysemys picta picta (Eastern painted turtle) at Swatara Creek, Lebanon Co., Pa.

nutrients, and siltation caused by road runoff, municipal point source, and an unknown source.

Two sites on Spring Creek (SPRG 0.0 and SPRG 0.4) had moderately impaired communities, either supporting or excellent habitat, and middle or lower water quality from elevated nitrate, total nitrogen, total sodium, and/or total dissolved solids. Spring Creek was identified in 1998 as impaired, requiring a TMDL for suspended solids, siltation, organic enrichment, and low dissolved oxygen caused by urban runoff, storm sewers, agriculture, municipal point source, and unknown causes.

Sites on Quittapahilla (QUIT 0.3) and Little Swatara Creeks (LSWT 0.6) had moderately impaired communities, supporting or partially supporting habitat, and middle water quality. Elevated nitrate and total nitrogen levels were measured on both of these creeks, but the Quittapahilla also had elevated orthophosphate and total phosphorus levels. Quittapahilla Creek was identified in 2002 as impaired, requiring a TMDL for siltation caused by grazing-related agriculture. Little Swatara Creek was identified in 1998 as impaired, requiring a TMDL for nutrients, siltation, organic enrichment, and low dissolved oxygen caused by agriculture, urban runoff, storm sewers, and onsite wastewater.

Four sites were located on Swatara Creek (SWAT 2.3 to SWAT 56.0). Macroinvertebrate communities at these sites range from nonimpaired in the headwaters to moderately impaired at the most downstream site, with habitat also spanning from partially supporting to excellent. Water quality is rated as middle for all four sites, with nitrate as the most common parameter of concern. Total nitrogen was elevated only at SWAT 21.7, and low total alkalinity was measured at the two upstream sites. Swatara Creek was identified from 1996 to 2002 as impaired, requiring a TMDL for metals, low dissolved oxygen, biological oxygen demand, pH, metals, suspended solids, siltation, and nutrients caused by AMD, urban runoff, storm sewers, agriculture, and crop-related agriculture.

Central Appalachian Ridge and Valley Ecoregions

East Conewago and West Conewago Creeks Watersheds

One site was located at the mouth of the East Conewago Creek (ECON 0.0) and had a slightly impaired macroinvertebrate community, excellent habitat, and middle water quality from elevated nitrate and total nitrogen.

Four sites were located on three tributaries to West Conewago Creek. The two sites on Bermudian Creek (BERM 1.2 and BERM 11.0) had either nonimpaired or slightly impaired communities, supporting or excellent habitat, and middle water quality. The site on Little Conewago Creek (LCON 1.5) had a moderately impaired community, excellent habitat, and middle water quality. The site on the South Branch Conewago Creek (SBCC 1.2) had a slightly impaired community, excellent habitat, and middle water quality. All these sites had elevated nitrate and total nitrogen levels. South Branch Conewago Creek was identified in 2004 as impaired, requiring a TMDL for siltation caused by agriculture.

Downstream view of Bermudian Creek, Adams Co., Pa.

Five sites were located on West Conewago Creek (WCON 2.9 to WCON 66.5). All sites had slightly impaired communities except for WCON 56.3, which had a nonimpaired community. Habitat at most of the sites was either excellent or supporting, with nonsupporting habitat conditions existing at WCON 35.5 because of lack of instream habitat and poor riparian conditions. All sites had middle water quality from elevated nitrate and total nitrogen.

Northern Piedmont Ecoregions

Codorus Creek Watershed

Two sites were located on South Branch Codorus Creek. One of these sites (SBCD 0.4) had a nonimpaired community, excellent habitat, middle water quality, and served as a 2011 reference site for the 64L subecoregion. The second site (SBCD 3.6) had a moderately impaired community, partially supporting habitat, and middle water quality. Both sites had elevated levels of nitrate and total nitrogen. South Branch Codorus Creek was identified in 1996 and 2002 as impaired, requiring a TMDL for nutrients, suspended solids, and siltation caused by agriculture, urban runoff, and storm sewers.

Five sites were located on Codorus Creek (CODO 0.6 to CODO 36.8) and had slightly impaired to moderately impaired communities and partially supporting to excellent habitat. All Codorus Creek sites had middle water quality from elevated nitrate and total nitrogen. CODO 33.0 had elevated total suspended solids, and the two most downstream sites (CODO 0.6 and CODO 22.4) had elevated sodium. CODO 0.6 is located downstream of the city of York, Pa. Codorus Creek was identified from 1996 through 2004 as impaired, requiring a TMDL for unknown toxicity, excessive algal growth, siltation, color, dissolved oxygen, biological oxygen demand, thermal modifications, suspended solids, and nutrients caused by urban runoff, storm sewers, industrial point source, and agriculture.

Chiques Creek Watershed

Little Chiques Creek (LCHQ 0.4) had a slightly impaired community, excellent habitat, and middle water quality. The two sites on Chiques Creek (CHIQ 3.0 and CHIQ 20.0) had either nonimpaired or slightly impaired communities, supporting or excellent habitat, and middle water quality. All three sites in this watershed had elevated nitrate and total nitrogen, with the Little Chiques Creek site and most downstream Chiques Creek site (CHIQ 3.0) experiencing levels among the highest observed during the survey. Little Chiques Creek was identified in 1998 as impaired, requiring a TMDL for nutrients, siltation, organic enrichment, and low dissolved oxygen caused by agriculture, urban runoff, storm sewers, and onsite wastewater. Chiques Creek was identified in 1996 and 1998 as impaired, requiring a TMDL for nutrients and siltation caused by agriculture, urban runoff, storm sewers, and unknown sources.

Kreutz Creek Watershed

One site was located on Kreutz Creek (KRTZ 1.5), which had a slightly impaired community, supporting habitat, and middle water quality based on elevated nitrate and total nitrogen. Kreutz Creek was identified in 2002 as impaired, requiring a TMDL for siltation problems caused by road runoff, urban runoff, and removal of vegetation.

Conestoga River Watershed

Sites on six tributaries to the Conestoga River were sampled as well as four sites on the river itself. Two sites on the Cocalico Creek (CCLC 0.4 and CCLC 12.2) had slightly impaired or nonimpaired communities, partially supporting or excellent habitat, and middle water quality from elevated nitrate, total nitrogen, and total orthophosphate. The sites on Hammer Creek (HAMM 0.2) and Muddy Creek (MUDD 0.2) had nonimpaired communities, supporting habitat, and middle water quality from elevated nitrate and total nitrogen. Both Hammer and Muddy Creeks were identified in 2002 as impaired and requiring a TMDL for siltation and nutrients caused by various agricultural practices.

Little Conestoga River (LCNT 1.7) had a nonimpaired community, excellent habitat, and middle water quality due to elevated nitrate, total nitrogen, total sodium, and hardness. LCNT 1.7 served as a 2011 reference site for the 64d subecoregion. Middle Creek (MIDD 0.0) had a nonimpaired community, partially supporting habitat, and middle water quality because of elevated nitrate and total nitrogen. Little Conestoga River was identified in 2002 as impaired, requiring a TMDL for siltation and nutrients caused by urban runoff, storm sewers, grazing-related and crop-related agriculture, erosion from derelict land, and unknown causes.

Mill Creek (MILL 0.3) had a slightly impaired community, supporting habitat, and lower water quality because of elevated nitrate, total nitrogen, orthophosphate, total sodium, and hardness. Mill Creek was identified in 1996 and 2002 as impaired, requiring a TMDL for salinity, total dissolved solids, chlorides, siltation, nutrients, and suspended solids caused by an industrial point source, agriculture, land development, and crop-related and grazing-related agriculture.

Conestoga River, Lancaster County, Pa.

The four sites on the Conestoga River (CNTG 0.9 to CNTG 43.9) had slightly impaired or nonimpaired communities and middle water quality. The Conestoga River runs through the city of Lancaster, Pa. Habitat ranged from supporting at the upstream sites to nonsupporting at the downstream sites due to lack of instream habitat and/or compromised riparian integrity. All sites had elevated nitrate and total nitrogen, but the two downstream sites also had elevated orthophosphate, total phosphorus, total sodium, and/or total suspended solids. The orthophosphate and total phosphorus levels seen at CNTG 0.9 were the highest seen in the survey.

The Conestoga River was identified in 2002 as impaired and requiring a TMDL for mercury, chlorine, organic enrichment, low dissolved oxygen, nutrients, and siltation caused by municipal point sources, various agricultural practices, small residential runoff, upstream impoundment, surface mining, golf courses, channelization, urban runoff, and removal of vegetation. Currently, SRBC is in the early stages of collecting data to develop the Conestoga River TMDL to address the nutrient and siltation pollutants.

Pequea Creek Watershed

The site on Big Beaver Creek (SBEV 2.5), a tributary to Pequea Creek, had a slightly impaired community, excellent habitat, and middle water quality. Both Pequea Creek sites (PQEA 3.3 and PQEA 15.2) had nonimpaired communities, partially supporting habitat, and middle water quality. All sites in the watershed had elevated nitrate and total nitrogen measurements. PQEA 15.2 also had elevated orthophosphate and total phosphorus and the highest levels of total aluminum (0.86 mg/l) measured during the survey. Pequea Creek was identified in 2002 and 2004 as impaired, requiring a TMDL for nutrients, organic enrichment, low dissolved oxygen, and siltation caused by agriculture.

Muddy Creek Watershed

Both the South Branch Muddy Creek (SBMY 0.0) and Muddy Creek (MDDY 3.3) sites had slightly impaired communities, either excellent or partially supporting habitat, and middle water quality. The North Branch Muddy Creek site (NBMY 0.0) had a nonimpaired community, excellent habitat, middle water quality, and functioned as a 2011 reference site for the 64ac subecoregion. In addition to elevated nitrate and total nitrogen measured at all three sites, the North Branch site had low total alkalinity. Muddy Creek was identified in 2002 as impaired, requiring a TMDL for siltation and nutrients caused by agricultural practices.

Conowingo Creek Watershed

The site on Conowingo Creek (CNWG 1.8) had a moderately impaired community, excellent habitat, and middle water quality. The elevated nitrate and total nitrogen levels measured at this site were among the highest observed during the survey. Conowingo Creek is sampled quarterly as part of SRBC's Interstate Streams Monitoring Program and consistently exhibits high levels of nitrate and total nitrogen. Conowingo Creek was identified in 1996 and 2004 as impaired, requiring a TMDL for nutrients, suspended solids, organic enrichment, and low dissolved oxygen caused by various agricultural practices.

Octoraro Creek Watershed

Both the East Branch and West Branch Octoraro Creek sites (EBOC 5.3 and WBOC 4.3, respectively) had excellent habitat and middle water quality, but the East Branch site had a moderately impaired community, while the West Branch site had a slightly impaired community. The Octoraro Creek site had a nonimpaired community, supporting habitat, and middle water quality. All sites in this watershed had elevated nitrate and total nitrogen levels. SRBC monitored the Octoraro Creek Watershed for about four years and is currently developing the Octoraro Creek TMDL under contract with PADEP.

Octoraro Creek, Cecil County, Md.

Deer Creek Watershed

The site on Cabbage Run (CABB 0.1), a tributary to Deer Creek, had a moderately impaired community, excellent habitat, and middle water quality. A site on another unnamed tributary (UNTD 0.5) had a slightly impaired community, excellent habitat, and middle water quality. The two sites on Deer Creek (DEER 1.2 and DEER 30.1) had either a slightly impaired or nonimpaired community, excellent or supporting habitat, and middle water quality. All sites within this watershed had middle water quality from elevated nitrate and total nitrogen.

Susquehanna River Mainstem

2011 was marked by record-setting precipitation amounts in the Susquehanna River Basin, which resulted in perpetual high flows that prevented SRBC from any sampling activities on the mainstem Susquehanna River. In particular, flooding from high flows and Hurricane Irene and Tropical Storm Lee in September guaranteed that no sampling could take place in 2011. Subsequently, there are no macroinvertebrate or water quality sampling results available for 2011.

Comparison to Historical Data

The data collected from the Lower Susquehanna River Subbasin in 2011 were compared to the data collected in 1996 and 2005. The number of sites sampled in all three years was similar. The results for biological, habitat, and water quality conditions for these three years are depicted in Figures 8 through 10. A comparison of condition categories throughout these surveys is shown in Table 4.

Biology

Overall, the 2011 biological results are similar to those observed in 1996, with the healthiest results being demonstrated in 2005 (Figure 8). The percentage of moderately impaired sites has steadily increased from 1996 (18 percent) to 2011 (27 percent), while the percentage of severely impaired sites has decreased from 1996 (4 percent) to 2011 (2 percent). Two of the four sites identified in 1996 as severely impaired—CODO 22.4 on Codorus Creek and WCON 35.5 on Conewago Creek—are currently classified as slightly impaired. The third site, SHAM 2.7 on Shamokin Creek, is now classified as moderately impaired, while the fourth site, PAXT 0.5 on heavily urbanized Paxton Creek, is still classified as severely impaired. A new site sampled for the first time in 2011, WICO 27.0 on Wiconisco Creek, was also classified as severely impaired.

Biological condition categories determined in 2011 were compared to those determined in the previous sampling event (either 1996 or 2005) for each site (Table 4). In the Northern Piedmont ecoregion, the majority of sites (average of 48 percent) demonstrated no change in biological condition categories. Degraded condition categories were noted at an average of 26 percent of sites, while improved condition categories were noted at an average of 18 percent of sites.

In the Blue Ridge and Ridge and Valley ecoregion, most sites (average of 41 percent) exhibited no change in biological condition category. Degraded condition categories were observed at an average of 25 percent of sites, and the same amount of sites showed condition category improvement.

Habitat

Like the trends observed for the biological data, the 2011 habitat results are most similar to those observed in 1996, when the number of sites with the highest habitat rating occurred (Figure 9). The percentage of sites with excellent habitat decreased from 56 percent in 1996 to 33 percent in 2005 before rebounding to 48 percent in 2011. Across sites, 79 percent of sites in 2011 either had excellent or supporting habitat, compared to 89 percent in 2005 and 82 percent in 1996. Twenty percent of sites in 2011 were classified as having partially supporting or nonsupporting habitat, compared to 11 percent in 2005 and 18 percent in 1996.

Habitat is the condition that can be more difficult to compare between sampling event years due to greater variability in assessments. However, in the Northern Piedmont ecoregion, an average of 50 percent of sites demonstrated stable habitat condition categories from the previous sampling event. An average of 26 percent of sites experienced a degradation, and an average of 20 percent demonstrated an improvement in habitat condition categories.

In the Blue Ridge and Ridge and Valley ecoregion, an average of 40 percent of sites maintained stable habitat condition categories, while an average of 31 percent of sites showed a degradation in condition categories. An average of 25 percent of sites exhibited an improvement in condition category.

Table 4. Comparison of Condition Categories (1996, 2005, and 2011 data)

		Percent of sites and pattern of changing Condition Categories (1996, 2005, and 2011 data)[1]								
		Biology			Habitat			Water Quality		
	Watershed Size	Improved	Degraded	No Change	Improved	Degraded	No Change	Improved	Degraded	No Change
Northern Piedmont sites	< 100 sq mi	17	40	30	27	10	53	10	3	77
	> 100 sq mi	18	12	65	12	41	47	24	0	76
	Mean	**18**	**26**	**48**	**20**	**26**	**50**	**17**	**2**	**77**
Blue Ridge and Ridge and Valley sites	< 100 sq mi	30	16	41	22	22	46	14	14	62
	> 100 sq mi	20	33	40	27	40	33	13	27	60
	Mean	**25**	**25**	**41**	**25**	**31**	**40**	**14**	**21**	**61**
Mainstem sites[2]		--	--	--	--	--	--	--	--	--

[1] Percentage differentials result from sites that were not included in analysis because of incomplete data.

[2] Mainstem sites were not sampled in 2011.

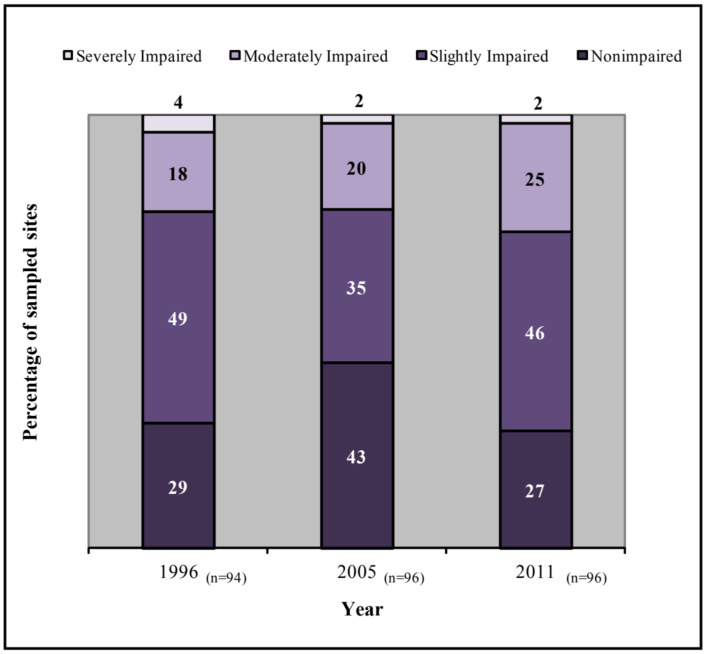


Figure 8. Historical Biological Condition Categories Among Sampled Sites in the Lower Susquehanna Subbasin Surveys

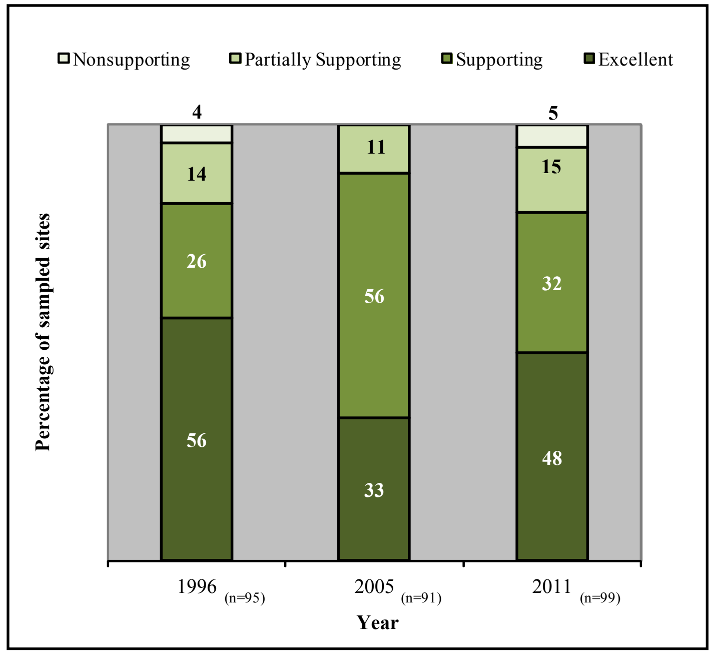


Figure 9. Historical Habitat Condition Categories Among Sampled Sites in the Lower Susquehanna Subbasin Surveys

Water Quality

Trends in water quality condition categories are illustrated in Figure 10. Lower water quality conditions were observed at 8 percent of sites in 2011, which is an improvement from the 2005 finding of 15 percent. The 2011 findings, however, were similar to the 8 percent observed in 1996. Higher water quality was observed at only 2 percent of sites in 2011, compared to 6 percent in 2005, and similar to the 2 percent in 1996. Stations with middle water quality were observed at 90 percent of sites in 2011, which is similar to the 89 percent in 1996 and more than the 77 percent in 1995.

Since the previous sampling event, an average of 77 percent of sites in the Northern Piedmont ecoregion experienced no change in water quality ratings. An average of 17 percent showed rating improvement, and only an average of 2 percent showed rating degradation. In the Blue Ridge and Ridge and Valley ecoregion, an average of 61 percent of sites showed no water quality rating change. An average of 21 percent demonstrated a rating degradation, and an average of 14 percent demonstrated rating improvement.

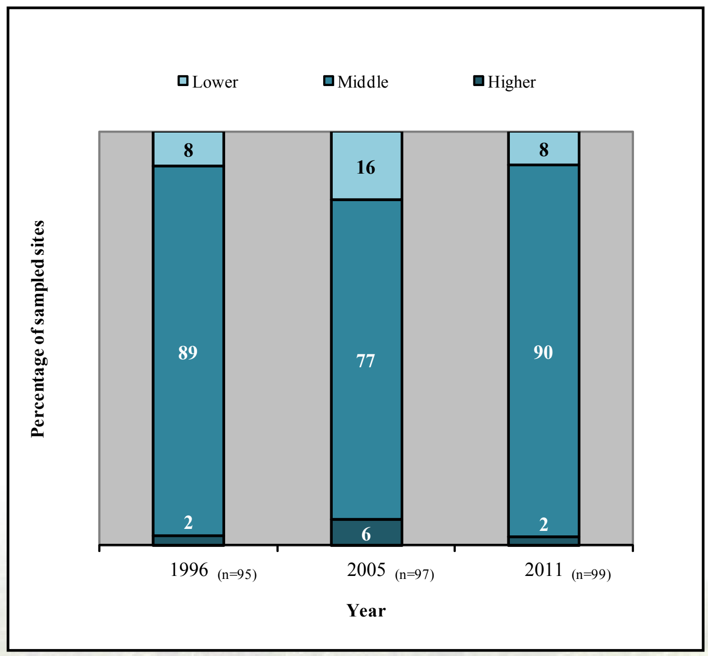
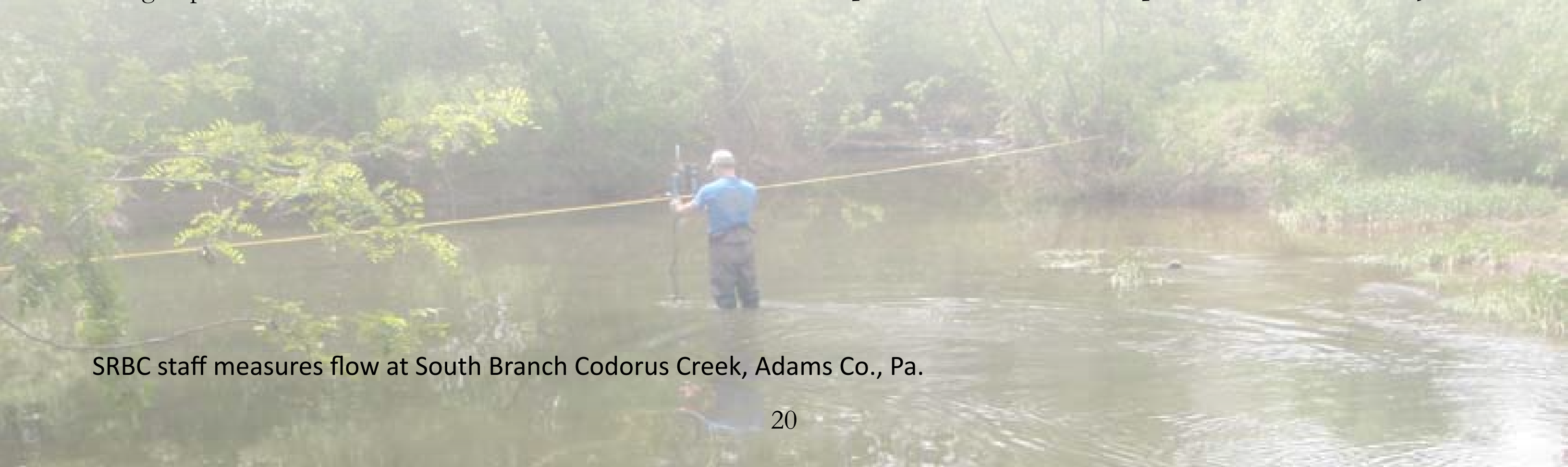


Figure 10. Historical Water Quality Categories Among Sampled Sites in the Lower Susquehanna Subbasin Surveys



SRBC staff measures flow at South Branch Codorus Creek, Adams Co., Pa.

General Trends

Overall, most regions experienced both improvements and degradation in the three condition categories among their sites, but a large percentage of condition categories remained stable in the six years since the last subbasin survey. Approximately 39 percent of all 2011 sites with historical data did not see a change in biological condition categories, with 24 percent of the sites showing degradation, and 21 percent showing improvement. Approximately 44 percent of all sites showed no condition category change for habitat, with 23 percent showing degradation, and 21 percent showing improvement. Approximately 65 percent of all sites showed no change in water quality condition categories, with 10 percent showing degradation, and 13 percent showing improvement. Percentages that are unaccounted for are comprised of sites that were new in 2011 or were not sampled in 2011.

Water quality data collected during the last three surveys in 1996, 2005, and 2011 were compared to determine what sites have chronic issues exceeding levels of concern and what parameters are involved (see Table 5). Consistent with patterns observed in the past subbasin surveys, nitrate and total nitrogen were the parameters that were consistently elevated at many of the sites (85 and 83 sites, respectively). These sites are evenly split among the Northern Piedmont and Ridge and Valley ecoregions for nitrate, but are slightly more prominent in the Northern Piedmont for total nitrogen.

The third most common parameter seen at levels of concern in the last three surveys was orthophosphate, which was observed consistently at seven sites, with five of those sites located in the Northern Piedmont. Total phosphorus was the next most prevalent parameter, with consistently elevated levels occurring at three sites in the subbasin, mostly in the Northern Piedmont. Low total alkalinity occurred at 11 sites in the subbasin, predominantly in the Blue Ridge/Ridge and Valley.

Of the five sites previously mentioned as having five or six parameters exceeding levels of concern in 2011, all of them have had consistent issues throughout the history of the subbasin surveys. The Conestoga River (CNTG 0.9) always has had issues with nitrate, total nitrogen, orthophosphate, total phosphorus, and total sodium. Mahanoy Creek (MHNY 0.3) has had consistent issues with nitrate, total nitrogen, hardness, manganese, magnesium, and sulfate. Mill Creek (MILL 0.3) has had issues with total nitrogen, orthophosphorus, sodium, and hardness. Pequea Creek (PQEA 15.2) has had consistent issues with nitrate, total nitrogen, orthophosphorus, and total phosphorus. Yellow Breeches Creek (YLBR 0.1) has had consistent issues with nitrate and total nitrogen.

Another site that had several recurring issues was Shamokin Creek (SHAM 2.7). Nitrate, iron, and manganese were consistently elevated at this site throughout surveys.

Table 5. List of Sites with Parameters Chronically Exceeding Levels of Concern (1996, 2005, and 2011 Data)

Parameter	Number of Exceeding Measurements	Value [a]			Number of Sites with Chronic Issues			
						Within each ecoregion		
		Minimum	Maximum	Median	Total	Northern Piedmont	Blue Ridge/Ridge and Valley	Mainstem [b]
Nitrate	263	0.61	12	3.69	85	42	42	1
Total Nitrogen	253	1.01	12.3	4	83	43	38	2
Orthophosphate	124	0.02	0.445	0.052	7	5	1	0
Total Phosphorus	49	0.1	0.902	0.147	3	2	1	0
Sodium	37	20.6	80.5	30.6	7	5	2	0
Alkalinity	36	0	19.4	11	11	1	10	0
Hardness	10	300	432.7	322	3	1	2	0
Iron	7	1.63	3.03	1.93	1	0	1	0
Manganese	6	1.71	2.91	2.31	2	0	2	0
Sulfate	3	305	381	325	1	0	1	0
Calcium	3	102	111	105	0	0	0	0
pH	3	4.25	5.95	4.5	0	0	0	0
Magnesium	3	46.1	47.3	46.2	1	0	1	0
Conductance	3	822	940	883	0	0	0	0
Acidity	2	22	24	23	0	0	0	0

Aluminum, TSS, TDS, and Turbidity not reported since they were not collected all three years.

[a] All values are in mg/l except for pH (standard pH units) and conductivity (µmhos/cm).

[b] Mainstem sites were not sampled for chemistry in 2011, so comparisons are only from 1996 to 2005.

Conclusions

In general, the sites sampled during the 2011 survey of the Lower Susquehanna Subbasin had satisfactory results, but problems persist throughout many areas. The majority of sites sampled had either nonimpaired or slightly impaired macroinvertebrate communities as well as excellent or supporting habitat. Nearly all sites had at least one water quality parameter exceed a level of concern. Less than 30 percent of the sites sampled had nonimpaired biological conditions, and less than 5 percent of the sites had higher water quality ratings. Less than 50 percent of the habitat assessments were excellent, suggesting more effort is needed to physically protect streams.

The largest cause of impairment appeared to be from nutrients, primarily nitrate and total nitrogen, which may have originated from excess fertilization of agricultural fields and residential lawns, uncontrolled barnyard runoff, livestock directly accessing streams, increased loads from point sources, leaking septic tanks, outdated sewage treatment plants, or combined sewer overflows. Combined sewer overflows occur in some older towns where the infrastructure was developed to channel stormwater runoff from the streets into the wastewater treatment plants. When these systems receive too much water, as occurs during a storm, they are unable to process and treat the waste, resulting in raw sewage discharge to the streams.

Another significant source of pollution appeared to be urbanization. Sodium levels were high in numerous streams, and habitat assessments indicated problems with channelized streams, eroded banks, and litter. In areas where most of the land is paved or developed, there is no place for precipitation to be absorbed in the ground, which leads to runoff. Problems that result from this runoff are higher water temperatures from the hot pavement, higher velocity and volume of water over shorter time periods, and higher concentrations of pollutants being washed off the pavement. Elevated sodium levels were found in streams that drain York, Lancaster, Hershey, and the greater Harrisburg area.

AMD in this subbasin was minimal and was concentrated mostly in a small northeastern section of the subbasin. Only a few sites showed possible effects due to AMD, and those effects were very slight for most of those sites. Restoration efforts by watershed groups and local government may have helped these watersheds.

In the past several years, SRBC has continued its focus on stormwater remediation support within targeted watersheds within the Lower Susquehanna Subbasin. In 2010, SRBC completed a four-year stormwater management demonstration


Sherman Creek, Perry County, Pa.

project using Paxton Creek in urbanized Dauphin County, Pa., as a model watershed in conjunction with the Paxton Creek Watershed and Project Education Association. More information on this project can be found at www.srbc.net/programs/paxton/index.asp. SRBC is currently in the early stages of collecting data to develop the TMDL for the urbanized Cedar Run Watershed in Cumberland County, Pa.

SRBC is also currently conducting long-term monitoring in the Conestoga River Watershed for the purpose of developing a TMDL in the future and is in the middle of developing the Octoraro Creek TMDL. In addition, SRBC has collected annual biological samples and annual and/or seasonal water chemistry since the 1980s along 11 sites located in the Lower Susquehanna Subbasin as part of its Interstate Water Quality Network (www.srbc.net/interstate_streams/).

Some of the highest quality watersheds within the Lower Susquehanna River Subbasin were Sherman, Powell, and Clarks Creeks. Some watersheds that also rated well overall were Muddy, Deer, Penns, Middle, North and West Branch Mahantango, Chiques, and Pequea Creeks and some portions of the Conestoga River. Although these watersheds contained a large amount of agricultural land and did have higher nutrient levels, they did not have heavy urban influence. Naturally vegetated buffers serve to protect the stream and provide necessary habitat to the aquatic insects and fish.

Some of the most degraded watersheds were Wiconisco, Conodoguinet, Swatara, Mahanoy, Codorus, Shamokin, and Paxton Creeks. Shamokin, Mahanoy, and Wiconisco Creeks were impacted by AMD, Paxton Creek by urban development, and the Swatara, Codorus, and Conodoguinet by a mix of agriculture and urban development. Portions of both the Conodoguinet and Yellow Breeches Watersheds appeared to be influenced by limestone geology. The sampling in this survey was a one-time event at sites that were chosen for ease of access, so replicate and more representative sampling along more segments in watersheds would be needed to truly identify and isolate problems in these watersheds.

Efforts should be made to restore the most degraded watersheds and protect the higher quality ones within this subbasin. Agricultural best management practices can be used to limit the impacts associated with farming operations. Information on these practices and other conservation methods can be obtained from county conservation district offices (www.pacd.org). Grant opportunities to alleviate AMD impacts and more information on remediation technologies also are available in county conservation district offices and from the Eastern Pennsylvania Coalition for Abandoned Mine Reclamation (www.orangewaternetwork.org). Urban stormwater problems can be minimized with low impact development and by allowing for groundwater recharge areas. More information on urban pollution remediation can be obtained from the Center for Watershed Protection through its Urban Subwatershed Restoration Manual series (www.cwp.org) and from the PADEP's Pennsylvania Stormwater Best Management Practices Manual (PADEP, 2006).

The Lower Susquehanna Subbasin Survey Year-2 assessment is being conducted in the three reservoirs along the last 45 miles of the Susquehanna River: Lake Aldred, Lake Clarke, and Conowingo Pond. This Year-2 study will focus on the Lower Susquehanna mainstem as a single hydrologic system and will involve the collection of water chemistry and biological data. Data collection began in April 2012 and is expected to go into November 2012, and a final report will be available in late 2013. More information on this project is available from SRBC.

Collecting macroinvertebrate samples along Rattling Creek, Dauphin County, Pa.

Appendix: Sample Site List

Sample Site #	Station Name	Location Description	Latitude	Longitude	Drainage (miles^2)	Designation
1	ARMS 0.1	Armstrong Creek upstream of Rt. 147 bridge near Halifax, Dauphin Co., Pa.	40.48419	-76.93178	32.3	67b
2	BEAV 0.6	Beaver Creek at third bridge from the mouth on Pleasant View Drive at Pleasant View, Dauphin Co., Pa.	40.27033	-76.74131	26.8	67a
3	BERM 1.2	Bermudian Creek at Blue Hill School Road bridge near Detters Mill, York Co., Pa.	39.99883	-76.94142	109.1	64L
4	BERM 11.0	Bermudian Creek at Latimore Valley Road bridge east of York Springs, Adams Co., Pa.	40.00144	-77.05867	44.2	64ac
5	CABB 0.1	Cabbage Run Branch upstream of Walters Mill Road near Chestnut Hill, Harford Co., Md.	39.62058	-76.33321	7.3	64ac
6	CCLC 0.4	Cocalico Creek at Log Cabin Road covered bridge near Millport, Lancaster Co., Pa.	40.13014	-76.23156	138.9	64L
7	CCLC 13.4	Cocalico Creek upstream of Royer Road bridge west of Ephrata, Lancaster Co., Pa.	40.17260	-76.20033	66.1	64d
8	CEDR 0.1	Cedar Run upstream of Creek Road bridge at Eberlys Mill, Cumberland Co., Pa.	40.22520	-76.90633	12.5	67a
9	CHIQ 3.0	Chiques Creek upstream of bridge at Marietta Pike near Marietta, downstream of confluence, Lancaster Co., Pa.	40.20601	-76.39430	108.0	64L
10	CHIQ 20.0	Chiques Creek at Elizabeth Road bridge north of Manheim, Lancaster Co., Pa.	40.06326	-76.51541	18.3	64ac
11	CLRK3.8	Clarks Creek upstream of Rt. 225 bridge north of Dauphin, Dauphin Co., Pa.	40.38804	-76.94174	40.0	67cd
12	**CNTG 0.9**	**Conestoga River along River Road in Safe Harbor Park, Lancaster Co., Pa.**	**39.93420**	**-76.38580**	**472.5**	**64L**
13	CNTG 22.6	Conestoga River at Penn Railroad bridge in Lancaster City, between dam and WWTP outlet, Lancaster Co., Pa.	40.05000	-76.27750	322.0	64L
14	CNTG 32.7	Conestoga River at SR 1010 bridge near Brownstown, Lancaster Co., Pa.	40.12801	-76.20006	125.7	64L
15	CNTG 43.9	Conestoga River ~150m downstream Quarry Road bridge near Weaverland, Lancaster Co., Pa.	40.13810	-76.06050	48.2	64d
16	CNWG 1.8	Conowingo Creek at Old Mill Road/Twn Rd 434 bridge near mouth at state line, Lancaster Co., Pa.	39.72453	-76.18336	33.3	64ac
17	CODO 0.6	Codorus Creek ~200m upstream of Codorus Furnace Road bridge, York Co., Pa.	40.05226	-76.65509	276.6	64L
18	CODO 20.9	Codorus Creek at Martin Road bridge downstream of Spring Grove, York Co., Pa.	39.88750	-76.83620	75.5	64d
19	**CODO 25.5**	**Codorus Creek upstream of SR 3053 (Colonial Valley Road) Bridge near Menges Mills, York Co., Pa.**	**39.86269**	**-76.88976**	**63.9**	**64d**
20	CODO 33.0	Codorus Creek along SR 3047 downstream of Lake Marburg outflow confluence, York Co., Pa.	39.82210	-76.88850	40.0	64ac
21	CODO 36.8	Codorus Creek upstream of Tannery Road bridge near Glenville, York Co., Pa.	39.78085	-76.84061	13.2	64ac
22	CONO 1.3	Conodoguinet Creek upstream of Center Road bridge near Camp Hill, Cumberland Co., Pa.	40.26053	-76.93489	502.3	67L
23	CONO 28.8	Conodoguinet Creek upstream of Middlesex Road near Carlisle, Cumberland Co., Pa.	40.23669	-77.14486	396.0	67L
24	CONO 51.8	Conodoguinet Creek at SR 4006 bridge near Newville, Cumberland Co., Pa.	40.17747	-77.45431	208.8	67L
25	CONO 66.0	Conodoguinet Creek at Burnt Mill Road bridge north of Shippensburg, Franklin Co., Pa.	40.10453	-77.56069	107.3	67L
26	DEEP 1.2	Deep Creek upstream of Mill Road bridge near Sacramento, Schuylkill Co., Pa.	40.63814	-76.60797	31.3	67b
27	DEER 1.2	Deer Creek ~200m upstream of Stafford Road bridge near Susquehanna State Park, Harford Co., Md.	39.62269	-76.16447	169.3	64L
28	DEER 30.1	Deer Creek upstream of Fawn Grove Road at Eden Mill Park, Harford Co., Md.	39.67490	-76.44830	61.3	64ac
29	EBOC 5.3	East Branch Octoraro Creek at John Evans Memorial Park near Cream, Lancaster/Chester Cos., Pa.	39.83061	-76.01756	75.6	64ac
30	ECON 0.0	East Conewago Creek upstream from Covered Road bridge near Falmouth, Lancaster/Dauphin Cos., Pa.	40.14722	-76.69931	51.3	64ac
31	ELKN 0.1	Elk Creek upstream of Pine Creek near Coburn, Centre Co., Pa.	40.86850	-77.45630	56.8	67a
32	EMAH 0.2	Mahantango Creek upstream of Rt. 147 bridge near Paxton at pull-off, Dauphin Co., Pa.	40.60989	-76.92958	164.2	67L
33	EMAH 17.1	Mahantango Creek in park at Klingerstown, Schuylkill Co., Pa.	40.66017	-76.68575	44.6	67b
34	EMAH 23.5	Mahantango Creek upstream of confluence, farther from Creek Road, Schuylkill Co., Pa.	40.67396	-76.61479	19.3	67b
35	EPIN 0.1	Pine Creek near Klingerstown, Schuylkill Co., Pa.	40.66144	-76.69278	77.0	67b

Sample Site #	Station Name	Location Description	Latitude	Longitude	Drainage (miles^2)	Designation
36	EPIN 12.7	Pine Creek at Spring Glen upstream of Spring Glen Drive, upstream of culvert, Schuylkill Co., Pa.	40.62753	-76.62075	28.5	67cd
37	HAMM 0.2	Hammer Creek at mouth along Millway Road, Lancaster Co., Pa.	40.16100	-76.23375	35.2	64d
38	KRTZ 1.5	Kreutz Creek at Cool Creek Road bridge, downstream of golf course in Wrightsville, York Co., Pa.	40.01528	-76.53950	32.8	64d
39	LCHQ 0.4	Little Chiques Creek upstream of Iron Bridge Road, Lancaster Co., Pa.	40.07933	-76.50700	43.1	64d
40	LCNT 1.7 *	Little Conestoga River at mouth near Rockhill along Creek Road, Lancaster Co., Pa.	39.95250	-76.36970	65.5	64d
41	LCON 1.5	Little Conewago Creek at mouth in Conewago Heights, upstream of Bowers Bridge Road, York Co., Pa.	40.08822	-76.72717	65.4	64ac
42	LRLN 0.8 *	Laurel Run downstream of SR 3020 bridge north of Laurelton, below confluence, Union Co., Pa.	40.89317	-77.20381	10.5	67b
43	LRSL 0.5 *	Laurel Run upstream of Laurel Run Road bridge near Landisburg, Perry Co., Pa.	40.32244	-77.37800	22.1	67cd
44	LSHM 0.8	Little Shamokin Creek near mouth at Sunbury along Rt. 890, Northumberland Co., Pa.	40.85498	-76.76166	29.0	67b
45	LSWT 0.6	Little Swatara Creek at mouth near Jonestown along Mill Street, Lebanon Co., Pa.	40.40811	-76.47408	99.0	67b
46	LTRT 0.1	Letort Spring Run at Rt. 11 bridge near Carlisle off Mill Road, Cumberland Co., Pa.	40.23425	-77.13858	21.8	67a
47	MDDY 3.3	Muddy Creek at SR 2024 (Paper Mill Road) near Coal Cabin Beach, York Co., Pa.	39.77261	-76.31625	132.8	64L
48	MHNY 0.3	Mahanoy Creek upstream of Rt. 147 bridge near Herdon, Northumberland Co., Pa.	40.72758	-76.83703	157.1	67L
49	MIDD 0.0	Middle Creek upstream of Middle Creek Road bridge north of Millway, Lancaster Co., Pa.	40.16483	-76.23250	31.5	64d
50	MIDL 0.7	Middle Creek downstream of Rt. 35 bridge near mouth at Kantz, Snyder Co., Pa.	40.77317	-76.89844	157.9	67L
51	MIDL 24.7	Middle Creek upstream of Rt. 235 bridge near Beaver Springs, Snyder Co., Pa.	40.76269	-77.20992	33.5	67b
52	MILL 0.3	Mill Creek at Elkman Road bridge near Lyndon, Lancaster Co., Pa.	40.00410	-76.30160	56.4	64d
53	MISP 0.5	Middle Spring Run along Burnt Mill Road north of Shippensburg, Cumberland Co., Pa.	40.09839	-77.56122	45.2	67a
54	MNDA 0.1	Manada Creek upstream of Shetland Drive bridge at mouth in Sand Beach, Dauphin Co., Pa.	40.30878	-76.67106	32.2	67b
55	MNTN 3.0	Mountain Creek along Rt. 34 upstream of Mount Holly Springs, Cumberland Co., Pa.	40.10733	-77.18153	45.0	67cd*
56	MUDD 0.2	Muddy Creek upstream of Frysville Road near Frysville, Lancaster Co., Pa.	40.17160	-76.10570	49.3	64d
57	NBMY 0.0 *	North Branch Muddy Creek near mouth at Muddy Creek Forks, York Co., Pa.	39.80792	-76.47586	43.8	64ac
58	NMHT 0.0	North Branch Mahantango Creek along Reichenbach Road at mouth near Mahantango, Snyder Co., Pa.	40.64770	-76.96630	37.1	67b
59	NMID 0.7	North Branch Middle Creek upstream of Creek Road bridge at Benfer, Snyder Co., Pa.	40.77458	-77.19803	26.1	67b
60	OCTO 1.0	Octoraro Creek at railroad bridges near Rowlandsville, Cecil Co., Md.	39.65989	-76.15333	209.9	64L
61	PAXT 0.5	Paxton Creek at Greenway bridge in Harrisburg, Dauphin Co., Pa.	40.24699	-76.86416	27.3	67b
62	PAXT 8.4	Paxton Creek upstream of Progress Avenue bridge near Harrisburg, Dauphin Co., Pa.	40.30872	-76.84989	11.2	67b
63	PENN 5.0	Penns Creek at Selinsgrove upstream of Mill Road bridge, Snyder Co., Pa.	40.86339	-77.23767	364.3	67L
64	PENN 30.0	Penns Creek at Glen Iron at pull-off along Creek Road, Union Co., Pa.	40.82706	-76.86872	254.1	67L
65	PENN 50.6	Penns Creek at intersection of Penns Creek Rd and Long Lane near Coburn, Centre Co., Pa.	40.85744	-77.48444	90.1	67a
66	POWL 0.1	Powell Creek upstream of Mountain Road bridge near Powells Valley, Dauphin Co., Pa.	40.42025	-76.95939	37.8	67b
67	PQEA 3.3	Pequea Creek at Rt. 324 bridge near Colemansville, Lancaster Co., Pa.	39.95593	-76.24984	150.2	64L
68	PQEA 15.2	Pequea Creek along Shiprock Road upstream of Big Beaver Creek, Lancaster Co., Pa.	39.90562	-76.32814	99.1	64d
69	QUIT 0.3	Quittapahilla Creek upstream of Valley Glen Road bridge in Valley Glen, Lebanon Co., Pa.	40.35225	-76.61169	77.3	67b
70	RATT 0.1	Rattling Creek at Glen Park on SR 4013 in Lykens, Dauphin Co., Pa.	40.56440	-76.69885	19.0	67cd
71	SBCC 1.2	South Branch Conewago Creek at Rt. 30 bridge near New Oxford, Adams Co., Pa.	39.86142	-77.07394	67.6	64ac

Sample Site #	Station Name	Location Description	Latitude	Longitude	Drainage ($miles^2$)	Designation
72	SBCD 0.4 *	South Branch Codorus Creek near mouth at Rails-To-Trails crossing, York Co., Pa.	39.91400	-76.75354	116.4	64L
73	SBCD 3.6	South Branch Codorus Creek at Twin Arch Road bridge at Reynolds Mill, York Co., Pa.	39.89528	-76.74366	68.3	64ac
74	SBEV 2.5	Big Beaver Creek at Krantz Mill Road near Refton, Lancaster Co., Pa.	39.94119	-76.22053	17.3	64d
75	SBMY 0.0	South Branch Muddy Creek along Muddy Creek Forks bridge at Muddy Creek Forks, York Co., Pa.	39.80736	-76.47650	28.1	64ac
76	SHAM 2.7	Shamokin Creek downstream of Rt. 147 bridge in Sunbury, Northumberland Co., Pa.	40.84344	-76.80453	136.9	67L
77	SHRM 2.0 *	Sherman Creek upstream of Dellville bridge in Dellville, Perry Co., Pa.	40.38036	-77.08256	240.9	67L
78	SHRM 27.5 *	Sherman Creek upstream of SR 382 bridge near Loysville, Perry Co., Pa.	40.35136	-77.33525	99.1	67a
79	SPRG 0.0	Spring Creek downstream pipeline at mouth near Hershey, Dauphin Co., Pa.	40.28550	-76.67920	24.0	67a
80	SPRG 0.4	Spring Creek near entrance to Capital Area Greenbelt off South Cameron Street, Dauphin Co., Pa.	40.24295	-76.85713	11.4	67a
81	STON 0.4	Stony Creek along Stony Creek Road near Dauphin, Dauphin Co., Pa.	40.37576	-76.91538	34.4	67cd
82	**SUSQ 44.5**	**Susquehanna River upstream of Rt. 30 bridge near Columbia, Lancaster Co., Pa.**	**40.03720**	**-76.52360**	**26007.0**	**River**
83	**SUSQ 77.0**	**Susquehanna River at Fort Hunter boating access area, Dauphin Co., Pa.**	**40.34360**	**-76.91110**	**23519.2**	**River**
84	**SUSQ 94.0**	**Susquehanna River near Halifax boating access area, Dauphin Co., Pa.**	**40.49000**	**-76.94330**	**19642.0**	**River**
85	**SUSQ 106.0**	**Susquehanna River between McKees Half Falls and Dalmatia, Northumberland Co., Pa.**	**40.65960**	**-76.91850**	**19206.8**	**River**
86	**SUSQ 122.0**	**Susquehanna River between Selinsgrove and Selinsgrove Junction, Northumberland Co., Pa.**	**40.81190**	**-76.84150**	**18442.7**	**River**
87	SWAT 2.3	Swatara Creek downstream of the Pennsylvania Turnpike bridge near Middletown, Dauphin Co., Pa.	40.20533	-76.71300	560.6	64L
88	**SWAT 21.7**	**Swatara Creek downstream of Gravel Hill Road bridge near Valley Glen, Lebanon Co., Pa.**	**40.35256**	**-76.61675**	**355.2**	**67L**
89	SWAT 39.0	Swatara Creek at Rt. 22 bridge near Jonestown, Lebanon Co., Pa.	40.41300	-76.48586	191.6	67L
90	SWAT 56.0	Swatara Creek upstream of Rt. 895 bridge in Pine Grove, Schuylkill Co., Pa.	40.54419	-76.38236	74.0	67b
91	TRDL 0.0	Trindle Spring Run near mouth north of Mechanicsburg, Cumberland Co., Pa.	40.25064	-77.00667	17.8	67a
92	UNTD 0.5	UNT Deer Creek at Thomas Bridge Road near Ady, Harford Co., Md.	39.63970	-76.35029	3.9	64ac
93	WBOC 4.3	West Branch Octoraro Creek upstream of Puseyville Road bridge at State Gamelands No. 136, Lancaster Co., Pa.	39.85106	-76.11011	30.1	64ac
94	WCON 2.9	Conewago Creek downstream Rt. 181 bridge in Conewago Heights, York Co., Pa.	40.08128	-76.71656	512.4	64L
95	WCON 20.4	Conewago Creek at bridge crossing off Conewago Road near Gifford Pinchot State Park, York Co., Pa.	40.06447	-76.86331	388.5	64L
96	WCON 35.5	Conewago Creek upstream of Bermudian Creek near Detters Mill, York Co., Pa.	40.00111	-76.92033	263.1	64L
97	WCON 56.3	Conewago Creek along Group Mill Road at pathway near New Chester, Adams Co., Pa.	39.89860	-77.08440	106.3	64L
98	WCON 66.5	Conewago Creek upstream of Rentzel Road bridge near Table Rock, Adams Co., Pa.	39.92431	-77.20956	39.1	64ac
99	WICO 0.3	Wiconisco Creek downstream of Rt. 147 bridge at recycling center in Millersburg, Dauphin Co., Pa.	40.53686	-76.96228	116.4	67L
100	WICO 27.0	Wiconisco Creek downstream of WWTP, upstream of Main Street bridge in Lykens, Dauphin Co., Pa.	40.56807	-76.71410	34.5	67b
101	WMHT 2.2	West Branch Mahantango Creek off Reichenback Road near pavilion near Mahantango, Snyder Co., Pa.	40.64620	-76.96620	46.9	67b
102	WPIN 0.8	Pine Creek upstream of Elk Creek near Coburn, Centre Co., Pa.	40.86810	-77.45570	93.4	67a
103	YLBR 0.1	Yellow Breeches Creek upstream Bridge Street in New Cumberland, Cumberland/York Cos., Pa.	40.22408	-76.86075	218.5	67L
104	YLBR 35.7	Yellow Breeches Creek upstream of Burnt House Road bridge near Barnitz, Cumberland Co., Pa.	40.12597	-77.21917	55.7	67a

MNTN 3.0 was grouped with 67cd since no other stations were in its subecoregion category.

Bolded blue sites are either missing water chemistry, biological, and/or habitat data from 2011.

Unbolded blue sites have missing data for biology, habitat, and/or water quality for 1996, 2005, and/or 2011.

* Sites serve as ecoregion reference sites for the 2011 study.

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