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Lower Susquehanna Subbasin Survey:

A Water Quality and Biological Assessment, June - November 2005

SUSQUEHANNA RIVER BASIN COMMISSION

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***For more information** on a particular stream or more details on the methods used in this survey, contact Susan L. Buda. For the raw survey data, visit the web site at www.srbc.net/docs/Publications/techreports.htm*

***For additional copies** of this subbasin survey, contact the Commission by e-mail at srbc@srbc.net (other contact information on back page).*

The Susquehanna River Basin Commission (SRBC) conducted a survey of water quality and biological conditions in the Lower Susquehanna Subbasin from June to November 2005. This survey was part of SRBC's Subbasin Survey Program, which is funded in part through the United States Environmental Protection Agency (USEPA). The Subbasin Survey Program consists of two-year assessments in each of the six major subbasins (Figure 1) on a rotating schedule. This report details the Year-1 survey, which entailed point-in-time water chemistry, macroinvertebrate, and habitat data collection and assessments of the major tributaries and areas of interest throughout the Lower Susquehanna Subbasin. A Year-2 survey of bacteriological conditions will be performed in the Yellow Breeches Creek Watershed in Cumberland and York Counties. Previous surveys of the Lower Susquehanna Subbasin were conducted in 1996 (Traver, 1997) and 1985 (McMorran, 1986). A comparison with the 1996 data and the 2005 data is included in this report.

***Figure 1.** The Susquehanna River Subbasin*

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.

Courtesy Susquehanna Greenway Partnership

Susquehanna River north of Harrisburg, Pennsylvania.

Description of the Lower Susquehanna Subbasin

The Lower Susquehanna 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, Pennsylvania, to where the Susquehanna River empties into the Chesapeake Bay in Havre de Grace, Maryland. The 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). Ecoregions that fall within the Lower Susquehanna Subbasin are (Figure 2):

- *Northern Piedmont (Ecoregion 64);*
- *Blue Ridge (Ecoregion 66);*
- *Ridge and Valley (Ecoregion 67); and*
- *Central Appalachians (Ecoregion 69).*

Ecoregion 64 is renowned for agriculture and consequently is dominated by this land use. The low hills, irregular plains, and open valleys are comprised of metamorphic, igneous, and sedimentary rocks. Only a small section of Ecoregion 66 occurs in the Lower Susquehanna Subbasin. This ecoregion has varying terrain comprised of ridges, hills, and mountains and is mostly forested with freestone streams on a mix of metamorphic, igneous, and sedimentary rock. Ecoregion 67 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. Ecoregion 69 is mainly a plateau formation that is predominantly sandstone, shale, conglomerate, and coal. The soils are not conducive to agriculture, so this ecoregion is mostly forested. Only a very small portion of the subbasin is in Ecoregion 69. Eleven different subecoregions are found in the Lower Susquehanna Subbasin (Figure 2):

- *64A - Triassic Lowlands;*
- *64B - Trap Rock and Conglomerate Uplands;*
- *64C - Piedmont Uplands;*
- *64D - Piedmont Limestone/Dolomite Lowlands;*
- *66B - Northern Sedimentary and Metasedimentary Ridges;*
- *67A - Northern Limestone/Dolomite Valleys;*
- *67B - Northern Shale Valleys;*
- *67C - Northern Sandstone Ridges;*
- *67D - Northern Dissected Ridges and Knobs;*
- *67E - Anthracite Subregion; and*
- *69A - Northern Igneous Ridges.*

The mixed land use in the Lower Susquehanna Subbasin is connected to the geology of the region (Figure 2 and Figure 3). In Ecoregion 67 the ridges are mostly forested, and the limestone/dolomite and shale valleys are predominately agricultural. There is little urban development in this Ecoregion portion of the subbasin, 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). The Northern Piedmont (Ecoregion 64) is dominated by cultivated and developed land. More natural vegetated areas are located in the upland and ridge areas, as in the subecoregions of 66B, 69A, and 64B. The largest urban centers in the Lower Susquehanna Subbasin are the Harrisburg, Lancaster, and York areas.

Many environmental organizations throughout the Lower Susquehanna Subbasin are working to restore and protect watersheds. Table 1 lists some of the watershed groups associated with the streams sampled in this survey. Many other local entities, such as county conservation districts and land conservation groups, protect and conserve land and water resources in the subbasin. There are also numerous Pennsylvania

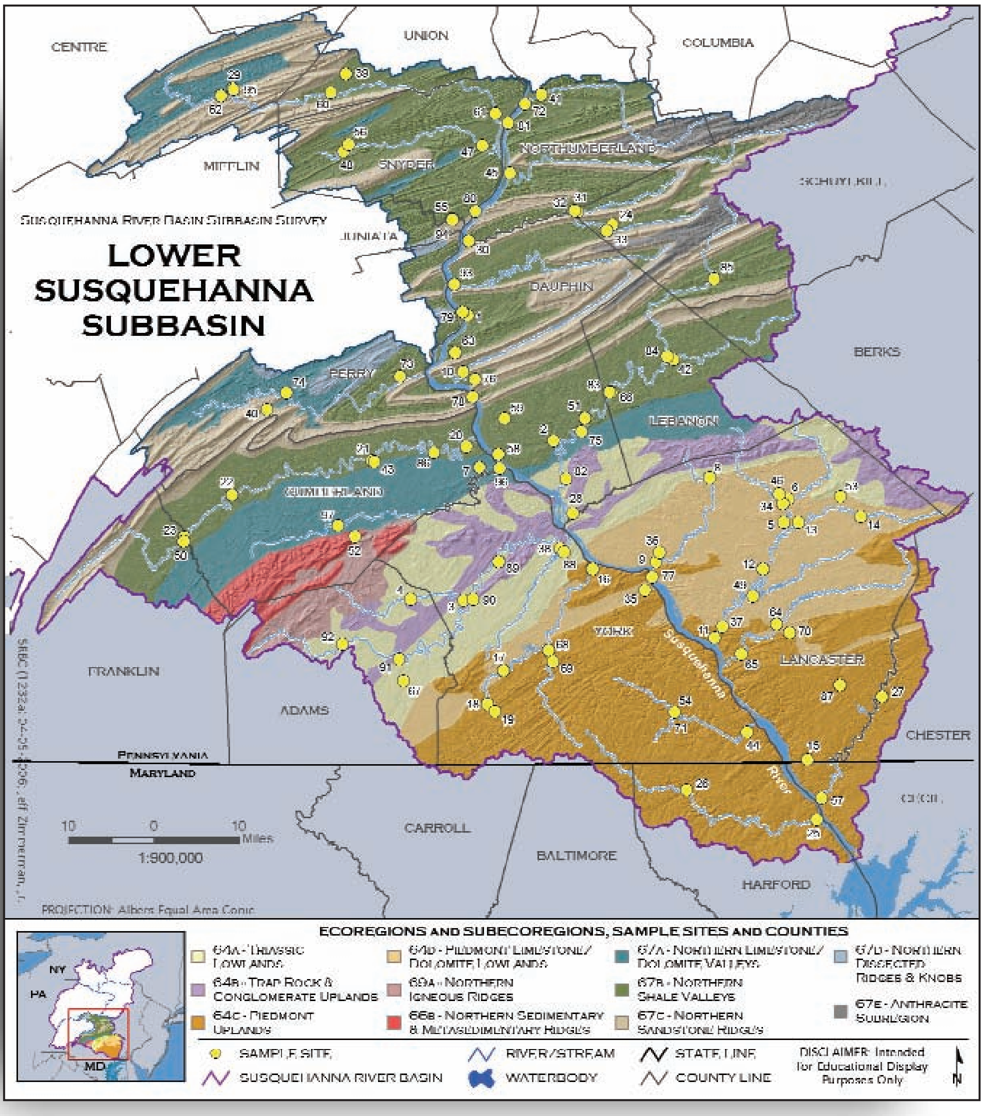

Figure 2. *Ecoregions, Subecoregions, Sample Sites, and Counties in the Lower Susquehanna Subbasin*

Senior Environment Corps (PaSEC) groups throughout the Lower Susquehanna Subbasin that include senior citizens who volunteer to protect and improve watersheds. The website for this organization is *http://www.easi.org/programs/program1.html*, which includes a list of the local PaSEC group locations.

Methods Used in the 2005 Subbasin Survey

DATA COLLECTION

During summer and fall of 2005, SRBC staff collected samples from 97 sites throughout the Lower Susquehanna Subbasin. The appendix 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 reference category. All sites also were sampled in 1996 except the two sites listed in green, CEDR 0.1 and CHIQ 20.0. 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 all 97 sites except BERM 11.0, which lacked riffle habitat. Habitat was rated at the sites where a macroinvertebrate sample was collected, except for the river sites.

The sites were sampled once during this Year-1 sampling effort to provide a point-in-time picture of stream characteristics throughout the whole 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).

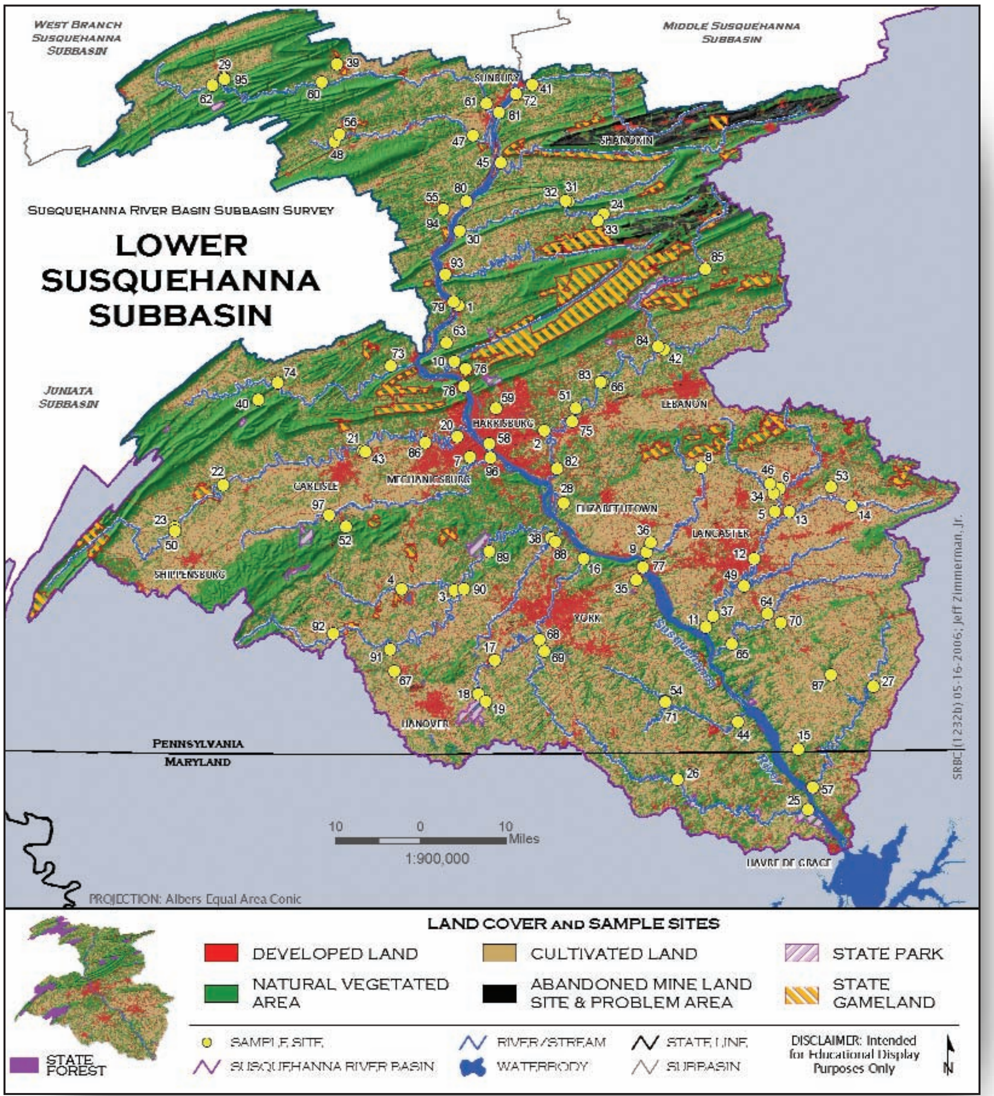

***Figure 3.** Land Cover and Sample Sites in the Lower Susquehanna Subbasin*

***Table 1.** Contact Information for Watershed Organizations of Streams Sampled in the Lower Susquehanna Subbasin*

Organization Name	County	Contact	Person Address	Phone	Email or Website
Chiques Creek Watershed Alliance	Lancaster	Ms. Nancy Halliwell	971 N. Colebrook Rd., Manheim, PA 17545	(717) 665-3827	nancy@raphotownship.com
Cocalico Creek Watershed Association	Lancaster	Mr. Mike Ashton	P.O. Box 121, Reinholds, PA 17569	(717) 733-6931	bbachman@ptd.net
Codorus Creek Improvement Partnership	York	Mr. Michael Helfrich	11 W. Philadelphia Street, York, PA 17403	(717) 848-1900	
Codorus Creek Watershed Association	York	Mr. Gary Peacock	PO Box 288, York, PA 17401	(717) 840-7430	
Codorus Creek Watershed Project	York	Ms. Genevieve Ray	101 Rathton Road, York, PA 17403	(717) 848-3320	creekstudy@aol.com
Codorus Monitoring Network, Inc.	York	Mr. John Klunk	60 New York Rd., Dover, PA 17315	(717) 308-0070	
Conodoguinet Creek Watershed Association	Cumberland	Mr. Gil Freedman	49 Sample Bridge Rd., Mechanicsburg, PA 17050	(717) 697-2513	gil49@comcast.net
Hammer Creek Watershed Association	Lancaster	Mr. Gary Trostle	21 Buch Mill Rd., Lititz, PA 17543	(717)738-1597	dgtrost@dejazzd.com
Letort Regional Authority	Cumberland	Ms. Brian Fischbach	415 Franklin St., Carlisle, PA 17013	(717) 245-0508	executive_director@letort.org
Little Chiques Watershed Association	Lancaster	Mr. Bob Hernandez	Mt. Joy Borough, P.O. Box 25, 21 E. Main St., Mt. Joy, PA 17552	(717) 653-5938	
Little Conestoga Watershed Alliance	Lancaster	Ms. Michelle Spitko	P.O. Box 6355, Lancaster, PA 17607		littleconestoga@cs.com
Little Shamokin Creek Watershed Association	Northumberland	Mr. Bob Herman	c/o Jack Neidig, RR 1, Box 151 A, Sunbury, PA 17801	(570) 286-7044	rjherman@ptd.net
Lower Susquehanna Riverkeeper	York	Mr. Michael Helfrich	11 West Philadelphia Street, York, PA 17403	(717) 779-7915	lowsusriver@hotmail.com
Mahanoy Creek Watershed Association	Northumberland	Ms. Roseann Weinrich	936 Centre Street, Ashland, PA 17921	(570) 875-3993	rbwbionerd@yahoo.com
Middle Creek Watershed Association	Lancaster	Mr. Russ Gooding	Golden Witch Tech., Inc, P.O. Box 159, Hopeland, PA 17533	(717) 738-4803	gw@dejazzd.com
Northern Swatara Watershed Association	Schuylkill	Mr. Bob Evanchalk	629 Mountain Rd., Pine Grove, PA 17963	(570) 628-1229	revanchalk@co.schuylkill.pa.us
Octoraro Watershed Association	Lancaster	Mr. Anders Alfelt	389 Pine Grove Rd., Nottingham, PA 19362	(717) 529-2132	owa@desupernet.com
Paxton Creek Watershed & Education Association	Dauphin	Mr. David Sheridan	P.O. Box 61674, Harrisburg, PA 17106	(717) 731-5683	wateradvise@aol.com
Penns Creek Watershed Association	Centre	Ms. Molly Buchanan	RR #1, Woodward, PA 16882	(814) 349-5100	
Penns Valley Conservation Association	Centre	Mr. Gary Gyekis	415 Lower Georges Valley Road, Spring Mills, PA 16875	(814) 349-5100	gyekis@uplink.net
Quittapahilla Watershed Association	Lebanon	Mr. David Lasky	610 East Walnut St., Annville, PA 17003	(717) 867-4837	
Shamokin Creek Restoration Alliance	Northumberland	Mr. Jim Koharski	828 W. Gowen Street, Coal Twp. 17866	(570) 339-3846	jkoharski@verizon.net
Shermans Creek Conservation Association	Perry	Ms. Linda Sieber	385 Dark Hollow Rd., Shermansdale, PA 17090	(717) 582-3376	lsieber@pa.net
Stony Creek Watershed Association	Dauphin	Mr. Shane Taylor	Dauphin Borough, P.O. Box 487 or 200 Church St., Dauphin, PA 17018	(717) 921 2633	dauphinboro@juno.com
Swatara Creek Watershed Association	Lebanon	Ms. Jo Ellen Litz	2501 Cumberland Street, Suite 2, Lebanon, PA 17042	(717) 274-1175	swatara@mbcomp.com
Tri-County Conewago Creek Association	Dauphin, Lancaster, Lebanon	Mr. Matt Royer	P.O. Box 107, Elizabethtown, PA 17022		conewagocreek@yahoo.com
Tri-Valley Watershed Association	Schuylkill	Mr. Jeffrey Stutzman	743 Union St., Millersburg, PA 17061	(717) 692-5066	jstutzman@co.schuylkill.pa.us
Twin Valley Conservation	Dauphin	Ms. Rudi Erb	4533 Back Road, Halifax, PA 17032	(717) 362-4123	frogwild@pa.net
Watershed Alliance of Adams County	Adams	Ms. Michelle Kirk	PO Box 4329, Gettysburg, PA 17325	(717) 334-0636	waterstartshere@yahoo.com
Watershed Alliance of York County	York	Mr. Gary Peacock	York County Conservation District, 118 Pleasant Acres Rd., York PA 17402	(717) 840-7430	Gpeacock@Yorkccd.org
Wiconisco Creek Restoration Association	Schuylkill	Mr. Walt Finch	1021 East Market St., Williamstown, PA 17098	(717) 647-4043	waltfinch@adelphia.net
Yellow Breeches Watershed Association	Cumberland	Mr. Rich Pugh	Gannett Fleming, Inc., 207 Senate Ave., Camp Hill, PA 17011	(717) 763-7211	rpugh@GFNET.com

Water Quality

A portion of the water sample from each collection site was separated for laboratory analysis, and the rest of the sample was used for field analyses. A list of the field and laboratory parameters and their units is found in Table 2. Measurements of flow, water temperature, dissolved oxygen, pH, conductivity, alkalinity, and acidity were taken in the field. Flow was measured using standard U.S. Geological Survey methodology (Buchanan and Somers, 1969). Temperature was measured in degrees Celsius with a field thermometer. A Cole-Parmer Model 5996 meter was used to measure pH. Dissolved oxygen was measured with a YSI 55 meter, and conductivity was measured with a Cole-Parmer Model 1481 meter. Alkalinity was determined by titrating a known volume of sample water to pH 4.5 with 0.02N H_2SO_4. Acidity was determined by titrating a known volume of sample water to pH 8.3 with 0.02N NaOH.

One 500-ml bottle and two 250-ml bottles of water were collected for laboratory analyses. One of the 250-ml samples was acidified with nitric acid for metal analyses. The other 250-ml sample was acidified with sulfuric acid for nutrient analyses. Water samples also were placed in two, 40-mL VOA amber vials with Teflon septa membranes and preserved with 1:1 H_2SO_4 prior to analysis for total organic carbon (TOC). Samples were iced and shipped to the Pennsylvania Department of Environmental Protection (PADEP), Bureau of Laboratories in Harrisburg, Pa., for laboratory analysis.

Macroinvertebrates

Benthic macroinvertebrates (organisms that live on the stream bottom, including aquatic insects, crayfish, clams, snails, and worms) were collected using a modified version of RBP III (Barbour and others, 1999). Two kick-screen samples were obtained at each station by disturbing the substrate of representative riffle/run areas and collecting dislodged material with a one-meter-square 600-micron mesh screen. Each sample was preserved in 95 percent denatured ethyl alcohol and returned to SRBC's lab, where the sample was sorted into a subsample of at least 200 organisms. Organisms in the subsample were identified to genus, except for midges and aquatic worms, which were identified to family.

Habitat

Habitat conditions were 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 weather, substrate material composition, surrounding land use, and any other relevant features in the watershed.

G. Hirschel

Kick-screen sampling of macroinvertebrates.

Table 2. *Water Quality Parameters Sampled in the Lower Subbasin*

FIELD PARAMETERS	
Flow, instantaneous cfs[a]	Conductivity, µmhos/cm[c]
Temperature, °C	Alkalinity, mg/l
pH	Acidity, mg/l
Dissolved Oxygen, mg/l[b]	
LABORATORY ANALYSIS	
Alkalinity, mg/l	Total Magnesium, mg/l
Total Suspended Solids, mg/l	Total Sodium, mg/l
Total Nitrogen, mg/l	Chloride, mg/l
Nitrite - N, mg/l	Sulfate - IC, mg/l
Nitrate - N, mg/l	Total Iron, µg/l[e]
Turbidity, NTU[d]	Total Manganese, µg/l
Total Organic Carbon, mg/l	Total Phosphorus, mg/l
Total Hardness, mg/l	Total Orthophosphate, mg/l
Total Calcium, 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
[e] µg/l = micrograms per liter

DATA ANALYSIS

Water quality was assessed by examining field and laboratory parameters that included nutrients, major ions, and metals (Table 2). The data collected were compared to water chemistry levels of concern based on current state and federal regulations, background levels for uninfluenced streams, or references for approximate tolerances of aquatic life (Table 3). Laboratory values were used when field and laboratory data existed for the same parameter. The difference between each value and the level of concern value from Table 3 was calculated for each site, and if the value did not exceed the level of concern value, the site was given a score of zero. If the level of concern value was exceeded, the difference was listed, and an average of all the parameters 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.

Eight reference categories were created for macroinvertebrate and habitat data analysis based on drainage size, ecoregions, and subecoregions (Omernik, 1987; Woods and others, 1996). All the sites were divided by drainage size into those less than 100 square miles and those greater than 100 square miles. River sites were separated into an independent group. The sites were grouped according to ecoregions and subecoregions. Those sites less than 100 square miles were grouped by subecoregion due to the smaller size of the watersheds, while the 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. Those sites with drainage areas greater than 100 square miles were designated with a letter "L." 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 eight reference categories used were: 64ac, 64d, 64L, 67a, 67b, 67cd, 67L, and River. The site on Mountain Creek (MNTN 3.0) was grouped with 67cd since no other sites were located within subecoregion 66B.

TAXONOMIC RICHNESS: Total number of taxa in the sample. Number decreases with increasing stress.

HILSENHOFF BIOTIC INDEX: A measure of organic pollution tolerance. Index value increases with increasing stress.

PERCENT EPHEMEROPTERA: Percentage of the number of Ephemeroptera (mayflies) in the sample divided by the total number of macroinvertebrates in the sample. Percentage decreases with increasing stress.

PERCENT CONTRIBUTION OF DOMINANT TAXA: Percentage of the taxon with the largest number of individuals out of the total number of macroinvertebrates in the sample. Percentage increases with increasing stress.

EPT INDEX: Total number of Ephemeroptera (mayfly), Plecoptera (stonefly), and Tricoptera (caddisfly) taxa present in a sample. Number decreases with increasing stress.

PERCENT CHIRONOMIDAE: Percentage of number of Chironomidae individuals out of total number of macroinvertebrates in the sample. Percentage increases with increasing stress.

SHANNON-WIENER DIVERSITY INDEX: A measure of taxonomic diversity of the community. Index value decreases with increasing stress.

Benthic macroinvertebrate samples were analyzed using seven metrics mainly derived from RBP III (Plafkin and others, 1989; Barbour and others, 1999): (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; (6) percent Chironomidae; and (7) Shannon-Wiener Diversity Index. Reference sites were determined for each reference category, 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. The metric scores were compared to the reference scores, and a biological condition category was assigned based on RBP III methods (Plafkin and others, 1989; Barbour and others, 1999). The ratings for each habitat condition were totaled, and a reference site was chosen based on the highest score of the habitat ratings in each reference category. A percentage of the reference site was calculated, and the percentages were used to assign a habitat condition category to each site (Plafkin and others, 1989; Barbour and others, 1999).

Table 3. *Water Quality Levels of Concern and References*

PARAMETER	LIMIT	REFERENCE CODE
Temperature	>25 °C	a,f
D.O.	<4 mg/l	a,g
Conductivity	>800 µmhos/cm	d
pH	<5.0	c,f
Acidity	>20 mg/l	m
Alkalinity	<20 mg/l	a,g
TSS	>25 mg/l	h
Nitrogen*	>1.0 mg/l	j
Nitrite-N	>0.06 mg/l	f,n,i
Nitrate-N	>1.0 mg/l	e,j
Turbidity	>150 NTU	h
Phosphorus	>0.1 mg/l	e,k
TOC	>10 mg/l	b
Hardness	>300 mg/l	e
Calcium	>100 mg/l	m
Magnesium	>35 mg/l	i
Sodium	>20 mg/l	i
Chloride	>250 mg/l	a
Sulfate	>250 mg/l	a
Iron	>1,500 µg/l	a
Manganese	>1,000 µg/l	a
Orthophosphate	>0.05 mg/l	l,f,j,k

REFERENCE CODE & REFERENCES	
a	http://www.pacode.com/secure/data/025/chapter93/s93.7.html
b	Hem (1970) - http://water.usgs.gov/pubs/wsp/wsp2254/
c	Gagen and Sharpe (1987) and Baker and Schofield (1982)
d	http://www.uky.edu/WaterResources/Watershed/KRB_AR/wq_standards.htm
e	http://www.uky.edu/WaterResources/Watershed/KRB_AR/krww_parameters.htm
f	http://www.hach.com/h2ou/h2wtrqual.htm
g	http://sites.state.pa.us/PA_Exec/Fish_Boat/education/catalog/pondstream.pdf
h	http://www.epa.gov/waterscience/criteria/sediment/appendix3.pdf
i	http://www.dec.state.ny.us/website/regs/part703.html
j*	http://water.usgs.gov/pubs/circ/circ1225/images/table.html
k	http://water.usgs.gov/nawqa/circ-1136/h6.html#NIT
l	http://www.epa.gov/waterscience/criteria/goldbook.pdf
m	based on archived data at SRBC
n	http://srmwww.gov.bc.ca/risc/pubs/aquatic/interp/

** Background levels for natural streams*

Results/Discussion

Water quality, biological (macroinvertebrate), and habitat site conditions for each sampling site in 2005 throughout the Lower Susquehanna Subbasin are depicted in Figure 4. Only one site, SHRM 2.0, located at the mouth of Sherman Creek demonstrated the best overall conditions in each category with nonimpaired macroinvertebrates, "higher" water quality, and excellent habitat. Furthermore, only six stations did not exceed water quality levels of concern and received a "higher" water quality condition rating. Those sites were NMHT 0.0, SHRM 2.0, SWAT 39.0, SWAT 56.0, SUSQ 122.0, and WICO 0.3. The low number of "higher" water quality ratings was mostly due to the widespread high nitrogen levels. There were 82 sites (84.5 percent) that exceeded the total nitrogen level of concern. Seventy-five stations slightly exceeded levels of concern and received a "middle" water quality designation, and 16 received a "lower" quality designation. Nonimpaired biological conditions were determined at 41 stations (43 percent), slightly impaired conditions were found at 32 sites (33 percent), moderately impaired conditions were found at 21 sites (22 percent), and severely impaired conditions were discovered at two sites (2 percent). Habitat conditions were excellent at 30 sites (33 percent), supporting at 51 sites (56 percent), and partially supporting at 10 sites (11 percent). One site, BERM 11.0, was not sampled for macroinvertebrates due to lack of available riffle/run habitat, and the river sites were not rated for habitat conditions.

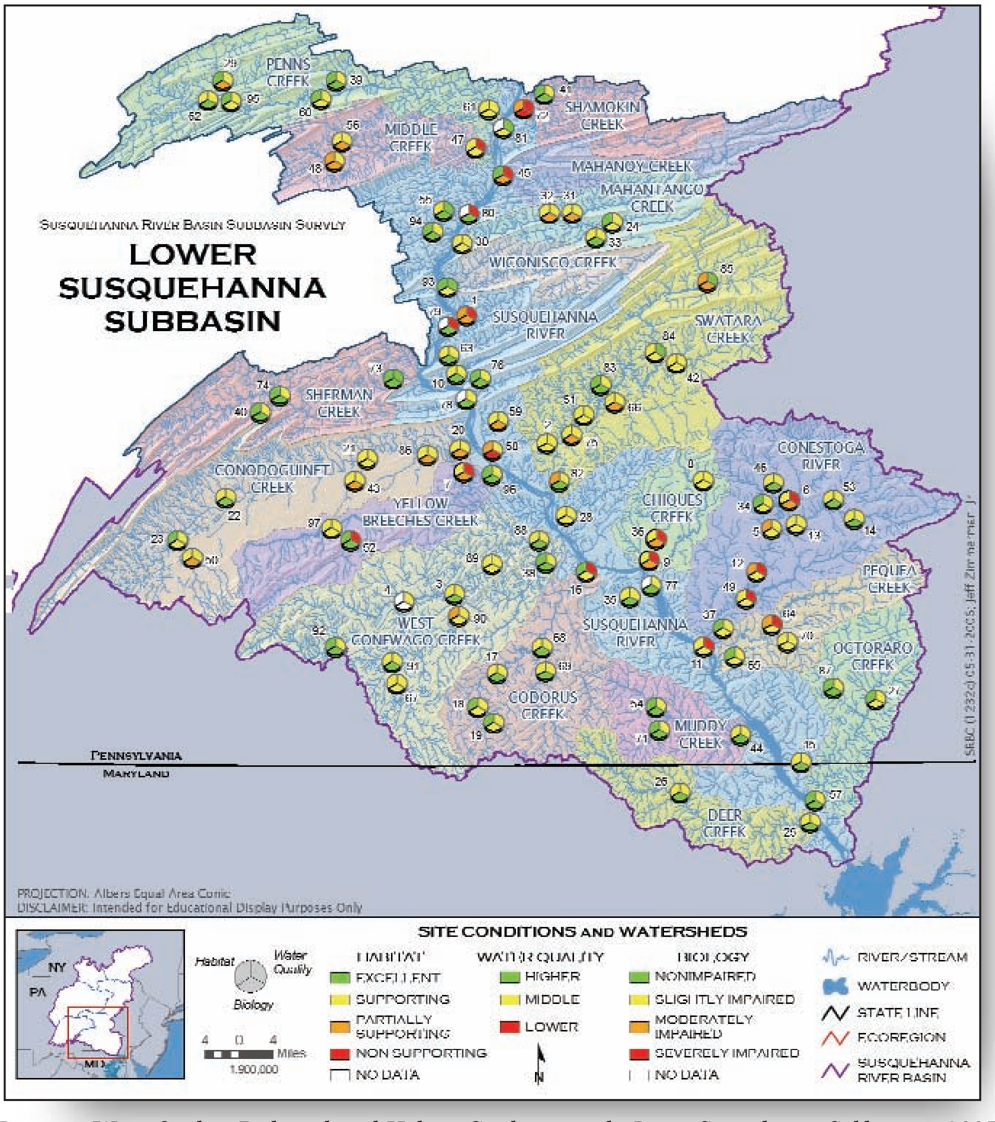

Figure 4. *Water Quality, Biological, and Habitat Conditions in the Lower Susquehanna Subbasin in 2005*

In addition to 84.5 percent of the samples exceeding levels of concern for total nitrogen, other nutrient parameters were exceeded in many of the samples. The five parameters with the highest number of values exceeding levels of concern were: total nitrogen, total nitrate-n (70), total orthophosphate (34), total phosphorus (29), and total sodium (21) (Table 4). The values set for total nitrogen and total nitrate-n (1.0 mg/l) were based on natural background conditions; therefore, values higher than 1.0 mg/l indicate the potential presence of nitrogen sources in the watershed (U.S. Geological Survey, 1999). The highest number of parameters to be exceeded at a site was seven at MILL 0.3. There were five sites where six parameters were exceeded, including ARMS 0.1, CNTG 0.9, CODO 0.6, LCHQ 0.4, and SHAM 2.7 (Table 4).

The high level of nutrients corresponds to the prevalence of cultivated land in the Lower Susquehanna Subbasin. The highest level of total nitrogen was 11.37 mg/l measured at LCHQ 0.4 on Little Chiques Creek. Total phosphorus and orthophosphate values were exceeded 29 and 34 times, respectively (Table 4). Orthophosphate and phosphorus can be indicators of wastewater and septic systems, detergents, chemical fertilizers, animal waste, some industrial discharges, and soil erosion. Sodium values were high at 21 of the sites, with the highest being 80.5 mg/l at MILL 0.3 (Table 4). As many of these sites were urban or suburban, the high sodium levels may have been due to road runoff. Abandoned mine lands were located in only a small section of the subbasin, and the associated water chemistry impacts were noted only in SHAM 2.7, SUSQ 94.0, SUSQ 106.0, MHNY 0.3, and possibly EPIN 0.1, EPIN 12.7, and SWAT 56.0.

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,

Table 4. *Lower Susquehanna River Subbasin Sites with Water Quality Values Exceeding Levels of Concern*

StationID	Lab Alkalinity	Calcium T	Hardness T	Iron T	Magnesium T	Manganese T	Nitrate-N T	Nitrite-N T	Nitrogen TOT	Phos T Ortho	Phosphorus T	Sodium T	Sulfate T	T Susp Solid	Acidity	Specific Cond.	Water Temp.	TOTAL
ARMS 0.1	17.8						1.1		1.4		0.572			**204**			25.6	6
BEAV 0.6							1.29		1.45			30.6						3
BERM 1.2									1.24	0.058							25.6	3
BERM 11.0							1.55		1.74									2
CCLC 0.4							7.48		7.88	0.137	0.147	23.3						5
CCLC 12.2							7.43		7.96	0.241	0.292	45.4						5
CEDR 0.1		**103**	318				3.05		3			39.1						5
CHIQ 20.0							3.81		4.26	0.075								3
CHIQ 3.0							11		11	0.068		33.6						4
CLRK 3.8	10.8																	1
CNTG 0.9							8.18		8.47	0.175	0.192	41.7					25.3	6
CNTG 22.6							8.61		8.7	0.131	0.138	30.1						5
CNTG 32.7							7.54		7.76	0.075								3
CNTG 43.9							6.18		6.31	0.056								3
CNWG 1.8							8.58	0.07	8.91	0.079	0.102							5
CODO 0.6							4.51	0.09	4.78	0.111	0.132	59.8						6
CODO 22.4							4.54		4.48	0.14	0.155							4
CODO 33.0							3.28		3.28									2
CODO 34.1							5.39		5.14									2
CONO 1.3							3.93		4.18								26.3	3
CONO 28.8							3.98		4.42								27.1	3
CONO 51.8							4.41		4.64								25.7	3
CONO 66.0							4.59		4.75									2
DEEP 1.2	11						1.23		1.49									3
DEER 1.2							3.72		3.7									2
DEER 30.1							4.43		4.43									2
EBOC 5.3							9.41		9.38	0.059								3
ECON 0.0							4.23		4.24									2
ELKN 0.1							2.55		2.75									2
EMAH 0.2							1.9		2.28	**0.445**	0.573						**27.3**	5
EMAH 17.1							3.5		3.85									2
EPIN 0.1	13.6								1.08									2
EPIN 12.7	13.4																	1
HAMM 0.2							5.85		6.08									2
KRTZ 1.5							5.56	0.07	5.91									3
LCHQ 0.4							**11.2**		**11.37**	0.073	0.114	27.1		28				6
LCNT 1.7							9.66		9.51									2
LCON 1.5							4.54		4.85	0.255	0.267	21.9						5
LRLN 0.8	9.4										0.192							2
LRLS 0.5	7.8																	1
LSHM 0.8							1.71		1.85									2
LSWT 0.6							7.46	**0.13**	7.67									3
LTRT 0.1							5.65		5.74									2
MDDY 3.3							5.36		5.32									2
MHNY 0.3			**356**	740	**47.3**	1710							**304**					5
MIDD 0.2							8.41		8.74									2
MIDL 0.7							1.12		1.51		**0.902**	44.2						4
MIDL 24.7											0.349							1
MILL 0.3							6.53		6.86	0.22	0.237	**80.5**				**940**	25.1	7
MISP 0.5							6.46		6.65									2
MNDA 0.1									1.01	0.075								2
MNTN 3.0				**2789**					1.12					118				3
MUDD 0.2							3.51		3.97	0.118	0.139	29.6						5
NBMY 0.0							5.1		4.9									2
NMID 0.7									1.35		0.185							2
OCTO 1.0							4.65		4.86	0.289	0.305							4
PAXT 0.5							1.19		1.6	0.069		39.8						4
PAXT 8.4												30.7						1
PENN 30.0							1.15		1.62		0.209							3
PENN 5.0									1.3		0.194						25.1	3
PENN 50.6							2.2		2.75	0.115	0.366							4
POWL 0.1	14.6						1.25		1.39									3
PQEA 15.2							8.65		8.85	0.133	0.187			42				5
PQEA 3.3							7.27		7.54	0.146	0.169							4
QUIT 0.3							9.39		9.96	0.101	0.119							4
SBCC 1.2							3.78		4.04	0.083								3
SBCD 0.4							4.18		4.2									2
SBCD 3.6							4.96		4.95	0.05								3
SBEV 2.5							6.62		6.92									2
SBMY 0.0							6.33		6.16									2
SHAM 2.7	**2.6**			1630		**2420**			1.82	0.082	0.17							6
SHRM 27.5							1.52		1.68									2
SPRG 0.0							6.33		6.6									2
STON 0.4	12.8																	1
SUSQ 106.0												23.1				883		2
SUSQ 44.5									1.3			22.6					26.9	3
SUSQ 77.0									1.21			20						2
SUSQ 94.0									1.72			22.5				822	25.3	4
SWAT 2.3							5.26		5.68	0.113	0.13	22.4						5
SWAT 21.7							2.55		2.69									2
TRDL 0.0							5.04		5.06			20.6			**22**			4
WBOC 4.3							10.1		9.8	0.11	0.111							4
WCON 2.9							2.88		3.17	0.126	0.134							4
WCON 20.4							2.26		2.62	0.06								3
WCON 35.5							1.72		2.12	0.153	0.158						26	5
WCON 56.3									1.09	0.08								2
WCON 66.5									1.03									1
WMHT 2.2							1.25		1.42									2
WPIN 0.8							1.43		1.49					44				3
YLBR 3.4							2.22		2.32									2
YLBR 35.7							1.39		1.53									2
TOTAL	10	1	2	3	1	2	70	4	82	34	29	21	1	5	1	3	12	

and if found to be impaired, a TMDL is calculated for the watershed. In Maryland, the Maryland Department of Natural Resources is performing assessments through its Maryland Biological Stream Surveys and Unified Watershed Assessment programs. Some of the watersheds in the Lower Susquehanna Subbasin have been rated impaired and, subsequently, will require a TMDL. Tables 5 and 6 identify those watersheds that have been found to be impaired, their impairment causes, the dates sampled, and Lower Susquehanna Subbasin Survey stations located in impaired sections. More information on the Pennsylvania and Maryland TMDL programs are available respectively at: *http://www.dep.state.pa.us/watermanagement_apps/tmdl/default.asp* and *http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/index.asp.*

Table 5. *Lower Susquehanna River Subbasin Survey Streams Identified as Impaired Streams Requiring a TMDL on PADEP's 2004 Integrated List of All Waters*

PA State WaterPlan	Watersheds	Major Sources of Impairment	Stations in Impaired Sections
6C	Armstrong Creek	Agriculture/Siltation:1998 Removal of Vegetation/Siltation:1998	
7K	Big Beaver Creek	Agriculture/Nutrients,Organic Enrichment Low DO,Siltation:2004	
7E	Cedar Run	Natural Sources/Siltation:1998 Source Unknown/Nutrients:1998 Urban Runoff/Storm Sewers/Nutrients,Siltation:1998 Source Unknown/Cause Unknown:1998 Agriculture/Nutrients,Siltation:1998	
7G	Chiques Creek	Agriculture/Nutrients,Siltation:1996,1998	CHIQ 3.0
7G	Chiques Creek	Urban Runoff/Storm Sewers/Cause Unknown:1998	
7J	Cocalico Creek	Crop Related Agric/Nutrients:2002 Grazing Related Agric/Siltation:2002 Urban Runoff/Storm Sewers/Cause Unknown,Nutrients,Siltation:2002 Agriculture/NutrientsSiltation:2002 Small Residential Runoff/Nutrients:2002 Road Runoff/Siltation:2002	CCLC 0.4, CCLC 12.2
7H	Codorus Creek	Urban Runoff/Storm Sewers/Unknown Toxicity, Excessive Algal Growth,Siltation:2004 Industrial Point Source/Color,DO,BOD,Thermal Modifications, Suspended Solids:1996, 2002 Agriculture/Siltation,Excessive Algal Growth,Nutrients:2004	CODO 0.6, CODO 22.4
7J	Conestoga River	Source Unknown/Mercury:2002 Municipal Point Source/Chlorine:2002 Agriculture/Organic Enrichment Low D.O.,Nutrients:1996,2002 Small Residential Runoff/Siltation,Nutrients:2002 Upstream Impoundment/Siltation:2002 Crop Related Agric/Nutrients:2002 Grazing Related Agric/Siltation,Nutrients,Organic Enrichment Low D.O.:2002 Surface Mining/Siltation:2002 Other/Organic Enrichment Low D.O.,Nutrients:1996 Golf Courses/Nutrients:2002 Channelization/Siltation:2002 Removal of Vegetation/Siltation:2002 Urban Runoff/Storm Sewers/Siltation:2002	CNTG 22.6, CNTG 43.9
7G	Conewago Creek	Agriculture/Nutrients,Siltation:1996,1998 Municipal Point Source/Organic Enrichment,Low DO,Suspended Solids:1996,1998	ECON 0.0
7G	Conewago Creek	Agriculture/Suspended Solids:1998	ECON 0.0
7F	Conewago Creek	Source Unknown/Mercury:2002	WCON 2.9
7B	Conodoquinet Creek	Agriculture/Siltation:1998	
7B	Conodoquinet Creek	Combined Sewer Overflow/Organic Enrichment Low DO:2002 Urban Runoff/Storm Sewers/Nutrients,Suspended Solids:1998,2004 Source Unknown/Cause Unknown:1998 Agriculture/Suspended Solids,Nutrients:1998,2002	CONO 66.0, CONO 51.8, CONO 28.8
7K	Conowingo Creek	Agriculture/Nutrients,Suspended Solids:1996 Crop Related Agriculture/Siltation, Organic Enrichment/Low DO, Nutrients:2004 Grazing Related Agriculture/Organic Enrichment/Low DO,Nutrients:2004 Agriculture/Organic Enrichment Low DO, Nutrients,Siltation:2004	CNWG 1.8
6C	Deep Creek	Source Unknown/Siltation:1998 Agriculture/Siltation:1998	
7K	East Branch Octoraro Creek	Agriculture/Siltation,Nutrients:2002	
6A	Elk Creek	Animal Feeding Ag/Siltation,Nutrients:2005	
7J	Hammer Creek	Crop Related Agric/Siltation,Nutrients:2002 Grazing Related Agric/Siltation,Nutrients:2002	HAMM 0.2
7I	Kreutz Creek	Removal of Vegetation/Siltation:2002 Road Runoff/Siltation:2002 Urban Runoff/Storm Sewers/Siltation:2002	
7A	Laurel Run	Atmospheric Deposition/Metals:1998	
7G	Little Chiques Creek	Agriculture/Nutrients,Siltation:1998 Urban Runoff/Storm Sewers/Siltation:1998 On site Wastewater/Organic Enrichment/Low D.O.:1998	LCHQ 0.4
7J	Little Conestoga Creek	Grazing Related Agric/Siltation,Nutrients:2002 Urban Runoff/Storm Sewers/Cause Unknown:2002 Crop Related Agric/Nutrients,Siltation:2002 Erosion from Derelict Land/Siltation,Cause Unknown:2002	
6B	Little Shamokin Creek	Agriculture/Siltation,Organic Enrichment Low DO:2002 Grazing Related Ag/Siltation, Organic Enrichment Low DO:2002	
7D	Little Swatara Creek	Agriculture/Nutrients,Siltation:1998 Urban Runoff/Storm Sewers/Siltation:1998 On site Wastewater/Organic Enrichment/Low D.O.:1998	
6B	Mahanoy Creek	AMD/Metals,pH,Siltation:1996,2002 Crop Related Ag/Siltation:2002 Atmospheric Deposition/pH:2002	MHNY 0.3

6C	Mahantango Creek	Agriculture/Siltation:1998 Removal of Vegetation/Siltation:1998 Road Runoff/Siltation:1998 Silvaculture/Siltation:1998	
7C	Manada Creek	Source Unknown/Pathogens:2004	MNDA 0.1
7D	Manada Creek	Road Runoff/Siltation:2002 Municipal Point Source/Nutrients:2002	MNDA 0.1
6A	Middle Creek	Source Unknown/Mercury:2002 Grazing Related Ag/Siltation:2002 Atmospheric Deposition/pH:2002	
7B	Middle Spring Run	Agriculture/Suspended Solids:1996 Urban Runoff/Storm Sewers/Suspended Solids:1996	MISP 0.5
7J	Mill Creek	Industrial Point Source/Salinity,TDS,Chlorides:1996	
7J	Mill Creek	Agriculture/Siltation,Nutrients,Suspended Solids:1996,2002 Land Development/Siltation:2002 Crop Related Agric/Nutrients:2002 Grazing Related Agric/Siltation,Nutrients:2002	
7E	Mountain Creek	Atmospheric Deposition/pH:1998	
7J	Muddy Creek	Crop Related Agric/Siltation,Nutrients:2002 Agriculture/Siltation,Nutrients:2002	
6C	North Branch Mahantango Creek	Agriculture/Siltation:1998	
7C	Paxton Creek	Agriculture/Nutrients,Siltation:1996,1998 Combined Sewer Overflow/Organic Enrichment/Low D.O.:1996 Urban Runoff/Storm Sewers/Suspended Solids,Nutrients,Cause Unknown,Siltation:1998,2004 Construction/Siltation:1998	PAXT 0.5
6A	Penns Creek	Source Unknown/Mercury:2002 Crop Related Ag/Siltation:2002 Small Residential Runoff/Siltation:2002	
7K	Pequea Creek	Agriculture/Nutrients,Organic Enrichment Low DO, Siltation:1996,2002,2004	
7K	Pequea Creek	Agriculture/Organic Enrichment Low D.O.,Siltation:2002,2004	
6A	Pine Creek	Grazing Related Ag/Siltation:2002	
6C	Pine Creek	Agriculture/Siltation:1998 AMD/Metals,Siltation:1996,1998 Source Unknown/Siltation:1998	EPIN 0.1 EPIN 12.7
6C	Powell Creek	Agriculture/Siltation:1998 Removal of Vegetation/Siltation:1998	
7D	Quittapahilla Creek	Agriculture/Siltation:2002	QUIT 0.3
6B	Shamokin Creek	Abandoned Mine Drainage/Metals,Siltation,pH:1996, 2004	SHAM 2.7
6B	Shamokin Creek	AMD/Siltation,Metals:2004 Urban Runoff/Storm Sewer/Siltation:2004 Road Runoff/Siltation:2004	SHAM 2.7
7A	Sherman Creek	Grazing Related Ag/Nutrients,Siltation:2002 Crop Related Ag/Siltation:2002 Removal of Vegetation/Siltation:2002	
7H	South Branch Codorus Creek	Agriculture/Nutrients,Suspended Solids:1996 Urban Runoff/Storm Sewers/Siltation:2002	SBCD 0.4 SBCD 3.6
7F	South Branch Conewago Creek	Agriculture/Siltation:2004	
7D	Spring Creek	Other/Suspended Solids:1998 Urban Runoff/Storm Sewers/Suspended Solids,Siltation:1998 Agriculture/Siltation,Organic Enrichment Low D.O.:1998 Municipal Point Source/Cause Unknown:1998	SPRG 0.0
7D	Swatara Creek	AMD/Metals:1996 Agriculture/DO,BOD:1996	SWAT 56.0
7D	Swatara Creek	Abandoned Mine Drainage/pH,Metals,Suspended Solids:1998,2002 Agriculture/Siltation:1998,2002 Other/Siltation:1998 Construction/Siltation:1998 Urban Runoff/Storm Sewers/Siltation:1998 Crop Related Agric/Siltation,Nutrients:2002	SWAT 56.0
7B	Trindle Spring Run	Construction,Agriculture/Siltation:1998 Land Disposal/Priority Organics:1998	TRDL 0.0
7B	Trindle Spring Run	Source Unknown/PCB:2002 Land Disposal/Priority Organics:1998 Urban Runoff/Storm Sewers/Cause Unknown:1998	TRDL 0.0
6C	West Branch Mahantango Creek	Agriculture/Siltation:1998	
7K	West Branch Octoraro Creek	Agriculture/Siltation,Nutrients:2002	
6C	Wiconisco Creek	AMD/Metals,pH,Siltation:1996,2002 Crop Related Ag/Siltation:2002 Source Unknown/Cause Unknown:2002 Removal of Vegetation/Siltation:2002 Small Residential Runoff/Nutrients:2002 Grazing Related Ag/Siltation:2002	
7E	Yellow Breeches Creek	Industrial Point Source/PCB:2002 Industrial Point Source/Organic Enrichment Low D.O.:2004 Urban Runoff/Storm Sewers/Siltation:1998 Agriculture/Siltation,Organic Enrichment Low D.O.,Nutrients:1998 Construction/Organic Enrichment Low D.O.,Siltation:1998 Source Unknown/Siltation:1998	

Table 6. *Lower Susquehanna River Subbasin Survey Streams Identified as Impaired Streams Requiring a TMDL on MDE's 2006 Draft Integrated 303(d) List*

Basin Code	Basin Name	303(d) Listing Year	Impairment Category	Impairing Pollutant	Stations In Impaired Sections
2120201	Lower Susquehanna River	1996, 2002	Metals, Sediment, Toxics	Cadmium, Sediments, PCBs-fish tissue	
2120202	Deer Creek	2002, 2006	Biological	Unknown	
2120203	Octoraro Creek	2006	Biological	Unknown	
2120204	Conowingo Dam Susquehanna River	1996	Sediments, Nutrients	Sediments, Nutrients	
2120204	Conowingo Dam Susquehanna River (Conowingo Creek)	2002	Biological	Unknown	CNWG 1.8

RIDGE AND VALLEY ECOREGION

Penns Creek Watershed

Penns Creek Watershed is comprised largely of forested ridges and agricultural valleys and includes popular recreation areas for camping and fishing in Poe Valley State Park and Poe Paddy State Forest. The headwaters site (PENN 50.6) had nonimpaired biology, although the sites downstream (PENN 30.0 and PENN 5.0) were rated slightly impaired. The habitat was excellent at PENN 30.0, although the macroinvertebrate community was slightly impaired, possibly due to the heavy recreational use. The water quality was rated "middle" throughout the watershed mostly due to slightly high nutrient concentrations and, at the mouth of Penns Creek, slightly high temperature, which often is a problem on Penns Creek due to its slow-moving nature near the mouth.

The biological conditions varied at the tributaries to Penns Creek, ELKN 0.1, WPIN 0.8, and LRLN 0.8. Although they had similar water quality and habitat ratings, these tributaries differed with regard to water quality impacts and land uses. ELKN 0.1 and WPIN 0.8 drain agricultural areas in Penns Valley and have slightly high nutrient levels and, at WPIN 0.8, high total suspended solids (TSS). ELKN 0.1 was moderately impaired, while WPIN 0.8 was only slightly impaired, possibly due to a higher percentage of forested cover in Pine Creek Watershed. Laurel Run (LRLN 0.8) was sampled as it came off forested ridges and has low alkalinity and slightly high total phosphorus. This site had nonimpaired biological conditions.

Middle Creek Watershed

Middle Creek suffers from impairments that appear to be due to high total phosphorus concentrations. Each site in the watershed, MIDL 24.7, NMID 0.7, and MIDL 0.7, exceeded the level of concern for total phosphorus, and MIDL 0.7 had the highest total phosphorus level (0.902 mg/l) of all the sites in the Lower Susquehanna Subbasin (Table 4). Biological conditions in the Middle Creek Watershed were moderately or slightly impaired. The habitat in this watershed was designated supporting and partially supporting due to low ratings for instream parameters such as cover, substrate, and embeddedness and riparian habitat such as riparian vegetative zone. The habitat assessment at MIDL 24.7 also indicated that the sediment had an odor. Further study is needed on Middle Creek to determine the source of high total phosphorus. Possibilities include malfunctioning or outdated wastewater treatment plants, leaking septic systems, chemical fertilizers, animal waste, and soil erosion.

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Penns Creek.

Shamokin, Mahanoy, Mahantango, and Wiconisco Creek Watersheds

Shamokin, Mahanoy, Mahantango, and Wiconisco Creek Watersheds all contain sections that were impacted by abandoned mine drainage (AMD). Shamokin Creek at SHAM 2.7 exhibited the worst impacts from AMD with severely impaired biology, "lower" water quality, and partially supporting habitat. SHAM 2.7 also was impacted by high nutrient levels since this site not only exceeded levels of concern for alkalinity, iron, and manganese, but also nitrogen, orthophosphate, and total phosphorus. This site had the lowest alkalinity (2.6 mg/l) and highest manganese (2420 µg/l) of all the Lower Susquehanna Subbasin sites (Table 4). Little Shamokin Creek contributes good water quality conditions to Shamokin Creek and does not appear to be impacted by AMD.

Mahanoy Creek exceeded levels of concern for hardness, iron, magnesium, manganese, and sulfate. In fact, the levels of hardness (356 mg/l), magnesium (47.3 mg/l), and sulfate (304 mg/l) were the highest of all the sites in the Lower Susquehanna Subbasin (Table 4). The station at the mouth of Mahanoy Creek had "lower" water quality, moderately impaired biology, and excellent habitat. Coal fines and silt were noted in the stream, but the rest of the habitat scored well. The aquatic insect population was dominated by Chironomidae (midges); however, there were a couple mayflies (Baetis) and a stonefly (Perlesta) in the macroinvertebrate sample, and small fish were noted in the stream.

Mahantango Creek on the east side of the Susquehanna River included Pine and Deep Creeks that also were sampled in this survey. Biology was nonimpaired only on Pine Creek at Spring Glen (EPIN 12.7), which includes the headwaters along Broad Mountain. Slightly impaired conditions existed at Deep Creek and the mouth of Mahantango Creek (EMAH 0.2). Moderately impaired conditions existed at the mouth of Pine Creek and at Mahantango Creek in Klingerstown, Pa. The water chemistry was rated "middle" at all five sites, and the only indicator of possible AMD conditions on the ridges was low alkalinity at DEEP 1.2, EPIN 0.1, and EPIN 12.7. The biological community did not seem to be significantly impaired by AMD at any of these sites, except possibly EPIN 0.1 and EMAH 17.1, although the impairment could be due to other causes. There is an active treatment plant for AMD on Rausch Creek, a tributary to Pine Creek, which may be improving the water quality and biological conditions of these streams. Habitat was rated supporting at all sites, except for DEEP 1.2, which had excellent conditions.

Wiconisco Creek was sampled at the mouth and had slightly impaired biological conditions, although the water chemistry and habitat at the time of sampling were "higher" and excellent, respectively. Although this site had a fair number of mayflies, there was only one stonefly taxon, and the site received a low score for percentage of Chironomidae (midges). Small fish were observed during the time of sampling. The Wiconisco Creek Restoration Association has been working in this watershed to remediate the effects of AMD. It is possible that the one-time sample did not reflect usual water quality conditions, which may be worse than the water chemistry sample indicated, or that remediation efforts have improved water quality and the macroinvertebrate population is in the process of recovering. Other SRBC monitoring efforts indicated that water chemistry exceeds the Pennsylvania standards upstream of the AMD treatment.

<u>West Branch and North Branch Mahantango Creek Watersheds</u>

Sampling was conducted on the West Branch and North Branch Mahantango Creeks on the west side of the Susquehanna River. Both of these sites were nonimpaired and contained fairly similar macroinvertebrate populations. The water chemistry was similar also; however, WMHT 2.2 had total nitrate-n and total nitrogen values that slightly exceeded the level of concern, giving it a "middle" quality rating instead of "higher." The habitat ratings were similar except that NMHT 0.0 was assessed lower for embeddedness, sediment deposition, and channel alterations due to the remnants of a dam upstream of the sampling site.

<u>Armstrong, Powell, Clarks, and Stony Creek Watersheds.</u>

Armstrong Creek had a moderately impaired macroinvertebrate score, "lower" water quality, and partially supporting habitat. A majority of the watershed was cropland, and the water quality analysis indicated high total phosphorus and total suspended solids, and slightly elevated water temperature, total nitrate-n, and total nitrogen. The total suspended solids (204 mg/l) were the highest of all the Lower Susquehanna Subbasin sites (Table 4). The macroinvertebrate population was lacking stoneflies, which was another indicator of possible agricultural pollution.

Powell, Clarks, and Stony Creeks all had nonimpaired biological conditions. These watersheds were protected by forested ridges and state game lands. Powell Creek served as a reference site (Ecoregion 67b watersheds less than 100 square miles). Water quality was rated "middle" at all three sites, due to low alkalinity at Clarks and Stony Creeks and low alkalinity and slightly elevated total nitrate-n and total nitrogen at Powell Creek. The habitat was excellent at Stony Creek and supporting at Powell and Clarks Creeks. The lower habitat rating on Powell and Clarks Creeks was due mostly to channel disturbances, such as a concrete wall on Powell Creek and an upstream fish hatchery on Clarks Creek.


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Kayaker on Sherman Creek.

<u>Sherman Creek Watershed</u>

Sherman Creek demonstrated overall excellent watershed conditions and had the best water quality, biological and habitat conditions in the Lower Susquehanna Subbasin. The two sites on the mainstem and the tributary, Laurel Run, had nonimpaired biological conditions and excellent habitat ratings. The headwater site on Sherman Creek (SHRM 27.5) had "middle" water quality due to slightly elevated total nitrate-n and total nitrogen, and Laurel Run (LRSL 0.5) had low alkalinity, which is found often in forested ridge headwater streams. The site near the mouth of Sherman Creek (SHRM 2.0) was the only site in the Lower Susquehanna Subbasin Survey to have "higher" water quality, nonimpaired biology, and excellent habitat. All three sites sampled in this watershed (SHRM 2.0, SHRM 27.5, LRSL 0.5) served as reference sites for 67L, 67a, and 67cd, respectively.

<u>Conodoguinet Creek Watershed</u>

Most of the mainstem Conodoguinet Creek was impaired due to agriculture, according to the TMDL assessments (Table 5). The only site sampled that was not in an impaired TMDL section was CONO 1.3. The subbasin survey results indicated that this site was moderately impaired, and the only site with nonimpaired biological conditions was CONO 51.8. The tributary sites sampled in this watershed were Middle Spring Run, Letort Spring Run, and Trindle Spring Run; all of these sites had moderately impaired biological conditions. The Conodoguinet Creek is a limestone-influenced stream with many spring sources. The tributaries mentioned above are true limestone streams and possibly should be assessed using protocol specific to limestone streams to comparatively determine level of impairment.

The mainstem Conodoguinet sites exceeded levels of concern for nitrate-n and total nitrogen with values ranging from 4.18 - 4.75 mg/l. This is a slow-moving valley stream that is wide and open in sections, so the temperatures exceeded the level of concern at all the sites except for the headwater site, CONO 66.0. The tributary sites also exceeded the levels of concern for total nitrate-n and total nitrogen with total nitrogen values ranging from 5.06 to 6.65 mg/l. Trindle Spring Run also exceeded the levels for sodium and acidity. TRDL 0.0 was downstream of residential, commercial, and industrial development. The habitat at all of the sites in the Conodoguinet Creek Watershed were rated supporting, except the headwater site, CONO 66.0, which was rated excellent. Abundant algae and aquatic vegetation were noted during the habitat assessment. The land use in this watershed was mostly agricultural and forested in the headwaters and mostly residential, commercial, and industrial uses toward the mouth.

Yellow Breeches Creek Watershed

Yellow Breeches Creek is a multi-use watershed that also serves as water supply for the surrounding area. The headwaters were rural, and state forest, state park lands, and agriculture were the primary land uses. As in the case of Conodoguinet Creek, the watershed becomes increasingly urbanized towards the mouth. However, this watershed was not as highly developed as the Conodoguinet Creek and was protected better by streamside vegetation. This is also a limestone-influenced stream, which was reflected in the macroinvertebrate population, especially at the headwater site, YLBR 25.7. This stream is a popular fishery and also is used for canoeing, kayaking, and tubing. Due to its multiple uses and interest to local residents, SRBC is conducting a Year-2 small watershed study on the Yellow Breeches Creek.

Two mainstem and two tributary sites were sampled on the Yellow Breeches Creek Watershed in the 2005 Lower Susquehanna Subbasin Survey. The two mainstem sites had "middle" water quality due to total nitrogen and nitrate-n values exceeding background levels. The biological condition at the headwater site (YLBR 25.7) was rated slightly impaired, although this may be due to it being a limestone-influenced stream. Further samples and study of this site would be necessary to determine level of impairment among other limestone-influenced streams. The site at the mouth was rated nonimpaired. The tributary sites, Mountain Creek and Cedar Run, represented two very different subwatersheds within the Yellow Breeches Watershed. Mountain Creek lies within the Michaux State Forest on the South Mountain sedimentary ridge and was dammed for recreational use as part of the Pine Grove Furnace State Park. Cedar Run is a limestone stream in an increasingly urbanized watershed that is heavily paved and developed. Both stream sample sites had "lower" water quality; however, Mountain Creek had high iron and total suspended solids concentrations and slightly elevated total nitrogen levels. The high iron was probably due to natural sources. This stream is listed on the TMDL 303(d) list due to atmospheric deposition. Limestone sand has been applied at select locations in the watershed to attempt to remediate the stream and raise the pH. Cedar Run contained high calcium, hardness, nitrate-n, total nitrogen, and sodium concentrations. Mountain Creek had nonimpaired biology and excellent habitat, while Cedar Run had moderately impaired biology and supporting habitat. The stream bed in Cedar Run was strewn with concrete, gravel, and asphalt pieces that embedded the substrate.

Paxton Creek Watershed

Paxton Creek Watershed is located in the urban and suburban Harrisburg, Pa., area. The lower stretches have been impacted due to outdated infrastructure, commercialization, and industrialization for decades.

Paxton Creek Watershed includes highly urbanized and more natural settings.

The upper stretches of the watershed have been developed more recently. Efforts are being made by the local watershed group, Paxton Creek Watershed and Education Association, to minimize the impact of new development. Unfortunately, the impacts of the development and urbanization in this watershed were evident in the severely and moderately impaired macroinvertebrate populations. The water chemistry performed may not have captured all of the impairments that exist in this watershed, but the parameters that did exceed levels of concern were nitrate-n, total nitrogen, and orthophosphate at PAXT 0.5, and sodium at both sites. Habitat was rated supporting and partially supporting at PAXT 8.4 and PAXT 0.5, respectively. Leeches and algae-covered substrate were noted at the sites, in addition to trash and litter. SRBC currently is conducting a stormwater, nutrient, and sediment study on the Paxton Creek Watershed with an emphasis on habitat remediation. This project was made possible through the support of the U.S. Environmental Protection Agency and the National Fish and Wildlife Foundation and will be implemented over the next three years.

Swatara Creek Watershed

An improvement in biological condition rating was evident at the Swatara Creek Watershed sites as the stream flowed from the headwaters to the mouth. The headwater site (SWAT 56.0) had a moderately impaired biological condition, which may have been due to the habitat, which was rated partially supporting. The area surrounding the stream was dominated by residential land use, and problems included an algae-covered bottom, low frequency of riffles, and high sediment deposition. The water chemistry analysis did not indicate that any parameters exceeded levels of concern. However, there were abandoned mine lands in the headwaters of Swatara Creek, which could have been a source of the impairment.

The biological and habitat conditions improved at the next site downstream, SWAT 39.0. Again, the water quality was rated "higher." Farther downstream (SWAT 21.7), biological and habitat conditions improved further; however, the water quality was rated "middle" due to elevated nitrate-n and total nitrogen. This increase in nitrogen may have been due to the influence of Little Swatara Creek, which enters Swatara Creek upstream of SWAT 21.7. Nitrate-n, nitrite-n, and total nitrogen were high at LSWT 0.6. The nitrite-n level (0.13 mg/l) was the highest recorded for the Lower Susquehanna Subbasin sites (Table 4).

Four tributary sites were sampled along Swatara Creek upstream of the site at the mouth. These tributaries were Quittapahilla, Manada, Spring, and Beaver Creeks. Water quality was rated "middle," and habitat was rated "supporting" on all these streams. MNDA 0.1 and BEAV 0.6 had slightly impaired biological conditions, while QUIT 0.3 and SPRG 0.0 were moderately impaired, most likely due to the high nutrient levels in each of these streams. QUIT 0.3 in particular exhibited very high nitrate-n (9.39 mg/l), total nitrogen (9.96 mg/l), orthophosphate (0.101 mg/l), and total phosphorus (0.119 mg/l) (Table 4). The site at the mouth of Swatara Creek had a nonimpaired macroinvertebrate community, although nutrient levels and sodium were elevated at the time of sampling, and habitat was rated partially supporting.

TRIASSIC LOWLANDS and TRAP ROCK and CONGLOMERATE UPLANDS ECOREGIONS

East Conewago and West Conewago Creeks Watersheds

A creek named Conewago Creek exists on both the east and west sides of the Susquehanna River south of Middletown near York Haven, Pa. Both creeks were located in agricultural areas and were impacted by nutrients. The eastern creek is much smaller and had slightly impaired biological conditions, "middle" water quality, and supporting habitat.

In this survey, West Conewago Creek contained five mainstem and four tributary sampling sites. All sites had "middle" water quality, mostly due to elevated nutrient levels. Biological conditions were either nonimpaired or slightly impaired, although the habitat ranged from excellent to partially supporting. The land use was mostly agriculture; however, most areas surrounding the stream had forested cover, and the lower section of Conewago Creek had a large percentage of natural vegetated area (Figure 3). The tributary Little Conewago Creek flowed through the northwestern part of suburban York, which may account for the five chemical parameters that exceeded levels of concern (Table 4); however, biological conditions were nonimpaired at the mouth. The other sites that had nonimpaired biological conditions were the two headwater Conewago Creek sites, the site at the mouth of Conewago Creek, and the site at the mouth of Bermudian Creek (BERM 1.2). One of the headwater sites, WCON 56.3, served as the reference site for group 64L. South Branch Conewago Creek was slightly impaired and was sampled near the Route 30 bridge in a developed area.

South Branch Codorus Creek.

S. Buda

PIEDMONT ECOREGION

Codorus Creek Watershed

Codorus Creek Watershed includes part of Hanover, Pa., and most of York, Pa. This survey included four mainstem samples and two samples taken on South Branch Codorus Creek. All the sites had "middle" water quality except for the site at the mouth, which exceeded levels of concern for six parameters (Table 4). This site was located in a picturesque glen along the Susquehanna River; however, the biology was slightly impaired, and a distinct wastewater odor was present. The habitat at this site was rated excellent, since it was located in the forested river hills. Upstream portions of the creek were completely channelized and degraded in the urban York area. Nutrient concentrations were high at the other mainstem sites, and CODO 22.4 was the only site with nonimpaired biology compared to other sites in its reference category (64d). No stoneflies were present, but a number of pollution-tolerant mayflies were present.

The two headwater sites, CODO 34.1 and CODO 33.0, were sampled upstream and downstream of the West Branch Codorus Creek, which includes Codorus Creek State Park and Lake Marburg. The West Branch Codorus Creek and the lake influenced biological conditions (such as a change in mayfly taxa, a decrease in Chironomidae, and the presence of amphipods) at the downstream site. Also, the levels of nitrate-n and total nitrogen were diluted by flow from the West Branch Codorus Creek. South Branch Codorus Creek had nonimpaired biological conditions, although the water quality was rated "middle" due to elevated nutrients, and the habitat was supporting. SBCD 3.6 was located downstream of a pasture where cows had access to the stream. Also, the headwaters of South Branch Codorus Creek are impacted by new development and associated municipal discharges, which could be a source of elevated nutrients.

Chiques Creek Watershed

Chiques Creek flows through the agricultural communities surrounding Mount Joy, Landisville, and Manheim, Pa. The headwaters of Chiques Creek originate in a forested state game lands area; however, forested areas make up a very small portion of the land use of the watershed, which was dominated highly by agriculture. The biological condition at the headwater site, CHIQ 20.0, was rated slightly impaired. The water quality was rated "middle" due to elevated nutrients, and the habitat was rated supporting. Little Chiques Creek was severely polluted by nutrients and had a "lower" water quality rating. This site had the highest levels of nitrate-n (11.2 mg/l) and total nitrogen (11.37 mg/l) in addition to elevated levels of orthophosphate, total phosphorus, sodium, and total suspended solids (Table 4). The macroinvertebrate population was moderately impaired and was dominated by amphipods, which is indicative of a limestone stream. There were few mayflies and no stoneflies in the sample. CHIQ 3.0, which was downstream of Little Chiques Creek, appeared to be influenced by the water quality of Little Chiques Creek. The nitrate-n and total nitrogen were both 11.0 mg/l, and orthophosphate and sodium levels were high also (Table 4). CHIQ 3.0 was downstream of the site sampled in 1996 due to lack of suitable sampling habitat.

"Also, the headwaters of South Branch Codorus Creek are impacted by new development and associated municipal discharges, which could be a source of elevated nutrients."

Kreutz Creek Watershed

Kreutz Creek, located on the western side of the Susquehanna River, flowed through small towns, suburbs of York, state and county parks, and agricultural areas. The biological condition of the site sampled was nonimpaired, although the water chemistry indicated elevated nitrate-n, nitrite-n, and total nitrogen levels. The habitat was influenced by a golf course upstream and was rated supporting.

Conestoga River Watershed

The biological conditions at most of the sites in the Conestoga River Watershed were rated slightly impaired, except MIDD 0.2, MUDD 0.2, and CNTG 43.9, which were rated nonimpaired. Additionally, the upper site on Cocalico Creek (CCLC 12.2) was rated moderately impaired. Both sites on Cocalico Creek were impacted by high nutrient levels. The upper site, CCLC 12.2, had slightly higher nutrient levels and higher sodium levels than CCLC 0.4 (Table 4). All the sites in the Conestoga River Watershed had high levels of nutrients with nitrate-n and total nitrogen concentrations higher than 5.0 mg/l except at MUDD 0.2, which served as the reference site for sites in the group 64d. MILL 0.3 had the highest level of sodium (80.5 mg/l), specific conductivity (940 µmhos/cm), and total chloride (130 mg/l) of all the streams in the Lower Susquehanna Subbasin (Table 4). Orthophosphate concentrations were high on all the mainstem Conestoga River sites with levels increasing toward the mouth. Total phosphorus and sodium exceeded levels of concern at the two most downstream sites, CNTG 22.6 and CNTG 0.9. At most sites, habitat was rated supporting, with two sites rated excellent (LCNT 1.7 and HAMM 0.2) and two sites rated partially supporting (CNTG 22.6 and CCLC 0.4).

SRBC conducted a periphyton study on the Conestoga River Watershed simultaneously with the Lower Susquehanna Subbasin Survey sampling. The periphyton study was part of a nutrient TMDL study funded by the PADEP. Low flow conditions were targeted to determine how point sources in this watershed impacted the stream water chemistry and periphyton populations. Also, an assessment of the relationship between the periphyton and macroinvertebrates will be conducted and the use of each as indicators of nutrient pollution will be analyzed. The periphyton study is ongoing with sampling planned for summer 2006 and 2007.

Pequea Creek Watershed

Like most of the other watersheds in the Piedmont Region, Pequea Creek was impacted by agricultural land use. The nutrient levels were high at both mainstem and tributary sites that were sampled. Of these sites, the headwater station (PQEA 15.2) had the highest levels of total nitrate-n (8.65 mg/l), nitrogen (8.85 mg/l), orthophosphate (0.133 mg/l), and phosphorus (0.187 mg/l), and also had elevated total suspended solids (42 mg/l) (Table 4). The water quality at PQEA 15.2 was rated "lower," while the other mainstem site (PQEA 3.3) and the tributary site (SBEV 2.5) were rated "middle" quality. The biological conditions at all three sites were rated slightly impaired. Habitat ranged from partially supporting to excellent. The habitat at PQEA 15.2 was rated low due to excessive bank erosion and siltation. SBEV 2.5 habitat had potential for improvement if a stream bank fencing program would be implemented. PQEA 3.3 was located in the southern portion of Lancaster County, which is more influenced by river hills and was more forested.

Muddy Creek Watershed

Muddy Creek Watershed located in southern York County was one of the higher quality watersheds in the Lower Susquehanna Subbasin. The biological conditions at all sites (MDDY 3.3, NBMY 0.0, and SBMY 0.0) sampled in this watershed were rated nonimpaired. The two sites on North Branch Muddy Creek and South Branch Muddy Creek also had excellent habitat conditions. The site on North Branch Muddy Creek (NBMY 0.0) served as a reference site for group 64ac. As with many streams in the Piedmont Region, the water quality was rated "middle" due to elevated total nitrate-n and total nitrogen. This watershed was more forested and less urban than the other watersheds in the Piedmont Region. Figure 3 indicates that the stream channel was buffered with natural vegetated areas.

Conowingo Creek Watershed

Conowingo Creek was sampled at the Pennsylvania and Maryland state line since this was also an SRBC Interstate Streams Monitoring Program station. In 2003, this site was rated slightly impaired, and nutrient and total iron concentrations were high in some of the quarterly samples (Hoffman and Sitlinger, 2005). In 2005, as part of the Lower Susquehanna Subbasin Survey, this site had a nonimpaired biological condition, and the water quality was rated "middle" due to high levels of nutrients. High levels of iron were not noted in this sample. The different biological rating may not be an indication of improvement as much as an indication of different reference conditions and stream sites in the reference category. The habitat score was slightly lower in 2005 than in 2003.

D. Hintz

Streambank fencing with cow passageway on Muddy Creek in Lancaster County.

Octoraro Creek Watershed

The east and west branches and the main stem near the mouth were sampled in the Octoraro Creek Watershed. All sites had "middle" water quality based on elevated levels of nutrients at the time of sampling. The highest levels of nitrates and nitrogen were found in the two branches of the creek and were diluted somewhat towards the mouth, whereas the highest levels of orthophosphates and phosphorus were found at the mouth. The habitat was rated excellent at all three sites; however, the macroinvertebrate populations were rated nonimpaired on the West Branch Octoraro and at the mouth and slightly impaired on East Branch Octoraro Creek. The West Branch Octoraro Creek is a popular fishing spot and is surrounded in parts by state game lands. Octoraro Creek at a station on the Pennsylvania-Maryland state line was rated slightly impaired in SRBC's last published Interstate Streams Report (Hoffman and Sitlinger, 2005); however, it has been rated nonimpaired in the past. Iron concentrations were high at the time of sampling, but this was most likely due to erosion of soils during high flows.

Deer Creek Watershed

Most of the Deer Creek Watershed lies in Maryland in a rural agricultural and forested area with no large urban areas. The macroinvertebrate populations at the two sampling sites on Deer Creek were nonimpaired. The water quality at both was rated "middle" due to somewhat elevated total nitrate-n and total nitrogen levels. This watershed also was monitored along the Pennsylvania-Maryland state line as part of the Interstate Streams Monitoring Program. Deer Creek and its tributaries often served as reference sites for the streams along the Pennsylvania-Maryland border (Hoffman and Sitlinger, 2005).

Harford County Department of Planning and Zoning in conjunction with Maryland DNR and other stakeholders is developing a Watershed Restoration Action Strategy (WRAS) for Deer Creek. A WRAS is a watershed plan that is developed to identify areas of concern or interest and create a plan for restoration and protection. These plans resulted from the 2000 Chesapeake Bay Agreement. Prior to the development of the WRAS, preliminary work was conducted on the watershed, and documents were created on the characterization of the watershed, assessments of the stream corridor, and synoptic surveys. These supporting documents provide a more detailed assessment of the Deer Creek Watershed and are located at *http://dnr.maryland.gov/watersheds/surf/proj/wras.html.* More information about the WRAS process is available at *http://dnr.maryland.gov/watersheds/WRAS/.*

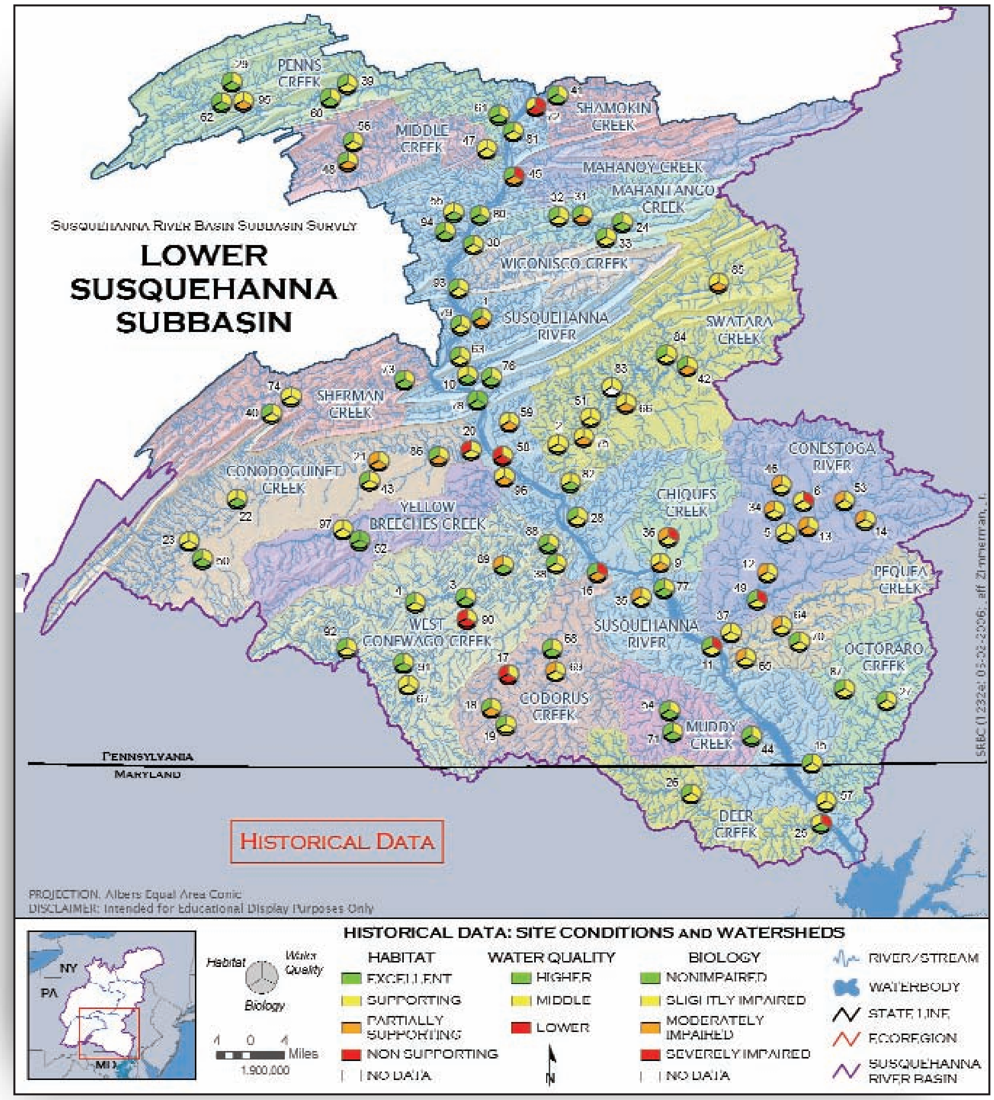
SUSQUEHANNA RIVER MAINSTEM

The Susquehanna River Mainstem sites were analyzed separately from other Lower Susquehanna Subbasin sites due to their large drainage size and different nature. SUSQ 77.0 served as a reference site for the Susquehanna River Mainstem sites. All the sites on the mainstem Susquehanna River had fairly similar biological conditions except for SUSQ 122.0, which was rated slightly impaired. Ironically, this was the only site to receive a “higher” water quality rating. This was most likely due to dilution or a one-time sample that was not representative of usual conditions. SUSQ 122.0 was located downstream of Sunbury, Pa., which is where the West Branch Susquehanna River and the North Branch Susquehanna River join to form the main stem. The next two sites downstream, SUSQ 106.0 and SUSQ 94.0, received “lower” water quality ratings mostly due to elevated specific conductivity. This elevated conductivity may be due to the influence of the AMD-impacted streams that flow into the Susquehanna from the east. The site farther downstream, SUSQ 77.0, was downstream of the high quality streams, such as Powell, Clark, Stony, and Sherman Creeks. Slightly elevated total nitrogen and sodium were the reason for the “middle” water quality rating. SUSQ 44.5 also was rated as “middle” quality with slightly elevated total nitrogen, sodium, and temperature. This site was an Interstate Streams Monitoring site and had received nonimpaired and slightly impaired ratings throughout the past couple years, although no sample was collected in 2003 (Hoffman and Sitlinger, 2005).

COMPARISON of 1996 and 2005 DATA

A comparison of historical Lower Susquehanna Subbasin data from 1996 and the current survey data from 2005 indicated overall similarity with some slight changes in biological and water quality conditions. Biological conditions seemed to be slightly better in 2005, while water quality appeared to improve in some parameters but degrade in others. The results for water quality, biological, and habitat conditions in the 1996 Lower Susquehanna Subbasin Survey are depicted in Figure 5. Two sites, CEDR 0.1 and CHIQ 20.0, were added to the survey in 2005 and are in blue print in the Appendix, since these sites were not included in the historical data. The methods have changed slightly throughout the years, and the methods for the 1996 survey can be found in Traver (1997). Specifically, the number of macroinvertebrates subsampled changed from 100 to 200, the habitat assessment form changed to assigning each parameter 20 points instead of weighting the parameters with different point ranges, and the water quality assessment analysis has changed. In the 1997 report, Traver assessed water quality using Principal Components Analysis and cluster analysis and did not assign rating categories for site conditions. For comparison purposes, the 1996 data were analyzed using current methodology to acquire water quality site condition ratings. In addition, the reference categories have changed due to advances in Geographic Information Systems technology and calculation of drainage size. MNTN 3.0 was the only site in Ecoregion 66, so this site was grouped with 67cd.

Figure 5. *Water Quality, Biological, and Habitat Conditions in 1996 Sample Sites in the Lower Susquehanna Subbasin*



Another difference between the data sets was flow, which varied from site to site for different years.

In 1996, 28 percent of the biological conditions were nonimpaired, 50 percent were slightly impaired, 18 percent were moderately impaired, and four percent were severely impaired (Figure 6). A summary of the biological conditions in 2005 showed a larger percentage rated as nonimpaired (43 percent), 33 percent slightly impaired, 22 percent moderately impaired, and two percent severely impaired (Figure 7). Of the sites that were sampled in 1996 and 2005, 59 percent maintained the same site condition rating, 28 percent improved, and 13 percent degraded. The improvements and degradations were only by one category step, except for CODO 22.4, WCON 35.5, and YLBR 3.4, which improved, and ELKN 0.1 and MISP 0.5, which degraded by more than one step in biological condition from 1996 to 2005. CODO 22.4 showed the most significant improvement from severely impaired to nonimpaired biological condition.

The 1996 water chemistry data were analyzed using current methods and levels of concern, and two percent of the sites were considered "higher," 90 percent were "middle" quality, and eight percent were considered "lower" quality. In 2005, six percent were "higher" water quality, 77 percent were "middle" quality, and 17 percent were considered "lower" quality. A site-to-site comparison indicated that 83 percent of the sites had the same water quality site condition category in 2005 as in 1996, seven percent improved, and ten percent degraded. The only site to change by more than one step was MNTN 3.0, which degraded from "higher" to "lower."

Figure 6. *Summary of the Biological Conditions in the Lower Subbasin in 1996*

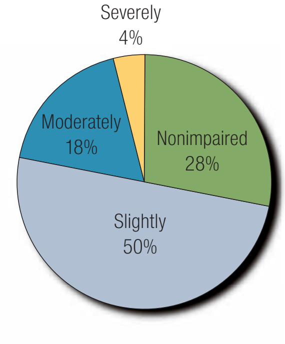


Figure 7. *Summary of the Biological Conditions in the Lower Subbasin in 2005*

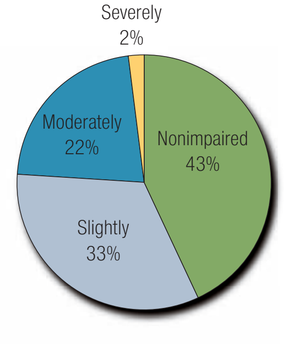


Table 7 shows a comparison of the total number of sites to exceed levels of concern for the sites that were sampled in both 1996 and 2005. The amount of sites to exceed levels of concern for each parameter was relatively similar except for total nitrate-n, total nitrogen, total phosphorus, and total sodium. The number of sites to exceed levels of concern for total nitrate-n and total nitrogen decreased; however, the number of sites for total phosphorus and total sodium increased from 1996 to 2005. A decrease in total nitrate-n and total nitrogen over the years may be due to localized implementation of Best Management Practices (BMPs) such as manure storage, manure digesters, contour plowing, etc. and updates in wastewater treatment systems and infrastructure. The increase in total phosphorus and sodium may be due to additional development increasing the amount of erosion from disturbed land, erosion from stream banks due to increased runoff, and more sodium from pavement runoff. The highest total nitrogen values in 1996 and 2005 were 12.3 mg/l and 11.37 mg/l, respectively, and they were both from the same site, LCHQ 0.4, on Little Chiques Creek. The same was true for total nitrate-n with values of 12 mg/l and 11.2 mg/l, respectively. CCLC 12.2 had the highest total phosphorus, total sodium, total chloride, and total orthophosphate in 1996. In 2005, this site had similar values for these parameters, but the highest values were found at MIDL 0.7 for total phosphorus, MILL 0.3 for total sodium and total chloride, and EMAH 0.2 for total orthophosphate.

Conclusions

Overall, conditions of streams sampled during the 2005 Lower Susquehanna Subbasin Survey were satisfactory; however, improvement was needed at many of the stations. Less than 50 percent of the sites sampled had nonimpaired biological conditions and less than 10 percent of the sites had "higher" water quality ratings. Only 30 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, 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 large an amount of water, such as during a large 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

Table 7. *Number of Water Quality Values Exceeding Levels of Concern for the same sites in 1996 and 2005*

Year	Lab Alkalinity	Calcium T	Hardness T	Iron T	Magnesium T	Manganese T	Nitrate-N T	Nitrite-N T	Nitrogen TOT	Phos T Ortho	Phosphorus T	Sodium T	Sulfate T	Acidity	Specific Cond.	Water Temp.	Lab pH
1996	13	0	1	2	0	2	95	2	100	32	16	8	1	1	0	4	1
2005	10	1	2	3	1	2	70	4	82	34	29	21	1	1	3	12	0

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 (streams peak higher and quicker causing more erosion of the stream channel), and higher concentrations of pollutants being washed off the pavement.

AMD pollution in this subbasin was minimal and was concentrated mostly in a small northeastern section of the subbasin. Only seven 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.

Some of the highest quality watersheds within this subbasin were Sherman, Powell, Clarks, Stony, West Branch Mahantango, and North Branch Mahantango Creeks. Some watersheds that also rated well overall were Muddy, Deer, Octoraro, Conowingo, and sections of West Conewago Creeks. Although these watersheds contained a large amount of agricultural land and did have higher nutrient levels, they did not have heavy urban influence. They also appeared to be more forested, especially around the stream corridor. A naturally vegetated area surrounding the stream serves to protect the stream and provides necessary habitat to the aquatic insects and fish.

Some of the most degraded watersheds were Shamokin, Mahanoy, Armstrong, Paxton, Chiques, Conestoga, and Conodoguinet Creeks. Shamokin and Mahanoy Creeks were impacted by AMD, Armstrong Creek was potentially impacted by agriculture, Paxton Creek by urban development, and Chiques, Conestoga, and Conodoguinet Creeks by a mix of agriculture and urban development. The sampling in this survey was a one-time event, so replicate sampling would be needed to truly identify problems in these watersheds. However, this survey indicates where additional study is needed, such as in the case of limestone streams. A different analysis may improve impairment level determinations, since limestone stream macroinvertebrate populations have unique characteristics. These populations are often abundant, dominated by a few taxa such as *Ephemerella* (mayfly), Amphipoda (freshwater crustacean), Isopoda (freshwater crustacean), and Chironomidae (midges), and have few stonefly taxa. This is due to limestone streams tending to have low gradient, constant temperatures, high alkalinity, and high aquatic plant production.

Efforts should be made to restore the most degraded watersheds and protect the higher quality ones within this subbasin. Agricultural BMPs 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 *(http://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 *(http://www.orange-waternetwork.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 *(http://www.cwp.org/)* and from the PADEP's Pennsylvania Stormwater Best Management Practices Manual *(http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/stormwatermanagement/BMP%20Manual/BMP%20Manual.htm)*.

The Lower Susquehanna Subbasin Survey, Year 2 assessment is being conducted in the Yellow Breeches Watershed and is focusing on bacterial monitoring and recreational and drinking water impacts in this highly used watershed. The study began in February 2006 and includes the mainstem Yellow Breeches, Cedar Run, Mountain Creek, Stony Run, Dogwood Run, and Trout Run. The study will help assess levels of bacterial contamination in the Yellow Breeches Watershed, documenting seasonal variability of bacteria levels, identifying sources of bacterial pollution, and providing information on differences in abundance of fecal coliform, enterococci, and *Escherichia coli (E. coli)*. More information on this project is available from SRBC.

REFERENCES

Baker, J.P. and C.L. Schofield 1982. Aluminum toxicity to fish in acidic waters. Water, Air, and Soil Pollution 18:289-309.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Buchanan, T.J. and W.P. Somers. 1969. Discharge Measurements at Gaging Stations: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A8, 65 p. Washington, D.C.

The Commonwealth of Pennsylvania. 2002. The Pennsylvania Code: Title 25 Environmental Protection. Fry Communications, Inc., Mechanicsburg, Pennsylvania. http://www.pacode.com

Gagen, C.J. and W.E. Sharpe. 1987. Net sodium loss and mortality of three Salmonid species exposed to a stream acidified by atmospheric deposition. Bull. Environ. Contam. Toxicol. 39:7-14.

Hach Company. 2003. Important Water Quality Factors. http://www.hach.com/h2ou/h2wtrqual.htm

Hem, J.D. 1970. Study and Interpretation of the Chemical Characteristics of Natural Water. 2nd Ed. Geological Survey Water-Supply Paper 1473. United States Department of the Interior. United States Government Printing Office, Washington, D.C. http://water.usgs.gov/pubs/wsp/wsp2254/

Hoffman, J. L. R. and D. Sitlinger. 2005. Assessment of Interstate Streams in the Susquehanna River Basin, Monitoring Report #18, July 1, 2003 - June 30, 2004. Susquehanna River Basin Commission (Publication No. 237), Harrisburg, Pennsylvania.

Kentucky Natural Resources and Environmental Protection Cabinet. 2003. Kentucky River Basin Assessment Report: Water Quality Parameters. http://www.uky.edu/WaterResources/Watershed/KRB_AR/krww_parameters.htm

–. 2003. Kentucky River Basin Assessment Report: Water Quality Standards. http://www.uky.edu/WaterResources/ Watershed/KRB_AR/wq_standards.htm

McMorran, C. P. 1986. Water Quality and Biological Survey of the Lower Susquehanna Subbasin. Susquehanna River Basin Commission (Publication No. 104), Harrisburg, Pennsylvania.

Ministry of Environment. 1998. Guidelines for Interpreting Water Quality Data. Resources Inventory Committee Publication. Version 1.0. British Columbia, Canada. http://srmwww.gov.bc.ca/risc/pubs/aquatic/interp/

New York State Department of Environmental Conservation. 1999. Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations. 6NYCRR Part 703. Division of Water, Albany, New York. http://www.dec.state.ny.us/website/regs/part703.html

Omernik, J.M., Brown, D.D., Kiilsgaard, C.W., and Piersen, S.M., 1992, Draft ecoregions and subregions of the Blue Ridge Mountains, Central Appalachian Ridges and Valleys, and Central Appalachians of USEPA Region 3: Corvallis, Oreg., U.S. Environmental Protection Agency, Environmental Research Laboratory, 1 map.

Omernik, J.M. 1987. Aquatic ecoregions of the conterminous United States. U.S. Geological Survey, Reston, Virginia.

Pennsylvania Department of Environmental Protection. 2005. emap PA. http://www.emappa.dep.state.pa.us/emappa/viewer.htm

Pennsylvania Fish and Boat Commission. 2003. Pond and Stream Study Guide. http://sites.state.pa.us/ PA_Exec/Fish_Boat/education/catalog/pondstream.pdf

Plafkin, J.L., M.T. Barbour, D.P. Kimberly, S.K. Gross, and R.M. Hughes. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. U.S. Environmental Protection Agency, Office of Water, Washington, D.C., EPA/440/4-89/001. May 1989.

Traver, C. L. 1997. Water Quality and Biological Assessment of the Lower Susquehanna Subbasin. Susquehanna River Basin Commission (Publication No. 190), Harrisburg, Pennsylvania.

United States Environmental Protection Agency. 1986. Quality Criteria for Water (Gold Book). EPA 440/5-86-001. Office of Water, Regulations and Standards. Washington, D.C. http://www.epa.gov/waterscience/criteria/goldbook.pdf

_____. 2003. Developing Water Quality Criteria for Suspended and Bedded Sediments (SABs); Potential Approaches (Draft). Appendix 3: EPA Summary Table of Current State Standards. Office of Water. Office of Science and Technology. http://www.epa.gov/waterscience/criteria/sediment/appendix3.pdf

U.S. Geological Survey. 1999. The Quality of Our Nation's Waters: Nutrients and Pesticides. Circular 1225. U.S. Department of the Interior, Reston, Virginia. http://water.usgs.gov/pubs/circ/circ1225/images/table.html

_____. 2001. National Water-Quality Assessment Program: Nutrients in the Nation's Waters-Too Much of a Good Thing? Circular 1136. U.S. Department of the Interior, Reston, Virginia. http://water.usgs.gov/nawqa/circ-1136/NIT

Woods, A.J., J. O. Omernik, D. D. Brown, C. W. Kiilsgaard, 1996. Level IV Ecoregions of Pennsylvania, Maryland, West Virginia, Virginia, and Delaware: Corvalis, OR, U.S. Environmental Protection Agency, National Health and Environmental Effects Laboratory (NHEERL).

APPENDIX

Sample Site #	Station Name	Latitude	Longitude	Location Description	Drainage (sq. miles)	Reference Category
1	ARMS 0.1	40.4841944	76.9317778	Armstrong Creek upstream of Route 147 bridge near Halifax, Dauphin Co.	32.3	67b
2	BEAV 0.6	40.2703333	76.7413056	Beaver Creek at third bridge from the mouth on Pleasant View Drive at Pleasant View, Dauphin Co.	26.8	67a
3	BERM 1.2	39.9988333	76.9414167	Bermudian Creek at Blue Hill School Road bridge near Detters Mill, York Co.	109.1	64L
4	BERM 11.0	40.0014444	77.0586667	Bermudian Creek at Latimore Valley Road/Pondtown Road east of York Springs, Adams Co.	44.2	64ac
5	CCLC 0.4	40.1301389	76.2315556	Cocalico Creek at Log Cabin Road covered bridge near Millport, Lancaster Co.	138.9	64L
6	CCLC 12.2	40.1691111	76.2203056	Cocalico Creek upstream of Royer Road bridge west of Ephrata, Lancaster Co.	66.1	64d
7	**CEDR 0.1**	**40.2251972**	**76.9063303**	**Cedar Run upstream of Creek Road bridge at Eberlys Mill, Cumberland Co.**	**12.5**	**67a**
8	**CHIQ 20.0**	**40.206005**	**76.3942978**	**Chiques Creek at Elizabeth Road bridge north of Manheim, Lancaster Co.**	**18.3**	**64ac**
9	CHIQ 3.0	40.0632615	76.5154102	Chiques Creek upstream of bridge at Marietta Pike near Marietta, Lancaster Co.	108.0	64L
10	CLRK3.8	40.3871111	76.9414444	Clarks Creek at Route 225 bridge north of Dauphin, Dauphin Co.	40.0	67cd
11	CNTG 0.9	39.9342	76.3858	Conestoga River along River Road in Safe Harbor Park, Lancaster Co.	472.5	64L
12	CNTG 22.6	40.05	76.2775	Conestoga River at Penn Railroad bridge in Lancaster City, Lancaster Co.	322.0	64L
13	CNTG 32.7	40.1299722	76.1993611	Conestoga River at SR 1010 bridge near Brownstown, Lancaster Co.	125.7	64L
14	CNTG 43.9	40.1381	76.0605	Conestoga River at Quarry Road near Weaverland, Lancaster Co.	48.2	64d
15	CNWG 1.8	39.7245278	76.1833611	Conowingo Creek near mouth at state line, Cecil Co./Lancasater Co.	33.3	64ac
16	CODO 0.6	40.0522592	76.6550881	Codorus Creek near mouth at Codorus Furnace, York Co.	276.6	64L
17	CODO 22.4	39.8791	76.8529	Codorus Creek at Hershey Road end downstream of Spring Grove, York Co.	75.5	64d
18	CODO 33.0	39.8221	76.8885	Codorus Creek along SR 3047 downstream of Lake Marburg outflow confluence, York Co.	40.0	64ac
19	CODO 34.1	39.8099	76.8726	Codorus Creek at SR 3051 bridge upstream of Lake Marburg outflow confluence, York Co.	13.2	64ac
20	CONO 1.3	40.2605278	76.9348889	Conodoguinet Creek upstream of Poplar Church Road near Camp Hill, Cumberland Co.	502.3	67L
21	CONO 28.8	40.2366944	77.1448611	Conodoguinet Creek upstream of Middlesex Road near Carlisle, Cumberland Co.	396.0	67L
22	CONO 51.8	40.1774722	77.4543056	Conodoguinet Creek at SR 4006 bridge near Newville, Cumberland Co.	208.8	67L
23	CONO 66.0	40.1045278	77.5606944	Conodoguinet Creek at Burnt Mill Road bridge north of Shippensburg, Franklin Co.	107.3	67L
24	DEEP 1.2	40.6381389	76.6079722	Deep Creek at Mill Road bridge near Sacramento, Schuylkill Co.	31.3	67b
25	DEER 1.2	39.6226944	76.1644722	Deer Creek upstream of Stafford Road bridge near Susquehanna State Park, Harford Co.	169.3	64L
26	DEER 30.1	39.6755556	76.4506111	Deer Creek upstream of Fawn Grove Road at Eden Mill Park, Harford Co.	61.3	64ac
27	EBOC 5.3	39.8306111	76.0175556	East Branch Octoraro Creek at John Evans Memorial Park near Cream, Lancaster Co./Chester Co.	75.6	64ac
28	ECON 0.0	40.1472222	76.6993056	East Conewago Creek at second bridge upstream from mouth near Falmouth, Lancaster Co./Dauphin Co.	51.3	64ac
29	ELKN 0.1	40.8702222	77.4588333	Elk Creek upstream of Pine Creek near Coburn, Centre Co.	56.8	67a
30	EMAH 0.2	40.6098889	76.9295833	Mahantango Creek at Route 147 bridge near Paxton, Dauphin Co.	164.2	67L
31	EMAH 17.1	40.6601667	76.68575	Mahantango Creek in park at Klingerstown, Schuylkill Co.	44.6	67b
32	EPIN 0.1	40.6614444	76.6927778	Pine Creek near Klingerstown, Schuylkill Co.	77.0	67b
33	EPIN 12.7	40.6275278	76.62075	Pine Creek at Spring Glen, Schuylkill Co.	28.5	67cd
34	HAMM 0.2	40.161	76.23375	Hammer Creek at mouth along Cocalico Road near Millway, Lancaster Co.	35.2	64d
35	KRTZ 1.5	40.0152778	6.5395	Kreutz Creek at Cool Creek Road in Wrightsville, York Co.	32.8	64d
36	LCHQ 0.4	40.0793275	76.5070022	Little Chiques Creek upstream of Iron Bridge Road, Lancaster Co.	43.1	64d
37	LCNT 1.7	39.9525	76.3697	Little Conestoga River at mouth near Rockhill, Lancaster Co.	65.5	64d
38	LCON 1.5	40.0882222	76.7271667	Little Conewago Creek at mouth in Conewago Heights, York Co.	65.4	64ac
39	LRLN 0.8	40.8931667	77.2038056	Laurel Run at SR 3020 north of Laurelton, Union Co.	10.5	67b
40	LRSL 0.5	40.3224444	77.378	Laurel Run upstream of Laurel Run Road bridge near Landisburg, Perry Co.	22.1	67cd
41	LSHM 0.8	40.8587778	76.7665556	Little Shamokin Creek near mouth at Sunbury, Northumberland Co.	29.0	67b
42	LSWT 0.6	40.4081111	76.4740833	Little Swatara Creek at mouth near Jonestown, Lebanon Co.	99.0	67b
43	LTRT 0.1	40.23425	77.1385833	Letort Spring Run at Route 11 bridge near Carlisle, Cumberland Co.	21.8	67a
44	MDDY 3.3	39.7726111	76.31625	Muddy Creek at SR2024 (Paper Mill Road) near Coal Cabin Beach, York Co.	132.8	64L
45	MHNY 0.3	40.7262778	76.8375	Mahanoy Creek at Route 147 bridge near Herdon, Northumberland Co.	157.1	67L
46	MIDD 0.2	40.177389	76.241278	Middle Creek upstream of Middle Creek Road bridge north of Millway, Lancaster Co.	31.5	64d
47	MIDL 0.7	40.7731667	76.8984444	Middle Creek near mouth at Kantz, Snyder Co.	157.9	67L
48	MIDL 24.7	40.7626944	77.2099167	Middle Creek upstream of Route 235 bridge near Beaver Springs, Snyder Co.	33.5	67b
49	MILL 0.3	40.0041	76.3016	Mill Creek at Elkman Road bridge near Lyndon, Lancaster Co.	56.4	64d
50	MISP 0.5	40.0983889	77.5612222	Middle Spring Run along Burnt Mill Road north of Shippensburg, Cumberland Co.	45.2	67a

Sample Site #	Station Name	Latitude	Longitude	Location Description	Drainage (sq. miles)	Reference Category
51	MNDA 0.1	40.3087778	76.6710556	Manada Creek at mouth in Sand Beach, Dauphin Co.	32.2	67b
52	MNTN 3.0	40.1073333	77.1815278	Mountain Creek along Route 34 upstream of Mount Holly Springs, Cumberland Co.	45.0	67cd*
53	MUDD 0.2	40.1716	76.1057	Muddy Creek upstream of Frysville Road near Frysville, Lancaster Co.	49.3	64d
54	NBMY 0.0	39.8079167	76.4758611	North Branch Muddy Creek near mouth at Muddy Creek Forks, York Co.	43.8	64ac
55	NMHT 0.0	40.6475	76.9661	North Branch Mahantango Creek at mouth near Mahantango, Snyder Co.	37.1	67b
56	NMID 0.7	40.7745833	77.1980278	North Branch Middle Creek at Benfer, Snyder Co.	26.1	67b
57	OCTO 1.0	39.6598889	76.1533333	Octoraro Creek at railroad bridges near Rowlandsville, Cecil Co.	209.9	64L
58	PAXT 0.5	40.2473056	76.8648889	Paxton Creek at Greenway bridge in Harrisburg, Dauphin Co.	27.3	67b
59	PAXT 8.4	40.3087222	76.8498889	Paxton Creek upstream of Progress Avenue bridge near Harrisburg, Dauphin Co.	11.2	67b
60	PENN 30.0	40.8633889	77.2376667	Penns Creek at Glen Iron, Union Co.	254.1	67L
61	PENN 5.0	40.8270556	76.8687222	Penns Creek at Selinsgrove, Snyder Co.	364.3	67L
62	PENN 50.6	40.8574444	77.4844444	Penns Creek upstream of Elks Creek near Coburn, Centre Co.	90.1	67a
63	POWL 0.1	40.42025	76.9593889	Powell Creek upstream of Peters Mountain Road near Powells Valley, Dauphin Co.	37.8	67b
64	PQEA 15.2	39.9559306	76.2498387	Pequea Creek along Shiprock Road upstream of Big Beaver Creek, Lancaster Co.	99.1	64d
65	PQEA 3.3	39.90562	76.32814	Pequea Creek at Route 324 bridge near Colemansville, Lancaster Co.	150.2	64L
66	QUIT 0.3	40.35225	76.6116944	Quittapahilla Creek at first bridge from mouth in Valley Glen, Lebanon Co.	77.3	67b
67	SBCC 1.2	39.8614167	77.0739444	South Branch Conewago Creek at Rout 30 bridge near New Oxford, Adams Co.	67.6	64ac
68	SBCD 0.4	39.9140036	76.7535406	South Branch Codorus Creek near mouth at Rails-To-Trails crossing, York Co.	116.4	64L
69	SBCD 3.6	39.8952789	76.7436608	South Branch Codorus Creek upstream of East Branch Codorus Creek at Reynolds Mill, York Co.	68.3	64ac
70	SBEV 2.5	39.941188	76.2205289	Big Beaver Creek at Krantz Mill Road near Refton, Lancaster Co.	17.3	64d
71	SBMY 0.0	39.8077222	76.4763333	South Branch Muddy Creek near mouth at Muddy Creek Forks, York Co.	28.1	64ac
72	SHAM 2.7	40.8434444	76.8045278	Shamokin Creek at Route 147 bridge in Sunbury, Northumberland Co.	136.9	67L
73	SHRM 2.0	40.3803611	77.0825556	Sherman Creek at Dellville bridge in Dellville, Perry Co.	240.9	67L
74	SHRM 27.5	40.3513611	77.33525	Sherman Creek upstream of SR 3011 bridge near Loysville, Perry Co.	99.1	67a
75	SPRG 0.0	40.2860833	76.6786667	Spring Creek at mouth near Hershey, Dauphin Co.	24.0	67a
76	STON 0.4	40.3765556	76.9169722	Stony Creek along Stony Creek Road near Dauphin, Dauphin Co.	34.4	67cd
77	SUSQ 44.5	40.0372	76.5236	Susquehanna River upstream of Route 30 bridge near Columbia, Lancaster Co.	26007.0	River
78	SUSQ 77.0	0.3456	76.9204	Susquehanna River at Fort Hunter boating access area, Dauphin Co.	23519.2	River
79	SUSQ 94.0	40.49	76.9433	Susquehanna River near Halifax boating access area, Dauphin Co.	19642.0	River
80	SUSQ 106.0	40.6608	76.9142	Susquehanna River between McKees Half Falls and Dalmatia, Northumberland Co.	19206.8	River
81	SUSQ 122.0	40.8119	76.8415	Susquehanna River between Selinsgrove and Selinsgrove Junction, Northumberland Co.	18442.7	River
82	SWAT 2.3	40.2053333	76.713	Swatara Creek downstream of the Pennsylvania Turnpike bridge near Middletown, Dauphin Co.	560.6	64L
83	SWAT 21.7	40.3525556	76.61675	Swatara Creek upstream of Quittapahilla Creek near Valley Glen, Lebanon Co.	355.2	67L
84	SWAT 39.0	40.413	76.4858611	Swatara Creek at Route 22 near Jonestown, Lebanon Co.	191.6	67L
85	SWAT 56.0	40.5441944	76.3823611	Swatara Creek between Upper and Lower Little Swatara Creeks in Pine Grove, Schuylkill Co.	74.0	67b
86	TRDL 0.0	40.2506389	77.0066667	Trindle Spring Run near mouth north of Mechanicsburg, Cumberland Co.	17.8	67a
87	WBOC 4.3	39.8510556	76.1101111	West Branch Octoraro Creek upstream of SR 2010 bridge at State Gamelands No. 136, Lancaster Co.	30.1	64ac
88	WCON 2.9	40.0812778	76.7165556	Conewago Creek at Route 181 bridge in Conewago Heights, York Co.	512.4	64L
89	WCON 20.4	40.0644722	76.8633056	Conewago Creek at bridge crossing off Conewago Road near Gifford Pinchot State Park, York Co.	388.5	64L
90	WCON 35.5	40.0011111	76.9203333	Conewago Creek upstream of Bermudian Creek near Detters Mill, York Co.	263.1	64L
91	WCON 56.3	39.8986	77.0844	Conewago Creek at Route 394 bridge near New Chester, Adams Co.	106.3	64L
92	WCON 66.5	39.9243056	77.2095556	Conewago Creek upstream of SR 4013 bridge near Table Rock, Adams Co.	39.1	64ac
93	WICO 0.3	40.5368611	76.9622778	Wiconisco Creek at Route 147 bridge in Millersburg, Dauphin Co.	116.4	67L
94	WMHT 2.2	40.6476667	76.9656667	West Branch Mahantango Creek upstream Route 104 bridge near Mahantango, Snyder Co.	46.9	67b
95	WPIN 0.8	40.8675833	77.4562778	Pine Creek upstream of Elk Creek near Coburn, Centre Co.	93.4	67a
96	YLBR 3.4	40.2240833	76.86075	Yellow Breeches Creek at Bridge Street in New Cumberland, Cumberland Co./York Co.	218.5	67L
97	YLBR 35.7	40.1259722	77.2191667	Yellow Breeches Creek upstream of Burnt House Road near Barnitz, Cumberland Co.	55.7	67a

Sites in green were not sampled in 1996

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

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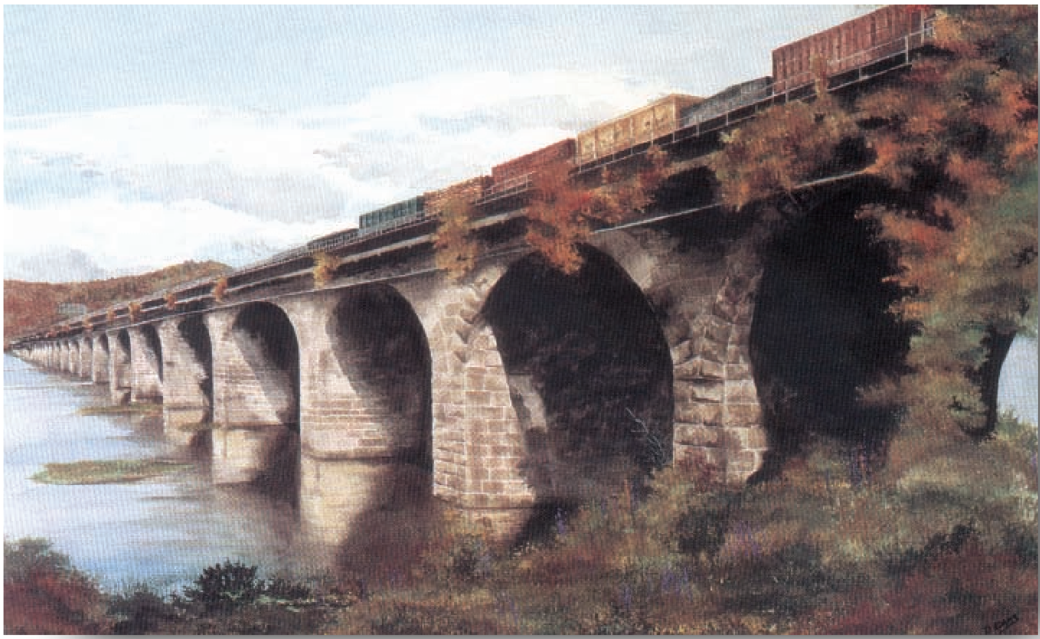

Rockville Bridge across the Susquehanna.

SUSQUEHANNA RIVER BASIN COMMISSION

In 1971, the Susquehanna River Basin Commission was created as an independent agency by a federal-interstate compact among the states of Maryland, New York, and the Commonwealth of Pennsylvania, and the federal government. In creating the Commission, the Congress and state legislatures formally recognized the water resources of the Susquehanna River Basin as a regional asset vested with local, state, and national interests for which all the parties share responsibility. As the single federal-interstate water resources agency with basinwide authority, the Commission's goal is to coordinate the planning, conservation, management, utilization, development and control of the basin's water resources among the public and private sectors.

SUSQUEHANNA RIVER BASIN COMMISSION

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