Results/Discussion

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

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

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

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

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

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

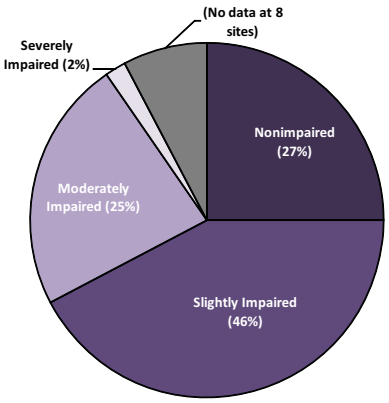

Figure 5. 2011 Biological Condition Categories for Sampled Lower Susquehanna Subbasin Sites

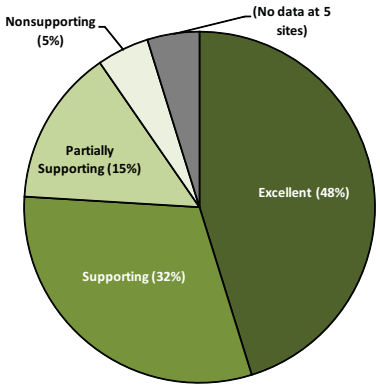

Figure 6. 2011 Habitat Condition Categories for Sampled Lower Susquehanna Subbasin Sites

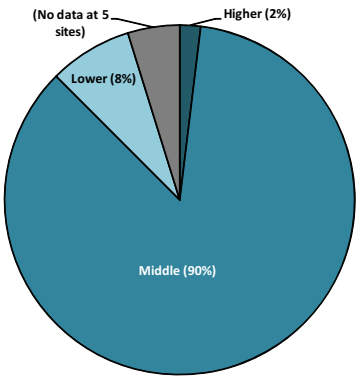

Figure 7. 2011 Water Quality Condition Categories for Sampled Lower Susquehanna Subbasin Sites

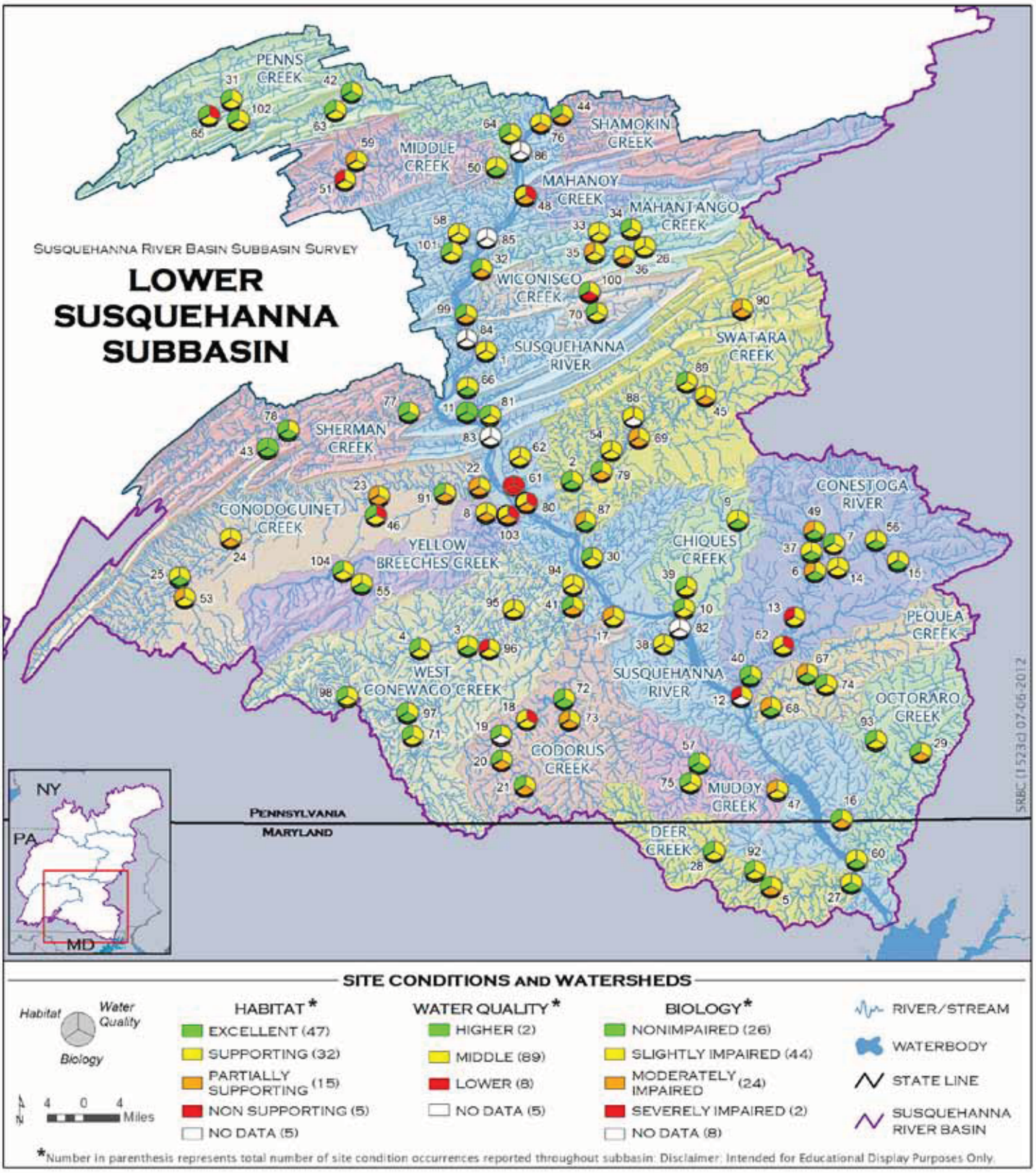

Figure 4. Lower Susquehanna Subbasin Site Conditions and Watersheds

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

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

(continued on page 12)

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

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

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

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

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

Total Maximum Daily Loads

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

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

Ten of the streams that are part of the Year-1 survey have stream segments that were listed since the 2006 subbasin report as impaired, requiring TMDLs to be established. East Branch Octoraro Creek, Mill Creek, Conestoga River, North Branch Muddy Creek, and Yellow Breeches were all listed for aquatic life impairment from siltation and/or nutrients with an agricultural source. The Yellow Breeches was listed for recreational use impairment with pathogens caused by agriculture.

Octoraro Creek was listed for potable water supply impairment resulting from nutrients caused by agriculture. Both Sherman Creek and Elk Creek were listed for recreational use impairment caused by pathogens derived from agriculture and on-site wastewater treatment (Sherman) or an unknown source (Elk). Bermudian Creek was listed for aquatic life impairment due to organic enrichment and low DO caused by an industrial point source. Beaver Creek was listed for aquatic life impairment caused by siltation resulting from a flow regulation/modification.

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

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

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

Ridge and Valley Ecoregion

Penns Creek Watershed

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

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

Middle Creek Watershed

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

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

East Mahantango Creek Watershed (East of Susquehanna)

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

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

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

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

Shamokin Creek Watershed

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

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

Mahanoy Creek Watershed

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

Wiconisco Creek Watershed

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

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

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

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

Armstrong Creek Watershed

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

Powell Creek Watershed

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

Clarks Creek Watershed

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

Stony Creek Watershed

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

Sherman Creek Watershed

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

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

Conodoguinet Creek Watershed

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

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

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

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

Yellow Breeches Creek Watershed

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

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

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

Paxton Creek Watershed

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

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

Swatara Creek Watershed

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

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

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

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

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

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

Central Appalachian Ridge and Valley Ecoregions

East Conewago and West Conewago Creeks Watersheds

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

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

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

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

Northern Piedmont Ecoregions

Codorus Creek Watershed

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

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

Chiques Creek Watershed

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

Kreutz Creek Watershed

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

Conestoga River Watershed

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

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

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

Conestoga River, Lancaster County, Pa.

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

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

Pequea Creek Watershed

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

Muddy Creek Watershed

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

Conowingo Creek Watershed

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

Octoraro Creek Watershed

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

Octoraro Creek, Cecil County, Md.

Deer Creek Watershed

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

Susquehanna River Mainstem

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