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."

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.

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

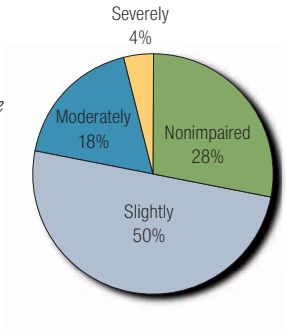
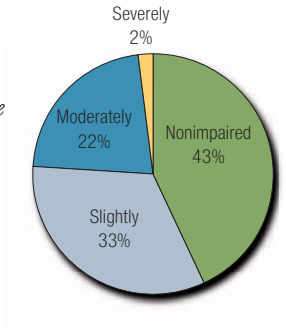


Figure 7. *Summary of the Biological Conditions in the Lower Subbasin in 2005*



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.

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