Total Maximum Daily Load
For the Conodoguinet Creek Watershed
Pennsylvania

Prepared for Pennsylvania
Department of Environmental Protection
and
EPA Region 3

Prepared by
Tetra Tech, Inc.
Fairfax, Virginia

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Table of Contents

Executive Summary

The Conodoguinet Creek basin in Cumberland and Franklin counties in Pennsylvania is 507 square miles in size. The protected water uses of the watershed are water supply, recreation and aquatic life. The aquatic life uses for the western part of the main stem of Conodoguinet Creek (in Franklin County) are warm water fishes and cold water fishes. Many of the tributaries in the Conodoguinet Creek basin are specially designated for warm water fishes, cold water fishes, trout stocking, high-quality waters, and exceptional value waters.

Total Maximum Daily Loads (TMDLs) were developed for 16 named subwatersheds and 2 unnamed subwatersheds in the Conodoguinet Creek basin to address the impairments noted on Pennsylvania's 1996 and 1998 Clean Water Act section 303(d) lists. The segments were listed based on biological surveys of the aquatic life in the streams. The impairments are caused by excess nutrient and sediment loads from agriculture, construction, and urban runoff and storm sewers. The nutrient portion of the TMDLs focuses on control of phosphorus. Phosphorus is generally held to be the limiting nutrient in a waterbody when the nitrogen/phosphorus ratio exceeds 10 to 1. All the subwatersheds studied in the Conodoguinet Creek basin have nitrogen/phosphorus ratios far greater than 10 to 1.

Pennsylvania does not currently have numeric water quality criteria for sediment or phosphorus. For this reason, a reference watershed approach was developed to identify the TMDL endpoints or water quality objectives for phosphorus and sediment in the impaired segments of the Conodoguinet Creek basin. Through comparison of the impaired watersheds to similar nonimpaired watersheds, Pennsylvania estimated the amount of phosphorus and/or sediment loading that will meet the water quality objectives for subwatersheds in the Conodoguinet Creek basin, as shown in the table below.

The TMDLs are allocated to the agricultural and urban nonpoint sources, load allocations, or LAs, and 10 percent of the allowable loading is reserved as a margin of safety (MOS). There is only one wasteload allocation (WLA) for a point source in the Rowe Run watershed. The TMDLs cover a total of 119.21 miles of stream segments in the Conodoguinet Creek basin. The TMDLs establish a total reduction for phosphorus loading of 36 percent from the average yearly loading of 55,391 pounds and a total reduction in sediment loading of 32 percent from the average yearly loading of 64,178,593 pounds in the 18 subwatersheds.

TMDLs for Big Spring Creek and the main stem of Conodoguinet Creek were not included in this study. The Big Spring Creek watershed contains a fish hatchery (PA Fish Commission—Big Spring Hatchery [NPDES PA0009865]) that is a contributor of nutrients and oxygen demanding substances to the stream. The impairments in Big Spring Creek will first be addressed through changes to the fish hatchery's NPDES permit.

The TMDLs for Bulls Head Branch and Green Spring Creek pesticide listing and Trindle Spring Run priority organics listing were deferred until quantitative evidence of the presence of specific chemicals in the streams is available.

The TMDL for the main stem of Conodoguinet Creek will be developed at a later date, after further analysis of the point source contributions to the stream. Implementation of the proposed tributary watershed TMDLs will reduce phosphorus and sediment loads to the main stem by 9.8 percent and 11.3 percent, respectively.

TMDLs for Subwatersheds in the Conodoguinet Creek Basin

Listed Streams	Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)	Existing Load (lb/yr)	Load Reduction (lb/yr)	% Reduc-tion
Alexanders Spring Creek	Sediment	5,904,194	5,313,774	0	590,419	8,482,433	3,168,659	37%
Bulls Head Branch & Green Spring Creek*	Phosphorus	10,853	9,768	0	1,085	13,754	3,986	29%
	Sediment	8,279,005	7,451,105	0	827,901	9,314,545	1,863,440	20%
Center Creek & Back Creek*	Phosphorus	1,456	1,310	0	146	1,815	505	28%
	Sediment	1,059,531	953,578	0	105,953	1,370,464	416,886	30%
Clippingers Run	Phosphorus	1,026	923	0	103	1,395	472	34%
Hogestown Run	Phosphorus	7,133	6,419	0	713	9,855	3,436	35%
	Sediment	5,440,933	4,896,839	0	544,093	6,857,481	1,960,642	29%
Mains Run & Gum Run*	Sediment	1,705,742	1,535,168	0	170,574	2,124,970	589,802	28%
Middle Spring Creek	Sediment	2,532,681	2,279,413	0	253268	2,785,986	506,573	18%
Mount Rock Spring Creek	Phosphorus	9,953	8,958	0	995	14,673	5,715	39%
	Sediment	7,592,471	6,833,224	0	759,247	11,068,148	4,234,924	38%
Newburg Run	Phosphorus	1,315	1,183	0	131	1,523	340	22%
	Sediment	873,236	785,913	0	87,324	1,105,941	320,028	29%
Paxton Run	Sediment	1,179,690	1,061,721	0	117,969	1,554,607	492,886	32%
Rowe Run	Phosphorus	7,604	5,078	1,765	760	12,376	5,533	45%
	Sediment	5,800,318	5,220,286	0	580,032	8,283,209	3,062,923	37%
Trindle Spring Run	Sediment	5,377,457	4,839,711	0	537,746	5,890,754	1,051,043	18%
Wertz Run	Sediment	914,964	823,468	0	91,496	1,437,577	614,109	43%
Unnamed 970729-1605-JLR	Sediment	1,157,160	1,041,444	0	115,716	2,750,374	1,708,929	62%
Unnamed 7403	Sediment	655,966	590,369	0	65,597	1,152,104	561,735	49%
Total Phosphorus						**55,391**	**19,987**	**36%**
Total Sediment						**64,178,593**	**20,552,580**	**32%**

***** Aggregated watershed

1.0 Introduction

Levels of sediment, nutrients, and organic enrichment can become elevated in waterbodies as a result of both point and nonpoint sources of pollution. Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting their designated uses even though pollutant sources have implemented technology-based controls. A TMDL establishes the allowable load of a pollutant or other quantifiable parameter based on the relationship between pollutant sources and in-stream water quality. A TMDL provides the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of the state's water resources (USEPA, 1991).

Stream segments in 18 subwatersheds in the Conodoguinet Creek basin in Pennsylvania have been placed on Pennsylvania's 1996 and 1998 303(d) lists as impaired by siltation, nutrient enrichment, and/or organic enrichment by the Pennsylvania Department of Environmental Protection (PADEP, 1998) (See Table 1.1.) These impairments indicate nonattainment of designated uses, including aquatic life use.

The PADEP listed 50.1 miles of streams (including 28.8 miles of the main stem) on the 1996 303(d) list. The total length of impaired stream segments reached 206.97 miles on the 1998 303(d) list, including 84.2 miles on the main stem of Conodoguinet Creek (Figure 1.1). Table 1.1 presents the streams that were listed for sediment (siltation), nutrient enrichment, and organic enrichment on Pennsylvania's 1996 and 1998 303(d) lists. Detailed listing information is presented in Section 6 before the TMDLs for each impaired watershed. Most of the listed stream segments were impaired because of elevated loadings of sediment and nutrients from agriculture, urban runoff and storm sewers, and construction.

A TMDL lawsuit settlement (American Littoral Society and PENNPIRG v. EPA, Civil No 96-489 [E.D. Pa]) with PENNPIRG, the Delaware Riverkeeper and Widener University School of Law, defined a schedule for TMDL development for waters based on Pennsylvania's 1996 303(d) list. The TMDLs for waterbodies listed on the 1996 303(d) list are scheduled to be developed by 2009. Newly listed waters on the 1998 303(d) list are required to have TMDLs developed for them within 3 years. This study will fulfill the requirement for the development of TMDLs for stream segments on both the 1996 and 1998 303(d) lists in the Conodoguinet Creek basin except those in the Big Spring Creek and the main stem.

TMDLs for Big Spring Creek and the main stem of Conodoguinet Creek were not included in this study. The Big Spring Creek watershed contains a fish hatchery (PA Fish Commission—Big Spring Hatchery [NPDES PA0009865]) that is a contributor of nutrients and oxygen demanding substances to the stream. The impairments in Big Spring Creek will first be addressed through changes to the fish hatchery's NPDES permit.

The TMDL for the main stem of Conodoguinet Creek will be developed at a later date, after further analysis of the point source contributions to the stream. Implementation of the proposed tributary watershed TMDLs will reduce phosphorus and sediment loads to the main stem by 9.8 percent and 11.3 percent, respectively.

The TMDLs for the pesticide listing for Bulls Head Branch and Green Spring Creek and the priority organics listing for Trindle Spring Run were deferred until quantitative evidence of the presence of specific chemicals in the streams is available.

For the 1996 303(d) list, water quality assessment was primarily based on the "surface water monitoring program". The PADEP's surface water monitoring program consists of ambient fixed-station monitoring and intense surveys. Sampling is conducted on major surface streams, selected reference waters, and selected lakes.

For the 1998 303(d) list the PADEP used a modification of EPA's Rapid Bioassessment Protocol II (RPB-II, the "Unassessed Waters Project" or "Unassessed Waters Protocol") as the primary mechanism to assess Pennsylvania's unassessed waters (PADEP, 2000). The unassessed water process uses a biological screening protocol to establish whether aquatic life uses are impaired. This process involves preliminary screening of each watershed followed by a field-level biological assessment. The assessment method requires selecting stream sites that reflect impacts from surrounding land uses that are representative of the listed stream segment being assessed. Biologists select as many sites as necessary to establish an accurate assessment for a stream segment. At each site, a biological assessment is conducted using the modified RBP II method. The length of stream that can be assessed per site varies. Several factors determine site location and how long a "single site" assessed segment can be. Some of these factors are distinct changes in stream characteristics, surface geology, riparian land use, point source and nonpoint source discharge locations, and the pollutant that is causing impairment.

Table 1.1 Summary of streams listed for siltation, nutrient enrichment, and organic enrichment on Pennsylvania's 1998 303(d) list

Stream Name	County	Miles Degraded	Watershed Area (mi^2)	Parameter of Concern	Potential Sources of Impairment
Alexanders Spring Creek	Cumberland	3.81	19.18	Siltation	Agriculture
Back Creek	Cumberland	4.34	4.13	Siltation, Organic Enrich/Low DO	Agriculture
Big Spring Creek[c]	Cumberland	4.1	12.91	Organic Enrich/Low DO Siltation	Other
Bulls Head Branch	Cumberland	9.4	24.06	Siltation, Organic Enrich/Low DO	Agriculture, Other
Center Creek	Cumberland	3.59	2.46	Siltation, Organic Enrich/Low DO	Agriculture
Clippingers Run[a]	Franklin	0.83	4.48	Nutrients, Organic Enrich/Low DO	Agriculture
Green Spring Creek[a]	Cumberland	7.61	2.85	Nutrients, Siltation, Organic Enrich/Low DO	Agriculture, Other
Gum Run	Franklin 8%, Cumberland 92%	7.79	5.10	Siltation	Agriculture, Habitat Modification
Hogestown Run	Cumberland	10.37	17.75	Organic Enrich/Low DO, Siltation	Agriculture, Urban Runoff/Storm Sewers
Mains Run	Franklin 61%, Cumberland 39%	5.28	2.25	Siltation	Agriculture, Habitat Modification

Stream Name	County	Miles Degraded	Watershed Area (mi^2)	Parameter of Concern	Potential Sources of Impairment
Middle Spring Creek[a]	Franklin 56%, Cumberland 44%	5.87	8.06	Suspended Solids	Urban Runoff/Storm Sewers, Agriculture
Mount Rock Spring Creek[a]	Cumberland	8.64	24.66	Nutrients, Siltation	Agriculture, Construction
Newburg Run	Cumberland	5.24	5.71	Nutrients, Siltation	Agriculture
Paxton Run[a]	Franklin 95%, Cumberland 5%	9.03	7.31	Siltation, Suspended Solids	Agriculture
Rowe Run	Franklin	19.75	18.83	Organic Enrich/Low DO Siltation	Agriculture
Trindle Spring Run	Cumberland	7.29	17.82	Siltation	Urban Runoff/Storm Sewers, Land Disposal, Agriculture, Construction
Wertz Run	Cumberland	1.73	5.73	Siltation	Agriculture Construction,
Unnamed Stream 970729-1605 JLR[b]	Cumberland	7.75	7.24	Siltation	Agriculture, Construction, Habitat Modification
Unnamed Stream 7403[b]	Cumberland	0.89	4.35	Suspended Solids	Agriculture
Conodoguinet Creek (Main stem)[a c]	Franklin 18%, Cumberland 67%	84.17	506.8	Siltation, Nutrients	Construction, Agriculture, Habitat Modification, Land Disposal

[a] Streams initially listed in 1996.
[b] The unnamed streams 970729-1605 JLR and 7403 are listed as part of the main stem of Conodoguinet Creek, but separate TMDLs were developed for these segments.
[c] TMDLs were not included in this report, see text for details.

The biological assessment in the Conodoguinet Creek basin used EPA waterbody cause code 1200, Organic Enrichment/Low Dissolved Oxygen (D.O.), to describe the impairment seen in some portions of the stream network. The listing was based on visual observation. No dissolved oxygen readings were used as the basis for this impairment listing. The listing for impairment caused by organic enrichment is addressed through reduction to the phosphorus load.

Although these TMDLs do not directly address habitat modification, which is not a pollutant, reductions of sediment and nutrient loads are expected to benefit habitat conditions. Management practices expected to be used in reducing sediment and nutrient loads will include riparian zone management that benefits habitat conditions as well, through stream shading and stream bank protection.

This report includes a summary of the analysis and load allocations required for a TMDL for the segments of the Conodoguinet Creek basin listed as impaired by siltation, nutrient enrichment, and/or organic enrichment on the 1996 and 1998 Pennsylvania 303(d) lists. Section 2 of this report characterizes the study area and identifies physical and land use characteristics. Section 3 describes the pollutants and their sources. Section 4 presents the selection of TMDL endpoints (or target limits). Section 5 describes the technical approach used to link watershed modeling and Pennsylvania geographic information system (GIS) data. Section 6 presents the elements of the TMDLs for the Conodoguinet Creek basin's 303(d)-listed segments. Detailed information on reference watersheds and modeling results are presented in Appendices A and B.

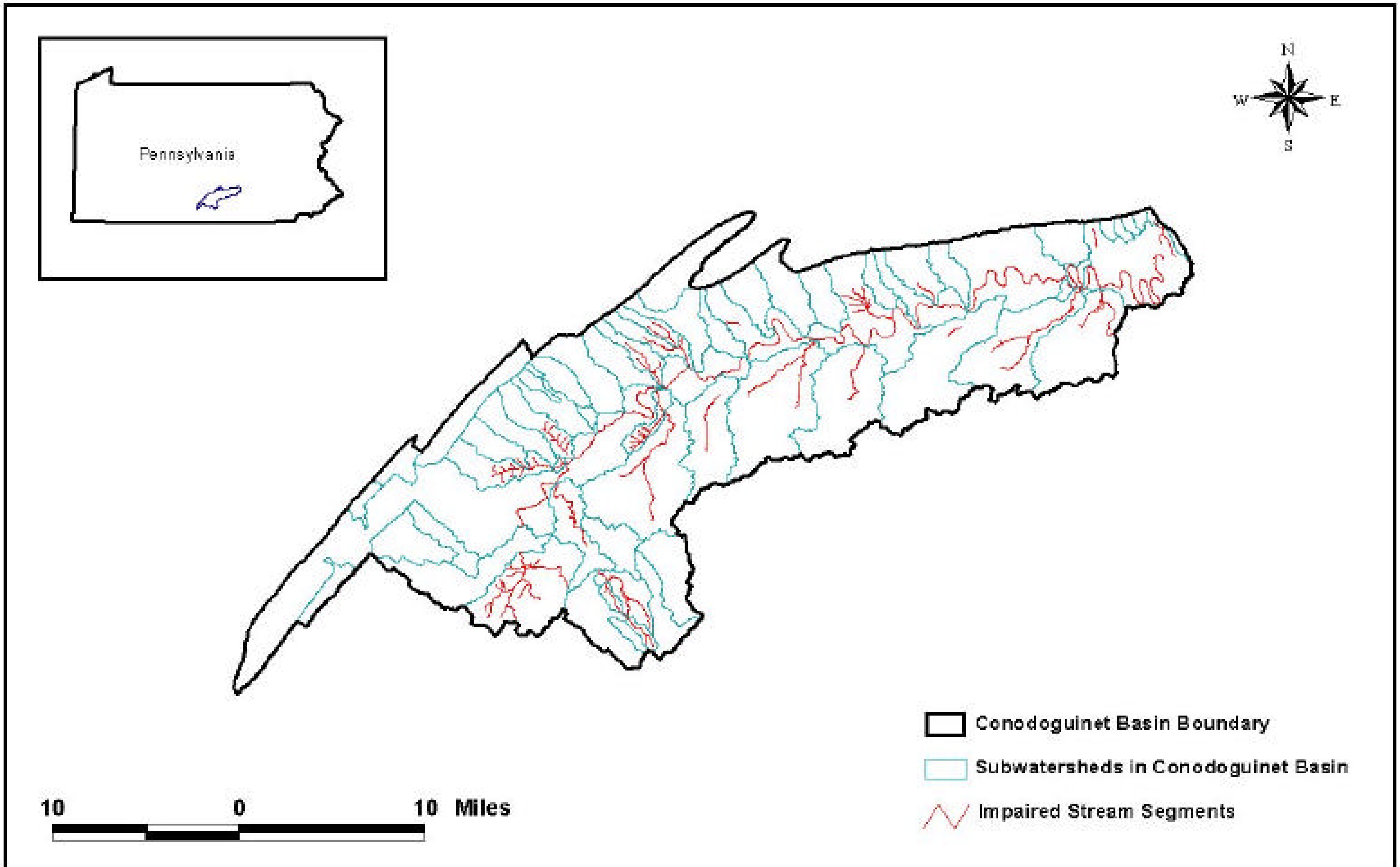

Figure 1.1 Impaired stream segments in the Conodoguinet Creek basin.

Data Sources: Pennsylvania Spatial Data Access

2.0 Watershed Description and History

The headwaters of Conodoguinet Creek originate at Kittatiny Mountain in the Appalachian mountain range. The creek flows 101 miles through the Cumberland Valley of Pennsylvania, draining into the Susquehanna River near Harrisburg. The creek is located in the Ridge and Valley physiographic province, primarily in the Great Valley section. Although the creek's western end originates in Franklin County, most of the creek flows through Cumberland County. As it meanders to the northeast, it drains approximately 507 square miles. The meanders in the eastern part of the valley close to the creek's confluence with the Susquehanna River are very tight. In the uplands of the basin, the land is predominantly forested. As the river approaches the Susquehanna in the eastern downstream sections, land uses are mostly agricultural, with significant areas of residential and commercial use. There are 59 small subwatersheds in the Conodoguinet Creek basin (Figure 2.1), most of which drain laterally into Conodoguinet Creek. Shale is the major rock type to the north of Conodoguinet Creek, and carbonate is the major rock type to the south (Figure 2.2).

In the 19th century, early pioneers built 100 mills along the banks of Conodoguinet Creek—a mill nearly every mile. These mills refined diverse products, including sumac leaves that were made into tanning and dyeing materials, grain, cider, nails, and wood. By l909 only l3 of the mills remained, and today the industry is largely forgotten. Most of the basin still has a strong agricultural presence (Alliance for the Chesapeake Bay, 2000). The percentage of agricultural land uses in the basin is approximately 61.3 percent (Table 2.1). Farming is the most prominent land use in the valley, but dramatic growth in recent years in the Carlisle-Camp Hill area has converted much of the agricultural land to residential and commercial uses, including sprawling truck terminals and strip development along two major interstate highways and the Pennsylvania turnpike. Figure 2.3 is a map of the watershed presenting major roads, cities, and towns. The total developed area in the entire basin is 5 percent based on EPA's Multi-Resolution Land Characteristics (MRLC) data (1991-1993). Table 2.1 and Figure 2.4 present the land use distribution in the Conodoguinet Creek basin.

Table 2.1 Land use distribution in the Conodoguinet Creek basin

Land Use Types	Area (ac)	Area (ha)	% Total
Water Bodies	2,606.6	1,054.9	0.8%
Low Intensity Development	11,331.0	4,585.7	3.5%
High Intensity Development	4,854.8	1,964.7	1.5%
Hay/Pasture	73,749.2	29,846.3	22.7%
Cropland	125,148.4	50,647.6	38.6%
Forest	4,816.3	1,949.2	1.5%
Mixed Forest	7,046.7	2,851.8	2.2%
Deciduous Forest	92,244.5	37,331.3	28.4%
Woody Wetland	1,507.8	610.2	0.5%
Emergent Wetland	643.2	260.3	0.2%
Quarry	68.9	27.9	0.0%
Coal Mine	5.3	2.2	0.0%
Transitional Land	343.8	139.1	0.1%
Total	324,366.5	131,271.1	100%

Population growth (Lazorchick, 1989), urbanization, and agricultural runoff have recently caused major water quality problems in the otherwise nearly pristine Conodoguinet Creek basin. As evidenced in the 1998 303(d) list, point and nonpoint source pollution has led to the impairment of stream segments in 24 out of 59 watersheds (Figure 2.1) in the Conodoguinet basin, 68 percent of the total watershed area.

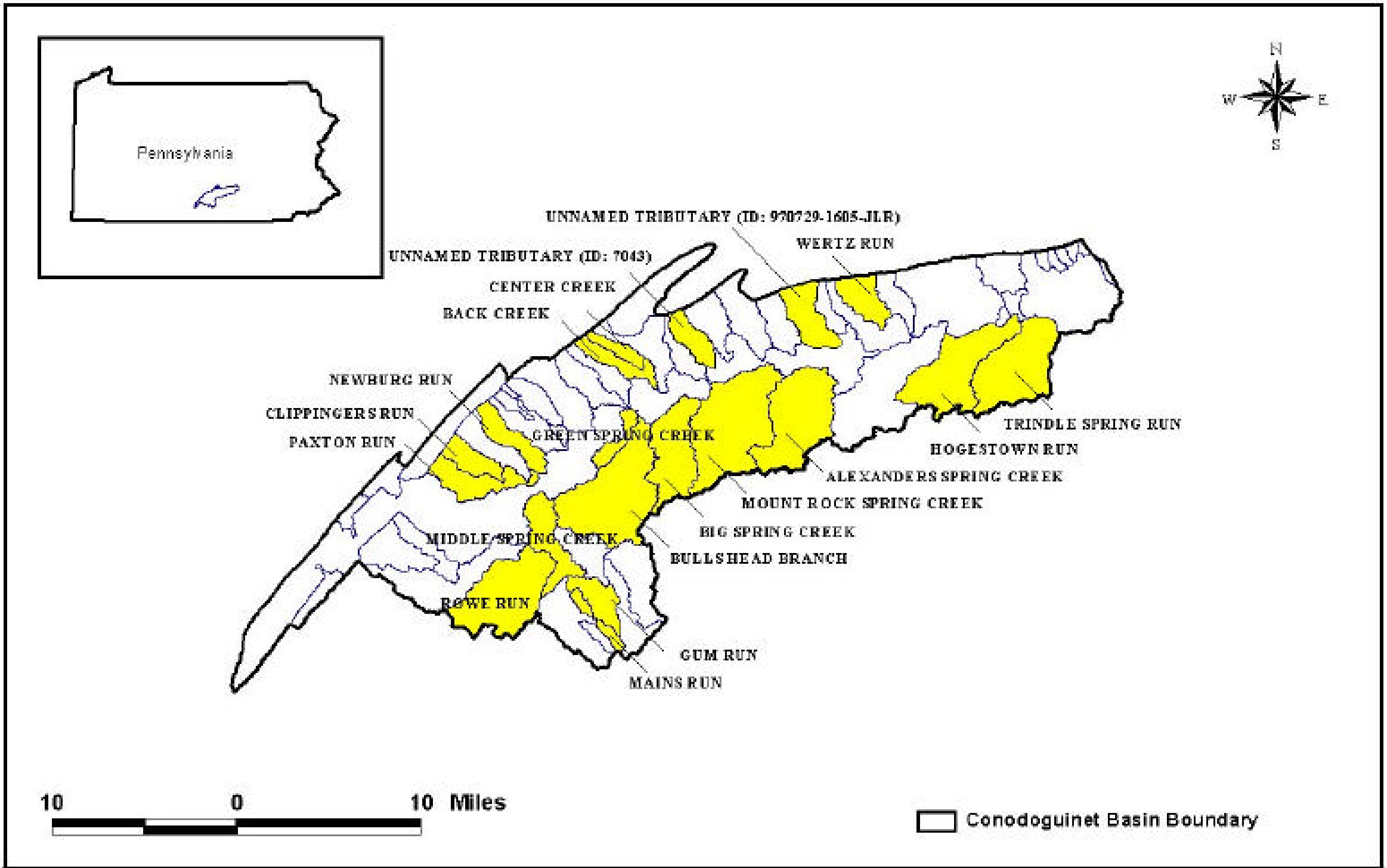

Figure 2.1 Names and locations of subwatersheds. Highlited watersheds contain impaired stream segments (excluding the main stem) listed for nutrients, siltation, and/or organic enrichment .

Data Sources: Pennsylvania Spatial Data Access

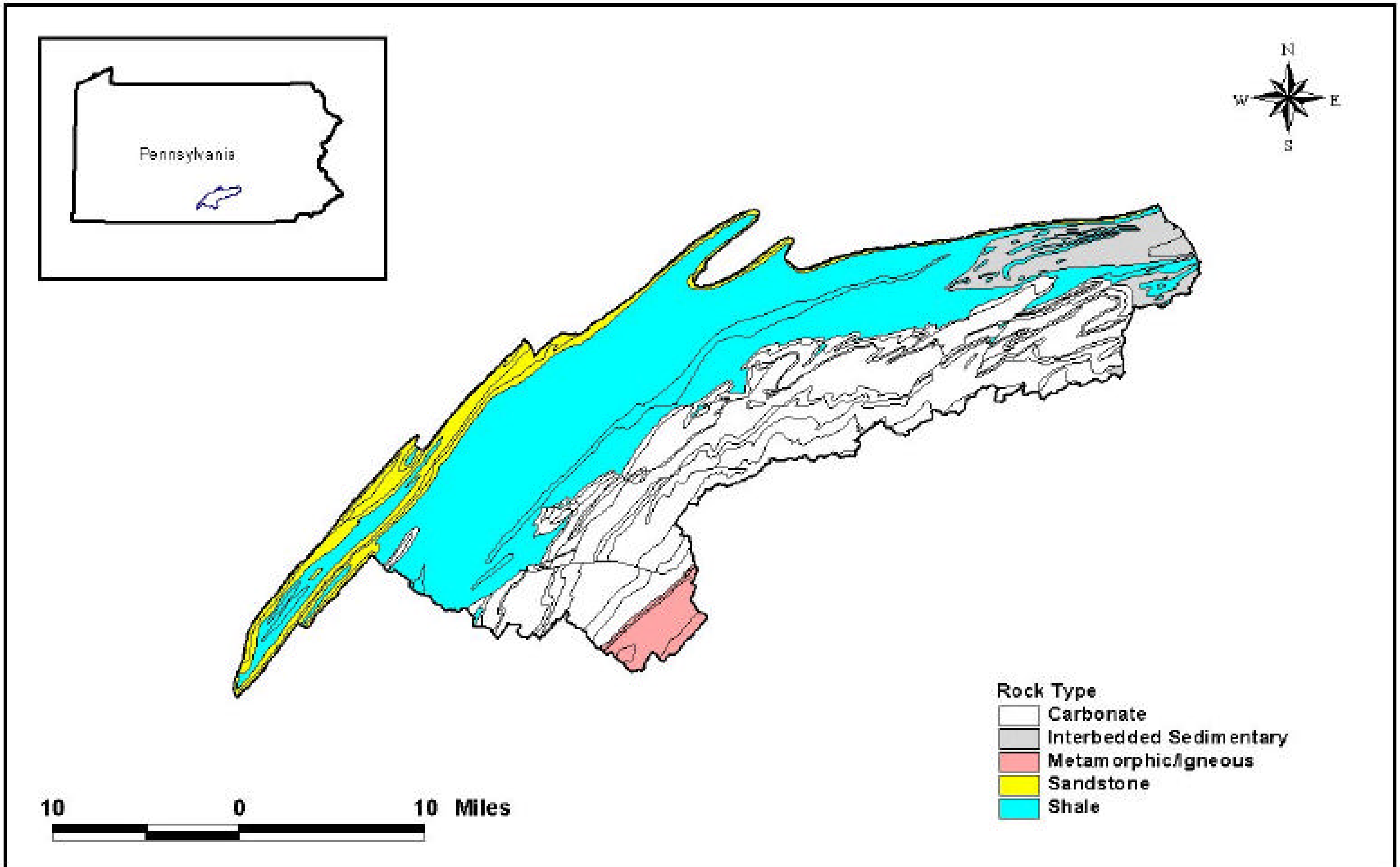

Figure 2.2 Surface geology (rock type) in the Conodoguinet Creek basin.

Data Sources: Pennsylvania Spatial Data Access

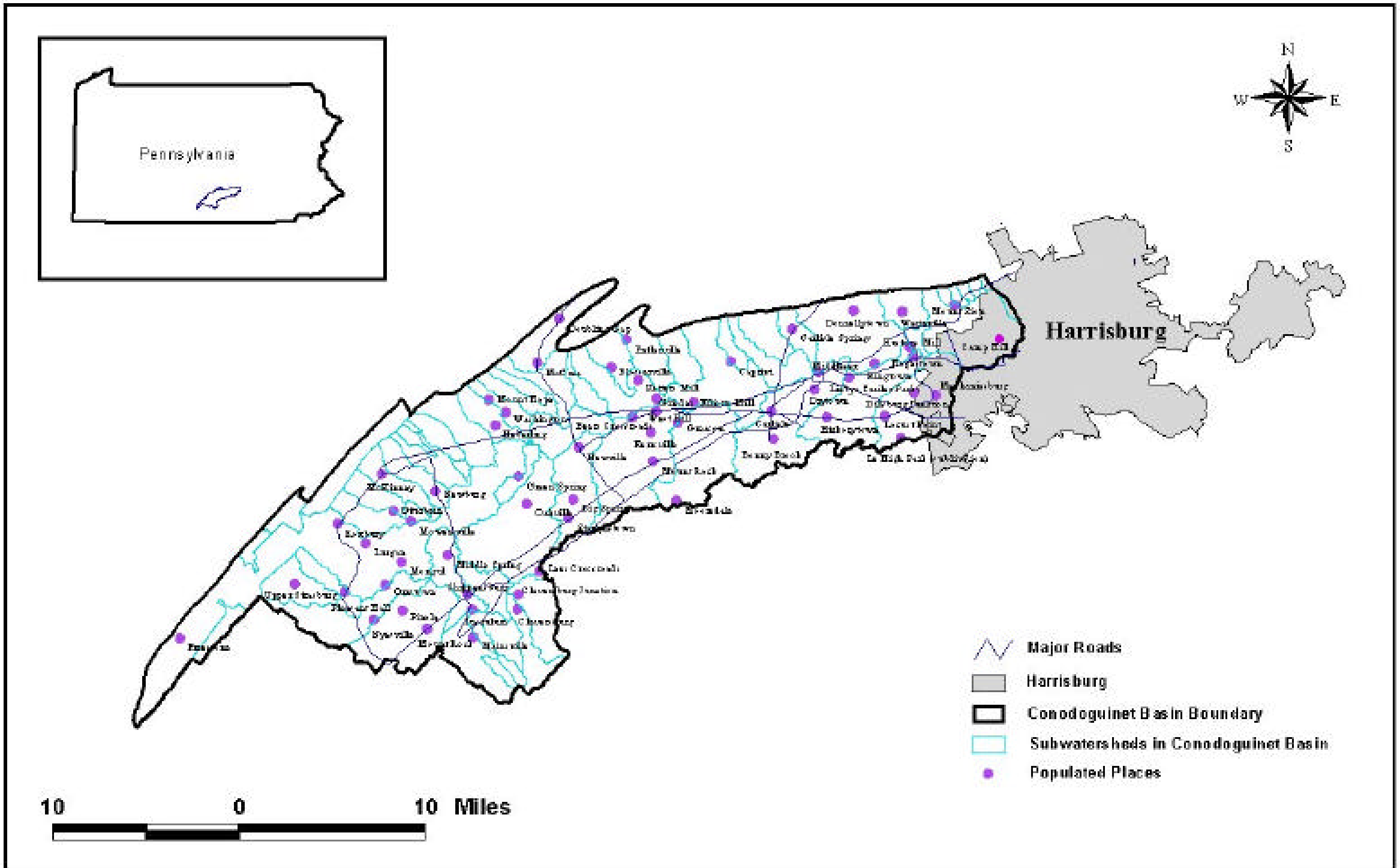

Figure 2.3 Major roads and populated places in the Conodoguinet Creek basin

Data Sources: Pennsylvania Spatial Data Access and EPA BASINS 2.0

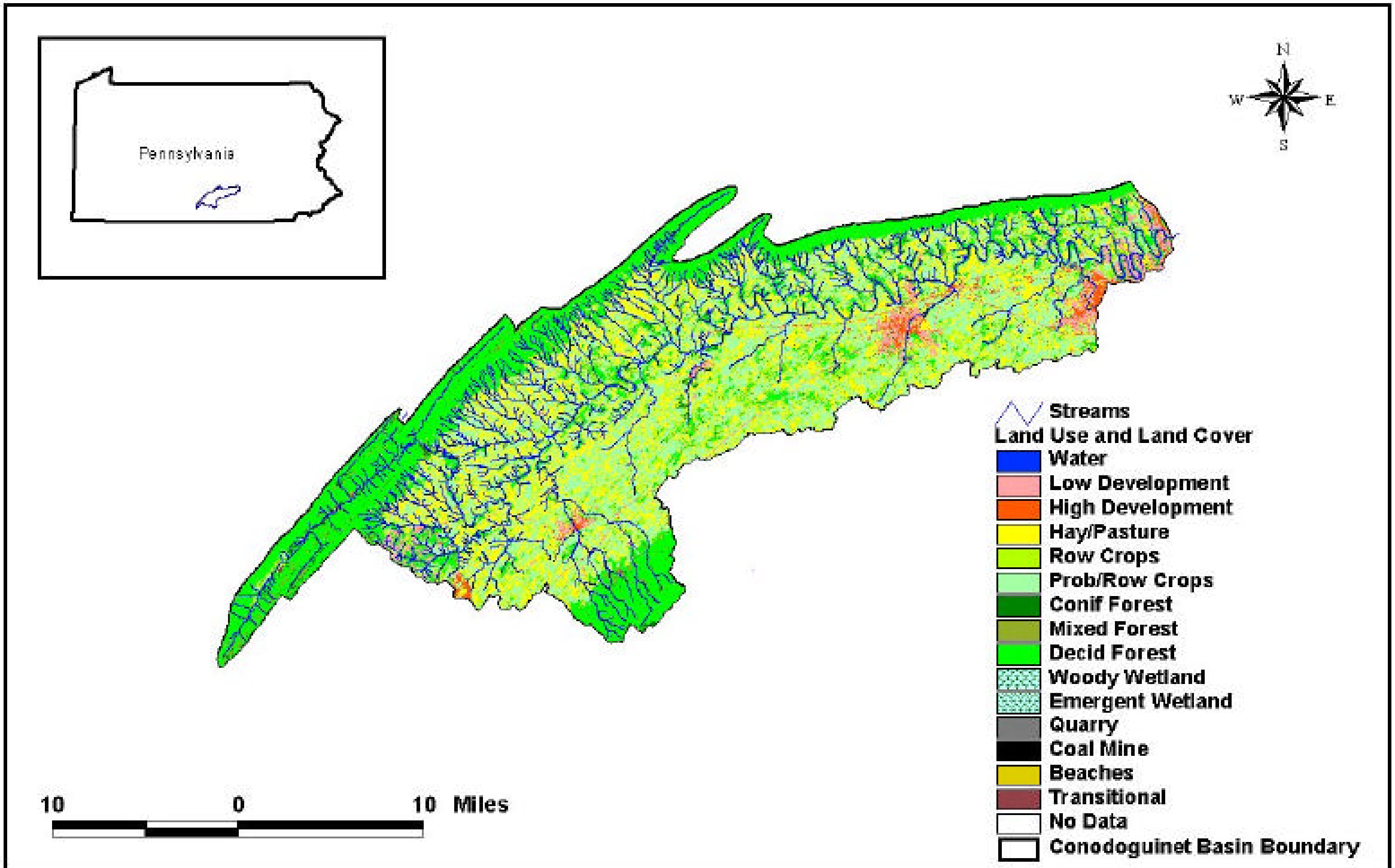

Figure 2.4 Land use and land cover in the Conodoguinet Creek basin.

Data Sources: Pennsylvania Spatial Data Access

3.0 Source Assessment

Sources of nutrients and sediment are numerous. Potential point sources for phosphorus include poorly treated municipal sewage and combined sewer overflows (CSOs). Potential nonpoint sources for phosphorus include soil erosion, wild animal wastes, leaf fall, failing or ill-sited septic systems, and runoff from agricultural lands. Sediment sources typically fall into the categories of agriculture, silviculture, rangeland, construction sites, roads, urban areas, landslide areas, and in-stream sources (e.g., stream or lake banks).

3.1 Assessment of Nonpoint Sources

Agriculture, urban runoff and storm sewers, and construction have been identified as the largest contributors of sediment and phosphorus to the Conodoguinet Creek basin. Population pressures can intensify nonpoint sources of pollution, such as agricultural and residential runoff. The average population change in the boroughs and townships of the Conodoguinet Creek basin was 24.4 percent between 1980 and 1990, and 22.56 percent between 1990 and 1998. The state average population change between 1990 and 1999 was 16.7 percent. As population grows, the demands on the creek intensify (Lazorchick, 1989). At the same time, the urbanization and paving of large areas of the watershed result in dramatic increases in storm water runoff, leading to periodic high flows that erode stream banks, contributing silt to the shallow creek bottom. These nonpoint sources are extremely difficult to pinpoint, measure, and control, but they are currently the leading cause of degradation of water quality in the Conodoguinet Creek basin.

3.1.1 Agricultural Land

Agricultural land was identified as a major source of nutrients and sediment to the Conodoguinet Creek basin. Agricultural runoff from cropland and pasture can often contribute increased pollutant loads to a waterbody when poor farm management practices allow soils rich in nutrients from fertilizers or animal waste to be washed into the stream, increasing in-stream nutrient and sediment levels.

Based on the MRLC land use coverage, the cropland percentage in the impaired watersheds ranges from 27 to 61.3 percent. When hay/pasture and cropland are combined, the percentage of agricultural land ranges from 39.6 to 92.9 percent. Table 3.1 shows the percentage of cropland, hay/pasture land and the total agricultural land in the impaired watersheds. The major crop type in the Conodoguinet Creek basin is corn; minor crop types include wheat, oats, potato, orchards, and others.

3.1.2 Livestock

Cattle and other agricultural animals deposit manure (and, therefore, nutrients) on the land surface, where it is available for washoff and delivery to receiving waterbodies. Spreading animal manure on agricultural lands also contributes to nutrient washoff. Data from the 1997 Census of Agriculture provided numbers of livestock in each county in the Conodoguinet Creek basin. Table 3.2 presents the livestock counts in each of the two counties in the basin, as well as estimated counts in the Conodoguinet Creek basin.

Table 3.1 Percentage of crop and hay/pasture land in the impaired watersheds

Watershed	Area (acres)	% Cropland	% Hay/Pasture	% Agricultural Land
Alexanders Spring Creek	12,273	58.9%	25.6%	84.5%
Bulls Head-Green Spring	17,225	61.3%	31.6%	92.9%
Center Run-Back Run	4,222	32.9%	34.2%	67.1%
Clippingers Run	2,868	39.3%	30.7%	70.0%
Hogestown Run	11,359	56.3%	31.0%	87.3%
Mains Run-Gum Run	4,704	27.0%	12.6%	39.6%
Middle Spring Creek	5,159	44.9%	35.9%	80.8%
Mount Rock Spring Creek	15,784	58.3%	29.1%	87.4%
Newburg Run	3,652	33.8%	33.4%	67.2%
Paxton Run	4,674	45.2%	31.2%	76.4%
Rowe Run	12,056	53.7%	35.2%	88.9%
Trindle Spring Run	11,405	44.8%	21.3%	66.1%
UNT 1605	4,637	41.6%	24.1%	65.7%
UNT 7403	2,782	35.3%	26.0%	61.3%
Wertz Run	3.667	30.3%	18.0%	48.3%
Conodoguinet Creek Basin	324,366	38.6%	22.7%	61.3%

Table 3.2 Livestock counts in the Conodoguinet Creek basin

Area	Livestock Counts					
	Beef Cows	**Cattle**	**Chickens**	**Hogs**	**Milk Cows**	**Sheep**
Cumberland County	2,962	44,620	N/A	24,783	18,393	898
Franklin County	3,942	95,764	1,775,852	104,320	44,201	2,377
Conodoguinet Creek Basin	2,678	46,775	35,025	35,025	20,117	1,021

Livestock densities were used to adjust nutrient concentrations from agricultural lands in the watershed modeling and analysis.

3.1.3 Forestry

Silviculture, especially forest harvesting, can be an important nonpoint source of sediment to waterbodies. The USDA's Forest Service FIA Database Retrieval System provided information on silvicultural practices in the Conodoguinet Creek basin. Table 3.3 presents the forest acreage, net growth rate, and removal rates for growing stock and sawtimber in the Conodoguinet Creek basin. Forestland in the basin includes all land with at least 10 percent stock forest trees of any size, or formerly having such tree cover, and not currently developed for non-forest use. Timberland represents the portion of forestland that is producing, or is capable of producing, crops of industrial wood and is not withdrawn from utilization. The average net annual growth is the average change in volume of either growing-stock or sawtimber in one year for the time period between two successive forest inventories minus the average annual volume lost to mortality from natural causes. The average annual removal rate is the average volume of either growing-stock or sawtimber removed in one year by harvesting, cultural operations, land clearing, or changes in land use for the time period between two successive forest inventories.

Table 3.3 Forest acreage, net growth rate, and removal rates for growing stock and sawtimber in the Conodoguinet Creek basin (1989)

Area	Inventory		Net Growth Rate		Removal Rate	
	Forestland (thousand acres)	Timberland (thousand acres)	Growing Stock (million cubic feet)	Sawtimber (million board feet)	Growing Stock (million cubic feet)	Sawtimber (million board feet)
Cumberland County	118.9	118.9	3.5	13.5	2.4	6.4
Franklin County	209.4	198	2.1	15.1	4.3	14.8
Conodoguinet Creek Basin	117	115	3	12	2	7

Because the forest growth rate exceeds the removal rate, most of the forest in the Conodoguinet Creek basin is not considered to be a significant source of pollutants to the watershed. Clear-cut forest areas, however, are a significant pollutant source and are represented in the MRLC land use type "transitional (barren) land" (Figure 2.4).

3.1.4 Urban Areas

Urban areas are represented in the MRLC land use coverage by the "high-intensity developed" and "low-intensity developed" land uses (Table 2.1, Figure 2.4). Nutrients from nonpoint sources are carried into streams through surface runoff and through erosion from unpaved areas and construction sites. Sources of sediment mainly include unpaved areas and construction sites. Some construction sites also are represented by the "transitional (barren) land" in the MRLC land use coverage.

3.1.5 Septic Systems

On-site septic systems have the potential to deliver nutrients to surface waters due to system failure and malfunction. Based on census data, the estimated population of the Conodoguinet Creek basin was approximately 129,585 in 1996, and 7.1 percent of the population uses septic systems. Normal septic systems contribute both dissolved nitrogen and phosphorus to the groundwater. Failed septic systems contribute greater amounts of nutrients to both groundwater and surface runoff. Limited data in Pennsylvania indicated that 0.34 percent of the septic systems in the state failed and were repaired or replaced in 1993 (NSFC, 1996).

3.1.6 Groundwater

Agriculture and septic systems are two major sources that enrich the groundwater. Based on USGS's water quality data, the estimated concentrations of nitrogen and phosphorus in groundwater in the Conodoguinet Creek basin are 2.7 mg/L and 0.019 mg/L, respectively, which are higher than the concentrations in the forested area (0.19 mg/L for nitrogen and 0.006 mg/L for phosphorus) (Haith et al., 1992).

3.2 Assessment of Point Sources

Along with population growth, increasing wasteloads are creating an abundance of nutrients such as nitrogen and phosphorus. There are 36 point source facilities in the Conodoguinet Creek basin. Only eight of these facilities, however, contribute significant amounts of nitrogen and/or phosphorus to the watershed. The discharging facilities listed in Table 3.4 are the eight facilities identified as major point sources in the watershed and considered in the TMDL analysis.

The state of Pennsylvania conducted a study in 1988 to assess the contribution of phosphorus from the sewer treatment plants in the lower part of the basin. The point source facilities were found to be contributing more than 0.25 percent of the total load of phosphorus to one or more of the impact points on Conodoguinet Creek (McMorran and Schott, 1988).

The Shippensburg Borough Authority sewerage treatment facility (NPDES PA0030643) is identified as a significant contributor of nutrients to Middle Spring Creek, but it was not included in the TMDL analysis for Middle Spring Creek because Middle Spring Creek was listed only for sediment, not nutrient enrichment. The Shippensburg Borough Authority sewerage facility will be, however, included in the calculations for the total load reduction analysis for the entire Conodoguinet Creek basin.

All of the potential sources mentioned above were considered in the watershed modeling described in section 5.0 of this report.

Table 3.4 Major point source facilities in the Conodoguinet Creek basin

NPDES	Name	Property	Address	County	Receiving Waterbody
PA0038415	East Pennsboro South Treatment	Sewerage Treatment	Board of Commissioners, 98 South Enola Dr.	Cumberland	Conodoguinet Creek
PA0026077	Carlisle STP	Sewerage Treatment	Attn: Mr. Paul T. Kulp, 53 West South St, Carlisle	Cumberland	Conodoguinet Creek
PA0028746	Hampden Township STP	Sewerage Treatment	Pinebrook STP, Lamp Post Lane, Camp Hill	Cumberland	Conodoguinet Creek
PA0080314	Hampden Township S.A. (Roth) STP	Sewerage Treatment	Roth Lane STP, 4200 Roth Lane, Mechanicsburg	Cumberland	Conodoguinet Creek
PA0020885	Mechanicsburg Borough Municipal STP	Sewerage Treatment	2 West Strawberry St, Mechanicsburg	Cumberland	Conodoguinet Creek
PA009865	Pennsylvania fish commission, fish hatchery	Fish Hatcheries and Preserves	844 Big Spring Road, Newville	Cumberland	Big Spring Creek
PA0030643	Shippensburg Borough Authority	Sewerage Treatment	60 West Burd St, Shippensburg	Franklin	Middle Spring Creek
PA0010502	Letterkenny Army Depot/IW	General Government	Franklin Street Extended, Chambersburg	Franklin	Rowe Run

4.0 Selection of TMDL Endpoints

4.1 Designated Uses

In addition to the general statewide water uses (aquatic life, water supply, and recreation [Pennsylvania Code Title 25, Chapter 93.9o]), many of the impaired streams have special designated uses to be protected. Key water uses in Pennsylvania include Cold Water Fishes, Warm Water Fishes, and Exceptional Value Waters. Table 4.1 shows the listed waterbodies and their designated water uses (Pennsylvania Code Title 25, Chapter 93.9o). The Conodoguinet Creek TMDLs are developed to achieve compliance with and support of the Pennsylvania water quality standards, including support of the designated uses.

Table 4.1 Designated water uses of impaired streams in the Conodoguinet Creek basin (Pennsylvania Code Title 25, Chapter 93.9o)

Stream	County	Designated Water Uses	Exceptions to Specific Criteria
Alexanders Spring Creek	Cumberland	CWF[a]	None
Back Creek	Cumberland	WWF[b]	None
Big Spring Creek	Cumberland	EV[c], CWF[a]	None
Green Spring Creek	Cumberland	CWF[a]	None
Hogestown Run	Cumberland	CWF[a]	None
Middle Spring Creek	Franklin- Cumberland	CWF[a]	None
Mount Rock Spring Creek	Cumberland	WWF[b]	None
Newburg Run	Cumberland	WWF[b]	None
Paxton Run	Cumberland	WWF[b]	None
Peebles Run	Cumberland	WWF[b]	None
Rowe Run	Franklin	CWF[a]	None
Trindle Spring Run	Cumberland	CWF[a]	None
UNT 1605	Cumberland	WWF[b]	None
UNT 7403	Cumberland	WWF[b]	None
Wertz Run	Cumberland	WWF[b]	None

[a] CWF (Cold Water Fishes) - Maintenance and/or propagation of fish species, including the family Salmonidae and additional flora and fauna that are indigenous to a cold water habitat.

[b] WWF (Warm Water Fishes) - Maintenance and propagation of fish species and additional flora and fauna that are indigenous to a warm water habitat.

[c] EV (Exceptional Value Waters) - A stream or watershed that constitutes an outstanding national, state, or county park or forest, or waters that are used as a source of unfiltered potable water supply, or waters of wildlife refuges or state game lands, or waters that have been characterized by the Fish Commission as "Wilderness Trout Streams," and other waters of substantial recreational or ecological significance.

4.2 Limiting Nutrients

Nutrients and sediment are the most likely pollutants causing the impairments identified in the listed segments of the Conodoguinet Creek basin. This conclusion is based on the dominant source types, the observed high sediment and nutrient loading, observations of the biological assessment teams, and similarities to other impaired waterbodies. In Donegal Creek, about 22 miles east of the Conodoguinet Creek basin, Pennsylvania identified similar impairments and source types and developed the TMDL by targeting nutrients and sediment as the pollutants of concern (PADEP, 1999).

Typically in aquatic ecosystems the quantities of trace elements are plentiful; however, nitrogen and phosphorus may be in short supply. The nutrient that is in the shortest supply is called the *limiting nutrient* because its relative quantity affects the rate of production (growth) of aquatic biomass. If the nutrient load to a waterbody can be reduced, the available pool of nutrients that can be utilized by plants and other organisms will be reduced and, in general, the total biomass can subsequently be decreased as well (Novotny and Olem, 1994). In most efforts to control eutrophication processes in waterbodies, emphasis is placed on the limiting nutrient. This is not always the case, however. For example, if nitrogen is the limiting nutrient, it still might be more efficient to control phosphorus loads if the nitrogen originates from sources that are difficult to control, such as nitrates in ground water.

In most freshwater bodies, phosphorus is the limiting nutrient for aquatic growth. In some cases, however, the determination of which nutrient is the most limiting is difficult. For this reason, the ratio of the amount of nitrogen to the amount of phosphorus is often used to make this determination (Thomann and Mueller, 1987). If the nitrogen/phosphorus ratio is less than 10, nitrogen is limiting; if the nitrogen/phosphorus ratio is greater than 10, phosphorus is the limiting nutrient. In the case of listed stream segments (nutrients and organic enrichment) in the Conodoguinet Creek basin, the nitrogen/phosphorus ratios are all greater than 15 (Table 4.2), pointing to phosphorus as the limiting nutrient. The nutrient portions of the TMDLs for the impaired watersheds address only phosphorus because it was determined that phosphorus was the limiting nutrient for plant growth in all the streams listed for nutrient or organic enrichment in the Conodoguinet Creek basin. Controlling the phosphorus loading to listed stream segments in the Conodoguinet Creek basin will limit plant growth and reduce eutrophication.

Table 4.2 Nitrogen/phosphorus ratios in streams listed for nutrients and/or organic enrichment in the Conodoguinet Creek basin

Streams	Listed Causes	Nitrogen/Phosphorus ratio
Big Spring Creek	Organic enrichment and siltation	16
Bulls Head Branch and Green Spring Creek	Siltation, nutrients, and organic enrichment	25
Center Run and Back Run	Siltation and organic enrichment	28
Clippingers Run	Nutrients and organic enrichment	28
Hogestown Run	Organic enrichment	24
Mount Rock Spring Creek	Nutrients and siltation	20
Newburg Run	Nutrients and siltation	30
Rowe Run	Organic enrichment and siltation	21

4.3 Derivation of Endpoints (Target Limits)

Because Pennsylvania has no numeric in-stream criteria for the pollutants of concern, a "reference watershed" approach was developed to set allowable loading rates in the impaired watersheds. The reference watershed approach is used to estimate the necessary loading reduction of phosphorus and sediment that would be needed to restore a healthy aquatic community and allow the streams in the watershed to achieve their designated uses. The reference watershed approach is based on determining the current loading rates for the pollutants of interest from a selected unimpaired watershed that has land use characteristics similar to those of the impaired watershed.

The reference watershed approach pairs two watersheds, one attaining its uses and one that is impaired based on biological assessment. Both watersheds must have similar land cover and land use characteristics. Other features such as base geologic formation should be matched to the extent possible; however, most variations can be adjusted in the watershed model (see Section 5). The objective of the process is to reduce the loading rate of nutrients and sediment in the impaired stream segment to a level equivalent to or slightly lower than the loading rate in the unimpaired reference stream segment. Achieving the phosphorus and/or sediment loadings recommended in the TMDLs will ensure that the aquatic life use of the impaired stream is achieved.

4.3.1 Considerations and Steps in the Selection of the Reference Watershed

Two factors formed the basis for selecting a suitable reference watershed. The first factor was to use a watershed that had been assessed by the PADEP using the Unassessed Waters Protocol (see Introduction) and had been determined to attain water quality standards. The second factor was to find a watershed that closely resembled the impaired watershed in physical properties such as land cover/land use, physiographic province, size, and geology. This was done by means of a desktop screening using several GIS coverages. The GIS coverages included the USGS named stream watershed coverage, the state water plan boundaries, the satellite image-derived land cover grid (MRLC), streams, and Pennsylvania's 305(b) assessed streams database.

There were four steps in determining the reference watersheds that were used to derive the target limits for the TMDLs. Figure 4.1 shows these four steps and how they are used in deriving the target limits. The first step was to locate watersheds that had been recently assessed and were not impaired. Step 2 was to identify a pool of unimpaired watersheds similar in size and geology to the impaired watersheds. Step 3 involved comparing the land cover data of the watersheds and selecting unimpaired watersheds that had land cover characteristics similar to those of the impaired watersheds. Land use distributions were compared on a percentage basis as calculated from EPA's Multi-Resolution Land Characteristics land use coverage (MRLC, 1991-1993). If for some cases a suitable reference watershed could not be found to match the impaired watershed in all desired aspects (size, location, geology, and land use distribution), the fourth step was used to regroup small unimpaired neighboring watersheds or to redelineate the large watersheds to produce reasonable matches to the impaired watersheds.

Once the reference watersheds were selected, their existing loading values could be estimated based on watershed modeling using state GIS data. The estimated existing loading values were analyzed and then considered as the endpoints or target limits.

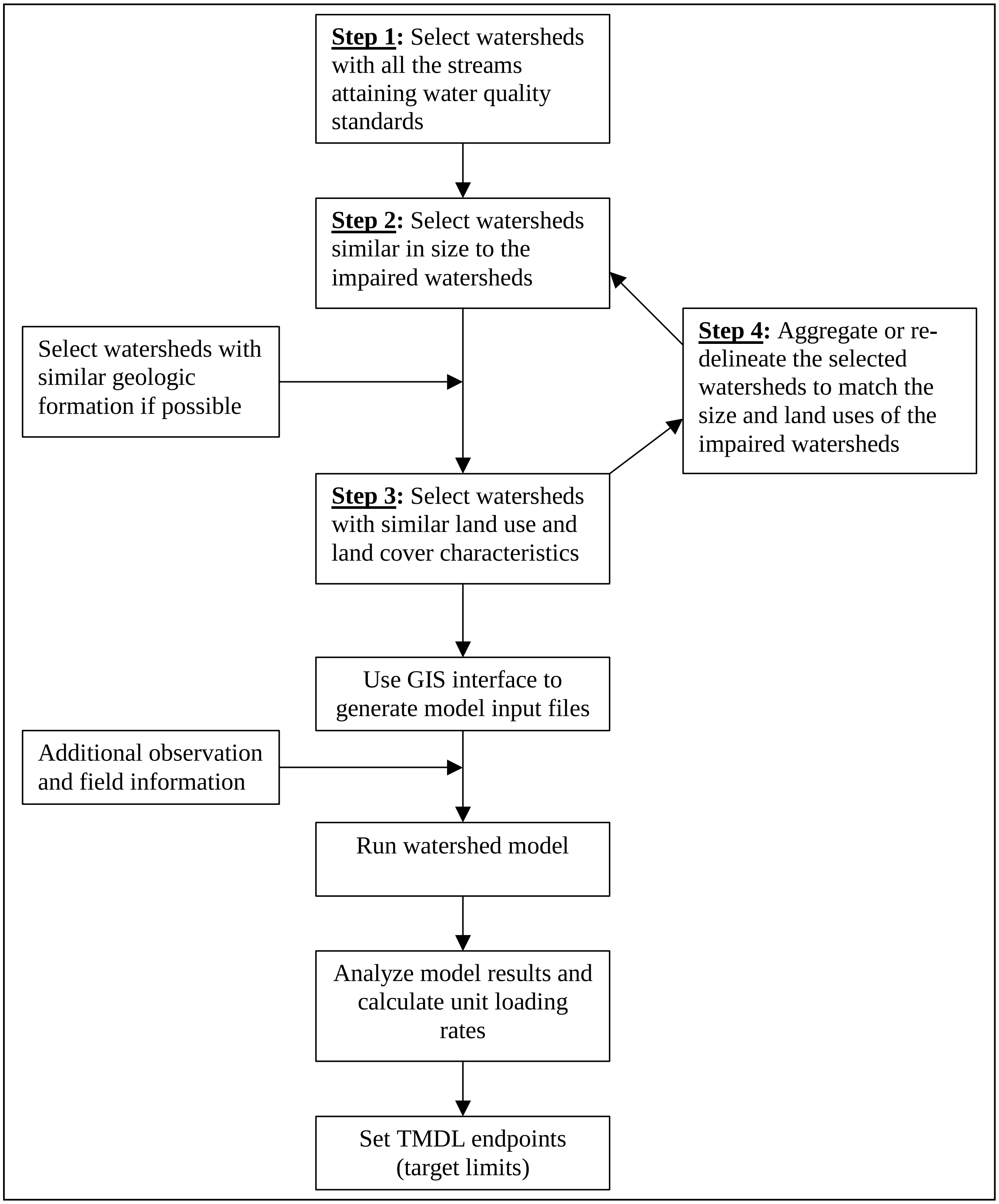

Figure 4.1 Flow chart for the derivation of TMDL target limits. Steps 1 to 4 are used for the determination of the reference watershed.

4.3.2 TMDL Endpoints for Impaired Watersheds in the Conodoguinet Creek Basin

The TMDL endpoints established for this study were determined using Lehman Run, Peebles-Bear Hollow Run, Griers Hollow-Devil Alex Hollow-Mountain Run, Upper Letort Spring Run, and Upper Yellow Breeches as the reference watersheds (Figure 4.2). Table 4.3 presents the listed watersheds and their corresponding reference watersheds and endpoints.

The TMDL process uses loading rates in the non-impaired watersheds as targets for loading reductions in the impaired watersheds. The impaired watersheds are modeled to determine the current loading rates and determine what reductions are necessary to meet the loading rates of the reference watersheds. Appendix A presents the pairing of each selected reference watershed with the impaired watersheds in the Conodoguinet Creek basin in more detail, including comparisons of watershed characteristics and existing loading rates.

Table 4.3 Summary of reference watersheds and TMDL endpoints

Reference Watershed	**Impaired Watershed**	**Existing Loads[a]**		**TMDL Endpoint[b]**	
		Phosphorus (lb/ac/yr)	**Sediment (lb/ac/yr)**	**Phosphorus (lb/ac/yr)**	**Sediment (lb/ac/yr)**
Lehman Run	Newburg Run	0.42	304.27	0.36	240.25
	Clippingers Run	0.49	407.17		
	UNT 7403	0.49	421.95		
Peebles - Bear Hollow Run	Center Creek and Back Creek	0.43	327.60	0.35	253.27
	Paxton Run	0.46	333.77		
	Wertz Run	0.42	397.94		
	UNT1605	0.68	601.99		
Griers Hollow-Devil Alex Hollow-Mountain Run	Mains Run and Gum Run	0.39	456.70	0.31	366.60
Yellow Breeches Creek-5K[c]	Alexanders Spring Creek	0.89	694.20	0.63	483.20
	Bulls Head Branch and Green Spring Creek	0.80	543.64		
	Hogestown Run	0.88	609.00		
	Mount Rock Spring Creek	0.93	704.40		
	Rowe Run	1.03	690.04		
Yellow Breeches Creek-2K[c]	Middle Spring Creek	1.29	546.79	0.61	497.08
(Upper) Letort Spring Run	Trindle Spring Run	0.76	521.09	0.66	475.68

[a] Existing loads from impaired watersheds in the Conodoguinet Creek basin
[b] TMDL endpoint = the existing loads from the reference watersheds in the Conodoguinet Creek basin
[c] Yellow Breeches Creek watershed was re-delineated in to three separate sizes to match the size of the impaired watersheds. See details in Appendix A.

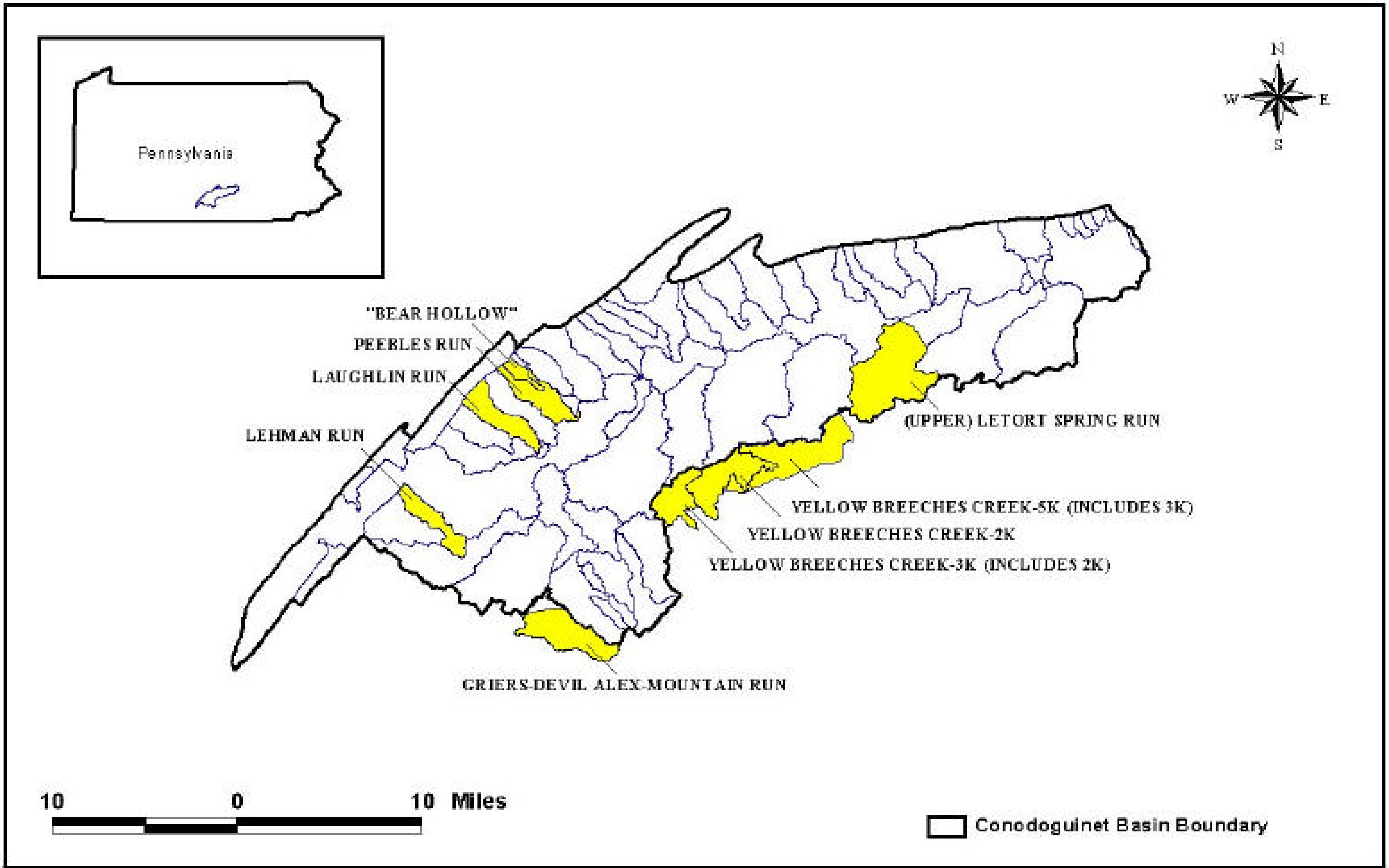

Figure 4.2 Selected reference watersheds for the impaired watersheds in the Conodoguinet Creek basin

Data Sources: Pennsylvania Spatial Data Access

5.0 Technical Approach

5.1 Overall Technical Approach

The “reference watershed” approach (see section 4.3) was used in this study to develop TMDLs for the impaired watersheds in the Conodoguinet Creek basin. Once the impaired and reference watersheds were matched, a watershed model was used to simulate the pollutant loads from different sources. The watershed model used in this study was the Generalized Watershed Loading function (GWLF) model (Haith and Shoemaker, 1987). The input data for GWLF was generated by a GIS interface developed by the Environmental Resources Research Institute of the Pennsylvania State University (details in section 5.3). The unit loading rates calculated for the reference watersheds were used as endpoints for the impaired watersheds. TMDLs were developed for the impaired watersheds based on the endpoints and using a load allocation procedure called “Equal Marginal Percent Reduction” (see Section 6.1). Figure 5.1 gives a general description of the technical approach taken in developing TMDLs for the impaired watersheds in the Conodoguinet Creek basin. The modeling effort is described in greater detail in sections 5.2 and 5.3.

5.2 Watershed Model

The TMDLs were developed using the GWLF model. The GWLF model, which was originally developed by Cornell University (Haith and Shoemaker, 1987; Haith et al., 1992), provides the ability to simulate runoff, sediment, and nutrient loadings from watersheds given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and it allows for the inclusion of point source discharge data. It is a continuous simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values.

GWLF is an aggregated distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios. Each area is assumed to be homogenous with respect to various attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but aggregates the loads from each area into a watershed total. In other words, there is no spatial routing. For subsurface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for subsurface flow contributions. Daily water balances are computed for an unsaturated zone as well as for a saturated subsurface zone, where infiltration is computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

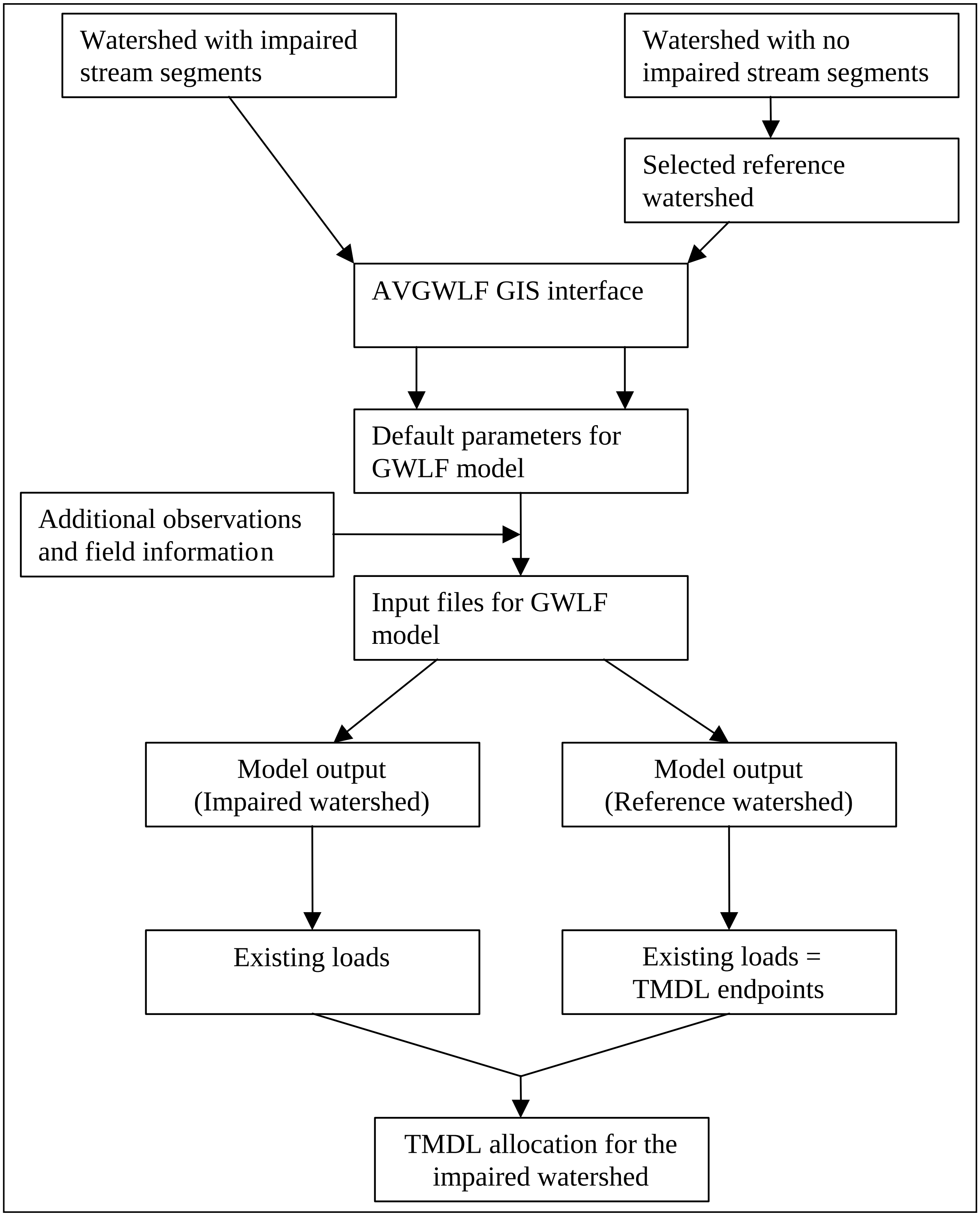

Figure 5.1 Technical approach for TMDL development in the Conodoguinet Creek basin.

GWLF models surface runoff using the Soil Conservation Service Curve Number (SCS-CN) approach with daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the Universal Soil Loss Equation (USLE) algorithm (with monthly rainfall-runoff coefficients) and a monthly composite of KLSCP values for each source area (e.g., land cover/soil type combination). The KLSCP factors are variables used in the calculations to depict changes in soil loss/erosion (K), the length/slope factor (LS), the vegetation cover factor (C), and the conservation practices factor (P). A sediment delivery ratio based on watershed size and a transport capacity based on average daily runoff are applied to the calculated erosion to determine sediment yield for each source area. Surface nutrient losses are determined by applying dissolved nitrogen and phosphorus coefficients to surface runoff and a sediment coefficient to the yield portion for each agricultural source area. Point source discharges also can contribute to dissolved loads to the stream and are specified in terms of kilograms per month. Manured areas, as well as septic systems, also can be considered. Urban nutrient inputs are all assumed to be solid-phase, and the model uses an exponential accumulation and washoff function for these loadings. Subsurface losses are calculated using dissolved nitrogen and phosphorus coefficients for shallow groundwater contributions to stream nutrient loads, and the subsurface submodel considers only a single, lumped-parameter contributing area. Evapotranspiration is determined using daily weather data and a cover factor dependent on land use/cover type. Finally, a water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and evapotranspiration values. All of the equations used by the model can be found in the original GWLF paper (Haith and Shoemaker, 1987) and GWLF User's Manual (Haith et. al, 1992).

For execution, the model requires three separate input files containing transport-, nutrient-, and weather-related data. The transport file (TRANSPRT.DAT) defines the necessary parameters for each source area to be considered (e.g., area size, curve number) as well as global parameters (e.g., initial storage, sediment delivery ratio) that apply to all source areas. The nutrient file (NUTRIENT.DAT) specifies the various loading parameters for the different source areas identified (e.g., number of septic systems, urban source area accumulation rates, manure concentrations). The weather file (WEATHER .DAT) contains daily average temperature and total precipitation values for each year simulated.

5.3 GIS-Based Derivation of Input Data for the Watershed Model

The primary sources of data for the TMDL analyses were GIS formatted databases. A specially designed interface, ArcView Version of the Generalized Watershed Loading Function (AVGWLF), was prepared by the Environmental Resources Research Institute of the Pennsylvania State University in ArcView (GIS software) to generate the data needed to run the GWLF model (Evans and Lehning, 2000; Evans et al., 2000).

In using the AVGWLF interface, the user is prompted to identify required GIS files and to provide other information related to "nonspatial" model parameters (e.g., beginning and end of the growing season, the months during which manure is spread on agricultural land, and the names of nearby weather stations). This information is subsequently used to automatically derive values for required model input parameters, which are then written to the

TRANSPRT.DAT, NUTRIENT.DAT and WEATHER.DAT input files needed to execute the GWLF model. For use in Pennsylvania, AVGWLF has been linked with statewide GIS data layers such as land use/cover, soils, topography, and physiography, and it includes location-specific default information such as background nitrogen and phosphorus concentrations and cropping practices. Complete GWLF-formatted weather files also are prepared for 88 weather stations around the state.

5.3.1 Statewide GIS Data Sets

Table 5.1 lists the GIS data sets and provides an explanation of how they were used for development of the input files for the GWLF model.

Table 5.1 Statewide GIS data sets (Source: Evans and Lehning, 2000; Evans et al., 2000)

Censustr	Coverage of census data including information on individual homes' septic systems. The attribute *susew_sept* includes data on conventional systems, and *su_other* provides data on short circuiting and other systems.
County	The county boundaries coverage lists data on conservation practices which provides C and P values for the Universal Soil Loss Equation (USLE).
Gwnback	A grid of background concentrations of nitrogen in groundwater derived from water well sampling.
Landuse5	Grid of the Multi-Resolution Land Characteristics (MRLC, 1991-1993) that has been reclassified into five categories. This is used primarily as a background.
Majoroad	Coverage of major roads. Used for reconnaissance of a watershed.
MCD	Minor civil divisions (boroughs, townships, and cities).
Npdes	A coverage of permitted point discharges. Provides background information and cross check for the point source coverage.
Padem	100-meter digital elevation model. This is used to calculate landslope and slope length.
Palumrlc	A satellite image-derived land cover grid (MRLC) that is classified into 15 different land cover categories. This data set provides land cover loading rates for the different categories in the model.
Pasingle	The 1:24,000 scale single-line stream coverage of Pennsylvania. Provides a complete network of streams with coded stream segments.
Physprov	A shapefile of physiographic provinces. Attributes *rain_cool* and *rain_warm* are used to set rainfall erosivity, and *gwrecess* is used to set recession coefficients.
Pointsrc	Major point source discharges with permitted nitrogen and phosphorus loads.
Refwater3	Shape file of reference watersheds for which nutrient and sediment loads have been calculated.
Soilphos	A grid of soil phosphorus loads that has been generated from soil sample data. Used to help set phosphorus and sediment values.
Smallsheds	A coverage of small watersheds for named streams at the 1:24,000 scale. This coverage is used with the stream network to delineate the desired watershed level.
STATSGO	A shape file of generalized soil boundaries. The attribute *mu_k* sets the k factor in

	the USLE. The attribute *mu_awc* is the unsaturated available capacity, and the *muhsg_dom* is used with land use/cover to derive curve numbers.
Strm305	A coverage of stream water quality as reported in Pennsylvania's 305(b) report. Current status of assessed streams.
Surfgeol	A shapefile of the surface geology used to compare watersheds with similar qualities.
Zipcode	A coverage of animal densities. Attribute *aeu_acre* helps estimate nitrogen and phosphorus concentrations in runoff in agricultural lands and over manured areas.
Weather Files	Historical weather files for stations around Pennsylvania to simulate flow.

As described in the Watershed Model section (5.2), the GWLF model provides the ability to simulate surface water runoff, as well as sediment and nutrient loads, from a watershed based on landscape conditions such as topography, land use/cover, and soil type. In essence, the model is used to estimate surface runoff and nonpoint source loads from different areas in the watershed. If point source discharges are identified and the corresponding nutrient loads are quantified, these loads are summed to represent the total pollutant loads for the watershed.

5.3.2 Explanation of Important Model Parameters

In the GWLF model, the nonpoint source load calculated is affected by terrain conditions such as amount of agricultural land, land slope, and inherent soil erodibility. It also is affected by farming practices used in the area, as well as by background concentrations of nutrients (nitrogen and phosphorus) in soil and groundwater. Various parameters are included in the model to account for these conditions and practices. Some of the more important parameters are summarized below:

Areal extent of different land use/cover categories: This parameter is calculated directly from a GIS layer of land use/cover.

Curve number: This parameter determines the amount of precipitation that infiltrates into the ground or enters surface water as runoff. It is based on specified combinations of land use/cover and hydrologic soil type and is calculated directly using digital land use/cover and soils layers.

K factor: This factor relates to inherent soil erodibility, and it affects the amount of soil erosion taking place on a given unit of land.

LS factor: This factor signifies the steepness and length of slopes in an area and directly affects the amount of soil erosion.

C factor: This factor is related to the amount of vegetative cover in an area. In agricultural areas, this factor is largely controlled by the crops grown and the cultivation practices used. Values range from 0 to 1.0, with larger values indicating greater potential for erosion.

P factor: This factor is directly related to the conservation practices used in agricultural areas. Values range from 0 to 1.0, with larger values indicating greater potential for erosion.

Sediment delivery ratio: This parameter specifies the percentage of eroded sediment delivered to surface water and is empirically based on watershed size.

Unsaturated available water-holding capacity: This parameter relates to the amount of water that can be stored in the soil and affects runoff and infiltration. It is calculated using a digital soils layer.

Dissolved nitrogen in runoff: This parameter varies according to land use/cover type, and reasonable values have been established in the literature. This rate, reported in milligrams per liter, can be readjusted based on local conditions such as rates of fertilizer application and farm animal populations.

Dissolved phosphorus in runoff: Similar to nitrogen, the value for this parameter varies according to land use/cover type, and reasonable values have been established in the literature. This rate, reported in milligrams per liter, can be readjusted based on local conditions such as rates of fertilizer application and farm animal populations.

Nutrient concentrations in runoff over manured areas: These concentrations are user-specified concentrations for nitrogen and phosphorus that are assumed to be representative of surface water runoff leaving areas on which manure has been applied. As with the runoff rates described above, these concentrations are based on values obtained from the literature. They also can be adjusted based on local conditions such as rates of manure application or farm animal populations.

Nutrient buildup in nonurban areas: In GWLF, rates of buildup for both nitrogen and phosphorus have to be specified. In Pennsylvania, these rates are estimated using historical information on atmospheric deposition.

Background nitrogen and phosphorus concentrations in groundwater: Subsurface concentrations of nutrients (primarily nitrogen) contribute to the nutrient loads in streams. In Pennsylvania, these concentrations are estimated using recently published data from the U.S. Geological Survey (USGS).

Background nitrogen and phosphorus concentrations in soil: Because soil erosion results in the transport of nutrient-laden sediment to nearby surface water bodies, reasonable estimates of background concentrations in soil must be provided. In Pennsylvania, this information is based on literature values as well as soil test data collected annually at Penn State University. These values can be adjusted locally depending on manure loading rates and farm animal populations.

Other less important factors that can affect sediment and nutrient loads in a watershed also are included in the model. More detailed information about these parameters and those outlined above can be obtained from the GWLF User's Manual (Haith et al., 1992). Specific details in the manual that describe equations and typical parameter values used can be found on pages 15 through 41.

5.4. Comparison of Modeling Results with Estimates from Observations

Using the input files generated by AVGWLF interface, GWLF predicted overall water balances in the Conodoguinet Creek basin. The average climate conditions from 1981-1991 were used as the weather input for the Conodoguinet Creek basin, and the model was run for the 10-year period based on the most recent land use data. Water balance estimation based on USGS data was summarized in the report by Lazorchick (1989). Table 5.2 shows the comparison of water balance components calculated from the different sources. Results from GWLF model are very close to that from USGS observation data.

Table 5.2 Comparison of water balance estimated from USGS observation data with that predicted by GWLF model for the Conodoguinet Creek basin.

	Precipitation (inch)	**Evapor-transpiration (inch)**	**Ground Water (inch)**	**Surface Flow (inch)**	**Stream Flow (inch)**
Estimated from USGS observation[a]	39-40	21.5	13.3	4.2	17.5-19.8
Predicted by GWLF	37.9[b]	20.5	14.0	3.4	17.4

[a]Summarized by Lazorchick (1989).

[b]10-year (4/1/1981-3/31/1991) average of actual data.

The pollutant loading rates predicted by GWLF model for the subwatersheds in the Conodoguinet Creek basin were within the ranges calculated for the subwatersheds in the Susquehanna River basin using the USGS observation data (Table 5.3). Because the watershed sizes in Conodoguinet Creek basin are much smaller (smaller watersheds have higher pollutants delivery ratio) than those used in the USGS estimation (Langland, 1998), the median loading values predicted by GWLF were higher than those estimated for subwatersheds in the Susquehanna River basin.

Table 5.3 Comparison of unit loading rates estimated from USGS observation data in the Susquehanna River basin with that predicted by GWLF for the Conodoguinet Creek.

	Watershed Area ($mile^2$) [b]		**Phosphorus (lb/ac/yr)**		**Sediment (lb/ac/yr)**		**Nitrogen (lb/ac/yr)**	
	Range	**Med-ian**	**Range**	**Med-ian**	**Range**	**Med-ian**	**Range**	**Med-ian**
Estimated from USGS observation[a]	87-27100	445	.11-3.5	.41	13.8-564	168	6.4-42	9.6
Predicted by GWLF – Impaired Watershed	5.7-27	8	.39-1.29	0.76	304-951	544	9-23	16.6
Predicted by GWLF – Reference Watershed	4.3-21	7	.31-.66	0.61	240-523	476	8.3-15	14.4

[a]Data from Langland (1998).
[b]Values in this column are not model results.

6.0 TMDLs

Eighteen streams (the unnamed streams 970720-1605-JLR and 7403 were listed as a part of the main stem) in the Conodoguinet Creek basin are listed on Pennsylvania's 1998 303(d) list as impaired by siltation, nutrient enrichment, and/or organic enrichment (Table 1.1). Except the Big Spring Creek and part of the main stem, all the other segments are considered for TMDL development in this study.

For the purpose of TMDL development it is often necessary to aggregate 303(d)-listed stream segments. The primary reason to address multiple segments in combination is compatibility with the data used in TMDL analyses. The land cover data and the Digital Elevation data sets used in this study are represented by 30 by 30 and 100 by 100 meter squares, respectively. If the stream segment area for TMDL development is too small, an error is introduced by using the data beyond its capability. For this reason three pairs of impaired watersheds in the Conodoguinet Creek basin (Bulls Head Branch and Green Spring Creek, Mains Run and Gum Run, and Center Creek and Back Creek) were aggregated. This approach results in completing TMDLs for all the segments in the aggregated watersheds, although the analyses were completed for each aggregated watershed as one watershed area.

6.1 TMDL Calculation Methodology

The GWLF model was run for 10 years (see Section 5.4) for both the impaired watershed and its corresponding reference watershed to establish existing loading conditions. Default parameters generated by the AVGWLF GIS interface were used for modeling. In some cases parameters were adjusted to more accurately reflect local conditions.

The 10-year means for sediment, nitrogen, and phosphorus loads were determined for each land use in each of the watersheds. The unit area load for each pollutant in each watershed was estimated by dividing the mean annual pollutant loading pounds per year by the total area (acres), resulting in approximate loading per unit area (unit loading rate in pounds per acre per year for the watershed. See Appendices A and B for the loading per unit area results for each watershed. Appendix A contains the loading values for the reference watersheds, and Appendix B presents the loading values for the impaired watersheds.

The TMDLs established for each impaired watershed consist of a point source wasteload allocation (WLA), a nonpoint source load allocation (LA), and a margin of safety (MOS) for the pollutants.

The load reduction in the impaired watersheds was based on current loading rates for phosphorus and/or sediment in the reference watersheds. The pollutant loading rates were computed for the reference watersheds using the GWLF model. These loading rates were then used as the basis for establishing the TMDLs for the impaired watersheds.

The TMDL equation is:

TMDL = WLA + LA + MOS

The WLA portion of this equation is the total loading assigned to point sources. The LA portion is the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and the computational methodology used for the analysis. The individual components of the TMDLs are discussed in detail below.

TMDL Computation

The TMDLs for both pollutants (sediment and phosphorus) were computed in the same manner. Each pollutant's unit loading rate (in pounds per acre per year) in the reference watershed was multiplied by the total watershed area (acres) of the impaired watershed to give the TMDL value.

Margin of Safety

The Margin of Safety (MOS) for this analysis is explicit. Ten percent of each of the TMDLs was reserved as the MOS. Using 10 percent of the TMDL load is based on professional judgment and will provide an additional level of protection to the designated uses of the waterbody.

Load Allocation

The LA for the entire watershed was computed by subtracting the margin of safety value from the TMDL value. Individual load allocations were then assigned to each land uses/source in the watershed. Not all land use/source categories were included in the allocation because some might be difficult to control or contribute an insignificant portion of the total load. Loading values for land uses/sources that were not part of the allocation were carried through at their existing loading value. The following section presents an example allocation process in detail. The example is based on the sediment TMDL developed for the Alexanders Spring Creek watershed.

1. The margin of safety value was subtracted from the TMDL value. This quantity represents the LA.

LA = 5,904,193.8 (TMDL value, lb/yr) – 590,419.4 (MOS, 10% of the TMDL value)

LA = 5,131,774 lb/yr

2. The loads not considered in the reduction scenario were subtracted from the LA value. Loads not considered include loads from coniferous forest, mixed forest, and deciduous forest. (Loads not considered in the phosphorus TMDLs include loads from low-intensity development, high-intensity development, forests, groundwater, and septic systems.) The total load from these land uses/sources was subtracted from the LA.

Adjusted LA = 5,313,774 – 18,787 (total load from land uses not considered)

Adjusted LA = 5,294,987 lb/yr

This step resulted in the portion of the load that is available to allocate among the contributing sources, termed the allocable load.

3. The allocable load quantity was allocated among the remaining land use/sources. The allocation method used was Equal Marginal Percent Reduction (EMPR).

EMPR was carried out in the following manner. Each land use/source load was compared with the allocable load to determine if any contributor would exceed the allocable load by itself. The evaluation was carried out as if each source was the only contributor to the pollutant load of the receiving waterbody. If the contributor exceeded the allocable load, that contributor was reduced to the allocable load. This was the baseline portion of EMPR. After any necessary reductions were made in the baseline, the multiple analysis was run.

The multiple analyses summed all of the baseline loads and compared them to the allocable load. If the allocable load was exceeded, an equal percent reduction was made to all contributors' baseline values. After any necessary reductions in the multiple analyses, the final reduction percentage for each contributor was computed.

The sediment load allocation used in the Alexanders Spring Creek example is shown in Section 6.2.

6.2 Proposed TMDL for Alexanders Spring Creek Watershed

Alexanders Spring Creek was listed on the 1998 303(d) list for siltation. The total length of the impaired segment is 3.81 miles. Table 6.1 details the listed stream segment, the miles degraded, sources, causes, and the initial year listed. The location of the Alexanders Spring Creek watershed is shown in Figure 2.1.

Table 6.1 Year 1998 303(d) List: Alexanders Spring Creek

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10302	970917-0910-JLR	3.81	Unassessed Project	Agriculture	Siltation	1998

The sediment TMDL established for Alexanders Spring Creek watershed consists of an LA and an MOS. There is no WLA for this TMDL because there are no known sediment point source discharges in the watershed. The reference watershed for Alexanders Spring Creek is Yellow Breeches Creek-5K (Figure 4.2). The TMDL for Alexanders Spring Creek watershed is presented in Tables 6.2 through 6.4.

Table 6.2 TMDL computation for Alexanders Spring Creek watershed

Pollutant	Unit Area Loading Rate in Yellow Breeches Creek-5K (lb/ac/yr)	Total Watershed Area in Alexanders Spring Creek (ac)	TMDL Value (lb/yr)
Sediment	483.73	12,219	5,904,194

Table 6.3 Load allocation for Alexanders Spring Creek watershed by land use/source

	Sediment				
Source	**Area (ac)**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduction**
Hay/Past	3,163	141.5	447,436	412,573	7.8%
Cropland	7,230	1,108.7	8,016,209	4,882,414	39.1%
Coniferous	101	4.8	488	488	0.0%
Mixed For	183	4.6	848	848	0.0%
Deciduous	1,277	6.8	8,655	8,655	0.0%
Lo Int Dev	166	36.8	6,090	6,090	0%
Hi Int Dev	99	27.4	2,708	2,708	0%
Groundwater					
Point Source					
Septic Systems					
Total	**12,219**	**1,330.6**	**8,482,433**	**5,313,774**	**37%**

Table 6.4 TMDL for Alexanders Spring Creek watershed

Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)
Sediment	5,904,194	5,313,774	0	590,419

6.3 Proposed TMDLs for Bulls Head Branch and Green Spring Creek Watershed

Bulls Head Branch was listed on the 1998 303(d) list for siltation and organic enrichment. The total length of the impaired segments is 9.4 miles. Table 6.5 details the listed stream segments, miles degraded, sources, causes, and initial year listed.

Green Spring Creek was initially listed on the 1996 303(d) list for nutrients, and it appeared in the 1998 list for siltation and organic enrichment. The total length of impaired segments was about 4 miles in 1996 and 7.6 miles in 1998. The location of the Bulls Head Branch and Green Spring Creek watershed is shown in Figure 2.1. Table 6.6 details the listed stream segments, miles degraded, sources, causes, and initial year listed.

No TMDLs have been prepared for the pesticide listing for the Bulls Head Branch and Green Spring Creek (970806-0950-JLR). There is currently insufficient information to determine whether the streams were impaired by pesticides from agriculture. This source and cause were listed based on qualitative comments found in the stream survey report about the potential for pesticide use from watercress farming. However, the survey report did not state that there was any evidence of impairment due to pesticides. The inclusion of this cause on the 303(d) list is in error until further investigation determines whether this source and cause are contributing to the impairment in this stream segment.

Table 6.5 Year 1998 303(d) List: Bulls Head Branch

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10431	970804-0950-JLR	9.4	Unassessed Project	Agriculture, Other	Siltation, Organic Enrichment/ Low DO, Pesticide	1998

Table 6.6 Year 1998 303(d) List: Green Spring Creek

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10430	6459	4.31	Surface Water Monitoring Program	Agriculture	Nutrients	1996
	970804-0950-JLR	3.3	Unassessed Project	Agriculture, Other	Nutrients, Siltation, Organic Enrichment/ Low DO, Pesticides	1998

The sediment and nutrient TMDLs established for Bulls Head Branch and Green Spring Creek watershed consist of an LA and an MOS. There is no WLA for these TMDLs because there are no known point source discharges in the watershed. The reference watershed for Bulls Head Branch and Green Spring Creek is Yellow Breeches Creek-5K (Figure 4.2). The TMDLs for Bulls Head Branch and Green Spring Creek are presented in Tables 6.7 through 6.11.

Table 6.7 TMDL Computation for Bulls Head Branch and Green Spring Creek watershed

Pollutant	Unit Area Loading Rate in Yellow Breeches Creek-5K (lb/ac/yr)	Total Watershed Area in the Aggregated Bulls Head Branch-Green Spring Creek (ac)	TMDL Value (lb/yr)
Phosphorus	0.63	17,134	10,853
Sediment	483.73	17,134	8,279,005

Tables 6.8, 6.9, and 6.10 present the load allocations by land use/source for the aggregated Bulls Head Branch and Green Spring Creek watershed, the Bulls Head Branch watershed, and the Green Spring Creek watershed, respectively.

Table 6.8 Load allocation for aggregated Bulls Head Branch and Green Spring Creek watershed by land use/source

		Phosphorus				Sediment			
Source	Area (ac)	Unit Area Loading Rate (lb/ac/yr)	Annual average load (lb/yr)	LA (annual average) (lb/yr)	% Reduc-tion	Unit Area Loading Rate (lb/ac/yr)	Annual average load (lb/yr)	LA (annual average) (lb/yr)	% Reduct-ion
Hay/Past	5,416	0.20	1,062	934	12.0%	95.11	515,168	479,591.5	6.9%
Cropland	10,558	1.03	10,917	7,078	35.2%	829.01	8,753,062	6,927,743.4	20.9%
Coniferous	57	0.00	0	0	0.0%	2.50	142	141.9	0.0%
Mixed For	170	0.01	1	1	0.0%	4.28	730	729.5	0.0%
Deciduous	803	0.01	8	8	0.0%	7.22	5,798	5,798.5	0.0%
Quarry	15	2.63	39	34	12.0%	2,486.50	36,864	34,318.5	6.9%
Lo Int Dev	79	0.08	6	6	0.0%	24.62	1,946	1,946.3	0.0%
Hi Int Dev	35	1.09	38	38	0.0%	24.14	835	835.0	0.0%
Groundwater			1,648	1,648					
Point Source			0	0					
Septic Systems			19	19					
Total	**17,134**	**0.80**	**13,739**	**9,768**	**29%**	**543.64**	**9,314,545**	**7,451,105**	**20%**

Table 6.9 Load allocation for the Bulls Head Branch watershed by land use/source

		Phosphorus				Sediment			
Source	**Area** (ac)	**Unit Area Loading Rate** (lb/ac/yr)	**Annual average load** (lb/yr)	**LA (annual average)** (lb/yr)	**% Reduc-tion**	**Unit Area Loading Rate** (lb/ac/yr)	**Annual average load** (lb/yr)	**LA (annual average)** (lb/yr)	**% Reduct-ion**
Hay/Past	4,923	0.20	965	849	12.0%	95.11	468,272	435,933.7	6.9%
Cropland	9,649	1.03	9,976	6,468	35.2%	829.01	7,998,937	6,330,879.9	20.9%
Coniferous	30	0.00	0	0	0.0%	2.50	75	74.9	0.0%
Mixed For	109	0.01	1	1	0.0%	4.28	467	467.0	0.0%
Deciduous	502	0.01	5	5	0.0%	7.22	3,623	3,622.9	0.0%
Quarry	15	2.63	39	34	12.0%	2,486.50	36,864	34,318.5	6.9%
Lo Int Dev	79	0.08	6	6	0.0%	24.62	1,936	1,935.5	0.0%
Hi Int Dev	33	1.09	36	36	0.0%	24.14	790	790.4	0.0%
Groundwater			1,474	1,474					
Point Source			0	0					
Septic Systems			17	17					
Total	**15,339**	**0.80**	**12,519**	**8,890**	**29%**	**543.64**	**8,510,964**	**6,808,023**	**20%**

Table 6.10 Load allocation for the Green Spring Creek watershed by land use/source

		Phosphorus				Sediment			
Source	**Area** (ac)	**Unit Area Loading Rate** (lb/ac/yr)	**Annual average load** (lb/yr)	**LA (annual average)** (lb/yr)	**% Reduc-tion**	**Unit Area Loading Rate** (lb/ac/yr)	**Annual average load** (lb/yr)	**LA (annual average)** (lb/yr)	**% Reduct-ion**
Hay/Past	493	0.20	97	85	12.0%	95.11	46,896	43,657.8	6.9%
Cropland	910	1.03	941	610	35.2%	829.01	754,125	596,863.5	20.9%
Coniferous	27	0.00	0	0	0.0%	2.50	67	67.0	0.0%
Mixed For	61	0.01	0	0	0.0%	4.28	262	262.5	0.0%
Deciduous	301	0.01	3	3	0.0%	7.22	2,176	2,175.6	0.0%
Quarry	0	2.63	0	0	0.0%	2,486.50	0	0.0	0.0%
Lo Int Dev	0	0.08	0	0	0.0%	24.62	11	10.8	0.0%
Hi Int Dev	2	1.09	2	2	0.0%	24.14	45	44.6	0.0%
Groundwater			175	175					
Point Source			0	0					
Septic Systems			2	2					
Total	**1,794**	**0.80**	**1,220**	**877**	**28%**	**543.64**	**803,582**	**643,082**	**20%**

Table 6.11 TMDLs for the aggregated Bulls Head Branch and Green Spring Creek watershed

Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)
Phosphorus	10,853	9,768	0	1,085
Sediment	8,279,005	7,451,105	0	827,901

6.4 Proposed TMDLs for the Center Creek and Back Creek Watershed

Center Creek was listed on the 1998 303(d) list for nutrients and organic enrichment. The total length of impaired segments is 3.59 miles. Table 6.12 details the listed stream segments, miles degraded, sources, causes, and initial year listed.

Back Creek was listed on the 1998 303(d) list for nutrients and organic enrichment. The total length of impaired stream segments is 4.34 miles. The location of the Center Creek and Back Creek watershed is shown in Figure 2.1. Table 6.13 details the listed stream segments, miles degraded, sources, causes, and initial year listed.

Table 6.12 Year 1998 303(d) List: Center Creek

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10419	970617-1250-JLR	3.59	Unassessed Project	Agriculture	Nutrients, Organic Enrichment/ Low DO	1998

Table 6.13 Year 1998 303(d) List: Back Creek

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10417	970617-1250-JLR	4.34	Unassessed Project	Agriculture	Nutrients, Organic Enrichment/ Low DO	1998

The sediment and nutrient TMDLs established for the Center Creek and Back Creek watershed consist of an LA and an MOS. There is no WLA for these TMDLs because there are no known point source discharges in the watershed. The reference watershed for Center Creek and Back Creek was Peebles-Bear Hollow Run (Figure 4.2). The TMDLs for the Center Creek and Back Creek watershed are presented in Tables 6.14 through 6.18.

Table 6.14 TMDL Computation for the Center Creek and Back Creek watershed

Pollutant	Unit Area Loading Rate in Peebles-Bear Holow Run (lb/ac/yr)	Total Watershed Area in Center-Back Creek (ac)	TMDL Value (lb/yr)
Phosphorus	0.35	4,183	1,456
Sediment	253.55	4,183	1,059,531

Tables 6.15, 6.16, and 6.17 present the load allocations by land use/source for the aggregated Center and Back Creek watershed, the Center Creek watershed, and the Back Creek watershed, respectively.

Table 6.15 Load allocation for aggregated Center and Back Creek watershed by land use/source

		Phosphorus				Sediment			
Source	**Area (ac)**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduc-tion**	**Unit Area Loading Rate lb/ac/yr**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduc-tion**
Hay/Past	1,450	0.19	270	210	22.1%	107.06	155,283	130,836.4	15.7%
Cropland	1,376	0.86	1,183	739	37.5%	793.89	1,092,652	700,213.1	35.9%
Coniferous	57	0.01	0	0	0.0%	3.83	218	217.8	0.0%
Mixed For	52	0.01	0	0	0.0%	4.64	241	240.5	0.0%
Deciduous	1,238	0.09	111	111	0.0%	98.50	121,939	121,939.4	0.0%
Lo Int Dev	5	0.09	0	0	0.0%	13.89	69	68.7	0.0%
Hi Int Dev	5	1.16	6	6	0.0%	12.50	62	61.8	0.0%
Groundwater			243	243					
Point Source			0	0					
Septic Systems			0	0					
Total	**4,183**	**0.43**	**1,815**	**1,310**	**28%**	**327.60**	**1,370,464**	**953,578**	**30%**

Table 6.16 Load allocation for the Center Creek watershed by land use/source

		Phosphorus				Sediment			
Source	**Area (ac)**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduc-tion**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduc-tion**
Hay/Past	637	0.19	119	92	22.1%	107.06	68,192	57,456.1	15.7%
Cropland	477	0.86	410	256	37.5%	793.89	378,586	242,612.3	35.9%
Coniferous	6	0.01	0	0	0.0%	3.83	24	24.2	0.0%
Mixed For	12	0.01	0	0	0.0%	4.64	55	55.4	0.0%
Deciduous	439	0.09	39	39	0.0%	98.50	43,202	43,201.8	0.0%
Lo Int Dev	0	0.09	0	0	0.0%	13.89	0	0.0	0.0%
Hi Int Dev	0	1.16	0	0	0.0%	12.50	0	0.0	0.0%
Groundwater			91	91					
Point Source			0	0					
Septic Systems			0	0					
Total	**1,571**	**0.43**	**658**	**479**	**27%**	**327.60**	**490,059**	**343,350**	**30%**

Table 6.17 Load allocation for Back Creek watershed by land use/source

		Phosphorus				Sediment			
Source	**Area (ac)**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduc-tion**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduc-tion**
Hay/Past	813	0.19	151	118	22.1%	107.06	87,092	73,380.3	15.7%
Cropland	899	0.86	773	483	37.5%	793.89	714,066	457,600.8	35.9%
Coniferous	51	0.01	0	0	0.0%	3.83	194	193.6	0.0%
Mixed For	40	0.01	0	0	0.0%	4.64	185	185.1	0.0%
Deciduous	799	0.09	72	72	0.0%	98.50	78,738	78,737.6	0.0%
Lo Int Dev	5	0.09	0	0	0.0%	13.89	69	68.7	0.0%
Hi Int Dev	5	1.16	6	6	0.0%	12.50	62	61.8	0.0%
Groundwater			152	152					
Point Source			0	0					
Septic Systems			0	0					
Total	**2,613**	**0.43**	**1,154**	**832**	**28%**	**327.60**	**880,405**	**610,228**	**31%**

Table 6.18 TMDLs for Center Creek and Back Creek watershed

Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)
Phosphorus	1,456	1,310	0	146
Sediment	1,059,531	953,578	0	105,953

6.5 Proposed TMDL for the Clippingers Run Watershed

Clippingers Run was initially listed on the 1996 303(d) list for nutrients and organic enrichment. The total length of impaired stream segments is 0.83 mile. The location of the Clippingers Run watershed is shown in Figure 2.1. Table 6.19 details the listed stream segments, miles degraded, sources, causes, and initial year listed.

Table 6.19 Year 1998 303(d) List: Clippingers Run

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10568	1529	0.83	Surface Water Monitoring Program	Agriculture	Nutrients, Organic Enrichment/ Low DO	1996

The nutrient TMDL established for the Clippingers Run watershed consists of an LA and an MOS. There is no WLA for this TMDL because there are no known point source dischargers in the watershed. The reference watershed for Clippingers Run was Lehman Run (Figure 4.2). The TMDL for the Clippingers Run watershed is presented in Tables 6.20 through 6.22.

Table 6.20 TMDL Computation for the Clippingers Run watershed

Pollutant	Unit Area Loading Rate in Lehman Run (lb/ac/yr)	Total Watershed Area in Clippingers Run (ac)	TMDL Value (lb/yr)
Phosphorus	0.36	2,837	1,026

Table 6.21 Load allocation for the Clippingers Run watershed by land use/source

		Phosphorus			
Source	**Area (ac)**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduction**
Hay/Past	914	0.19	169	130	23.0%
Row Crops	1,090	0.83	901	472	47.5%
Coniferous	5	0.00	0	0	0.0%
Mixed For	27	0.01	0	0	0.0%
Deciduous	778	0.15	119	119	0.0%
Transition	2	5.80	14	11	23.0%
Lo Int Dev	15	0.07	1	1	0.0%
Hi Int Dev	5	1.07	5	5	0.0%
Groundwater			177	177	
Point Source			0	0	
Septic Systems			7	7	
Total	**2,837**	**0.49**	**1,395**	**923**	**34%**

Table 6.22 TMDL for the Clippingers Run watershed

Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)
Phosphorus	1,026	923	0	103

6.6 Proposed TMDLs for the Hogestown Run Watershed

Hogestown Run was initially listed on the 1998 303(d) list for organic enrichment and siltation. The total length of impaired stream segments is 10.37 miles. The location of the Hogestown Run watershed is shown in Figure 2.1. Table 6.23 details the listed stream segments, miles degraded, sources, causes, and initial year listed.

Table 6.23 Year 1998 303(d) List: Hogestown Run

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10224	970612-1405-JLR	10.37	Unassessed Project	Agriculture Urban Runoff/Storm Sewers	Siltation, Organic Enrichment/Low DO, Unknown	1998

The sediment and nutrient TMDLs established for the Hogestown Run watershed consist of an LA and an MOS. There is no WLA for these TMDLs because there are no known point source discharges in the watershed. The reference watershed for Hogestown Run was Yellow Breeches Creek-5K (Figure 4.2). The TMDLs for the Hogestown Run watershed are presented in Tables 6.24 through 6.26.

Table 6.24 TMDL computation for the Hogestown Run watershed

Pollutant	Unit Area Loading Rate in Yellow Breeches Creek-5K (lb/ac/yr)	Total Watershed Area in Hogestown Run (ac)	TMDL Value (lb/yr)
Phosphorus	0.63	11,260	7,133
Sediment	483.73	11,260	5,440,933

Table 6.25 Load allocation for the Hogestown Run watershed by land use/source

		Phosphorus				Sediment			
Source	**Area (ac)**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduc-tion**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduct-ion**
Hay/Past	3,509	0.23	809	695	14.0%	127.29	446,643	407,709.5	8.7%
Cropland	6,355	1.19	7,585	4,265	43.7%	1,004.80	6,385,811	4,465,894.3	30.1%
Coniferous	91	0.01	1	1	0.0%	3.65	334	334.1	0.0%
Mixed For	163	0.01	1	1	0.0%	4.19	683	683.3	0.0%
Deciduous	647	0.01	6	6	0.0%	5.35	3,463	3462.6	0.0%
Lo Int Dev	255	0.09	23	23	0.0%	35.60	9,061	8,271.2	8.7%
Hi Int Dev	240	1.18	282	282	0.0%	47.92	11,486	10,484.3	8.7%
Groundwater			1,080	1,079					
Point Source			0	0					
Septic Systems			68	68					
Total	**11,260**	**0.88**	**9,855**	**6,419**	**35%**	**609.00**	**6,857,481**	**4,896,839**	**29%**

Table 6.26 TMDLs for the Hogestown Run watershed

Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)
Phosphorus	7,133	6,419	0	713
Sediment	5,440,933	4,896,839	0	544,093

6.7 Proposed TMDL for the Mains Run and Gum Run Watershed

Mains Run was listed on the 1998 303(d) list for siltation. The total length of impaired stream segments is 5.28 miles. Table 6.27 details the listed stream segments, miles degraded, sources, causes, and initial year listed.

Gum Run was listed on the 1998 303(d) list for siltation. The total length of impaired stream segments is 7.79 miles. The location of the Mains Run and Gum Run watershed is shown in Figure 2.1. Table 6.28 details the listed stream segments, miles degraded, sources, causes, and initial year listed. Sources that caused the stream impairment were agriculture and habitat modification; however, the methodology employed in this TMDL development cannot directly address habitat modification, which is not a pollutant, reductions of sediment load are expected to benefit habitat conditions. Management practices expected to be used in reducing sediment load will include riparian zone management that benefits habitat conditions as well, through stream shading and stream bank protection.

Table 6.27 Year 1998 303(d) List: Mains Run

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10625	970806-0855-JLR	5.28	Unassessed Project	Agriculture, Habitat Modification	Siltation, Other Habitat Alterations	1998

Table 6.28 Year 1998 303(d) List: Gum Run

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10624	970806-0855-JLR	7.79	Unassessed Project	Agriculture, Habitat Modification	Siltation, Other Habitat Alterations	1998

The sediment TMDL established for the Mains Run and Gum Run watershed consists of an LA and an MOS. There is no WLA for this TMDL because there are no known point source discharges in the watershed. The reference watershed for Mains Run and Gum Run was Griers-Devil-Mountain watershed (Figure 4.2). The TMDL for the Mains Run and Gum Run watershed is presented in Tables 6.29 through 6.33.

Table 6.29 TMDL computation for Mains Run and Gum Run watershed

Pollutant	Unit Area Loading Rate in Griers-Devil-Mountain (lb/ac/yr)	Total Watershed Area in Mains Run and Gum Run (ac)	TMDL Value (lb/yr)
Sediment	367.01	4,653	1,705,742

Tables 6.30, 6.31, and 6.32 present the load allocations by land use for the aggregated Mains and Gum Run watershed, the Mains Run watershed, and the Gum Run watershed, respectively.

Table 6.30 Load allocation for the aggregated Mains and Gum Run watershed by land use/source

		Sediment			
Source	**Area (ac)**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduction**
Hay/Past	588	143.25	84,244	59,437.5	29.4%
Cropland	1,248	1,096.26	1,367,949	942,271.4	31.1%
Coniferous	69	17.38	1,203	1,202.6	0.0%
Mixed For	358	31.82	11,402	11,402.0	0.0%
Deciduous	2,286	81.12	185,407	185,407.5	0.0%
Transition	42	11,263.41	473,135	333,817.5	29.4%
Lo Int Dev	59	27.09	1,607	1,606.7	0.0%
Hi Int Dev	2	9.05	22	22.4	0.0%
Groundwater					
Point Source					
Septic Systems					
Total	**4,653**	**456.70**	**2,124,970**	**1,535,168**	**28%**

Table 6.31 Load allocation for the Mains Run watershed by land use/source

		Sediment			
Source	**Area (ac)**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduction**
Hay/Past	90	143.25	12,958	9,142.7	29.4%
Cropland	350	1,096.26	383,559	264,203.0	31.1%
Coniferous	23	17.38	401	400.9	0.0%
Mixed For	91	31.82	2,902	2,901.7	0.0%
Deciduous	863	81.12	70,009	70,008.6	0.0%
Transition	5	11,263.41	55,689	39,291.2	29.4%
Lo Int Dev	6	27.09	166	166.4	0.0%
Hi Int Dev	0	9.05	0	0.0	0.0%
Groundwater					
Point Source					
Septic Systems					
Total	**1,429**	**12,669.37**	**525,684**	**386,114**	**27%**

Table 6.32 Load allocation for the Gum Run watershed by land use/source

		Sediment			
Source	Area (ac)	Unit Area Loading Rate (lb/ac/yr)	Annual average load (lb/yr)	LA (annual average) (lb/yr)	% Reduction
Hay/Past	498	143.25	71,285	50,294.8	29.4%
Cropland	898	1,096.26	984,391	678,068.4	31.1%
Coniferous	46	17.38	802	801.8	0.0%
Mixed For	267	31.82	8,500	8,500.3	0.0%
Deciduous	1,423	81.12	115,399	115,398.9	0.0%
Transition	37	11,263.41	417,446	294,526.3	29.4%
Lo Int Dev	53	27.09	1440	1,440.4	0.0%
Hi Int Dev	2	9.05	22	22.4	0.0%
Groundwater					
Point Source					
Septic Systems					
Total	**3,224**	**456.70**	**1,599,286**	**1,149,053**	**28%**

Table 6.33 TMDL for Mains Run and Gum Run watershed

Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)
Sediment	1,705,742	1,535,168	0	170,574

6.8 Proposed TMDL for the Middle Spring Creek Watershed

Middle Spring Creek was initially listed on the 1996 303(d) list for suspended solids. The total length of impaired stream segments was 6.4 miles in 1996. The location of the Middle Spring Creek watershed is shown in Figure 2.1. Table 6.34 details the listed stream segments, miles degraded, sources, causes, and initial year listed.

Table 6.34 Year 1998 303 (d) List: Middle Spring Creek

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10602	6460	5.87	Surface Water Monitoring Program	Agriculture, Urban Runoff/Storm Sewers	Suspended Solids	1996

The sediment TMDL established for the Middle Spring Creek watershed consists of an LA and an MOS. There is no WLA for this TMDL because there are no known point source discharges in the watershed. The reference watershed for Middle Spring Creek was Yellow Breeches Creek-2K (Figure 4.2). The TMDL for Middle Spring Creek watershed is presented in Tables 6.35 through 6.37.

Table 6.35 TMDL computation for the Middle Spring Creek watershed

Pollutant	Unit Area Loading Rate in Yellow Breeches Creek-2K (lb/ac/yr)	Total Watershed Area in Middle Spring Creek (ac)	TMDL Value (lb/yr)
Sediment	497.63	5,095	2,532,681

Table 6.36 Load allocation for the Middle Spring Creek watershed by land use/source

		Sediment			
Source	**Area** (ac)	**Unit Area Loading Rate** (lb/ac/yr)	**Annual average load** (lb/yr)	**LA (annual average)** (lb/yr)	**% Reduction**
Hay/Past	1,856	116.69	216,533	196,927.0	9.1%
Cropland	2,325	1,099.55	2,556,660	2,070,610.3	19.0%
Coniferous	52	3.30	171	171.1	0.0%
Mixed For	67	4.19	280	279.5	0.0%
Deciduous	381	5.79	2,205	2,204.8	0.0%
Lo Int Dev	250	25.43	6,346	5,771.7	9.1%
Hi Int Dev	166	22.91	3,792	3,448.8	9.1%
Groundwater					
Point Source					
Septic Systems					
Total	**5,095**	**546.79**	**2,785,986**	**2,279,413**	**18%**

Table 6.37 TMDL for the Middle Spring Creek watershed

Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)
Sediment	2,532,681	2,279,413	0	253,268

6.9 Proposed TMDLs for the Mount Rock Spring Creek Watershed

Mount Rock Spring Creek was initially listed on the 1996 303(d) list for nutrients, and it appeared in the 1998 for siltation. The total length of impaired stream segments is 8.64 miles. The location of the Mount Rock Spring Creek watershed is shown in Figure 2.1. Table 6.38 details the listed stream segments, miles degraded, sources, causes, and initial year listed.

Table 6.38 Year 1998 303(d) List: Mount Rock Spring Creek

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10319	6457	1.42	Surface Water Monitoring Program	Agriculture	Nutrients	1996
	970811-0925-JLR	7.22	Unassessed Project	Agriculture, Construction	Siltation	1998

The sediment and nutrient TMDLs established for the Mount Rock Spring Creek watershed consist of an LA and an MOS. There is no WLA for this TMDL because there are no known point source discharges in the watershed. The reference watershed for Mount Rock Spring Creek was Yellow Breeches Creek-5K (Figure 2.4). The TMDLs for the Mount Rock Spring Creek watershed are presented in Tables 6.39 through 6.41. The reduction of erosion or other sediment sources in urban areas (high or low intensity development) will reduce the impact of construction on water quality in the watershed.

Table 6.39 TMDL computation for the Mount Rock Spring Creek watershed

Pollutant	Unit Area Loading Rate in Yellow Breeches Creek-5K (lb/ac/yr)	Total Watershed Area in Mount Rock Spring Creek (ac)	TMDL Value (lb/yr)
Phosphorus	0.63	15,713	9,953
Sediment	483.73	15,713	7,592,471

Table 6.40 Load allocation for the Mount Rock Spring Creek watershed by land use/source

		Phosphorus				Sediment			
Source	Area (ac)	Unit Area Loading Rate (lb/ac/yr)	Annual average load (lb/yr)	LA (annual average) (lb/yr)	% Reduc-tion	Unit Area Loading Rate (lb/ac/yr)	Annual average load (lb/yr)	LA (annual average) (lb/yr)	% Reduct-ion
Hay/Past	4,529	0.22	1,013	891	11.9%	129.17	585,026	538,087.8	8.0%
Cropland	9,345	1.30	12,169	6,577	45.9%	1,119.16	10,458,812	6,271,611.0	40.0%
Coniferous	77	0.01	0	0	0.0%	4.19	321	320.9	0.0%
Mixed For	143	0.01	1	1	0.0%	5.26	754	753.7	0.0%
Deciduous	1,324	0.01	17	17	0.0%	10.16	13,459	13,459.0	0.0%
Lo Int Dev	227	0.09	20	20	0.0%	36.02	8,188	7,530.7	8.0%
Hi Int Dev	67	1.15	77	76	0.0%	23.80	1,588	1,460.6	8.0%
Groundwater			1,321	1,320					
Point Source			0	0					
Septic Systems			54	54					
Total	**15,713**	**0.93**	**14,673**	**8,958**	**39%**	**704.40**	**11,068,148**	**6,833,224**	**38%**

Table 6.41 TMDLs for the Mount Rock Spring Creek watershed

Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)
Phosphorus	9,953	8,958	0	995
Sediment	7,592,471	6,833,224	0	759,247

6.10 Proposed TMDLs for the Newburg Run Watershed

Newburg Run was listed on the 1998 303(d) list for nutrients and siltation. The total length of impaired stream segments was 5.24 miles. The location of the Newburg Run watershed is shown in Figure 2.1. Table 6.42 details the listed stream segments, miles degraded, sources, causes, and initial year listed.

Table 6.42 Year 1998 303(d) List: Newburg Run

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10531	970807-1115-JLR	5.24	Unassessed Project	Agriculture	Nutrients Siltation	1998

The sediment and nutrient TMDLs established for the Newburgh Run watershed consist of an LA and an MOS. There is no WLA for this TMDL because there are no known point source discharges in the watershed. The reference watershed for Newburg Run was Lehman Run. The TMDLs for the Newburg Run watershed are presented in Tables 6.43 through 6.45.

Table 6.43 TMDL computation for the Newburg Run watershed

Pollutant	Unit Area Loading Rate in Lehman Run (lb/ac/yr)	Total Watershed Area in Newburg Run (ac)	TMDL Value (lb/yr)
Phosphorus	0.36	3,635	1,315
Sediment	240.51	3,635	873,236

Table 6.44 Load allocation for the Newburg run watershed by land use/source

		Phosphorus				Sediment			
Source	Area (ac)	Unit Area Loading Rate (lb/ac/yr)	Annual average load (lb/yr)	LA (annual average) (lb/yr)	% Reduc-tion	Unit Area Loading Rate (lb/ac/yr)	Annual average load (lb/yr)	LA (annual average) (lb/yr)	% Reduct-ion
Hay/Past	1,216	0.18	224	177	21.0%	101.44	123,325	104,392.5	15.4%
Row Crops	1,203	0.79	954	662	30.5%	728.55	876,707	575,611.0	34.3%
Coniferous	5	0.00	0	0	0.0%	1.16	6	5.7	0.0%
Deciduous	1,151	0.08	94	94	0.0%	90.39	104,080	104,080.2	0.0%
Lo Int Dev	32	0.08	3	3	0.0%	38.91	1250	1,250.0	0.0%
Hi Int Dev	27	1.09	30	30	0.0%	21.09	573	573.0	0.0%
Groundwater			213	213					
Point Source			0	0					
Septic Systems			6	6					
Total	**3,635**	**0.42**	**1,523**	**1,183**	**22%**	**304.27**	**1,105,941**	**785,913**	**29%**

Table 6.45 TMDLs for the Newburg Run watershed

Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)
Phosphorus	1,315	1,183	0	131
Sediment	873,236	785,913	0	87,324

6.11 Proposed TMDL for the Paxton Run Watershed

A small section of Paxton Run, 0.39 mile, was initially listed on the 1996 303(d) list for suspended solids. In 1998, however, more than 8.6 miles of the stream were listed for siltation. The location of the Paxton Run watershed is shown in Figure 2.1. Table 6.46 details the listed stream segments, miles degraded, sources, causes, and initial year listed.

Table 6.46 Year 1998 303(d) List: Paxton Run

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10549	7039	0.39	Surface Water Monitoring Program	Agriculture	Suspended Solids	1996
	970819-1315-JLR	8.64	Unassessed Project	Agriculture	Siltation	1998

The sediment TMDL established for the Paxton Run watershed consists of an LA and an MOS. There is no WLA for this TMDL because there are no known point source discharges in the watershed. The reference watershed for Paxton Run was Peebles-Bear Hollow Run (Figure 4.2). The TMDL for the Paxton Run watershed is presented in Tables 6.47 through 6.49.

Table 6.47 TMDL computation for the Paxton Run watershed

Pollutant	Unit Area Loading Rate in Peebles-Bear Hollow Run (lb/ac/yr)	Total Watershed Area in Paxton Run (ac)	TMDL Value (lb/yr)
Sediment	253.55	4,658	1,179,690

Table 6.48 Load allocation for the Paxton Run watershed by land use/source

		Sediment			
Source	**Area (ac)**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduction**
Hay/Past	1,418	75.1	106,582	96,032	9.9%
Cropland	2,142	633.2	1,356,454	874,119	35.6%
Coniferous	7	1.7	13	13	0.0%
Mixed For	32	3.2	103	103	0.0%
Deciduous	1,043	87.5	91,278	91,278	0.0%
Lo Int Dev	5	12.8	63	63	0.0%
Hi Int Dev	10	11.5	113	113	0.0%
Groundwater					
Point Source					
Septic Systems					
Total	**4,658**	**334.8**	**1,554,607**	**1,061,721**	**32%**

Table 6.49 TMDLs for the Paxton Run watershed

Pollutant	**TMDL (lb/yr)**	**LA (lb/yr)**	**WLA (lb/yr)**	**MOS (lb/yr)**
Sediment	1,179,690	1,061,721	0	117,969

6.12 Proposed TMDLs for the Rowe Run Watershed

Rowe Run was initially listed on the 1998 303(d) list for organic enrichment and siltation. The total length of impaired stream segments was about 19.75 miles. The location of the Rowe Run watershed is shown in Figure 2.1. Table 6.50 details the listed stream segments, miles degraded, sources, causes, and initial year listed.

Table 6.50 Year 1998 303 (d) List: Rowe Run

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10668	970819-1030-JLR	19.75	Unassessed Project	Agriculture	Siltation, Organic Enrichment/ Low DO	1998

The sediment and nutrient TMDLs established for the Rowe Run watershed consist of an LA and an MOS. There is a WLA for this TMDL because there is a known point source discharge in the watershed. The point source discharge is the Letterkenny Army Depot/IW in Chambersburg, Pennsylvania (NPDES ID PA0010502). The reference watershed for Rowe Run was Yellow Breeches Creek-5K (Figure 4.2). The TMDLs for the Rowe Run watershed are presented in Tables 6.51 through 6.53.

Table 6.51 TMDL computation for Rowe Run watershed

Pollutant	Unit Area Loading Rate in Yellow Breeches Creek-5K (lb/ac/yr)	Total Watershed Area in Rowe Run (ac)	TMDL Value (lb/yr)
Phosphorus	0.63	12,004	7,604
Sediment	483.73	12,004	5,800,318

Table 6.52 Load allocation for the Rowe Run watershed by land use/source

		Phosphorus				Sediment			
Source	**Area (ac)**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduc-tion**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduct-ion**
Hay/Past	4,220	0.23	981	770	21.5%	147.08	620,749	554,347.9	10.7%
Cropland	6,489	1.25	8,135	2,815	65.4%	1,176.93	7,636,801	4,640,459.3	39.2%
Coniferous	47	0.00	0	0	0.0%	3.21	151	150.7	0.0%
Mixed For	77	0.01	0	0	0.0%	3.57	273	273.1	0.0%
Deciduous	455	0.01	4	4	0.0%	5.17	2,351	2,350.7	0.0%
Transition	2	0.89	2	2	21.5%	678.45	1,676	1,497.1	10.7%
Lo Int Dev	321	0.08	26	26	0.0%	26.57	8,536	8,535.9	0.0%
Hi Int Dev	393	1.09	427	427	0.0%	32.25	12,672	12,671.8	0.0%
Groundwater			1,001	1,001					
Point Source			1765	1765	0.0%				
Septic Systems			34	34					
Total	**12,004**	**1.03**	**12,376**	**6,843**	**45%**	**690.04**	**8,283,209**	**5,220,286**	**37%**

Table 6.53 TMDLs for the Rowe Run watershed

Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)
Phosphorus	7,604	5,078	1,765	760
Sediment	5,800,318	5,220,286	0	580,032

6.13 Proposed TMDL for the Trindle Spring Run Watershed

Trindle Spring Run was initially listed on the 1996 303(d) list for priority organics; in addition, it was listed for siltation in 1998. The total length of impaired stream segments was approximately 8 miles. The location of the Trindle Spring Run watershed is shown in Figure 2.1. Table 6.54 details the listed stream segments, miles degraded, sources, causes, and initial year listed. This TMDL addresses only the sediment impairment for Trindle Spring Run. The TMDL for the priority organics in Trindle Spring Run was deferred until sufficient quantitative evidence of the presence of specific chemicals in the stream is available.

Table 6.54 Year 1998 303(d) List: Trindle Spring Run

<table>
<tr><th>Stream Code</th><th>Segment ID</th><th>Miles Degraded</th><th>Data Source</th><th>Source Code</th><th>Cause Code</th><th>Initial Year Listed</th></tr>
<tr><td rowspan="2">10222</td><td>9334</td><td>0.68</td><td>Surface Water Monitoring Program</td><td>Land Disposal</td><td>Priority Organics</td><td>1996</td></tr>
<tr><td>970605-0930-JLR</td><td>7.29</td><td>Unassessed Project</td><td>Agriculture, Construction, Urban Runoff/Storm Sewers</td><td>Siltation
Unknown</td><td>1998</td></tr>
</table>

The sediment TMDL established for the Trindle Spring Run watershed consists of an LA and an MOS. There is no WLA for this TMDL because there are no known point source discharges in the watershed. The reference watershed for Trindle Spring Run was upper Letort Spring Run (Figure 4.2). The TMDL for the Trindle Spring Run watershed is presented in Tables 6.55 through 6.57. The reduction of erosion or other sediment sources in urban areas (high or low intensity development) will reduce the impact of construction on water quality in the watershed.

Table 6.55 TMDL computation for the Trindle Spring Run watershed

Pollutant	Unit Area Loading Rate in Upper Letort Spring Run (lb/ac/yr)	Total Watershed Area in Trindle Spring Run (ac)	TMDL Value (lb/yr)
Sediment	476.21	11,305	5,377,457

Table 6.56 Load allocation for the Trindle Spring Run watershed by land use/source

		Sediment			
Source	Area (ac)	Unit Area Loading Rate (lb/ac/yr)	Annual average load (lb/yr)	LA (annual average) (lb/yr)	% Reduction
Hay/Past	2,459	137.90	339,045	304,878.2	10.1%
Cropland	5,095	1,048.39	5,341,670	4,345,198.7	18.7%
Coniferous	111	4.90	545	545.2	0.0%
Mixed For	161	6.06	974	973.6	0.0%
Deciduous	610	9.89	6,039	6,039.0	0.0%
Quarry	10	1,617.64	15,989	14,377.3	10.1%
Lo Int Dev	1,717	67.79	116,413	104,681.9	10.1%
Hi Int Dev	1,142	61.39	70,080	63,017.4	10.1%
Total	**11,305**	**521.09**	**5,890,754**	**4,839,711**	**18%**

Table 6.57 TMDL for the Trindle Spring Run watershed

Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)
Sediment	5,377,457	4,839,711	0	537,746

6.14 Proposed TMDL for the Wertz Run Watershed

Wertz Run was initially listed on the 1998 303(d) list for siltation. The location of the Wertz Run watershed is shown in Figure 2.1. Table 6.58 details the listed stream segments, miles degraded, sources, causes, and initial year listed.

Table 6.58 Year 1998 303 (d) List: Wertz Run

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10276	970702-1500-JLR	1.73	Unassessed Project	Agriculture, Construction	Siltation	1998

The sediment TMDL established for the Wertz Run watershed consists of an LA and an MOS. There is no WLA for this TMDL because there are no known point source discharges in the watershed. The reference watershed for Wertz Run was Peebles-Bear Hollow Run (Figure 4.2). The TMDL for the Wertz Run watershed is presented in Tables 6.59 through 6.61. The reduction of erosion or other sediment sources in urban areas (high or low intensity development) will reduce the impact of construction on water quality in the watershed.

Table 6.59 TMDL computation for the Wertz Run watershed

Pollutant	Unit Area Loading Rate in Peebles-Bear Hollow Run (lb/ac/yr)	Total Watershed Area in Wertz Run (ac)	TMDL Value (lb/yr)
Sediment	253.55	3,613	914,964

Table 6.60 Load allocation for the Wertz Run watershed by land use/source

		Sediment			
Source	Area (ac)	Unit Area Loading Rate (lb/ac/yr)	Annual average load (lb/yr)	LA (annual average) (lb/yr)	% Reduction
Hay/Past	672	103.40	69,498	60,055	13.6%
Row Crops	1,087	909.95	989,322	384,724	61.1%
Coniferous	143	6.69	958	958	0.0%
Mixed For	109	7.49	814	814	0.0%
Deciduous	1,576	238.81	376,476	376,476	0.0%
Lo Int Dev	15	21.52	319	276	13.6%
Hi Int Dev	10	19.26	190	164	13.6%
Groundwater					
Point Source					
Septic Systems					
Total	**3,613**	**397.94**	**1,437,577**	**823,468**	**43%**

Table 6.61 TMDL for the Wertz Run watershed

Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)
Sediment	914,964	823,468	0	91,496

6.15 Proposed TMDL for the UNT 1605 Watershed

UNT 1605 is an unnamed tributary listed with the main stem of Conodoguinet Creek. UNT 1605 was initially listed on the 1998 303(d) list for siltation. The total length of impaired stream segments was 7.75 miles. The location of the UNT 1605 watershed is shown in Figure 2.1. Table 6.62 details the listed stream segments, miles degraded, sources, causes, and initial year listed. The sources that caused stream impairment were agriculture, construction, and habitat modification; however, the methodology employed in this TMDL development cannot directly address habitat modification, which is not a pollutant, reductions of sediment load are expected to benefit habitat conditions. Management practices expected to be used in reducing sediment load will include riparian zone management that benefits habitat conditions as well, through stream shading and stream bank protection.

Table 6.62 Year 1998 303(d) List: UNT 1605

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10290- 10296 64134	970729-1605-JLR	7.75	Unassessed Project	Agriculture Construction Habitat Modification	Siltation Flow Alterations	1998

The sediment TMDL established for the UNT 1605 watershed consists of an LA and an MOS. There is no WLA for this TMDL because there are no known point source discharges in the watershed. The reference watershed for UNT 1605 was Peebles-Bear Hollow Run (Figure 4.2). The TMDL for the UNT 1605 watershed is presented in Tables 6.63 through 6.65. Because the construction source was short-term and sporadic in this watershed, and further analysis shows that construction is not a major contributor to impairment in the creek and the allocation is targeted to reduction of agricultural sources.

Table 6.63 TMDL computation for the UNT 1605 watershed

Pollutant	Unit Area Loading Rate in Peebles-Bear Hollow Run (lbs/ac/yr)	Total Watershed Area in UNT1605 (ac)	TMDL Value (lb/yr)
Sediment	253.55	4,569	1,157,160

Table 6.64 Load allocation for the UNT 1605 watershed by land use/source

		Sediment			
Source	**Area** **(ac)**	**Unit Area Loading Rate** **(lb/ac/yr)**	**Annual average load** **(lb/yr)**	**LA (annual average)** **(lb/yr)**	**% Reduction**
Hay/Past	1,095	147.88	161,880	131,706.6	18.6%
Cropland	1,915	1,176.84	2,253,645	574,889.6	74.5%
Coniferous	52	3.65	190	189.6	0.0%
Mixed For	62	4.55	281	280.8	0.0%
Deciduous	1,446	231.32	334,378	334,377.8	0.0%
Lo Int Dev	0	0.00	0		0.0%
Hi Int Dev	0	0.00	0		0.0%
Groundwater					
Point Source					
Septic Systems					
Total	**4,569**	**601.99**	**2,750,374**	**1,041,444**	**62%**

Table 6.65 TMDL for the UNT 1605 watershed

Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)
Sediment	1,157,160	1,041,444	0	115,716

6.16 Proposed TMDL for the UNT 7043 Watershed

UNT 7043 is an unnamed tributary listed with the main stem of Conodoguinet Creek. UNT 7043 was initially listed on the 1996 303(d) list for suspended solids. The total length of impaired stream segments is 0.89 miles.

As part of this the unnamed tributary with stream code 10359 is addressed. Investigation into the listing history for this stream segment was done to verify the original listing date. The stream is believed to have been incorrectly listed as Mount Rock Spring Creek with stream code 10361 on the 1996 303(d) list. There are two listings for Mount Rock Spring Creek on the 1996 303(d) list, one is correct, the other identifies an un-named tributary of the Conodoguinet. The 1998 303(d) list correctly identifies this segment as an un-named tributary of the Conodoguinet, (1998 303(d) list - Segment ID 7043) however, the stream code is absent from this record. The current 305(b) database shows that stream code 10359 is impaired and is identified as Segment ID 7043.

The location of the UNT 7043 watershed is shown in Figure 2.1. Agricultural land uses dominate the middle and lower parts of the watershed, and nutrients and sediment from the watershed have a direct impact on the impaired main stem. Table 6.66 details the listed stream segments, miles degraded, sources, causes, and initial year listed.

Table 6.66 Year 1998 303(d) List: UNT 7043

Stream Code	Segment ID	Miles Degraded	Data Source	Source Code	Cause Code	Initial Year Listed
10359	7043	0.89	Surface Water Monitoring Program	Agriculture	Suspended Solids	1996

The sediment TMDL established for the UNT 7043 watershed consists of an LA and an MOS. There is no WLA for this TMDL because there are no known point source discharges in the watershed. The reference watershed for UNT 7043 was Lehman Run (Figure 4.2). The TMDL for the UNT 7043 watershed is presented in Tables 6.67 through 6.69.

Table 6.67 TMDL computation for the UNT 7043 watershed

Pollutant	Unit Area Loading Rate in Peebles-Bear Hollow Run (lbs/ac/yr)	Total Watershed Area in UNT7043 (ac)	TMDL Value (lb/yr)
Sediment	240.51	2,730	655,966

Table 6.68 Load allocation for the UNT 7043 watershed by land use/source

		Sediment			
Source	**Area (ac)**	**Unit Area Loading Rate (lb/ac/yr)**	**Annual average load (lb/yr)**	**LA (annual average) (lb/yr)**	**% Reduction**
Hay/Past	739	164.20	121,312	93,238	23.1%
Cropland	936	900.50	843,317	309,655	63.3%
Coniferous	12	3.30	41	40	0.0%
Mixed For	35	5.35	185	185	0.0%
Deciduous	1,006	186.13	187,184	187,184	0.0%
Lo Int Dev	0	0.00	0	0.0	0.0%
Hi Int Dev	2	26.48	65	65	0.0%
Groundwater					
Point Source					
Septic Systems					
Total	**2,730**	**421.95**	**1,152,104**	**590,369**	**49%**

Table 6.69 TMDL for the UNT 7043 watershed

Pollutant	TMDL (lb/yr)	LA (lb/yr)	WLA (lb/yr)	MOS (lb/yr)
Sediment	655,966	590,369	0	65,597

6.17 Consideration of Critical Conditions

The AVGWLF model is a continuous-simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values. Therefore, all flow conditions are taken into account for loading calculations. Because there is usually a significant lag time between the introduction of sediment and nutrients to a waterbody and the resulting impact on beneficial uses, establishing these TMDLs using average annual conditions is protective of the waterbody.

6.18 Consideration of Seasonal Variations

The continuous-simulation model used for this analysis considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations. The model requires specification of the growing season and hours of daylight for each month. The model also considers the months of the year when manure is applied to the land. The combination of these model features accounts for seasonal variability.

6.19 Recommendations

Sediment and phosphorus reductions in the TMDLs are allocated entirely to agricultural activities in the watershed. Implementation of best management practices (BMPs) in the affected areas should achieve the loading reduction goals established in the TMDLs. Substantial reductions in the amount of sediment reaching the streams can be made through the planting of riparian buffer zones, contour strips, and cover crops. These BMPs range in efficiency from 20% to 70% for sediment reduction. Implementation of BMPs aimed at sediment reduction will also assist in the reduction of phosphorus. Additional phosphorus reductions can be achieved through the installation of more effective animal waste management systems and stone ford cattle crossings. Other possibilities for attaining the desired reductions in phosphorus and sediment include stabilization of streambanks and streambank fencing. Further “ground truthing” will be performed in order to assess both the extent of existing BMPs, and to determine the most cost-effective and environmentally protective combination of BMPs required for meeting the sediment and nutrient reductions outlined in this report.

6.20 Public Participation

A public meeting to discuss and accept comments on proposed TMDLs was held on January 17, 2001 beginning at 6:30 p.m., at the Carlisle Community Center. Public notice of the draft TMDL and the public meeting was published in the *Pennsylvania Bulletin* and the *Harrisburg Patriot News*. Notice of final plan approval will be published in the *Pennsylvania Bulletin.*

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Appendix A

Reference Watersheds:
Comparison of Watershed Characteristics and Unit Loading Rates (Endpoints)

List of Tables in Appendix A

Reference Watershed: Lehman Run

Table A.1 compares two impaired watersheds, Newburg Run, Clippingers Run, and UNT 7403 with two reference watersheds, Lehman Run and Laughlin Run. (See Figure 4.2 for the location of the reference watersheds.) Lehman Run was selected as the final reference watershed because it was not connected directly to a listed stream. Although Laughlin Run was not used as the final reference watershed, it gave reference TMDL endpoints almost identical to those of Lehman Run with the GWLF model (sediment: 256 vs. 240 lb/ac/yr; phosphorus: 0.36 vs. 0.36 lb/ac/yr). The data related to Laughlin Run watershed in Table A.1 is shown to illustrate that TMDL endpoints can be the same for a watershed size varying from 2,800 acres to 3,600 acres. Table A.1 also shows that the impaired and reference watersheds have very similar characteristics. Table A.2 presents the existing loading values for the Lehman Run watershed.

Table A.1 Reference watersheds for Newburg Run, Clippingers Run, and UNT 7403: Comparison of watershed characteristics

	Newburg Run	**Clippingers Run**	**UNT 7403**	**Lehman Run**	**Laughlin Run**
Watershed Type	***Impaired***			***Reference***	
Bedrock	Shale	Shale	Shale	Shale	Shale
Watershed Size (acres)	3652	2868	2782	2827	3556
% Cropland	33.8%	39.3%	35.3%	34.9%	33.6%
% Agriculture land	67.2%	70.0%	61.3%	72.4%	66.0%
Land Use Types:	**% Land Uses**			**% Land Uses**	
Water Bodies	0.0%	0.4%	0.2%	1.0%	0.1%
Low Development	1.2%	0.6%	0.0%	1.6%	0.3%
High Development	0.7%	0.4%	0.0%	0.2%	0.1%
Hay/Pasture	33.4%	30.7%	26.0%	37.5%	32.4%
Cropland	33.8%	39.3%	35.3%	34.9%	33.6%
Forest	0.0%	0.2%	0.4%	1.1%	0.2%
Mixed Forest	0.3%	0.8%	0.9%	1.8%	0.4%
Deciduous Forest	30.6%	27.5%	36.3%	20.7%	32.7%
Woody Wetland	0%	0%	0.8%	1.1%	0%
Emergent Wetland	0%	0%	0.1%	0.1%	0.1%
Quarry	0%	0%	0.0%	0%	0%
Coal Mine	0%	0%	0.0%	0%	0%
Beaches	0%	0%	0.0%	0%	0%
Transitional Land	0%	0.1%	0.0%	0%	0%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Table A.2 Existing loading values for the Lehman Run watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lbs/acre/ yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	1,050	168	0.16	3,928	3.74	81,162	77.3
Cropland	951	610	0.64	7,058	7.42	550,787	579.0
Coniferous	30	1	0.02	5	0.16	616	20.8
Mixed For	57	2	0.03	10	0.18	1,672	29.4
Deciduous	591	21	0.04	123	0.21	22,952	38.9
Lo Int Dev	49	4	0.08	30	0.61	966	19.6
Hi Int Dev	12	13	1.09	121	9.82	199	16.1
Groundwater		169		24,121		0	
Point Source		0		0		0	
Septic Systems		7		621		0	
Total	**2,740**	**996**	**0.36**	**36,017**	**13.14**	**658,355**	**240.25**

Reference Watershed: Griers Hollow-Devil Alex Hollow-Mountain Run

An aggregated reference watershed (Griers Hollow-Devil Alex Hollow-Mountain Run (Figure 4.2)) was selected for the aggregated impaired Mains Run and Gum Run watershed (Table A.3). The Mountain Run watershed was redelineated for the aggregated reference watershed to match the size and land use distribution of the impaired watershed. Table A.4 presents the existing loading values for the Griers-Devil-Mountain watershed.

Table A.3 Reference watershed for the Mains Run and Gum Run watershed: Comparison of watershed characteristics

	Aggregated: Mains Run and Gum Run	**Aggregated: Griers Hollow, Devil Alex Hollow, and Mountain Run**
Watershed Type	***Impaired***	***Reference***
Bedrock	Carbonate and Metamorphic/Igneous	Carbonate and Metamorphic/Igneous
Watershed Size (acres)	4704	5197
% Cropland	27.0%	26.9%
% Agriculture land	39.6%	39.6%
Land Use Types:	**% Land Uses**	**% Land Uses**
Water Bodies	0.0%	0.2%
Low Development	1.2%	0.5%
High Development	0.1%	0.1%
Hay/Pasture	12.6%	12.7%
Cropland	27.0%	26.9%
Forest	1.9%	1.9%
Mixed Forest	6.6%	4.0%
Deciduous Forest	49.0%	52.5%
Woody Wetland	0.2%	0.7%
Emergent Wetland	0.4%	0.1%
Quarry	0.0%	0%
Coal Mine	0.0%	0%
Beaches	0.0%	0%
Transitional Land	1.1%	0.4%
Total	**100.0%**	**100.0%**

Table A.4 Existing loading values for the Griers-Devil-Mountain watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	667	74	0.11	1,161	1.74	75,529	113.2
Cropland	1,404	1,128	0.80	9,305	6.63	1,541,857	1,098.6
Coniferous	109	1	0.01	15	0.14	1725	15.9
Mixed For	213	3	0.02	31	0.15	4073	19.2
Deciduous	2,679	136	0.05	834	0.31	197,460	73.7
Transition	17	42	2.43	243	14.07	57,374	3,317.0
Lo Int Dev	32	2	0.07	16	0.49	653	20.3
Hi Int Dev	5	4	0.85	38	7.76	92	18.6
Groundwater		206		29,403		0	
Point Source		0		0		0	
Septic Systems		6		1,533		0	
Total	**5,125**	**1,602**	**0.31**	**42,580**	**8.31**	**1,878,762**	**366.60**

Reference Watershed: Peebles Run and Bear Hollow Run

The aggregated Peebles-Bear Hollow reference watershed (Figure 4.2) was a good mach to Paxton Run, Center and Back Creek, and the unnamed tributary (UNT1605) of Conodoguinet Creek (Table A.5). Although Wertz Run has relatively low percentage in total agricultural land compared to the reference watershed, its cropland percentage is similar. Wertz Run was listed for siltation, and it is the percentage of cropland area that mainly determines the unit area sediment load. Table A.6 presents the existing loading values for the Peebles-Bear Hollow Run watershed.

Table A.5 Reference watershed for Paxton Run, Center and Back Run, Wertz Run and UNT1605: Comparison of watershed characteristics

	Paxton Run	**Center Run and Back Run**	**Wertz Run**	**UNT1605**	**Peebles Run and Bear Hollow Run**
Watershed Type	***Impaired***				***Reference***
Bedrock	Shale	Shale	Shale	Shale	Shale
Watershed Size (a.)	4674	4222	3667	4634	4154
% Cropland	45.2%	32.9%	30.3%	41.6%	36.2%
% Agriculture land	76.4%	67.1%	48.3%	65.7%	62.5%
Land Use Types:	**% Land Uses**				**% Land Uses**
Water Bodies	0.3%	0.1%	0.3%	0.05%	0.1%
Low Development	0.1%	0.1%	0.7%	0.0%	0.6%
High Development	0.1%	0.0%	0.2%	0.0%	0.3%
Hay/Pasture	31.2%	34.2%	18.0%	24.1%	26.3%
Cropland	45.2%	32.9%	30.3%	41.6%	36.2%
Forest	0.2%	1.4%	3.8%	1.0%	0.4%
Mixed Forest	0.8%	1.7%	2.9%	1.2%	0.5%
Deciduous Forest	22.0%	28.7%	43.1%	31.5%	35.7%
Woody Wetland	0.0%	0.6%	0.3%	0.5%	0%
Emergent Wetland	0.0%	0.2%	0.3%	0.1%	0.1%
Quarry	0.0%	0.0%	0%	0.0%	0%
Coal Mine	0.0%	0.0%	0%	0.0%	0%
Beaches	0.0%	0.0%	0%	0.0%	0%
Transitional Land	0.0%	0.0%	0%	0.0%	0%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Table A.6 Existing loading values for the Peebles-Bear Hollow Run watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	1,117	166	0.15	3913	3.50	77,258	69.2
Row Crops	1,468	919	0.63	10,259	6.99	824,011	561.4
Coniferous	15	0	0.00	1	0.09	21	1.4
Mixed For	17	0	0.00	2	0.09	31	1.8
Deciduous	1,465	123	0.08	549	0.37	139,891	95.5
Lo Int Dev	20	2	0.08	11	0.58	533	27.0
Hi Int Dev	12	13	1.07	119	9.66	262	21.2
Groundwater		215		30,753		0	
Point Source		0		0		0	
Septic Systems		0		0		0	
Total	**4,114**	**1,439**	**0.35**	**45,608**	**11.09**	**1,042,008**	**253.27**

Reference Watershed: Upper Letort Spring Run

The reference watershed for the Trindle Spring Run watershed is the upper Letort Spring Run (see Figure 4.2 and Table A.7). The Letort Spring Run watershed was redelineated to exclude the lower stream, which had a small portion listed for pesticides, priority organics, and metals. The upper stream had attained water quality standards. There is a local watershed management plan for the Letort Spring Run. Local citizens and government are making every effort to protect this "internationally famous trout stream." Table A.8 presents the existing loading values for the upper Letort Spring Run watershed.

Table A.7 Reference watershed for the Trindle Spring Run watershed: Comparison of watershed characteristics

	Trindle Spring Run	**Upper Letort Spring Run**
Watershed Type	***Impaired***	***Reference***
Bedrock	Carbonate	Carbonate
Watershed Size (acres)	11405	10366
% Cropland	44.8%	44.5%
% Agriculture land	66.1%	66.2%
Land Use Types:	**% Land Uses**	**% Land Uses**
Water Bodies	0.4%	0.1%
Low Development	15.3%	15.6%
High Development	10.2%	7.9%
Hay/Pasture	21.3%	21.7%
Cropland	44.8%	44.5%
Forest	0.9%	1.0%
Mixed Forest	1.4%	1.9%
Deciduous Forest	5.4%	6.7%
Woody Wetland	0.0%	0.1%
Emergent Wetland	0.1%	0.4%
Quarry	0.1%	0.1%
Coal Mine	0.0%	0%
Beaches	0.0%	0%
Transitional Land	0.0%	0%
Total	**100.0%**	**100.0%**

Table A.8 Existing loading values for the upper Letort Spring Run watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	2,189	452	0.21	8,028	3.67	288,438	131.8
Row Crops	4,633	4,627	1.00	39,250	8.47	4,464,482	963.6
Coniferous	96	1	0.01	10	0.10	387	4.0
Mixed For	193	2	0.01	21	0.11	1,048	5.4
Deciduous	692	7	0.01	79	0.11	5,427	7.8
Quarry	10	12	1.25	43	4.35	14,237	1440.4
Lo Int Dev	1,646	148	0.09	1,107	0.67	82,653	50.2
Hi Int Dev	828	949	1.15	8,556	10.34	36,520	44.1
Groundwater		606		86,547		0	
Point Source		0		0		0	
Septic Systems		13		4,974		0	
Total	**10,287**	**6,817**	**0.66**	**148,616**	**14.45**	**4,893,192**	**475.68**

Reference Watershed: Yellow Breeches Creek

The upper part of the Yellow Breeches Creek watershed, which is located south of the Conodoguinet Creek basin (Figure 4.2), was selected as the reference watershed for many of the carbonate-based impaired watersheds; however, a few lateral small streams in the forested area of the Yellow Breeches watershed were listed for low pH, caused by atmospheric deposition. To exclude the streams listed for pH and to match the size and land use distributions for the impaired watersheds in the Conodoguinet Creek basin, the upper Yellow Breeches Creek watershed was redelineated in three sizes: (1) Yellow Breeches Creek-5K (14,027 acres), (2) Yellow Breeches Creek-3K (7,812 acres), and (3) Yellow Breeches Creek-2K (4,697 acres).

Yellow Breeches Creek-5K is the reference watershed for Alexanders Spring Creek, Bulls Head Branch and Green Spring Creek, Hogestown Run, Mount Rock Spring Creek, and Rowe Run (Table A.9). Yellow Breeches Creek-2K is the reference watershed for Middle Spring Creek (Table A.10). Tables A.11, A.12, and A.13 present the existing loading values for the Yellow Breeches Creek-5K, Yellow Breeches Creek-3K, and Yellow Breeches Creek-2K watersheds, respectively.

Table A.9 Reference watershed for Alexanders Spring Creek, Bulls Head Brach and Green Spring Creek, Hogestown Run, Mount Rock Spring Creek, and Rowe Run: Comparison of watershed characteristics

	Alexanders Spring Creek	**Bulls Head Branch and Green Spring Creek**	**Hogestown Run**	**Mount Rock Spring Creek**	**Rowe Run**	**Yellow Breeches-5K**
Watershed Type			***Impaired***			***Reference***
Bedrock	Carbonate	Carbonate	Carbonate	Carbonate	Carbonate	Carbonate
Watershed Size (acres)	12273	17225	11359	15784	12056	14027
% Cropland	58.9%	61.3%	56.3%	58.3%	53.7%	56.4%
% Agriculture land	84.5%	92.9%	87.3%	87.4%	88.9%	85.7%
Land Use Types:			**% Land Uses**			**% Land Uses**
Water Bodies	0.0%	0.1%	0.1%	0.0%	0.0%	0.4%
Low Development	1.5%	0.5%	2.1%	1.4%	2.9%	1.2%
High Development	0.7%	0.2%	2.1%	0.5%	3.2%	0.2%
Hay/Pasture	25.6%	31.6%	31.0%	29.1%	35.2%	29.3%
Cropland	58.9%	61.3%	56.3%	58.3%	53.7%	56.4%
Forest	0.9%	0.4%	0.8%	0.4%	0.2%	0.9%
Mixed Forest	1.5%	0.8%	1.3%	1.2%	0.7%	1.4%
Deciduous Forest	10.8%	4.9%	6.0%	8.8%	4.0%	7.2%
Woody Wetland	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%
Emergent Wetland	0.2%	0.1%	0.2%	0.2%	0.0%	0.7%
Quarry	0.0%	0.1%	0.0%	0.0%	0.0%	0%
Coal Mine	0.0%	0.0%	0.0%	0.0%	0.0%	0%
Beaches	0.0%	0.0%	0.0%	0.0%	0.0%	0%
Transitional Land	0.0%	0.0%	0.0%	0.0%	0.0%	0%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Table A-10. Reference watersheds for Middle Spring Creek: Comparison of watershed characteristics

	Middle Spring Creek	Yellow Breeches-2K
Watershed Type	***Impaired***	***Reference***
Bedrock	Carbonate	Carbonate
Watershed Size (acres)	5159	4697
% Cropland	44.9%	50.9%
% Agriculture land	80.8%	77.2%
Land Use Types:	**% Land Uses**	
Water Bodies	0.1%	0.05%
Low Development	5.2%	0.7%
High Development	3.2%	0.1%
Hay/Pasture	35.9%	26.3%
Cropland	44.9%	50.9%
Forest	0.8%	0.9%
Mixed Forest	1.5%	2.1%
Deciduous Forest	8.3%	15.7%
Woody Wetland	0.2%	2.5%
Emergent Wetland	0.0%	0.9%
Quarry	0.0%	0%
Coal Mine	0.0%	0%
Beaches	0.0%	0%
Transitional Land	0.0%	0%
Total	**100.0%**	**100.0%**

Table A.11 Existing loading values for the Yellow Breeches Creek-5K watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	4,087	574	0.14	7,542	1.85	405,485	99.2
Row Crops	7,929	6,887	0.87	46,188	5.82	6,116,891	771.4
Coniferous	124	1	0.01	6	0.05	485	3.9
Mixed For	198	1	0.01	9	0.05	846	4.3
Deciduous	1,008	9	0.01	58	0.06	7,549	7.5
Lo Int Dev	143	10	0.07	73	0.51	3,928	27.4
Hi Int Dev	37	33	0.88	294	7.93	621	16.8
Groundwater		982		140,319		0	
Point Source		0		0		0	
Septic Systems		75		5,538		0	
Total	**13,526**	**8,571**	**0.63**	**200,028**	**14.79**	**6,535,805**	**483.20**

Table A.12 Existing loading values for the Yellow Breeches Creek-2K watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	1,221	161	0.13	2,242	1.84	117,515	96.3
Row Crops	2,414	2,223	0.92	14,807	6.13	2,110,449	874.2
Coniferous	40	0	0.01	5	0.12	307	7.8
Mixed For	99	2	0.02	8	0.08	1445	14.6
Deciduous	717	22	0.03	91	0.13	21,974	30.7
Lo Int Dev	37	2	0.07	19	0.51	868	23.4
Hi Int Dev	5	4	0.89	39	7.94	79	16.1
Groundwater		328		46,919		0	
Point Source		0		0		0	
Septic Systems		26		1,898		0	
Total	**4,532**	**2,769**	**0.61**	**66,027**	**14.57**	**2,252,637**	**497.08**

Appendix B

Existing Loading Values and Unit Loading Rates for Impaired Watersheds

List of Tables in Appendix B

The following tables present the existing load values per unit area (pounds per acre per year) for each of the watersheds that have impaired streams listed for siltation, nutrients, and/or organic enrichment.

Table B.1 Existing loading values for the Alexanders Spring Creek watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	3,163	737	0.23	11,690	3.70	447,436	141.5
Cropland	7,230	9,145	1.26	64,403	8.91	8,016,209	1,108.7
Coniferous	101	1	0.01	11	0.11	488	4.8
Mixed For	183	1	0.01	19	0.10	848	4.6
Deciduous	1,277	12	0.01	143	0.11	8,655	6.8
Lo Int Dev	166	15	0.09	111	0.67	6,090	36.8
Hi Int Dev	99	113	1.15	1,022	10.34	2,708	27.4
Groundwater		837		119,634			
Point Source		0		0			
Septic Systems		51		5,722			
Total	**12,219**	**10,913**	**0.89**	**202,755**	**16.59**	**8,482,433**	**694.20**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Table B.2 Existing loading values for the aggregated Bulls Head-Green Spring watersheds

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	5,416	1,063	0.20	20,548	3.79	515,168	95.1
Cropland	10,558	10,929	1.04	86,269	8.17	8,753,062	829.0
Coniferous	57	0	0.00	6	0.10	142	2.5
Mixed For	170	1	0.01	18	0.10	730	4.3
Deciduous	803	8	0.01	92	0.11	5,798	7.2
Quarry	15	39	2.63	111	7.48	36,864	2486.5
Lo Int Dev	79	6	0.08	48	0.61	1,946	24.6
Hi Int Dev	35	38	1.09	339	9.81	835	24.1
Groundwater		1,650		235,747			
Point Source		0		0			
Septic Systems		19		2,454			
Total	**17,134**	**13,754**	**0.80**	**345,632**	**20.17**	**9,314,545**	**543.64**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Table B.3 Existing loading values for the aggregated Center-Back Creek watersheds

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	1,450	270	0.19	5,211	3.59	155,283	107.1
Cropland	1,376	1,183	0.86	10,959	7.96	1,092,652	793.9
Coniferous	57	0	0.01	6	0.10	218	3.8
Mixed For	52	0	0.01	6	0.11	241	4.6
Deciduous	1,238	111	0.09	479	0.39	121,939	98.5
Lo Int Dev	5	0	0.09	3	0.58	69	13.9
Hi Int Dev	5	6	1.16	51	10.35	62	12.5
Groundwater		243		34,709			
Point Source		0		0			
Septic Systems		0		0			
Total	**4,183**	**1,815**	**0.43**	**51,422**	**12.29**	**1,370,464**	**327.60**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Table B.4 Existing loading values for the Clippingers Run watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	914	169	0.19	3,509	3.84	100,516	109.9
Cropland	1,090	901	0.83	8,872	8.14	893,766	820.2
Coniferous	5	0	0.00	0	0.09	6	1.2
Mixed For	27	0	0.01	3	0.11	116	4.3
Transition	2	14	5.80	60	24.45	16,740	6,774.7
Deciduous	778	119	0.15	499	0.64	142,531	183.1
Lo Int Dev	15	1	0.07	9	0.61	1,209	81.6
Hi Int Dev	5	5	1.07	49	9.82	128	26.0
Groundwater		177		25,314			
Point Source		0		0			
Septic Systems		7		630			
Total	**2,837**	**1,395**	**0.49**	**38,945**	**13.73**	**1,155,014**	**407.17**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Table B.5 Existing loading values for the Hogestown Run watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	3,509	809	0.23	13,445	3.83	446,643	127.3
Cropland	6,355	7,585	1.19	56,188	8.84	6,385,811	1004.8
Coniferous	91	1	0.01	11	0.12	334	3.7
Mixed For	163	1	0.01	20	0.12	683	4.2
Deciduous	647	6	0.01	80	0.12	3,463	5.3
Lo Int Dev	255	23	0.09	175	0.69	9,061	35.6
Hi Int Dev	240	282	1.18	2,547	10.63	11,486	47.9
Groundwater		1,080		154,249			
Point Source		0		0			
Septic Systems		68		9,270			
Total	**11,260**	**9,855**	**0.88**	**235,985**	**20.96**	**6,857,481**	**609.00**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Table B.6 Existing loading values for the aggregated Mains-Gum watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	588	82	0.14	1,163	1.98	84,244	143.2
Cropland	1,248	1,050	0.84	8,486	6.80	1,367,949	1096.3
Coniferous	69	1	0.01	6	0.09	1,203	17.4
Mixed For	358	8	0.02	47	0.13	11,402	31.8
Deciduous	2,286	129	0.06	638	0.28	185,407	81.1
Transition	42	330	7.86	1,536	36.56	473,135	11263.4
Lo Int Dev	59	4	0.07	30	0.51	1,607	27.1
Hi Int Dev	2	2	0.89	20	7.94	22	9.0
Groundwater		209		29,918			
Point Source		0		0			
Septic Systems		7		1,177			
Total	**4,653**	**1,823**	**0.39**	**43,020**	**9.25**	**2,124,970**	**456.70**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Table B.7 Existing loading values for the Middle Spring Creek watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	1,856	376	0.20	7,160	3.86	216,533	116.7
Cropland	2,325	2,715	1.17	20,888	8.98	2,556,660	1099.6
Coniferous	52	0	0.00	5	0.10	171	3.3
Mixed For	67	0	0.01	7	0.11	280	4.2
Deciduous	381	3	0.01	42	0.11	2,205	5.8
Lo Int Dev	250	17	0.07	127	0.51	6,346	25.4
Hi Int Dev	166	146	0.88	1,313	7.93	3,792	22.9
Groundwater		434		61,931			
Point Source		2,883		25,656			
Septic Systems		15		1,222			
Total	**5,095**	**6,588**	**1.29**	**118,352**	**23.23**	**2,785,986**	**546.79**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Table B.8 Existing loading values for the Mount Rock Spring Creek watershed

Land Use Category	**Area (ac)**	**Total P (lb/yr)**	**Unit Area P Load (lb/ac/yr)**	**Total N (lb/yr)**	**Unit Area N Load (lb/ac/yr)**	**Sed Load (lb/yr)**	**Unit Area Sed Load (lb/ac/yr)**
Hay/Past	4,529	1,013	0.22	16,572	3.66	585026	129.2
Cropland	9,345	12,169	1.30	83,537	8.94	10458812	1119.2
Coniferous	77	0	0.01	8	0.10	321	4.2
Mixed For	143	1	0.01	15	0.11	754	5.3
Deciduous	1,324	17	0.01	161	0.12	13459	10.2
Lo Int Dev	227	20	0.09	153	0.67	8188	36.0
Hi Int Dev	67	77	1.15	690	10.34	1588	23.8
Groundwater		1,321		188,770			
Point Source		0		0			
Septic Systems		54		8314			
Total	**15,713**	**14,673**	**0.93**	**298,219**	**18.98**	**11068148**	**704.40**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Table B.9 Existing loading values for the Newburg Run watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	1,216	224	0.18	4,635	3.81	123,325	101.4
Cropland	1,203	954	0.79	9,469	7.87	876,707	728.5
Coniferous	5	0	0.00	0	0.09	6	1.2
Deciduous	1,151	94	0.08	419	0.36	104,080	90.4
Lo Int Dev	32	3	0.08	20	0.61	1250	38.9
Hi Int Dev	27	30	1.09	267	9.81	573	21.1
Groundwater		213		30,392			
Point Source		0		0			
Septic Systems		6		912			
Total	**3,635**	**1,523**	**0.42**	**46,114**	**12.69**	**1,105,941**	**304.27**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Table B.10 Existing loading values for the Paxton Run watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	1,418	227	0.16	5,296	3.73	106,582	75.1
Cropland	2,142	1,501	0.70	16,244	7.58	1,356,454	633.2
Coniferous	7	0	0.00	1	0.09	13	1.7
Mixed For	32	0	0.01	3	0.10	103	3.2
Deciduous	1,043	81	0.08	370	0.36	91,278	87.5
Lo Int Dev	5	0	0.09	3	0.62	63	12.8
Hi Int Dev	10	11	1.09	97	9.82	113	11.5
Groundwater		303		43,336			
Point Source		0		0			
Septic Systems		13		1,040			
Total	**4,658**	**2,138**	**0.46**	**66,391**	**14.25**	**1,554,607**	**333.77**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Table B.11 Existing loading values for the Rowe Run watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)*	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	4,220	981	0.23	16,651	3.95	620,749	147.1
Cropland	6,489	8,135	1.25	59,731	9.21	7,636,801	1176.9
Coniferous	47	0	0.00	5	0.10	151	3.2
Mixed For	77	0	0.01	8	0.10	273	3.6
Deciduous	455	4	0.01	49	0.11	2,351	5.2
Transition	2	2	0.89	15	6.15	1,676	678.5
Lo Int Dev	321	26	0.08	195	0.61	8,536	26.6
Hi Int Dev	393	427	1.09	3,849	9.80	12,672	32.3
Groundwater		1001.32		143,035			
Point Source		1765		626.211			
Septic Systems		33.7004		3554.41			
Total	**12,004**	**12,376**	**1.03**	**227,719**	**18.97**	**8,283,209**	**690.04**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Table B.12 Existing loading values for the Trindle Spring Run watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	2,459	545	0.22	9,499	3.86	339,045	137.9
Cropland	5,095	5,542	1.09	45,713	8.97	5,341,670	1048.4
Coniferous	111	1	0.01	14	0.12	545	4.9
Mixed For	161	1	0.01	20	0.13	974	6.1
Deciduous	610	7	0.01	84	0.14	6,039	9.9
Quarry	10	14	1.41	48	4.89	15,989	1617.6
Lo Int Dev	1,717	157	0.09	1,181	0.69	116,413	67.8
Hi Int Dev	1,142	1,345	1.18	12,132	10.63	70,080	61.4
Groundwater		822		117,412			
Point Source		86		5,362			
Septic Systems		56		9,315			
Total	**11,305**	**8,577**	**0.76**	**200,780**	**17.76**	**5,890,754**	**521.09**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Table B.13 Existing loading values for Wertz Run watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	672	114	0.17	2,407	3.58	69,498	103.4
Cropland	1,087	917	0.84	9,036	8.31	989,322	910.0
Coniferous	143	1	0.01	16	0.11	958	6.7
Mixed For	109	1	0.01	12	0.11	814	7.5
Deciduous	1,576	287	0.18	1,275	0.81	376,476	238.8
Lo Int Dev	15	1	0.09	10	0.67	319	21.5
Hi Int Dev	10	11	1.14	102	10.33	190	19.3
Groundwater		168		23,948			
Point Source		0		0			
Septic Systems		4		383			
Total	**3,613**	**1,505**	**0.42**	**37,188**	**10.29**	**1,437,577**	**397.94**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Table B.14 Existing loading values for the UNT 1605 watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	1,095	241	0.22	4,067	3.72	161,880	147.9
Cropland	1,915	2,263	1.18	17,450	9.11	2,253,645	1176.8
Coniferous	52	0	0.00	5	0.10	190	3.7
Mixed For	62	0	0.01	6	0.10	281	4.5
Deciduous	1,446	294	0.20	1,136	0.79	334,378	231.3
Lo Int Dev	0	0	0	0	0	0	0
Hi Int Dev	0	0	0	0	0	0	0
Groundwater		270		38,613			
Point Source		0		0			
Septic Systems		17		3,294			
Total	**4,569**	**3,087**	**0.68**	**64,572**	**14.13**	**2,750,374**	**601.99**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Table B.15 Existing loading values for the UNT 7043 watershed

Land Use Category	Area (ac)	Total P (lb/yr)	Unit Area P Load (lb/ac/yr)	Total N (lb/yr)	Unit Area N Load (lb/ac/yr)	Sed Load (lb/yr)	Unit Area Sed Load (lb/ac/yr)
Hay/Past	739	168	0.23	2,682	3.63	121,312	164.2
Cropland	936	850	0.91	7,467	7.97	843,317	900.5
Coniferous	12	0	0.00	1	0.11	41	3.3
Mixed For	35	0	0.01	4	0.11	185	5.3
Deciduous	1,006	159	0.16	654	0.65	187,184	186.1
Lo Int Dev	0	0	0	0	0	0	0
Hi Int Dev	2	3	1.16	26	10.35	65	26.5
Groundwater		152		21,766			
Point Source		0		0			
Septic Systems		0		0			
Total	**2,730**	**1,333**	**0.49**	**32,598**	**11.94**	**1,152,104**	**421.95**

***** Note that the totals for Unit Area P, N, and Sediment Load were calculated by dividing the total of each pollutant (lb/yr) by the total area (ac).

Comment and Response Document
Tributaries to Conodoguinet Creek Watershed TMDL

Comment:

TMDL proposals should cite the specific use of water that is impaired, thereby requiring the TMDL's development. This is especially the case when the impairing pollutants have no numerical water quality criteria. In the case of Trindle Spring Run and Conowingo Creek, these streams are considered impaired by sediment and nutrients when, in a separate Department of Environmental Protection action, they are acknowledged as supporting Class A Wild Trout Fisheries. If the impairment is not sufficient to prevent the stream from supporting the top functional fishery classification, is the use of the stream as a Cold Water Fishery really impaired?

Response:

It is possible for a stream to have a very good fish population and at the same time demonstrate impairments to other aquatic life, water supply, or recreational uses. Most of the entries on the PA 303(d) list are the result of biological surveys conducted as part of the Department's Unassessed Waters Program. A rapid biological screening protocol is used to evaluate numerous aspects of in-stream or riparian physical habitat and macroinvertebrate community structure, and make a determination of attainment or non-attainment of water quality standards.

The section of Trindle Spring Run that was added recently to the list of Class A wild trout streams is currently on the 303(d) list because of impairment from priority organics. This will result in a fish consumption advisory for that stream segment. The un-named tributary and upper section of the main stem of Trindle Spring Run as well as Conowingo Creek are currently on the 303(d) list for impairment related to sediment and nutrients based on physical habitat and benthic macroinvertebrate community impacts.

Comment:

The PBA appreciates the efforts of the Department in translating narrative water quality criteria into a quantitative TMDL. Further, PBA conceptually approves of the modeling techniques used to develop the TMDL. PBA further recommends that the Department consider developing numeric water quality criteria for phosphorus and sediment.

Response:

We are currently working with EPA to develop nutrient criteria.

Comment:

PBA is very concerned about the use of reference watersheds to establish TMDLs. Under federal requirements, loading capacity represents the maximum concentration of a pollutant at which a stream can remain in attainment of water quality standards. A TMDL should equal loading capacity plus a quantitative margin of safety. In establishing the TMDL for the streams in question, DEP fails to establish their respective loading capacities. Additionally, the specific selection of reference streams seems to be significantly flawed. Warm Water Fisheries are referenced against Cold Water Fisheries (Mains and Gum Runs compared to Griers Hollow, et.al. as well as Pequea and Chickies Creeks compares to Conococheague Creek). Of even greater concern is the issue that numerous impaired streams are compared against High Quality (HQ) streams (Yellow Breeches Creek, Letort Spring Run). Since a HQ stream (Pennsylvania equivalent to federal Tier II) represents a condition where ambient water quality exceeds the water quality necessary to support existing uses, the use of HQ streams as referenced for non-HQ streams will result in a TMLD that is overly restrictive. Finally, the ad-hoc subdivision of a watershed for use as a reference is highly subjective, and to PBA's understanding, is not supported by any forma scientific review.

Response:

In order to establish a loading capacity for an impaired stream segment where no numerical water quality criteria exist, Pennsylvania has developed a reference watershed approach. The allowable loading rate for an impaired stream is established by evaluating the loading rate of a non-impaired watershed selected based on matching the land use distribution, surface geology, and size of the impaired watershed. The modeling methods used for these analyses are sensitive to land use characteristics, geology, known nutrient soil concentrations, rainfall and drainage area. A good match for a reference watershed based on these characteristics over-rides concerns about matching use classifications of the streams in making our selections. The important common feature of the reference watersheds is that their biological communities are unimpaired. The reduction in loads projected in the TMDL should, therefore, restore the biological condition of the impaired water to an unimpaired level. However, the degree of recovery will be controlled, and in some cases limited, by numerous physical habitat issues. Impaired, non-HQ or EV waters, will not be expected to "recover" to antidegradation levels as the result of TMDL implementation.

As far as selecting portions of a watershed to use as a reference the following rule was applied; only upstream headwater stream segments could be cut out for the purpose of a reference (this means that no downstream impaired segment could be cut out, also that no portion of the reference watershed should drain into any section where an impairment is present). There could be exceptions to this practice, however, there must be very good justification in order to deviate from the rule.

Comment: Any remediation measures to address identified water quality problems may benefit certain threatened and endangered species in certain watersheds by improving water quality. However, in some instances, these measures have the potential to adversely affect federally listed species; therefore, further consultation will be necessary to identify and address these cases as described above. (2)

Response: Detailed remediation and implementation plans are not required as part of the TMDL submittal and have not been completed at this time. All current regulations will be followed and threatened and endangered species will be protected in developing a remediation plan for the watershed.

Commentors

1) Mark Maurer
   Regulatory Specialist
   Pennsylvania Builders Association
   600 N. Twelfth Street
   Lemoyne, PA 17043

2) U.S. Fish & Wildlife Service