

WARRIOR RUN WATERSHED TMDL

Northumberland and Lycoming Counties

Prepared for:

Pennsylvania Department of Environmental Protection



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TMDL SUMMARIES

1. The impaired stream segments addressed by this Total Maximum Daily Load (TMDL) are located in Delaware, Lewis, and Muncy Creek Townships in Northumberland and Lycoming Counties, Pennsylvania. The stream segments drain approximately 12.6 square miles as part of State Water Plan subbasin 10D. The aquatic life existing uses for Warrior Run, including its tributaries, are warm water fishes and migratory fishes (25 Pa. Code Chapter 93).
2. Pennsylvania's 2010 303(d) list identified 66.66 miles within the Warrior Run Watershed as impaired by organic enrichment/low dissolved oxygen (D.O.) and sediment from agricultural land use and municipal point source. The listings were based on data collected in 1997 through the Pennsylvania Department of Environmental Protection's (PADEP's) Surface Water Monitoring Program. In order to ensure attainment and maintenance of water quality standards in the Warrior Run Watershed, mean annual loadings for sediment and phosphorus will need to be limited to 12,585.76 pounds per day (lbs/day) and 8.30 lbs/day, respectively.

The major components of the Warrior Run Watershed TMDL are summarized below.

Warrior Run Watershed Components	Sediment (lbs/day)	Phosphorus (lbs/day)
TMDL (Total Maximum Daily Load)	12,585.76	8.30
MOS (Margin of Safety)	1,258.58	0.83
WLA (Waste Load Allocation)	171.18	3.36
LA (Load Allocation)	11,156.01	4.11

3. Mean annual sediment and phosphorus loadings are estimated at 13,951.62 lbs/day and 11.09 lbs/day, respectively. To meet the TMDL, the sediment and phosphorus loadings will require reductions of 10 percent and 25 percent, respectively.
4. Permit PA0111414 (McEwensville Boro) has a sediment and phosphorus waste load allocation (WLA) of 11.27 lbs/day and 0.32 lbs/day. Permit PA0028100 (Turbotville Municipal Authority) has a sediment and phosphorus WLA of 34.05 lbs/day and 2.96 lbs/day. Bulk reserves of 125.86 lbs/day for sediment and 0.08 lbs/day for phosphorus have been inserted into the TMDL to reflect dynamic permit activity.
5. The adjusted load allocation (ALA) is the actual portion of the load allocation (LA) distributed among nonpoint sources receiving reductions, or sources that are considered controllable. Controllable sources receiving allocations are hay/pasture, cropland, developed lands, and streambanks. The sediment and phosphorus TMDL includes a nonpoint source ALA of 11,021.53 lbs/day and 3.90 lbs/day, respectively. Sediment and phosphorus loadings from all other sources, such as forested, wetlands, and septic systems were maintained at their existing levels. Allocations of sediment and phosphorus to controllable nonpoint sources, or the ALA, for the Warrior Run Watershed TMDL are summarized below.

Warrior Run: Adjusted Load Allocations for Sources of Sediment and Phosphorus			
Pollutant	TMDL Loading (lbs/day)	Adjusted Load Allocation (lbs/day)	% Reduction
Sediment	12,585.76	11,021.53	12
Phosphorus	8.30	3.90	53

- Ten percent of the Warrior Run Watershed sediment TMDL was set-aside as a margin of safety (MOS). The MOS is that portion of the pollutant loading that is reserved to account for any uncertainty in the data and computational methodology used for the analysis. The MOS for the sediment and phosphorus TMDL is 1,258.58 lbs/day and 0.83 lbs/day, respectively.
- The continuous simulation model used for developing the Warrior Run Watershed TMDL 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 actions accounts for seasonal variability.

WATERSHED BACKGROUND

The Warrior Run Watershed is approximately 21.6 square miles in area. The headwaters of Warrior Run are located inside the northern portion of Northumberland County, a few miles north of Turbotville, Pa. The watershed is located on the U.S. Geological Survey (USGS) 7.5 minute quadrangles of Hughesville, Milton, and Muncy, Pa. The stream flows southwest to its confluence with the West Branch Susquehanna River. The major tributaries to Warrior Run include several unnamed tributaries (UNTs). Interstate 180 runs north to south within the watershed while State Highway 54 runs through the center of the watershed east to west. Numerous township roads provide access to the Warrior Run Watershed and its tributaries.

The TMDL watershed is located within the Appalachian Mountain Section of the Ridge and Valley physiographic province. The highest elevations are located in the northern portion of the watershed within the Muncy Hills region. The total change in elevation in the watershed is approximately 300 feet from the headwaters to the mouth.

The majority of the rock type in the upland portions of the watershed is interbedded sedimentary (35 percent), predominantly associated with the Hamilton Group and the Onondaga Formation and Old Port Formation Undivided (Figure 1). The remaining rock types found in the watershed are sandstone and shale (65 percent combined), predominantly associated with the Trimmers Rock Formation and the Wills Creek Formation.

The Berks-Weikert-Bedington series is the predominant soil type in the TMDL watershed. This soil is listed as a shaly-silt-loam soil and is mostly associated in the gently sloping plains and uplands of the watershed (Figure 2). Other dominant soils in the watershed consist of Watson-Berks-Alvira and Hagerstown-Edom-Washington.

Based on GIS datasets created in 2001, land use values were calculated for the TMDL watershed. Agriculture was the dominant land use at approximately 55 percent (Figure 3). Forested land uses account for approximately 35 percent of the watershed. Developed areas are 10 percent of the watershed, covering low-intensity residential and transitional. Riparian buffer zones are nearly nonexistent (Figure 4) in some of the agricultural lands. Livestock also have unlimited access to streambanks in certain parts of the watershed, resulting in streambank trampling and severe erosion. Some contiguous forested tracts remain in the watershed.

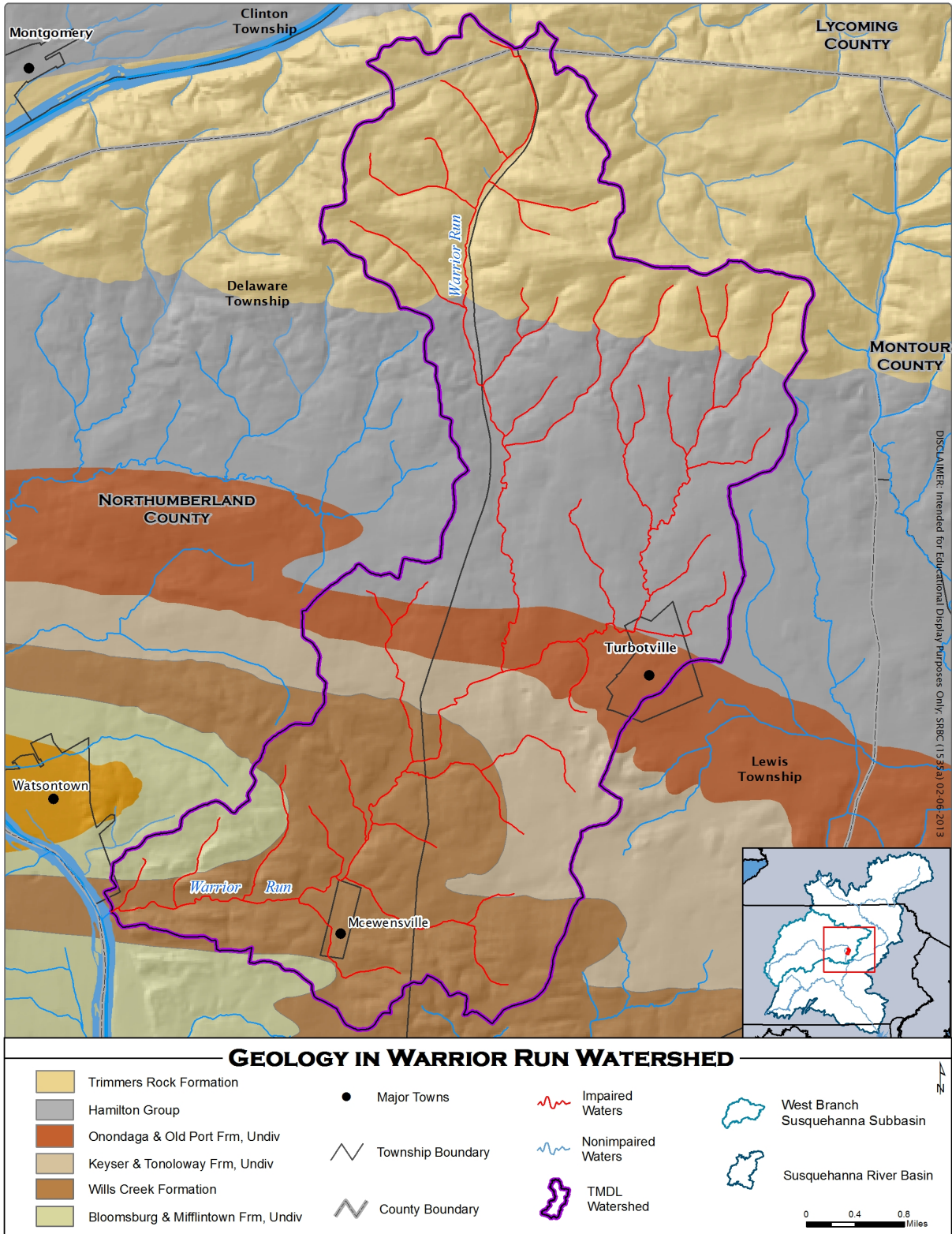


Figure 1. Geology Map of Warrior Run Watershed

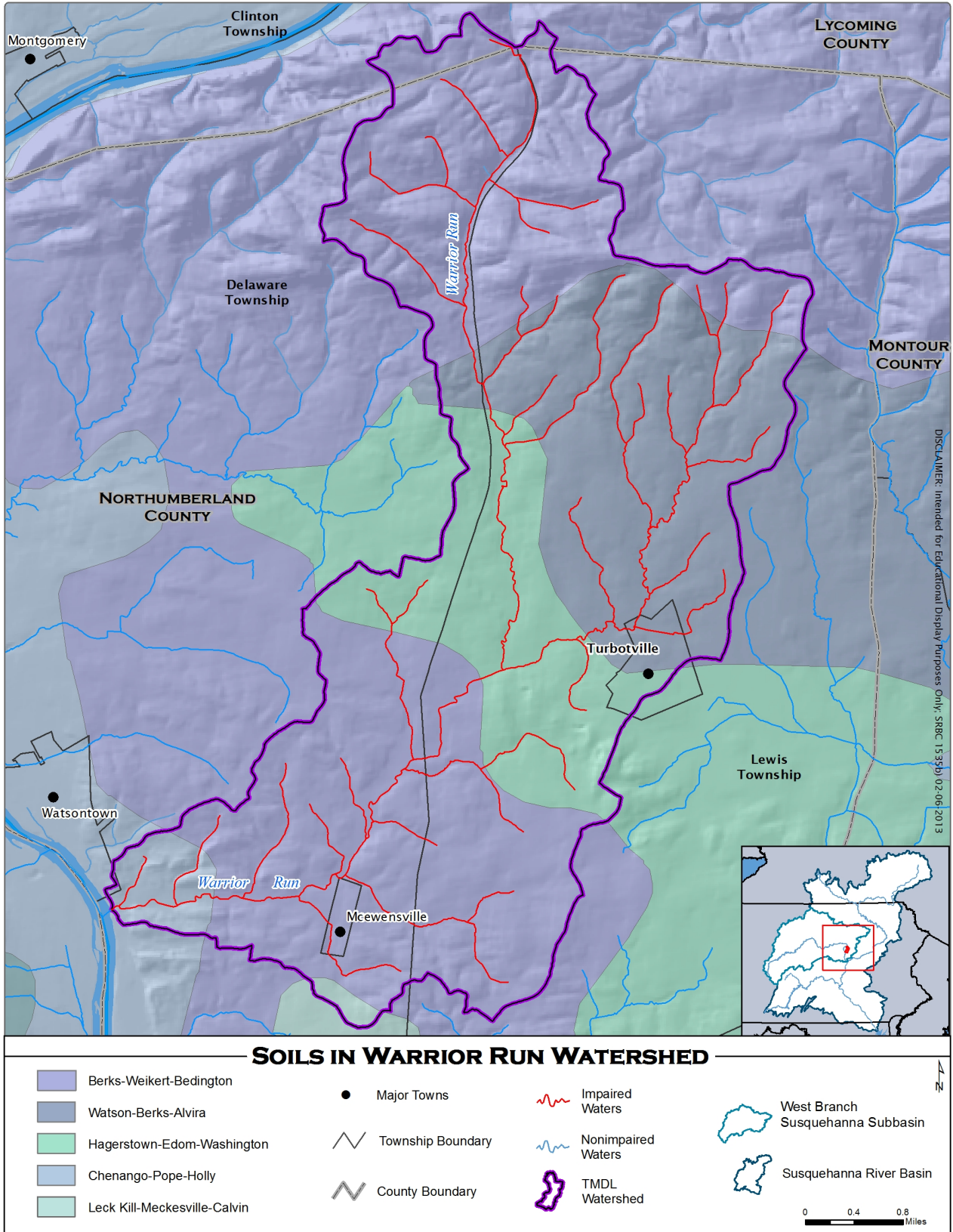


Figure 2. Soils Map of Warrior Run Watershed

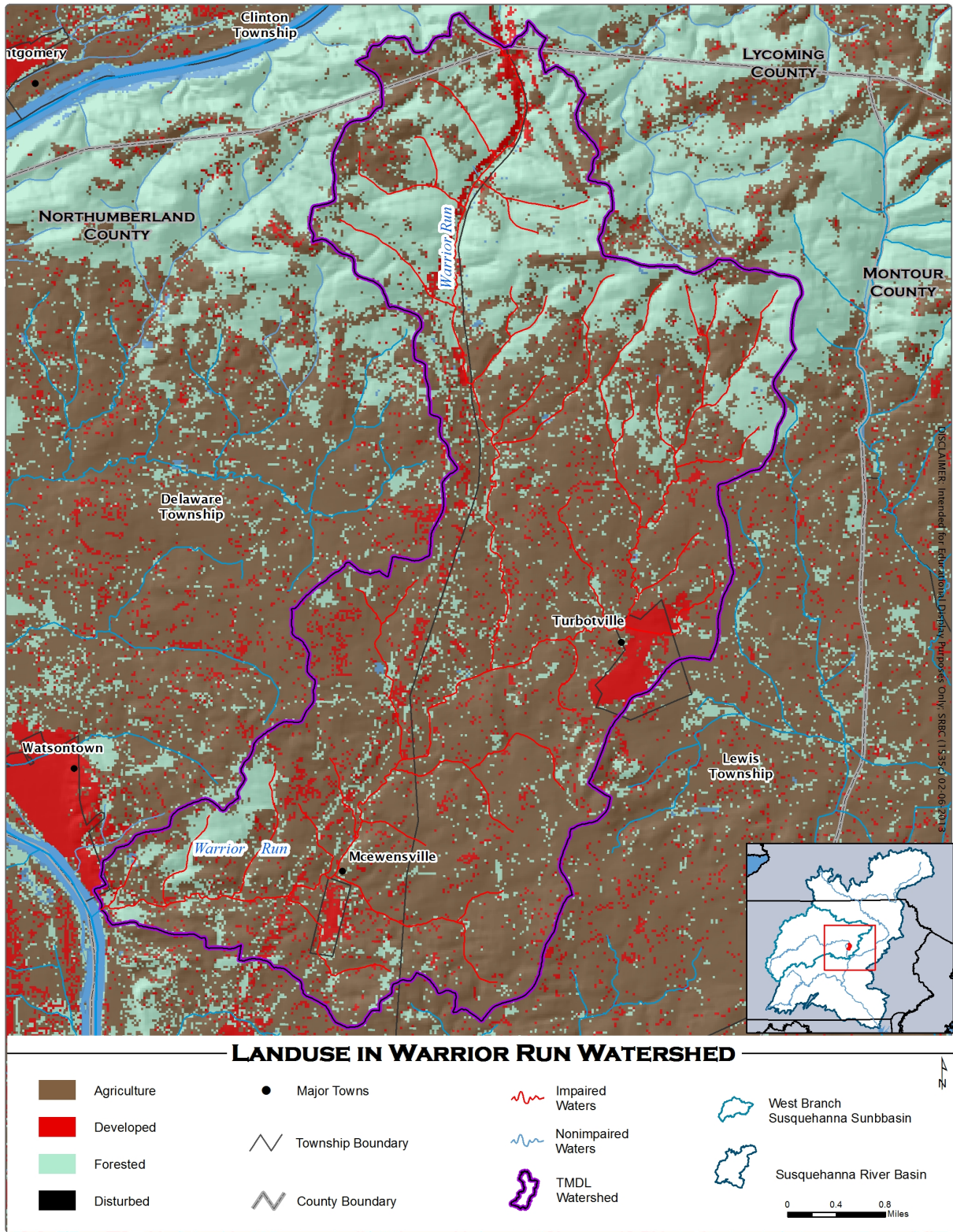


Figure 3. Land Use Map of Warrior Run Watershed



Figure 4. Evidence of Degraded Riparian Buffers (right bank) in Warriors Run Watershed.

Surface Water Quality

Pennsylvania's 2010 edition of the 303(d) list identified 66.66 miles of the Warrior Run Watershed as impaired by nutrients and siltation emanating from agricultural practices (Table 1).

Table 1. Integrated Water Quality Monitoring and Assessment Report Listed Segments

State Water Plan (SWP) Subbasin: 10D				
HUC: 02050206 – Lower West Branch Susquehanna				
Watershed – Warrior Run				
Source	EPA 305(b) Cause Code	Miles	Designated Use	Use Designation
Agriculture*	Siltation	48.75	WWF, MF	Aquatic Life
Agriculture	Organic Enrichment/Low D.O.	15.05	WWF, MF	Aquatic Life
Municipal Point Source	Siltation	1.43	WWF, MF	Aquatic Life
Municipal Point Source	Organic Enrichment/Low D.O.	1.43	WWF, MF	Aquatic Life

* Please see Attachment H for more details. Unionized ammonia listings in Warrior Run Watershed will be evaluated with future sampling and are not included in this TMDL.

In general, soil erosion is a major problem in the Warrior Run Watershed. Unrestricted access of livestock to streams results in trampled streambanks, excessive stream sedimentation, increased nutrient levels, and sparse streamside buffers and riparian vegetation. Large areas of row crops and use of conventional tillage, as well as unrestricted cattle access to streams, combine to leave the soil vulnerable to erosion. Seasonal thunderstorms can cause the watershed to become excessively muddy for several days. The resulting high sediment can make water unfit to drink, smother aquatic life and fish eggs, clog fish gills, and block sunlight into the creeks and rivers. Runoff from road construction also can be an additional, although temporary, source of stream sedimentation and increased nutrient levels.

APPROACH TO TMDL DEVELOPMENT

Pollutants & Sources

Nutrients and sediment have been identified as the pollutants causing designated use impairments in the Warrior Run Watershed, with the source(s) listed as agricultural. At present, there are no point source contributions within the segments addressed in this TMDL.

As stated in previous sections, the land use is dominantly agriculture. Pasture and croplands extend right up to the streambanks with little to no riparian buffer zones present. Livestock have unlimited access to streambanks throughout most of the watershed. Based on visual observations, streambank erosion is severe in most reaches of the streams.

TMDL Endpoints

In an effort to address the sediment and nutrients problem found in the Warrior Run Watershed, a TMDL was developed to establish loading limits for sediment and nutrients. The TMDL is intended to address sediment and nutrient impairments from developed land uses that were first identified in Pennsylvania's 1998 303(d) list, as well as other nonpoint sources such as agriculture. The decision to use phosphorus load reductions to address nutrient enrichment is based on an understanding of the relationship between nitrogen, phosphorus, and organic enrichment in stream systems. Elevated nutrient loads from human activities (nitrogen and phosphorus in particular) can lead to increased productivity of aquatic plants and other organisms, resulting in the degradation of water quality conditions through the depletion of dissolved oxygen in the water column (Novotny and Olem, 1994; Hem, 1983). In aquatic ecosystems, the quantities of trace elements are typically 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 limiting 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 the eutrophication processes in waterbodies, emphasis is placed on the limiting nutrient. However, this is not always the case. For example, if nitrogen is the limiting nutrient, it still may be more efficient to control phosphorus loads if the nitrogen originates from difficult to control sources, such as nitrates in groundwater.

In most freshwater systems, 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 (N/P) ratio is less than 10, nitrogen is limiting. If the N/P ratio is greater than 10, phosphorus is the limiting nutrient. For the Warrior Run Watershed, the average N/P ratio is approximately 20, which indicates that phosphorus is the limiting nutrient. Controlling the phosphorus loading to the Warrior Run Watershed will limit plant growth, thereby helping to eliminate use impairments currently being caused by excess nutrients.

Pennsylvania does not currently have specific numeric criteria for sediment and phosphorus. Therefore, to establish endpoints such that the designated uses of the Warrior Run watershed are attained and maintained, Pennsylvania utilizes its narrative water quality criteria, which states that:

Water may not contain substances attributable to point or nonpoint source discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life.

Reference Watershed Approach

The TMDL developed for the Warrior Run Watershed addresses sediment and nutrients. Because neither Pennsylvania nor the U.S. Environmental Protection Agency (USEPA) has instream numerical water quality criteria for sediment and phosphorus, a method was developed to implement the applicable narrative criteria. The method for these types of TMDLs is termed the “Reference Watershed Approach.” Meeting the water quality objectives specified for this TMDL will result in the impaired stream segment attaining its designated uses.

The Reference Watershed Approach compares two watersheds: one attaining its uses and one that is impaired based on biological assessments. Both watersheds ideally have similar land use/cover distributions. Other features such as base geologic formation should be matched to the extent possible; however, most variations can be adjusted for in the model. The objective of the process is to reduce the loading rate of pollutants in the impaired stream segment to a level equivalent to the loading rate in the nonimpaired, reference stream segment. This load reduction will result in conditions favorable to the return of a healthy biological community to the impaired stream segments.

Selection of the Reference Watershed

In general, three factors are considered when selecting a suitable reference watershed. The first factor is to use a watershed that the PADEP has assessed and determined to be attaining water quality standards. The second factor is to find a watershed that closely resembles the impaired watershed in physical properties such as land cover/land use, physiographic province, and geology/soils. Finally, the size of the reference watershed should be within 20-35 percent of the impaired watershed area. The search for a reference watershed for the Warrior Run Watershed to satisfy the above characteristics was done by means of a desktop screening using several GIS coverages, including the Multi-Resolution Land Characteristics (MRLC), Landsat-derived land cover/use grid, Pennsylvania’s streams database, and geologic rock types.

Upper Little Swatara Creek was selected as the reference watershed for developing the Warrior Run Watershed TMDL. Upper Little Swatara Creek is located just east of Pine Grove, in Schuylkill County, Pa. (Figure 5). The watershed is located in State Water Plan subbasin 7D, a tributary to Swatara Creek, and protected uses include aquatic life and recreation. The tributary is currently designated as a Cold Water Fishery (25 Pa. Code Chapter 93). PADEP’s attainment decisions make no distinction between uses, any score above 63 is attained regardless of use. Therefore, while a WWF reference would have seemed more appropriate on the surface, differences in uses do not introduce different tolerances to nutrient/sediment loads. Based on PADEP assessments, Upper Little Swatara

Creek is currently attaining its designated uses. The attainment of designated uses is based on sampling done by PADEP as part of its State Surface Water Assessment Program.

Drainage area, location, and other physical characteristics of the impaired segments of the Warrior Run Watershed were compared to the Upper Little Swatara Creek Watershed (Table 2). Agricultural land is a dominant land use category in the Warrior Run Watershed (55 percent) and Upper Little Swatara Creek (36 percent). The geology, soils, and precipitation in both are also similar (Table 2).

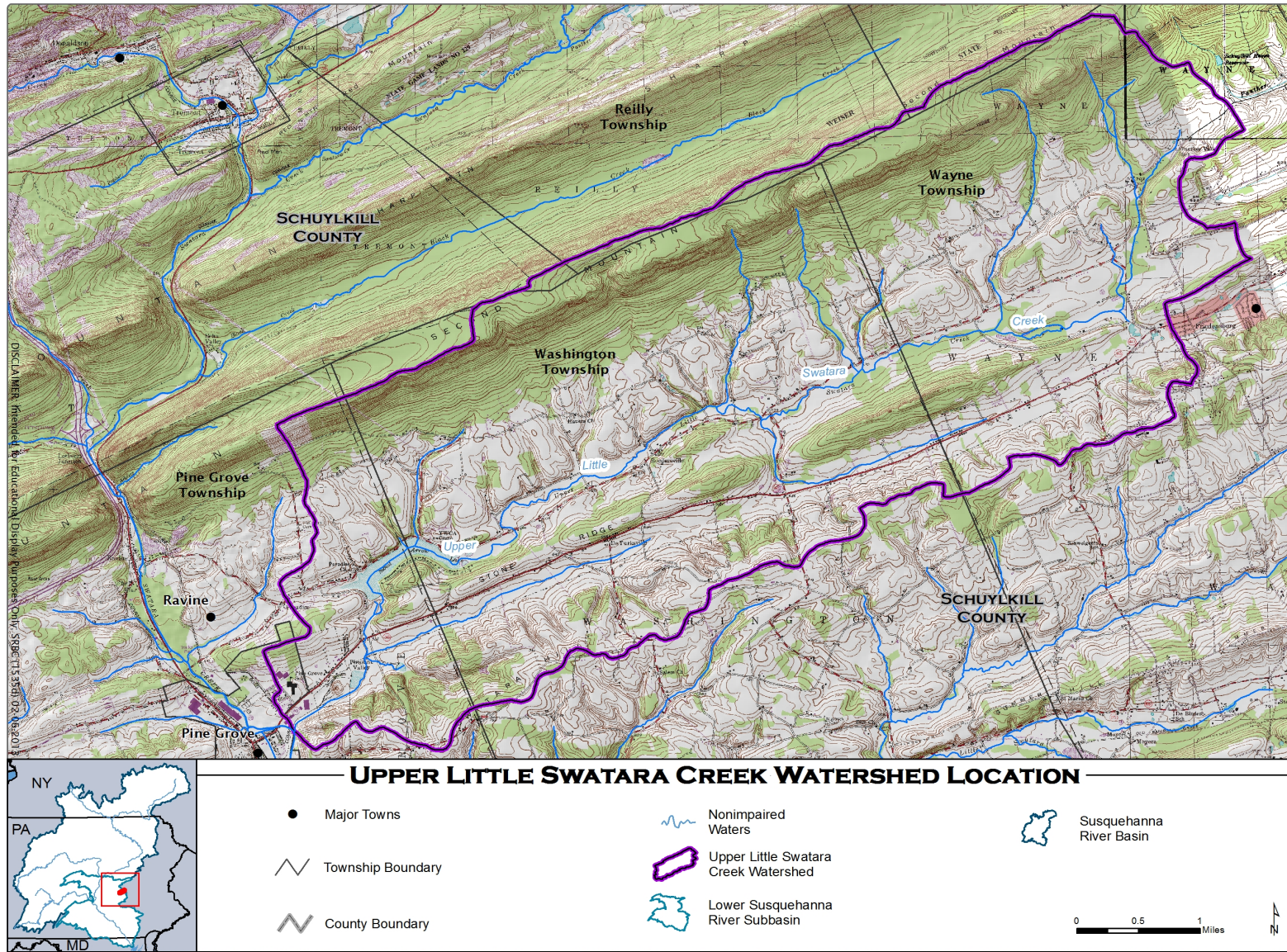


Figure 5. Location Map for Reference Watershed Upper Little Swatara Creek

Table 2. Comparison Between Warrior Run Watershed and Upper Little Swatara Creek Watershed

	Warrior Run Subwatershed	Upper Little Swatara Creek Watershed
Physiographic Province	Appalachian Mountain Section – Ridge & Valley Province (100%)	Ridge and Valley
Area (acres)	13,830.5	15,411.8
Land Use Distribution		
% Agriculture	54.75	37.87
% Forested	34.88	54.56
% Other	10.37	7.57
Soils		
Dominant Group C %	97.3	100.0
Surface Geology		
Sedimentary %	35.0	64.0
Average Rainfall (in)	37.74, 8 years	43.15, 8 years
Average Runoff (in)	0.13, 8 years	0.26, 8 years

Watershed Assessment and Modeling

The TMDL for the impaired segments of the Warrior Run Watershed was developed using the ArcView Generalized Watershed Loading Function model (AVGWLF) as described in Attachment C. The AVGWLF model was used to establish existing loading conditions for the impaired segments of the Warrior Run Watershed and the Upper Little Swatara Creek reference watershed. All modeling inputs have been attached to this TMDL as Attachments D and E. SRBC staff visited the watershed in winter 2012 and spring 2013. The field visits were conducted to get a better understanding of existing conditions that might influence the AVGWLF model.

The AVGWLF model produced information on watershed size, land use, nutrients, and sediment loading. The sediment and nutrient loadings represent an annual average over a 8-year period, from 1985 to 1992, and for the Warrior Run Watershed and Upper Little Swatara Creek Watershed, respectively. This information was then used to calculate existing unit area loading rates for the two watersheds. Acreage and sediment loading information for both the impaired watershed and the reference watershed are shown in Tables 3 and 4, respectively.

Table 3. Existing Sediment and Phosphorus Loads for Warrior Run Watershed

Pollutant Source	Acreage	Phosphorus		Sediment	
		Mean Annual Loading (lbs/day)	Unit Area Loading (lbs/ac/day)	Mean Annual Loading (lbs/day)	Unit Area Loading (lbs/ac/day)
HAY/PAST	3,083.9	0.89	0.0003	384.00	0.12
CROPLAND	4,487.4	6.99	0.0016	8,181.26	1.82
FOREST	4,806.2	0.10	0.0000	134.47	0.03
WETLAND	17.3	0.00	0.0000	0.00	0.00
UNPAVED RD	12.4	0.01	0.0010	9.59	0.77
TRANSITION	64.2	0.06	0.0009	40.88	0.64
LO INT DEV	1,359.1	0.17	0.0001	167.18	0.12
Streambank	-	0.11	-	5,034.24	-
Groundwater	-	2.65	-	-	-
Septic System	-	0.11	-	-	-
TOTAL	13,830.5	11.09	0.0008	13,951.62	1.01

Table 4. Existing Sediment and Phosphorus Loads for Upper Little Swatara Creek Watershed

Pollutant Source	Acreage	Phosphorus		Sediment	
		Mean Annual Loading (lbs/day)	Unit Area Loading (lbs/ac/day)	Mean Annual Loading (lbs/day)	Unit Area Loading (lbs/ac/day)
HAY/PAST	3,526.2	1.70	0.0005	922.52	0.26
CROPLAND	2,310.4	3.63	0.0016	8,834.25	3.82
FOREST	8,287.9	0.29	0.0000	954.85	0.12
WETLAND	69.2	0.00	0.0000	0.11	0.00
TURF GRASS	133.4	0.02	0.0002	51.78	0.39
UNPAVED RD	4.9	0.01	0.0013	9.26	1.89
TRANSITION	64.2	0.07	0.0011	70.14	1.09
LO INT DEV	971.1	0.16	0.0002	171.89	0.18
HI INT DEV	44.5	0.09	0.0020	1.92	0.04
Streambank	-	0.07	-	3,058.29	-
Groundwater	-	3.28	-	-	-
Septic System	-	0.02	-	-	-
TOTAL	15,411.8	9.34	0.0006	14,075.01	0.91

TMDLS

The targeted TMDL value for the Warrior Run Watershed was established based on current loading rates for sediment and phosphorus in the Upper Little Swatara Creek reference watershed. Biological assessments have determined that Upper Little Swatara Creek is currently attaining its designated uses.

Reducing the loading rate of sediment and phosphorus in the Warrior Run Watershed to levels equivalent to those in the reference watershed will provide conditions favorable for the reversal of current use impairments.

Background Pollutant Conditions

There are two separate considerations of background pollutants within the context of this TMDL. First, there is the inherent assumption of the reference watershed approach that because of the similarities between the reference and impaired watershed, the background pollutant contributions will be similar. Therefore, the background pollutant contributions will be considered when determining the loads for the impaired watershed that are consistent with the loads from the reference watershed. Second, the AVGWLF model implicitly considers background pollutant contributions through the soil and the groundwater component of the model process.

Targeted TMDLs

The targeted TMDL value for sediment and phosphorus was determined by multiplying the total area of the Warrior Run Watershed (13,830.5 acres) by the appropriate unit-area loading rate for the Upper Little Swatara Creek reference watershed (Table 4). The existing mean annual loading of sediment and phosphorus to Warrior Run Watershed (13,951.62 lbs/day and 11.09 lbs/day, respectively) will need to be reduced by 10 and 25 percent, respectively, to meet the targeted TMDL of 12,585.76 lbs/day and 8.30 lbs/day, respectively.

Table 5. Targeted TMDL for Warrior Run Watershed

Pollutant	Area (ac)	Unit Area Loading Rate Upper Little Swatara Creek Reference Watershed (lbs/ac/day)	Targeted TMDL for Warrior Run (lbs/day)
Sediment	13,830.5	0.91	12,585.76
Phosphorus	13,830.5	0.0006	8.30

Targeted TMDL values were used as the basis for load allocations and reductions in the Warrior Run Watershed, using the following two equations:

1. $TMDL = WLA + LA + MOS$
2. $LA = ALA + LNR$

where:

TMDL = Total Maximum Daily Load
WLA = Waste Load Allocation (point sources)
LA = Load Allocation (nonpoint sources)
ALA = Adjusted Load Allocation
LNR = Loads not Reduced

Margin of Safety

The MOS is that portion of the pollutant loading that is reserved to account for any uncertainty in the data and computational methodology used for the analysis. For this analysis, the MOS is explicit. Ten percent of the targeted TMDL for sediment and phosphorus were 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 Warrior Run Watershed. The MOS used for the sediment and phosphorus TMDL is shown below.

Warrior Run Watershed:

$$\text{MOS (sediment)} = 12,585.76 \text{ lbs/day (TMDL)} \times 0.1 = 1,258.58 \text{ lbs/day}$$

$$\text{MOS (phosphorus)} = 8.30 \text{ lbs/day (TMDL)} \times 0.1 = 0.83 \text{ lbs/day}$$

Waste Load Allocation

The WLA portion of the TMDL equation is the total loading of a pollutant that is assigned to point sources. Reviewing the PADEP’s permitting files identified two point source discharges for sediment and phosphorus in the watershed.

The McEwensville Boro Municipal Authority discharges treated sewage effluent into the streams covered by this TMDL, permit number PA0028100. The monthly average for suspended solids is 30.0 mg/L and ~0.8390 mg/L for phosphorus, which was included in the AVGWLF modeling runs for determining existing conditions. The design flow for the McEwensville Boro Municipal Authority is 0.045 million gallons per day (mgd). Based on the monthly average for this facility, the potential for sediment and phosphorus loads if the McEwensville Boro Municipal Authority capacities were fully utilized is 11.27 lbs/day and 0.32 lbs/day, respectively. This loading rate based on the design capacities of the plant is used in the final TMDL allocations (WLA).

The Turbotville Boro discharges treated sewage effluent into the streams covered by this TMDL, permit number PA0111414. The monthly average for suspended solids is 30.0 mg/L and ~2.6096 mg/L for phosphorus, which was included in the AVGWLF modeling runs for determining existing conditions. The design flow for the Turbotville Boro is 0.136 mgd. Based on the monthly average for this facility, the potential for sediment and phosphorus loads if the Turbotville Boro capacities were fully utilized is 34.05 lbs/day and 2.96 lbs/day, respectively. This loading rate based on the design capacities of the plant is used in the final TMDL allocations (WLA).

The bulk reserve is explicit and is calculated as one percent of the targeted TMDL. This bulk reserve enables the TMDL to account for the dynamic nature of permit activity (Table 6).

Table 6. Waste Load Allocations for the Warrior Run Watershed

Name	NPDES Permit #	Phosphorus WLA (lb/yr)	Phosphorus WLA (lb/day)	Sediment WLA (lb/yr)	Sediment WLA (lb/day)
McEwensville Municipal Authority	PA0028100	115.0	0.32	4,112.0	11.27
Turbotville Municipal Authority	PA0111414	1,081.0	2.96	12,427.4	34.05
Bulk Reserve		29.2	0.08	45,938.9	125.86
Total		1,225.2	3.36	62,478.3	171.18

Adjusted Load Allocation

The ALA is the actual portion of the LA distributed among those nonpoint sources receiving reductions. It is computed by subtracting those nonpoint source loads that are not being considered for reductions (loads not reduced or LNR) from the LA. Sediment and phosphorus reductions were made to the hay/pasture, cropland, developed areas (sum of LO_INT_DEV and TRANSITION), and streambanks. Those land uses/sources for which existing loads were not reduced (FOREST, WETLANDS, and Septic Systems) were carried through at their existing loading values (Table 7).

Table 7. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for Warrior Run

Component	Sediment (lbs/day)	Phosphorus (lbs/day)
Load Allocation	11,156.01	4.11
Loads not Reduced	134.47	0.21
FOREST	134.47	0.10
WETLANDS	0.00	0.00
Septic Systems	-	0.11
Adjusted Load Allocation	11,021.53	3.90

TMDLs

The sediment and phosphorus TMDL established for the Warrior Run Watershed consists of a LA, ALA, and MOS. The individual components of the TMDL are summarized in Table 8.

Table 8. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for Warrior Run

Component	Sediment (lbs/day)	Phosphorus (lbs/day)
TMDL (Total Maximum Daily Load)	12,585.76	8.30
MOS (Margin of Safety)	1,258.58	0.83
WLA (Waste Load Allocation)	171.18	3.36
LA (Load Allocation)	11,156.01	4.11
LNR (Loads not Reduced)	134.47	0.21
ALA (Adjusted Load Allocation)	11,021.53	3.90

CALCULATION OF SEDIMENT LOAD REDUCTIONS

The ALA established in the previous section represents the annual total sediment and phosphorus loads that are available for allocation between contributing sources in the Warrior Run Watershed. The ALA for sediment and phosphorus was allocated between agriculture, developed areas, and streambanks. LA and reduction procedures were applied to the entire Warrior Run Watershed using the Equal Marginal Percent Reduction (EMPR) allocation method (Attachment F). The LA and EMPR procedures were performed using MS Excel, and results are presented in Attachment G.

In order to meet the sediment and phosphorus TMDL, the load currently emanating from controllable sources must be reduced (Table 8). This can be achieved through reductions in

current sediment and phosphorus loadings from cropland, from hay/pasture, developed areas, and streambanks (Table 9).

Table 9. Sediment and Phosphorus Load Allocations and Reductions for Warrior Run Subwatershed

Pollutant Source	Acres	Unit Area Loading Rate (lbs/ac/day)		Pollutant Loading (lbs/day)		% Reduction
		Current	Allowable	Current	Allowable (LA)	
Sediment						
Hay/Pasture	3,083.90	0.12	0.10	384.00	306.31	20
Cropland	4,487.40	1.82	1.45	8,181.26	6,525.95	20
Developed	1,435.70	0.15	0.12	217.65	173.61	20
Streambanks	-	-	-	5,034.24	4,015.66	20
Total				13,817.15	11,021.53	20
Phosphorus						
Hay/Pasture	3,083.90	0.0003	0.0001	0.89	0.45	50
Cropland	4,487.40	0.0016	0.0004	6.99	1.95	72
Developed	1,435.70	0.0002	0.0001	0.24	0.12	50
Groundwater	-	-	-	2.65	1.33	50
Streambanks	-	-	-	0.11	0.06	50
Total				10.88	3.90	64

CONSIDERATION OF CRITICAL CONDITIONS

The AVGWLF model is a continuous simulation model which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment 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 generally a significant lag time between the introduction of sediment to a waterbody and the resulting impact on beneficial uses, establishing these TMDLs using average annual conditions is protective of the waterbody.

CONSIDERATION OF SEASONAL VARIATIONS

The continuous simulation model used for these analyses 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 actions by the model accounts for seasonal variability.

RECOMMENDATIONS FOR IMPLEMENTATION

TMDLs represent an attempt to quantify the pollutant load that may be present in a waterbody and still ensure attainment and maintenance of water quality standards. The Warrior Run Watershed TMDL identifies the necessary overall load reductions for sediment and phosphorus currently causing use impairments and distributes those reduction goals to the appropriate

nonpoint sources. Reaching the reduction goals established by this TMDL will only occur through Best Management Practices (BMPs). BMPs that would be helpful in lowering the amounts of sediment and phosphorus reaching Warrior Run include the following: streambank stabilization and fencing; riparian buffer strips; strip cropping; conservation tillage; stormwater retention wetlands; and heavy use area protection, among many others.

The Natural Resources Conservation Service maintains a *National Handbook of Conservation Practices* (NHCP), which provides information on a variety of BMPs. The NHCP is available online at http://www.ncg.nrcs.usda.gov/nhcp_2.html. Many of the practices described in the handbook could be used in the Warrior Run Watershed to help limit sediment and phosphorus impairments. Determining the most appropriate BMPs, where they should be installed, and actually putting them into practice, will require the development and implementation of restoration plans. Development of any restoration plan will involve the gathering of site-specific information regarding current land uses and existing conservation practices. This type of assessment has been ongoing in the Warrior Run Watershed, and it is strongly encouraged to continue.

The nitrogen, phosphorus and sediment reductions for the Bay TMDL are independent of those needed to implement any TMDLs developed to address nitrogen, phosphorus and sediment-related impairments in Pennsylvania's non-tidal waterbodies (including Warrior Run watershed), although their reduction goals and strategies do overlap. For example, the implementation planning framework, developed by the Bay watershed jurisdictions in partnership with EPA, provides a staged approach to achieving Bay TMDL reduction goals that are also applicable to implementation of nitrogen, phosphorus and sediment TMDLs in local non-tidal watersheds. In short, reductions required to meet the Chesapeake Bay TMDL will also support the restoration and protection of local water quality.

The sediment reductions for the Bay TMDL are independent of those needed to implement any TMDLs developed to address sediment-related impairments in Pennsylvania's non-tidal waterbodies, although their reduction goals and strategies do overlap. For example, the implementation planning framework, developed by the Bay watershed jurisdictions in partnership with USEPA, provides a staged approach to achieving Bay TMDL sediment reduction goals that is also applicable to implementation of sediment TMDLs in local non-tidal watersheds. In short, sediment reductions required to meet the Chesapeake Bay TMDL will also support the restoration and protection of local water quality and vice versa. Links to Chesapeake Bay TMDL related documents are provided below.

PADEP Chesapeake Bay Program website:

http://www.portal.state.pa.us/portal/server.pt/community/chesapeake_bay_program/10513

Pennsylvania's Phase I WIP:

<http://files.dep.state.pa.us/Water/Chesapeake%20Bay%20Program/ChesapeakePortalFiles/WIPs/REVISED%20FINAL%20Chesapeake%20Bay%20WIP%20-%20sent%20to%20EPA%2012-23-10.pdf>

Pennsylvania's Phase II WIP:

[http://files.dep.state.pa.us/Water/Chesapeake%20Bay%20Program/ChesapeakePortalFiles/4-2-2012/Clean%20FINAL%20Phase%202%20WIP%203-30-2012%20\(2\).pdf](http://files.dep.state.pa.us/Water/Chesapeake%20Bay%20Program/ChesapeakePortalFiles/4-2-2012/Clean%20FINAL%20Phase%202%20WIP%203-30-2012%20(2).pdf)

Pennsylvania's Phase II WIP Wastewater Supplement:

http://files.dep.state.pa.us/Water/Wastewater%20Management/EDMRPortalFiles/Phase_2_WIP_Supplement.pdf

Pennsylvania's Milestones for 2012-2013:

<http://files.dep.state.pa.us/Water/Chesapeake%20Bay%20Program/ChesapeakePortalFiles/7-9-2012/PA%20FINAL%202012-2013%20Milestones.pdf>

The Federal Nonpoint Source Management Program (§ 319 of the Clean Water Act) is one funding source for nonpoint source pollution reduction BMPs, such as those described above. This grant program provides funding to assist in implementing Pennsylvania's Nonpoint Source Management Program. This includes funding for abandoned mine drainage, agricultural and urban run-off, and natural channel design/streambank stabilization projects. Information on Pennsylvania's Nonpoint Source Management Program can be found at: http://www.portal.state.pa.us/portal/server.pt/community/nonpoint_source_management/10615

A second funding source is Pennsylvania's Growing Greener Watershed Grants, which provides nearly \$547 million in funding to clean up non-point sources of pollution throughout Pennsylvania. Examples of projects include acid mine drainage abatement, mine cleanup efforts, abandoned oil and gas well plugging and local watershed-based conservation projects. The grants were established by the Environmental Stewardship and Watershed Protection Act. Information on Pennsylvania's Growing Greener Watershed Grants can be found at: http://www.depweb.state.pa.us/portal/server.pt/community/growing_greener/13958

Information on these and other programs and additional funding sources can be found at: <http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Grants/GrantLoans>

By developing a sediment and phosphorus TMDL for the Warrior Run Watershed, PADEP continues to support design and implementation of restoration plans to correct current use impairments. PADEP welcomes local efforts to support watershed restoration plans. For more information about this TMDL, interested parties should contact the appropriate watershed manager in PADEP's Northcentral Regional Office (570-327-3636).

PUBLIC PARTICIPATION

A notice of availability for comments on the draft Warrior Run Watershed TMDL was published in the Pa. Bulletin on June 8th, 2013, and *The Standard Journal* and *Daily Item* on June 13, 2013, to foster public comment on the allowable loads calculated. A public meeting was held on June 20, 2013, at the McEwensville Borough Community Hall to discuss the proposed TMDL. The public participation process (which ended on July 8th, 2013) was provided for the submittal of comments. There were no public comments received for this TMDL (Attachment I).

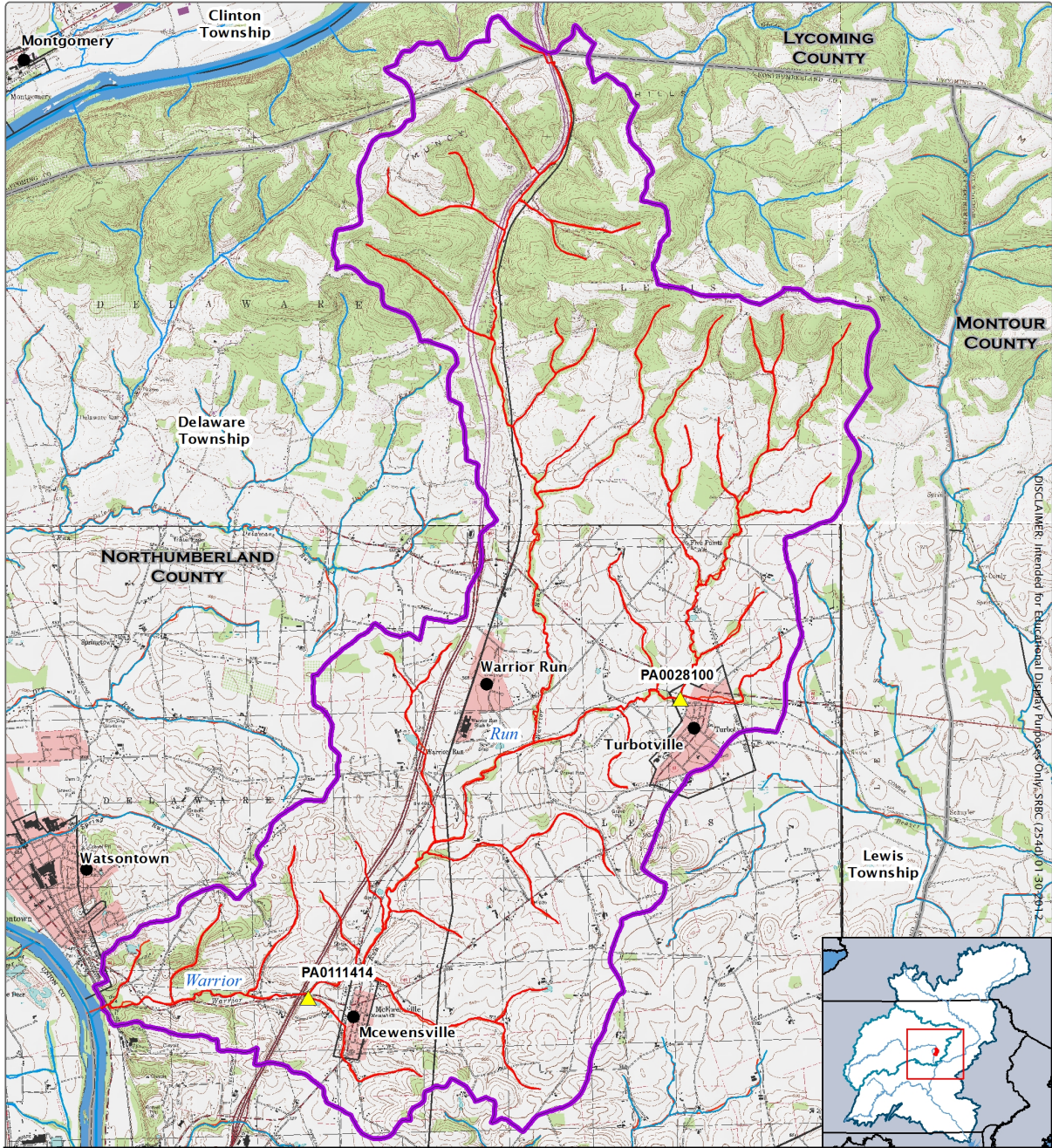
Notice of final TMDL approval will be posted on the PADEP's web site.

REFERENCES

- Commonwealth of Pennsylvania. 2001. Pennsylvania Code. Title 25 Environmental Protection. Department of Environmental Protection. Chapter 93. Water Quality Standards. Harrisburg, Pa.
- Hem, J.D. 1983. Study and Interpretation of the Chemical Characteristics of Natural Water. U.S. Geological Survey Water Supply Paper 1473.
- Novotny, V. and H. Olem. 1994. Water Quality: Prevention, Identification, and Management of Diffuse Pollution. Van Nostrand Reinhold, N.Y.
- Thomann, R.V. and J.A. Mueller. 1987. Principles of Surface Water Quality Modeling and Control. Harper & Row, N.Y.

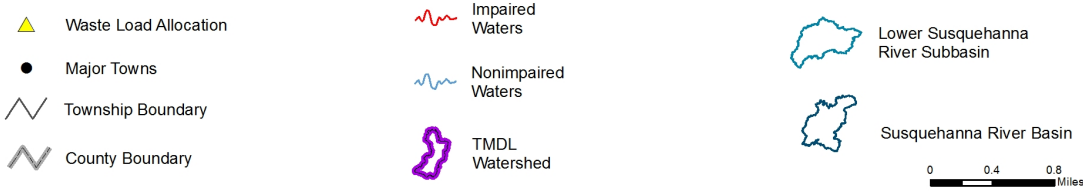
Attachment A

Warrior Run Watershed Impaired Waters



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WARRIOR RUN WATERSHED LOCATION



Attachment B

Information Sheet for the Warrior Run Watershed TMDL

What is being proposed?

Total Maximum Daily Load (TMDL) plans have been developed to improve water quality in the Warrior Run Watershed.

Who is proposing the plans? Why?

The Pennsylvania Department of Environmental Protection (PADEP) is proposing to submit the plans to the U.S. Environmental Protection Agency (USEPA) for review and approval as required by federal regulation. In 1995, USEPA was sued for not developing TMDLs when Pennsylvania failed to do so. PADEP has entered into an agreement with USEPA to develop TMDLs for certain specified waters over the next several years. This TMDL has been developed in compliance with the state/USEPA agreement.

What is a TMDL?

A TMDL sets a ceiling on the pollutant loads that can enter a waterbody so that it will meet water quality standards. The Clean Water Act requires states to list all waters that do not meet their water quality standards even after pollution controls required by law are in place. For these waters, the state must calculate how much of a substance can be put in the water without violating the standard, and then distribute that quantity to all the sources of the pollutant on that waterbody. A TMDL plan includes waste load allocations for point sources, load allocations for nonpoint sources, and a margin of safety. The Clean Water Act requires states to submit their TMDLs to USEPA for approval. Also, if a state does not develop the TMDL, the Clean Water Act states that USEPA must do so.

What is a water quality standard?

The Clean Water Act sets a national minimum goal that all waters be “fishable” and “swimmable.” To support this goal, states must adopt water quality standards. Water quality standards are state regulations that have two components. The first component is a designated use, such as “warm water fishes” or “recreation.” States must assign a use or several uses to each of their waters. The second component relates to the instream conditions necessary to protect the designated use(s). These conditions or “criteria” are physical, chemical, or biological characteristics such as temperature and minimum levels of dissolved oxygen, and maximum concentrations of toxic pollutants. It is the combination of the “designated use” and the “criteria” to support that use that make up a water quality standard. If any criteria are being exceeded, then the use is not being met and the water is said to be in violation of water quality standards.

What is the purpose of the plans?

The Warrior Run Watershed is impaired due to sediment and phosphorus emanating from agricultural runoff. The plans include a calculation of the loading for sediment that will correct the problem and meet water quality objectives.

Why was the Warrior Run Watershed selected for TMDL development?

In 2010, PADEP listed segments of the Warrior Run Watershed under Section 303(d) of the federal Clean Water Act as impaired due to causes linked to sediment and phosphorus.

What pollutants do these TMDLs address?

The proposed plans provide calculations of the stream's total capacity to accept sediment and phosphorus.

Where do the pollutants come from?

The sediment and phosphorus related impairments in the Warrior Run Watershed come from nonpoint sources of pollution, primarily overland runoff from developed areas and agricultural lands, as well as from streambank erosion.

How was the TMDL developed?

PADEP used a reference watershed approach to estimate the necessary loading reduction of sediment that would be needed to restore a healthy aquatic community. The reference watershed approach is based on selecting a nonimpaired watershed that has similar land use characteristics and determining the current loading rates for the pollutants of interest. This is done by modeling the loads that enter the stream, using precipitation and land use characteristic data. For this analysis, PADEP used the AVGWLF model (the Environmental Resources Research Institute of the Pennsylvania State University's ArcView-based version of the Generalized Watershed Loading Function model developed by Cornell University). This modeling process uses loading rates in the nonimpaired watershed as a target for load reductions in the impaired watershed. The impaired watershed is modeled to determine the current loading rates and determine what reductions are necessary to meet the loading rates of the nonimpaired watershed. The reference stream approach was used to set allowable loading rates in the affected watershed because neither Pennsylvania nor USEPA has instream numerical water quality criteria for sediment.

How much pollution is too much?

The allowable amount of pollution in a waterbody varies depending on several conditions. TMDLs are set to meet water quality standards at the critical flow condition. For a free flowing stream impacted by nonpoint source pollution loading of sediment, the TMDL is expressed as an annual loading. This accounts for pollution contributions over all streamflow conditions. PADEP established the water quality objectives for sediment by using the reference watershed approach. This approach assumes that the impairment is eliminated when the impaired watershed achieves loadings similar to the reference watershed. Reducing the current loading rates for sediment and phosphorus in the impaired watershed to the current loading rates in the reference watershed will result in meeting the water quality objectives.

How will the loading limits be met?

Best Management Practices (BMPs) will be encouraged throughout the watershed to achieve the necessary load reductions.

How can I get more information on the TMDL?

To request a copy of the full report, contact William Brown at (717) 783-2938 between 8:00 a.m. and 3:00 p.m., Monday through Friday. Mr. Brown also can be reached by mail at the Office of Water Management, PADEP, Rachel Carson State Office Building, 400 Market Street, Harrisburg, PA 17105 or by e-mail at willbrown@pa.gov

How can I comment on the proposal?

You may provide e-mail or written comments postmarked no later than July 8th, 2013 to the above address.

Attachment C

AVGWLF Model Overview & GIS-Based Derivation of Input Data

The TMDL for the Warrior Run Watershed was developed using the Generalized Watershed Loading Function or GWLF model. The GWLF model provides the ability to simulate runoff, sediment, and nutrient (nitrogen and phosphorus) loadings from the watershed given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. It is a continuous simulation model, which 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 a combined 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 in regard 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 a saturated subsurface zone, where infiltration is computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

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 conservation practices factor (P). A sediment delivery ratio based on watershed size, transport capacity, and average daily runoff is applied to the calculated erosion for determining 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 losses to the stream and are specified in terms of kilograms per month. Manured areas, as well as septic systems, can also 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 only considers a single, lumped-parameter contributing area. Evapotranspiration is determined using daily weather data and a cover factor dependent upon 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 viewed in GWLF Users Manual.

For execution, the model requires three separate input files containing transport-, nutrient-, and weather-related data. The transport (TRANSPRT.DAT) file defines the necessary parameters for each source area to be considered (e.g., area size, curve number, etc.), as well as global parameters (e.g., initial storage, sediment delivery ratio, etc.) that apply to all source areas. The

nutrient (NUTRIENT.DAT) file specifies the various loading parameters for the different source areas identified (e.g., number of septic systems, urban source area accumulation rates, manure concentrations, etc.). The weather (WEATHER.DAT) file contains daily average temperature and total precipitation values for each year simulated.

The primary sources of data for this analysis were Geographic Information System (GIS) formatted databases. A specially designed interface 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, which was developed by Cornell University. The new version of this model has been named AVGWLF (ArcView Version of the Generalized Watershed Loading Function).

In using this interface, the user is prompted to identify required GIS files and to provide other information related to “non-spatial” 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 includes location-specific default information such as background nitrogen and phosphorus concentrations and cropping practices. Complete GWLF-formatted weather files also are included for 80 weather stations around the state.

The following table lists the statewide GIS data sets and provides an explanation of how they were used for development of the input files for the GWLF model.

GIS Data Sets	
DATASET	DESCRIPTION
Censustr	Coverage of Census data including information on individual homes septic systems. The attribute <i>usew_sept</i> includes data on conventional systems, and <i>sew_other</i> provides data on short-circuiting and other systems.
County	The County boundaries coverage lists data on conservation practices, which provides C and P values in the Universal Soil Loss Equation (USLE).
Gwnback	A grid of background concentrations of N in groundwater derived from water well sampling.
Landuse5	Grid of the MRLC that has been reclassified into five categories. This is used primarily as a background.
Majored	Coverage of major roads. Used for reconnaissance of a watershed.
MCD	Minor civil divisions (boroughs, townships, and cities).
Npdespts	A coverage of permitted point discharges. Provides background information and cross check for the point source coverage.
Padem	100-meter digital elevation model. Used to calculate landslope and slope length.
Palumrlc	A satellite image derived land cover grid that is classified into 15 different land cover categories. This dataset provides land cover loading rate 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 <i>rain_cool</i> and <i>rain_warm</i> are used to set recession coefficient.
Pointsrc	Major point source discharges with permitted nitrogen and phosphorus loads.
Refwater	Shapefile of reference watersheds for which nutrient and sediment loads have been calculated.
Soilphos	A grid of soil phosphorus loads, which has been generated from soil sample data. Used to help set phosphorus and sediment values.
Smallsheds	A coverage of watersheds derived at 1:24,000 scale. This coverage is used with the stream network to delineate the desired level watershed.
Statsgo	A shapefile of generalized soil boundaries. The attribute <i>mu_k</i> sets the k factor in the USLE. The attribute <i>mu_awc</i> is the unsaturated available capacity, and the <i>muhsg_dom</i> 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 of similar qualities.
T9sheds	Data derived from a PADEP study conducted at PSU with N and P loads.
Zipcode	A coverage of animal densities. Attribute <i>aeu_acre</i> helps estimate N & P concentrations in runoff in agricultural lands and over manured areas.
Weather Files	Historical weather files for stations around Pennsylvania to simulate flow.

Attachment D

AVGWLF Model Inputs for the Warrior Run Watershed

Warrior Run Watershed Nutrient Input File

Runoff Coefficients by Source			Nitrogen and Phosphorus Loads from Point Sources and Septic Systems							
Rural Runoff	Dis N mg/L	Dis P mg/L	Point Source Loads/Discharge			Septic System Populations				
Hay/Past	2.9	0.197	Month	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Cropland	2.9	0.197	Jan	0.0	0.0	0.0	675	0	22	0
Forest	0.19	0.006	Feb	0.0	0.0	0.0	675	0	22	0
Wetland	0.19	0.006	Mar	0.0	0.0	0.0	675	0	22	0
Unpaved_Rd	2.9	0.2	Apr	0.0	0.0	0.0	675	0	22	0
Transition	2.9	0.2	May	0.0	0.0	0.0	675	0	22	0
	0	0	Jun	0.0	0.0	0.0	675	0	22	0
	0	0	Jul	0.0	0.0	0.0	675	0	22	0
	0	0	Aug	0.0	0.0	0.0	675	0	22	0
	0	0	Sep	0.0	0.0	0.0	675	0	22	0
Manure	2.44	0.38	Oct	0.0	0.0	0.0	675	0	22	0
Urban Build-Up	N Kg/ha/d	P Kg/ha/d	Nov	0.0	0.0	0.0	675	0	22	0
Lo_Int_Dev	0.012	0.002	Dec	0.0	0.0	0.0	675	0	22	0
	0	0								
Groundwater (mg/L)		Tile Drainage (mg/L)		Per capita tank effluent		Growing season N/P uptake		Sediment		
N (mg/L)	P (mg/L)	N	P	Sed	N (g/d)	P (g/d)	N (g/d)	P (g/d)	N (mg/Kg)	P (mg/Kg)
2.16	0.026	15	0.1	50	12	2.5	1.6	0.4	3000.0	624.0

Warrior Run Watershed Transport Input File

Rural LU	Area (ha)	CN	K	LS	C	P	Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Hay/Past	1248	75	0.268	0.476	0.03	0.45	Jan	0.61	9.3	0	0.12	0	0
Cropland	1816	82	0.267	0.432	0.42	0.52	Feb	0.66	10.3	0	0.12	0	0
Forest	1945	73	0.262	1.641	0.002	0.45	Mar	0.69	11.8	0	0.12	0	0
Wetland	7	87	0.261	0.082	0.01	0.1	Apr	0.88	13.2	1	0.3	0	0
	0	0	0	0	0	0	May	0.99	14.4	1	0.3	0	0
	0	0	0	0	0	0	Jun	1.05	15	1	0.3	0	0
	0	0	0	0	0	0	Jul	1.09	14.7	1	0.3	0	0
	0	0	0	0	0	0	Aug	1.11	13.7	1	0.3	0	0
	0	0	0	0	0	0	Sep	1.12	12.3	1	0.3	0	0
	0	0	0	0	0	0	Oct	1.13	10.8	1	0.12	0	0
	0	0	0	0	0	0	Nov	0.96	9.6	0	0.12	0	0
	0	0	0	0	0	0	Dec	0.86	9	0	0.12	0	0
Bare Land	Area (ha)	CN	K	LS	C	P							
Unpaved_Rd	5	87	0.266	0.405	0.1	1							
Transition	26	87	0.26	0.423	0.1	0.8							
Urban LU	Area (ha)	CN	K	LS	C	P							
Lo_Int_Dev	550	83	0.27	0.394	0.08	0.2							
	0	0	0	0	0	0							
Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1								
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.136	Seepage Coefficient	0								
Unsat Avail Wat (cm)	13.7239	Tile Drain Ratio	0.5	Sediment A Factor	6.7572E-04								
		Tile Drain Density	0	Sed A Adjustment Factor	1								

Attachment E

AVGWLF Model Inputs for the Upper Little Swatara Creek Reference Watershed

Upper Little Swatara Creek Nutrient Input File

Runoff Coefficients by Source			Nitrogen and Phosphorus Loads from Point Sources and Septic Systems							
Rural Runoff	Dis N mg/L	Dis P mg/L	Point Source Loads/Discharge			Septic System Populations				
Hay/Past	2.9	0.121	Month	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Cropland	2.9	0.121	Jan	0.0	0.0	0.0	96	0	4	0
Forest	0.19	0.006	Feb	0.0	0.0	0.0	96	0	4	0
Wetland	0.19	0.006	Mar	0.0	0.0	0.0	96	0	4	0
Turf_Grass	2.5	0.073	Apr	0.0	0.0	0.0	96	0	4	0
Unpaved_Rd	2.9	0.2	May	0.0	0.0	0.0	96	0	4	0
Transition	2.9	0.2	Jun	0.0	0.0	0.0	96	0	4	0
	0	0	Jul	0.0	0.0	0.0	96	0	4	0
	0	0	Aug	0.0	0.0	0.0	96	0	4	0
	0	0	Sep	0.0	0.0	0.0	96	0	4	0
Manure	2.44	0.38	Oct	0.0	0.0	0.0	96	0	4	0
Urban Build-Up	N Kg/ha/d	P Kg/ha/d	Nov	0.0	0.0	0.0	96	0	4	0
Lo_Int_Dev	0.012	0.002	Dec	0.0	0.0	0.0	96	0	4	0
Hi_Int_Dev	0.101	0.011								

Groundwater (mg/L)		Tile Drainage (mg/L)			Per capita tank effluent		Growing season N/P uptake		Sediment	
N (mg/L)	P (mg/L)	N	P	Sed	N (g/d)	P (g/d)	N (g/d)	P (g/d)	N (mg/Kg)	P (mg/Kg)
1.489	0.022	15	0.1	50	12	2.5	1.6	0.4	3000.0	222.0

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Upper Little Swatara Creek Transport Input File

Rural LU							Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Area (ha)	CN	K	LS	C	P								
Hay/Past	1427	75	0.24	0.819	0.03	0.45	Jan	0.65	9.4	0	0.12	0	0
Cropland	935	82	0.24	0.855	0.42	0.45	Feb	0.7	10.4	0	0.12	0	0
Forest	3354	73	0.229	4.905	0.002	0.52	Mar	0.73	11.8	0	0.12	0	0
Wetland	28	87	0.24	0.086	0.01	0.1	Apr	0.9	13.2	1	0.3	0	0
Turf_Grass	54	71	0.24	1.025	0.08	0.2	May	0.99	14.4	1	0.3	0	0
	0	0	0	0	0	0	Jun	1.05	14.9	1	0.3	0	0
	0	0	0	0	0	0	Jul	1.08	14.6	1	0.3	0	0
	0	0	0	0	0	0	Aug	1.1	13.6	1	0.3	0	0
	0	0	0	0	0	0	Sep	1.11	12.2	1	0.3	0	0
	0	0	0	0	0	0	Oct	1.12	10.8	1	0.12	0	0
	0	0	0	0	0	0	Nov	0.97	9.6	0	0.12	0	0
	0	0	0	0	0	0	Dec	0.89	9.1	0	0.12	0	0

Bare Land						
Area (ha)	CN	K	LS	C	P	
Unpaved_Rd	2	87	0.234	0.811	0.1	1
Transition	26	87	0.24	0.576	0.1	0.8

Urban LU						
Area (ha)	CN	K	LS	C	P	
Lo_Int_Dev	393	83	0.24	0.467	0.08	0.2
Hi_Int_Dev	18	93	0.24	0.113	0.08	0.2

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.131	Seepage Coefficient	0
Unsat Avail Wat (cm)	11.5073	Tile Drain Ratio	0.5	Sediment A Factor	5.3280E-04
		Tile Drain Density	0	Sed A Adjustment Factor	1

[Load File](#) [Save File](#) [Export to JPEG](#) [Close](#)

Attachment F

Equal Marginal Percent Reduction Method

The Equal Marginal Percent Reduction (EMPR) allocation method was used to distribute Adjusted Load Allocations (ALAs) between the appropriate contributing nonpoint sources. The load allocation and EMPR procedures were performed using MS Excel and results are presented in Attachment G. The five major steps identified in the spreadsheet are summarized below:

1. Calculation of the TMDL based on impaired watershed size and unit area loading rate of the reference watershed.
2. Calculation of Adjusted Load Allocation based on TMDL, Margin of Safety, and existing loads not reduced.
3. Actual EMPR Process.
 - a. Each land use/source load is compared with the total ALA to determine if any contributor would exceed the ALA by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load of the receiving waterbody. If the contributor exceeds the ALA, that contributor would be reduced to the ALA. If a contributor is less than the ALA, it is set at the existing load. This is the baseline portion of the EMPR.
 - b. After any necessary reductions have been made in the baseline, the multiple analyses are run. The multiple analyses will sum all of the baseline loads and compare them to the ALA. If the ALA is exceeded, an equal percent reduction will be made to all contributors' baseline values. After any necessary reductions in the multiple analyses, the final reduction percentage for each contributor can be computed.
4. Calculation of total loading rate of all sources receiving reductions.
5. Summary of existing loads, final load allocations, and percent reduction for each pollutant source.

Attachment G

Equal Marginal Percent Reduction Calculations for the Warrior Run Watershed TMDL

Step 1: TMDL Total Load			Step 2: Adjusted LA = (TMDL total load - MOS) - uncontrollable									
Load = loading rate in ref. * Acres in Impaired			Adjusted LA = (TMDL total load - MOS) - uncontrollable									
8.30			3.90 4									
PHOSPHORUS LOADING												
Step 3:	Non-MS4 Daily Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reduction	Initial LA	Acres	Allowable Loading Rate	% Reduction	
	Hay/Past.	0.89	10.88	good	1	ADJUST	0.11	0.44	0.45	3083.90	0.00	50%
	Cropland	6.99		bad	4	4	0.50	1.95	1.95	4487.40	0.00	72%
	Developed	0.24		good	0		0.03	0.12	0.12	1435.70	0.00	50%
	Groundwater	2.65		good	3		0.34	1.32	1.33			50%
	Streambank	0.11		good	0		0.01	0.05	0.06			50%
	Total	10.88			7.78847		1.00		3.90			
Step 4 All Ag. Loading Rat			0.00									
Step 5:	Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.						
	Final Hay/Past. LA	3083.90	0.0001	0.45	0.0003	0.89	50%					
	Final Cropland LA	4487.40	0.0004	1.95	0.0016	6.99	72%					
	Developed	1435.70	0.0001	0.12	0.0002	0.24	50%					
	Groundwater			1.33		2.65	50%					
	Streambank			0.06		0.11	50%					
	Total			3.90		10.88	64%					
Warrior Run												

Step 1: TMDL Total Load				Step 2: Adjusted LA = (TMDL total load - MOS) - uncontrollable									
Load = loading rate in ref. * Acres in Impaired				11021.53				11022					
12585.76													
SEDIMENT LOADING													
Step 3:	Non-MS4 Daily Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reductior	Initial LA	Acres	Allowable Loading Rate	% Reduction		
	Hay/Past.	384.00	13817.15	good	384	ADJUST	0.03	77.69	306.31	3083.90	0.10	20%	
	Cropland	8181.26		good	8181	2796	0.59	1655.31	6525.95	4487.40	1.45	20%	
	Developed	217.65		good	218		0.02	44.04	173.61	1435.70	0.12	20%	
	Streambank	5034.24		good	5034		0.36	1018.58	4015.66			20%	
	Total	13817.15			13817.15		1.00		11021.53				
Step 4	All Ag. Loading Rat	0.90											
Step 5:	Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.							
	Final Hay/Past. LA	3083.90	0.10	306.31	0.12	384.00	20%						
	Final Cropland LA	4487.40	1.45	6525.95	1.82	8181.26	20%						
	Developed	1435.70	0.12	173.61	0.15	217.65	20%						
	Streambank			4015.66		5034.24	20%						
	Total			11021.53		13817.15	20%						
Warrior Run													

Attachment H

Warrior Run Watershed Impaired Segment Listings

**Pennsylvania Integrated Water Quality Monitoring and Assessment Report
Streams, Category 5 Waterbodies, Pollutants Requiring a TMDL**

Stream Name	Use Designation (Assessment ID)	Cause	Date Listed	TMDL Date
Hydrologic Unit Code: 02050206 - Lower West Branch Susquehanna				
<u>Warrior Run</u>				
HUC: 02050206				
Aquatic Life (8381) - 4.91 miles; 13 Segment(s)*				
Agriculture		Siltation	1998	2011
Aquatic Life (8384) - 6.15 miles; 12 Segment(s)*				
Agriculture		Siltation	1998	2011
<u>Warrior Run (Unt 19145)</u>				
HUC: 02050206				
Aquatic Life (8381) - 0.50 miles; 3 Segment(s)*				
Agriculture		Siltation	1998	2011
<u>Warrior Run (Unt 19146)</u>				
HUC: 02050206				
Aquatic Life (8381) - 0.91 miles; 3 Segment(s)*				
Agriculture		Siltation	1998	2011
<u>Warrior Run (Unt 19147)</u>				
HUC: 02050206				
Aquatic Life (8381) - 1.28 miles; 2 Segment(s)*				
Agriculture		Siltation	1998	2011
<u>Warrior Run (Unt 19148)</u>				
HUC: 02050206				
Aquatic Life (8381) - 1.35 miles; 4 Segment(s)*				
Agriculture		Siltation	1998	2011
<u>Warrior Run (Unt 19149)</u>				
HUC: 02050206				
Aquatic Life (8381) - 0.72 miles; 2 Segment(s)*				
Agriculture		Siltation	1998	2011
<u>Warrior Run (Unt 19150)</u>				
HUC: 02050206				
Aquatic Life (8381) - 1.90 miles; 3 Segment(s)*				
Agriculture		Siltation	1998	2011
<u>Warrior Run (Unt 19151)</u>				
HUC: 02050206				
Aquatic Life (8381) - 0.52 miles; 2 Segment(s)*				
Agriculture		Siltation	1998	2011

*Segments are defined as individual COM IDs.

**Pennsylvania Integrated Water Quality Monitoring and Assessment Report
Streams, Category 5 Waterbodies, Pollutants Requiring a TMDL**

Stream Name

Use Designation (Assessment ID)

Source

Cause

Date Listed

TMDL Date

Warrior Run (Unt 19152)

HUC: 02050206

Aquatic Life (8381) - 0.74 miles; 2 Segment(s)*

Agriculture

Siltation

1998

2011

Warrior Run (Unt 19153)

HUC: 02050206

Aquatic Life (8381) - 0.58 miles; 2 Segment(s)*

Agriculture

Siltation

1998

2011

Warrior Run (Unt 19154)

HUC: 02050206

Aquatic Life (8381) - 1.92 miles; 3 Segment(s)*

Agriculture

Siltation

1998

2011

Warrior Run (Unt 19155)

HUC: 02050206

Aquatic Life (8381) - 0.66 miles; 1 Segment(s)*

Agriculture

Siltation

1998

2011

Warrior Run (Unt 19156)

HUC: 02050206

Aquatic Life (8381) - 2.08 miles; 4 Segment(s)*

Agriculture

Siltation

1998

2011

Warrior Run (Unt 19158)

HUC: 02050206

Aquatic Life (8382) - 1.43 miles; 3 Segment(s)*

Agriculture

Siltation

1998

2011

Municipal Point Source

Organic Enrichment/Low D.O.

1998

2011

Aquatic Life (8553) - 3.71 miles; 7 Segment(s)*

Agriculture

Organic Enrichment/Low D.O.

1998

2011

Agriculture

Siltation

1998

2011

Warrior Run (Unt 19159)

HUC: 02050206

Aquatic Life (8553) - 0.79 miles; 1 Segment(s)*

Agriculture

Organic Enrichment/Low D.O.

1998

2011

Agriculture

Siltation

1998

2011

Warrior Run (Unt 19160)

HUC: 02050206

Aquatic Life (8553) - 1.23 miles; 2 Segment(s)*

Agriculture

Organic Enrichment/Low D.O.

1998

2011

*Segments are defined as individual COM IDs.

**Pennsylvania Integrated Water Quality Monitoring and Assessment Report
Streams, Category 5 Waterbodies, Pollutants Requiring a TMDL**

Stream Name

Use Designation (Assessment ID)

Source

Cause

Date Listed

TMDL Date

Warrior Run (Unt 19160)

HUC: 02050206

Aquatic Life (8553) - 1.23 miles; 2 Segment(s)*

Agriculture	Siltation	1998	2011
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Warrior Run (Unt 19161)

HUC: 02050206

Aquatic Life (8553) - 1.19 miles; 2 Segment(s)*

Agriculture	Organic Enrichment/Low D.O.	1998	2011
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Agriculture	Siltation	1998	2011
-------------	-----------	------	------

Warrior Run (Unt 19162)

HUC: 02050206

Aquatic Life (8553) - 0.73 miles; 2 Segment(s)*

Agriculture	Organic Enrichment/Low D.O.	1998	2011
-------------	-----------------------------	------	------

Agriculture	Siltation	1998	2011
-------------	-----------	------	------

Warrior Run (Unt 19163)

HUC: 02050206

Aquatic Life (8553) - 2.32 miles; 3 Segment(s)*

Agriculture	Organic Enrichment/Low D.O.	1998	2011
-------------	-----------------------------	------	------

Agriculture	Siltation	1998	2011
-------------	-----------	------	------

Warrior Run (Unt 19164)

HUC: 02050206

Aquatic Life (8553) - 0.56 miles; 2 Segment(s)*

Agriculture	Organic Enrichment/Low D.O.	1998	2011
-------------	-----------------------------	------	------

Agriculture	Siltation	1998	2011
-------------	-----------	------	------

Warrior Run (Unt 19165)

HUC: 02050206

Aquatic Life (8553) - 0.87 miles; 1 Segment(s)*

Agriculture	Organic Enrichment/Low D.O.	1998	2011
-------------	-----------------------------	------	------

Agriculture	Siltation	1998	2011
-------------	-----------	------	------

Warrior Run (Unt 19166)

HUC: 02050206

Aquatic Life (8553) - 0.70 miles; 3 Segment(s)*

Agriculture	Organic Enrichment/Low D.O.	1998	2011
-------------	-----------------------------	------	------

Agriculture	Siltation	1998	2011
-------------	-----------	------	------

Warrior Run (Unt 19167)

HUC: 02050206

Aquatic Life (8553) - 0.03 miles; 2 Segment(s)*

Agriculture	Organic Enrichment/Low D.O.	1998	2011
-------------	-----------------------------	------	------

Agriculture	Siltation	1998	2011
-------------	-----------	------	------

*Segments are defined as individual COM IDs.

**Pennsylvania Integrated Water Quality Monitoring and Assessment Report
Streams, Category 5 Waterbodies, Pollutants Requiring a TMDL**

Stream Name

Use Designation (Assessment ID)

Source

Cause

Date Listed

TMDL Date

Warrior Run (Unt 19167)

HUC: 02050206

Warrior Run (Unt 19168)

HUC: 02050206

Aquatic Life (8553) - 1.06 miles; 2 Segment(s)*

Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011

Warrior Run (Unt 19169)

HUC: 02050206

Aquatic Life (8553) - 0.49 miles; 1 Segment(s)*

Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011

Warrior Run (Unt 19170)

HUC: 02050206

Aquatic Life (8384) - 2.00 miles; 3 Segment(s)*

Agriculture	Siltation	1998	2011
-------------	-----------	------	------

Warrior Run (Unt 19171)

HUC: 02050206

Aquatic Life (8384) - 0.67 miles; 1 Segment(s)*

Agriculture	Siltation	1998	2011
-------------	-----------	------	------

Warrior Run (Unt 19172)

HUC: 02050206

Aquatic Life (8384) - 0.99 miles; 2 Segment(s)*

Agriculture	Siltation	1998	2011
-------------	-----------	------	------

Warrior Run (Unt 19173)

HUC: 02050206

Aquatic Life (8384) - 0.47 miles; 1 Segment(s)*

Agriculture	Siltation	1998	2011
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Warrior Run (Unt 19174)

HUC: 02050206

Aquatic Life (8384) - 1.23 miles; 2 Segment(s)*

Agriculture	Siltation	1998	2011
-------------	-----------	------	------

Warrior Run (Unt 19175)

HUC: 02050206

Aquatic Life (8384) - 1.17 miles; 3 Segment(s)*

Agriculture	Siltation	1998	2011
-------------	-----------	------	------

*Segments are defined as individual COM IDs.

**Pennsylvania Integrated Water Quality Monitoring and Assessment Report
Streams, Category 5 Waterbodies, Pollutants Requiring a TMDL**

Stream Name

Use Designation (Assessment ID)

Source

Cause

Date Listed

TMDL Date

Warrior Run (Unt 19176)

HUC: 02050206

Aquatic Life (8384) - 0.50 miles; 1 Segment(s)*

Agriculture

Siltation

1998

2011

Warrior Run (Unt 19177)

HUC: 02050206

Aquatic Life (8384) - 0.97 miles; 2 Segment(s)*

Agriculture

Siltation

1998

2011

Warrior Run (Unt 19178)

HUC: 02050206

Aquatic Life (8384) - 0.44 miles; 1 Segment(s)*

Agriculture

Siltation

1998

2011

Warrior Run (Unt 19179)

HUC: 02050206

Aquatic Life (8384) - 0.88 miles; 1 Segment(s)*

Agriculture

Siltation

1998

2011

Report Summary

Watershed Summary

	Stream Miles	Assessment Units	Segments (COMIDs)
Watershed Characteristics	48.78	4	105

Impairment Summary

Source	Cause	Miles	Assessment Units	Segments (COMIDs)
Agriculture	Organic Enrichment/Low D.O.	13.66	1	28
Agriculture	Siltation	48.60	4	104
Municipal Point Source	Organic Enrichment/Low D.O.	1.43	1	3
		48.60 **	4 **	104 **

**Totals reflect actual miles of impaired stream. Each stream segment may have multiple impairments (different sources or causes contributing to the impairment), so the sum of individual impairment numbers may not add up to the totals shown.

Use Designation Summary

	Miles	Assessment Units	Segments (COMIDs)
Aquatic Life	48.60	4	104

*Segments are defined as individual COM IDs.

Attachment I

Comment & Response Document for the Warrior Run Watershed TMDL

There were no public comments received for this TMDL.