DELAWARE RUN WATERSHED TMDL

Northumberland and Lycoming Counties

Prepared for:

Pennsylvania Department of Environmental Protection

April 30, 2011

TABLE OF CONTENTS

FIGURES

TABLES

ATTACHMENTS

TMDL SUMMARIES

1. The impaired stream segments addressed by this Total Maximum Daily Load (TMDL) are located in Muncy and Delaware Townships in Columbia and Lycoming Counties, Pennsylvania. The stream segments drain approximately 11.7 square miles as part of State Water Plan subbasin 10D. The aquatic life existing uses for Delaware Run, including its tributaries, are warm water fisheries (25 Pa. Code Chapter 93).

2. Pennsylvania's 2008 303(d) list identified 18.61 miles within the Delaware Run Watershed as impaired by sediment from agricultural land use practices. The listings were based on data collected in 2001 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 Delaware Run Watershed, mean annual loadings for sediment will need to be limited 9,387.7266 pounds per day (lbs/day).

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

Delaware Run Watershed Components	**Sediment (lbs/day)**
TMDL (Total Maximum Daily Load)	9,387.7266
WLA (Wasteload Allocation)	-
MOS (Margin of Safety)	938.7727
LA (Load Allocation)	8,448.9539

3. Mean annual sediment is estimated at 15,937.4753 lbs/day. To meet the TMDL, the sediment loadings will require reductions of 41 percent.

4. There are no point sources addressed in these TMDL segments.

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 TMDL includes a nonpoint source ALA of 8,345.0635 lbs/day. Sediment loadings from all other sources, such as forested and wetlands were maintained at their existing levels. Allocations of sediment to controllable nonpoint sources, or the ALA, for the Delaware Run Watershed TMDL are summarized below.

Delaware Run: Adjusted Load Allocations for Sources of Sediment			
Pollutant	**Current Loading (lbs/day)**	**Adjusted Load Allocation (lbs/day)**	**% Reduction**
Sediment	8,448.9539	8,345.0635	1

6. Ten percent of the Delaware 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 TMDL is 938.7727 lbs/day.

7. The continuous simulation model used for developing the Delaware 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 Delaware Run Watershed is approximately 11.7 square miles in area. The headwaters of Delaware Run are located inside the western portion of Northumberland County, a few miles west of Turbotville, Pa. The watershed is located on the U.S. Geological Survey (USGS) 7.5 minute quadrangles of Allenwood, Muncy, Montoursville South, and Milton, Pa. The stream flows west to its confluence with the West Branch Susquehanna River. The major tributaries to Delaware Run include several unnamed tributaries (UNTs). State Highway 54 bisects the central portion of the watershed. Numerous township roads provide access to the Delaware 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. The total change in elevation in the watershed is approximately 580 feet from the headwaters to the mouth.

The majority of the rock type in the upland portions of the watershed is sedimentary (90 percent), predominantly associated with the Wills Creek Formation, Clinton Group, Onondaga/Old Port Formation, Trimmers Rock Formation, Hamilton Group, and Bloomsburg/Mifflinburg Formation (Figure 1). The remaining rock types found in the watershed are carbonate (5 percent), predominantly associated with the Keyser/Tonoloway 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 Hagerstown-Edom-Washington, Watson-Berks-Alvira, and Chenango-Pope-Holly.

Based on GIS datasets created in 2001, land use values were calculated for the TMDL watershed. Agriculture was the dominant land use at approximately 54 percent (Figure 3). Forested land uses account for approximately 37 percent of the watershed. Developed areas are 9 percent of the watershed, covering low-intensity residential and transitional. Riparian buffer zones are nearly nonexistent 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 (Figure 4). Some contiguous forested tracts remain in the watershed.

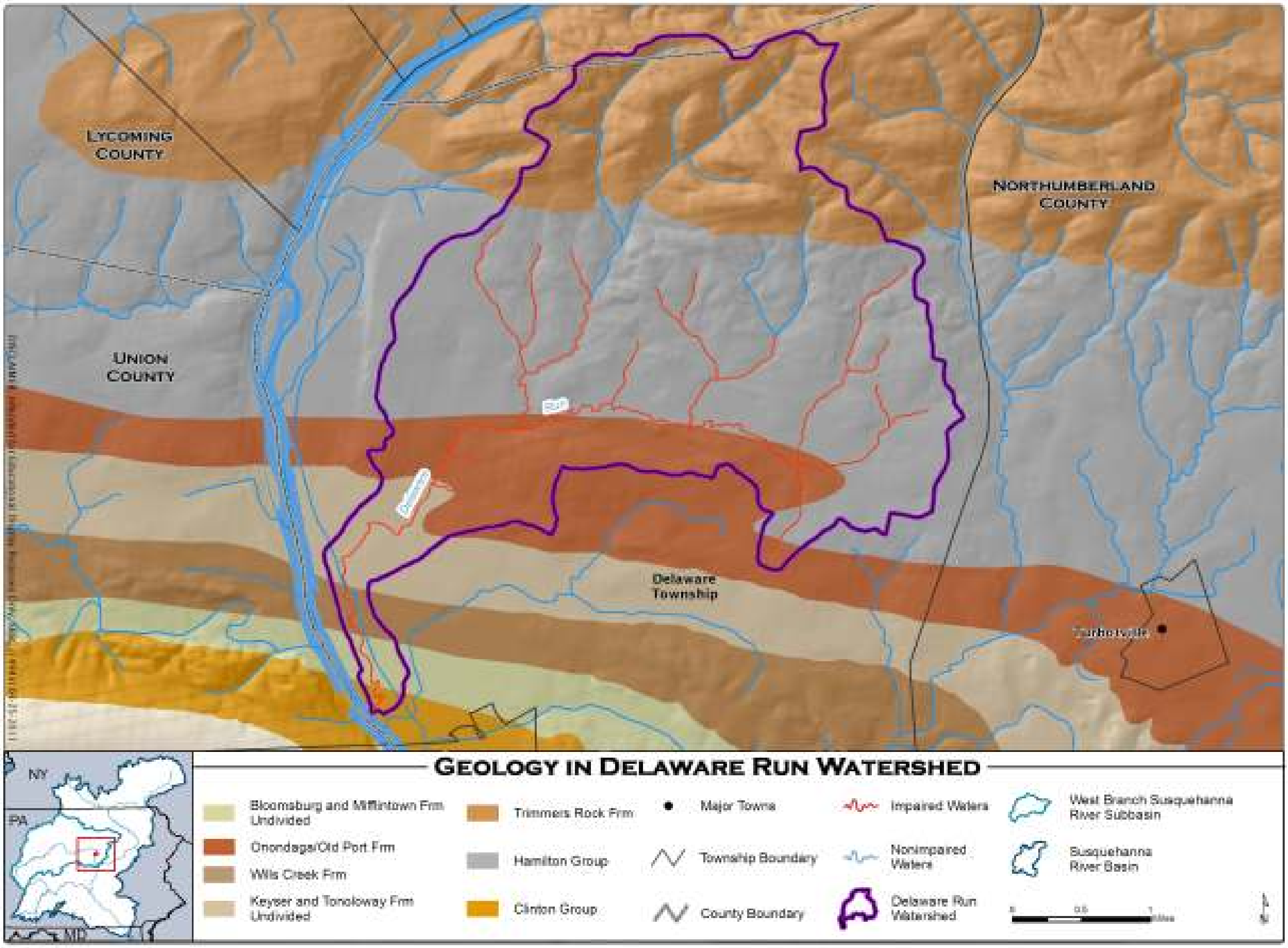

Figure 1. Geology Map of Delaware Run Watershed

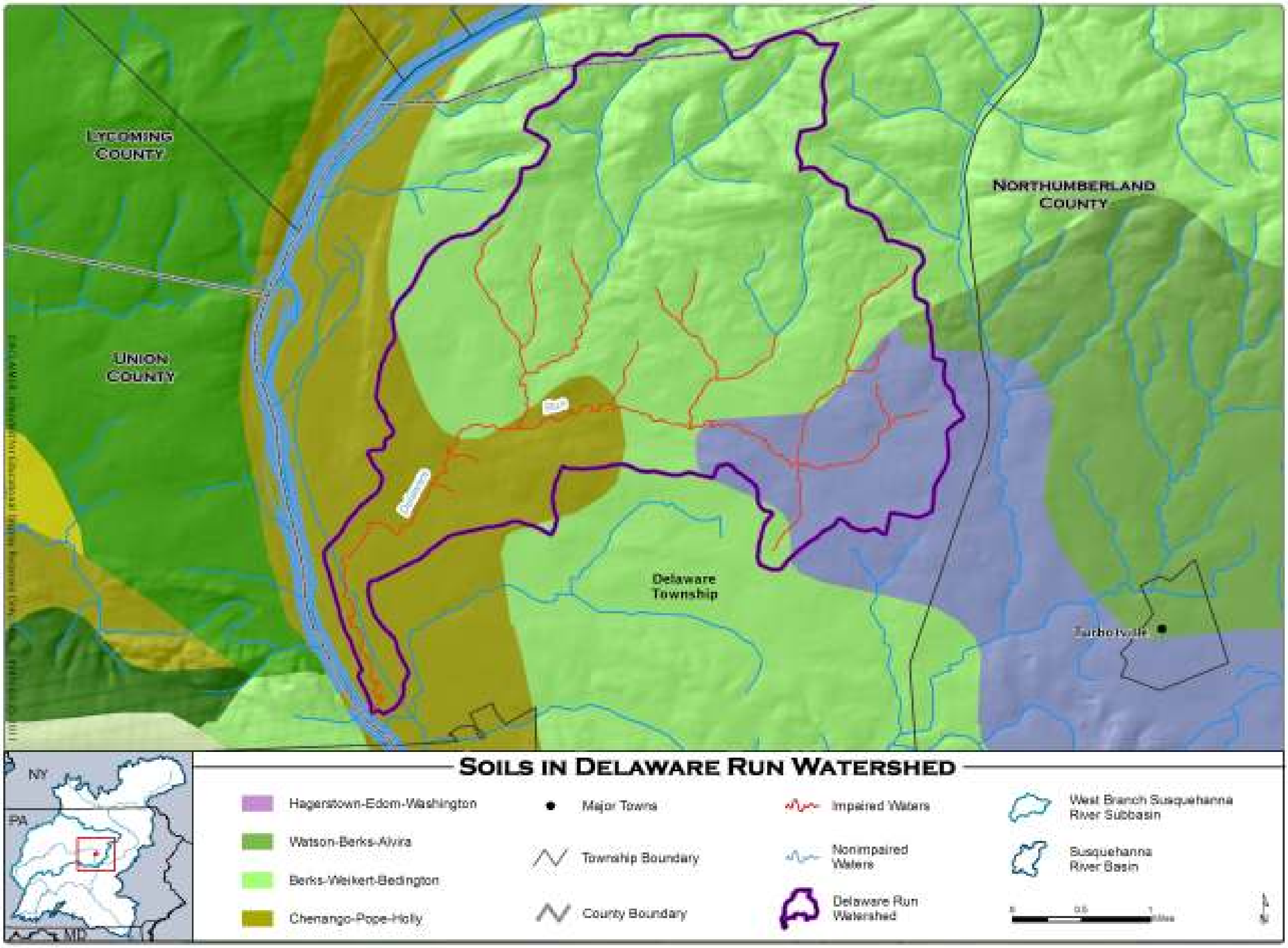

Figure 2. Soils Map of Delaware Run Watershed

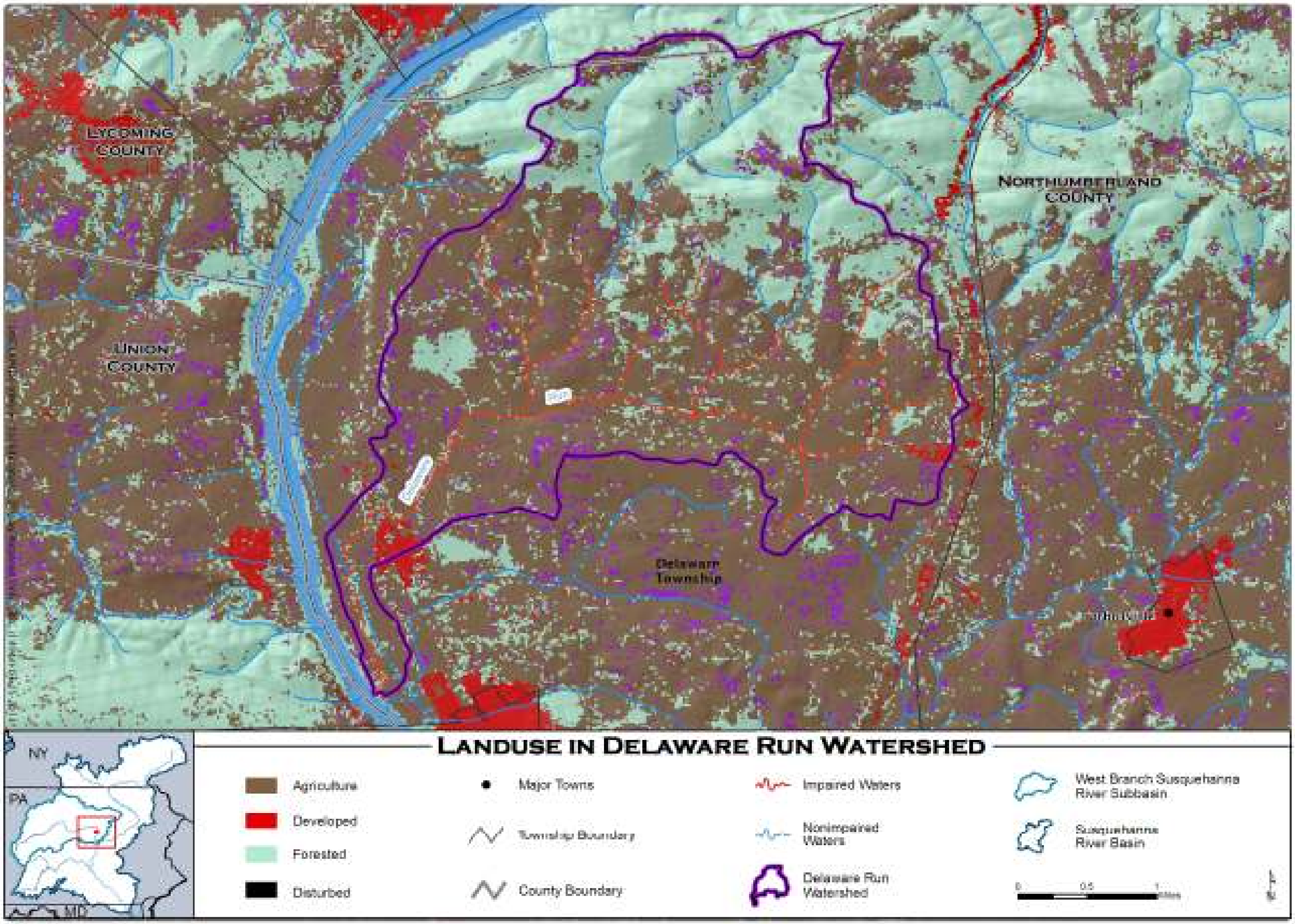

Figure 3. Land Use Map of Delaware Run Watershed

Figure 4. Evidence of Streambank Erosion in the Delaware Run Watershed

Surface Water Quality

Pennsylvania's 2008 edition of the 303(d) list identified 18.61 miles of the Delaware Run Watershed as impaired by 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 – Delaware Run				
Source	**EPA 305(b) Cause Code**	**Miles**	**Designated Use**	**Use Designation**
Agriculture*	Siltation	18.61	CWF, MF	Aquatic Life

* Please see Attachment H for more details.

In general, soil erosion is a major problem in the Delaware Run Watershed. Unrestricted access of livestock to streams results in trampled streambanks, excessive stream sedimentation, 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.

APPROACH TO TMDL DEVELOPMENT

Pollutants & Sources

Sediment has been identified as the pollutant causing designated use impairments in the Delaware 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.

Reference Watershed Approach

The TMDL developed for the Delaware Run Watershed addresses sediment. Because neither Pennsylvania nor the U.S. Environmental Protection Agency (USEPA) has instream numerical water quality criteria for sediment, 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 Delaware 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.

Mugser Run was selected as the reference watershed for developing the Delaware Run Watershed TMDL. Mugser Run is located just south of Numidia, in Columbia County, Pa. (Figure 5). The watershed is located in State Water Plan subbasin 5E, a tributary to Roaring Creek, and protected uses include aquatic life and recreation. The tributary is currently designated as a High Quality Cold Water Fishery (25 Pa. Code Chapter 93). Based on PADEP assessments, Mugser Run 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 Delaware Run Watershed were compared to the Mugser Run Watershed (Table 2). Agricultural land is a dominant land use category in the Delaware Run Watershed (54 percent) and Mugser Run (46 percent). The geology, soils, and precipitation in both are also similar (Table 2).

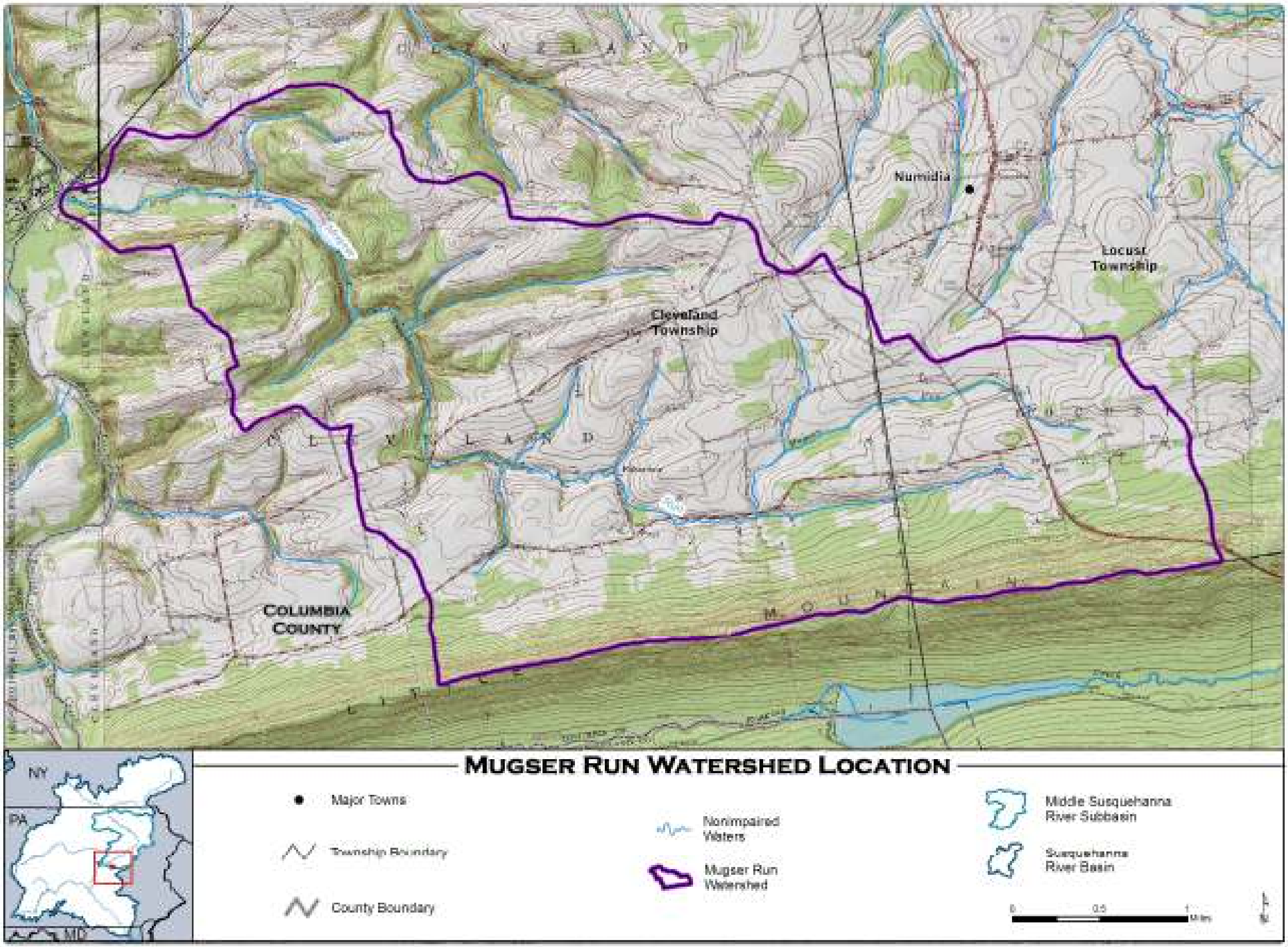

Figure 5. Location Map for Reference Watershed Mugser Run

Table 2. Comparison Between Delaware Run Watershed and Mugser Run Watershed

Attribute	Watershed	
	Delaware Run Watershed	**Mugser Run**
Physiographic Province	Appalachian Mountain Section: Ridge and Valley (100%)	Appalachian Mountain Section: Ridge and Valley (100%)
Area (mi^2)	11.7	11.9
Land Use	Agriculture (53.56%) Development (9.47%) Forested (36.97%)	Agriculture (45.65%) Development (4.11%) Forested (50.24%)
Geology	Hamilton Group (55%) Trimmers Rock (35%) Onondaga/Old Port Formation (10%) Keyser/Tonoloway Formation (5%) Wills Creek Formation (5%) Bloomsburg/Mifflintown Formation (4%) Clinton Group (1%)	Trimmers Rock Formation (35%) Catskill Formation–Buddys Run (35%) Catskill Formation–Irish Valley (20%) Hamilton Group (6%) Spechty Kopf Formation (4%)
Soils	Berks-Weikert-Bedington (60%) Chenango-Pope-Holly (20%) Hagerstown-Edom-Washington (17%) Watson-Berks-Alvira (3%)	Berks-Weikert-Bedington (34%) Leck Kill-Meckesville-Calvin (33%) Hazleton-Dekalb-Buchanan (33%)
Dominant HSG	Berks-Weikert-Bedington A (0%) B (13%) C (52%) D (35%) Chenango-Pope-Holly A (26%) B (37%) C (20%) D (17%) Hagerstown-Edom-Washington A (12%) B (2%) C (82%) D (2%) Watson-Berks-Alvira A (2%) B (18%) C (58%) D (22%)	Berks-Weikert-Bedington A (0%) B (13%) C (52%) D (35%) Leck Kill-Meckesville-Calvin A (0%) B (43%) C (50%) D (7%) Hazleton-Dekalb-Buchanan A (2%) B (45%) C (53%) D (0%)
K Factor	Berks-Weikert-Bedington (0.24) Chenango-Pope-Holly (0.30) Hagerstown-Edom-Washington (0.29) Watson-Berks-Alvira (0.30)	Berks-Weikert-Bedington (0.24) Leck Kill-Meckesville-Calvin (0.24) Hazleton-Dekalb-Buchanan (0.18)
20-Yr. Ave. Rainfall (in)	37.7	39.3
20-Yr. Ave. Runoff (in)	0.13	0.22

Watershed Assessment and Modeling

The TMDL for the impaired segments of the Delaware 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 Delaware Run Watershed and the Mugser Run reference watershed. All modeling inputs have been attached to this TMDL as Attachments D and E. SRBC staff visited the watershed in winter 2010 and spring 2011. The field visits were conducted to get a better understanding of existing conditions that might influence the AVGWLF model. General observations of the individual watershed characteristics include:

Delaware Run Watershed

- Reset P factor for cropland (0.52) and hay/pasture (0.45) land uses to 0.78 and 0.68, respectively, while forested (0.45) remained unchanged. These changes were made to account for the lack of riparian buffer zones, streambank fencing, and stable streambanks.
- Reset C factor for cropland (0.42) and hay/pasture (0.03) land uses to 0.63 and 0.05, respectively, while forested (0.002) remained unchanged. These changes were made to account for the lack of general management practices such as no-till farming and increased presence of erosion through lack vegetative cover.

The AVGWLF model produced information on watershed size, land use, and sediment loading. The sediment loadings represent an annual average over an 8-year period, from 1985 to 1992, and for the Delaware Run Watershed and Mugser Run 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 Loads for Delaware Run Watershed

Pollutant Source	Acreage	Sediment	
		Mean Annual Loading (lbs/day)	Unit Area Loading (lbs/ac/day)
HAY/PAST	1,502.4	521.3699	0.3470
CROPLAND	2,510.6	12,846.7945	5.1170
FOREST	2,770.0	103.8904	0.0375
UNPAVED ROAD	14.8	19.9452	1.3476
TRANSITION	29.7	13.7532	0.4631
LO_INT_DEV	664.7	126.3014	0.1900
Streambank	-	2,305.4205	-
TOTAL	7,492.2	15,937.4753	2.1272

Table 4. Existing Sediment Loads for Mugser Run Watershed

Pollutant Source	Acreage	Sediment	
		Mean Annual Loading (lbs/day)	Unit Area Loading (lbs/ac/day)
HAY/PAST	1,781.6	509.4247	0.2859
CROPLAND	1,685.3	7,515.1233	4.4592
FOREST	3,805.4	483.0685	0.1269
WETLAND	9.9	0.0548	0.0055
UNPAVED ROAD	12.4	44.0548	3.5528
TRANSITION	19.8	31.3973	1.5857
LO_INT_DEV	276.8	229.7532	0.8300
HI_INT_DEV	2.5	0.1096	0.0438
Streambank	-	702.2062	-
TOTAL	7,593.7	9,515.1925	1.2530

TMDLS

The targeted TMDL value for the Delaware Run Watershed was established based on current loading rates for sediment in the Mugser Run reference watershed. Biological assessments have determined that Mugser Run is currently attaining its designated uses.

Reducing the loading rate of sediment in the Delaware 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 was determined by multiplying the total area of the Delaware Run Watershed (7,492.2 acres) by the appropriate unit-area loading rate for the Mugser Run reference watershed (Table 5). The existing mean annual loading of sediment to Delaware Run Watershed (15,937.4753 lbs/day) will need to be reduced by 41 percent, to meet the targeted TMDL of 9,387.7266 lbs/day.

Table 5. Targeted TMDL for Delaware Run Watershed

Pollutant	Area (ac)	Unit Area Loading Rate Mugser Run Reference Watershed (lbs/ac/day)	Targeted TMDL for Delaware Run (lbs/day)
Sediment	7,492.2	1.2530	9,387.7266

Targeted TMDL values were used as the basis for load allocations and reductions in the Delaware 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 TMDLs for sediment 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 Delaware Run Watershed. The MOS used for the sediment TMDLs is shown below.

Delaware Run Watershed:
MOS (sediment) = 9,387.7266 lbs/day (TMDL) x 0.1 = 938.7727 lbs/day

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 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) were carried through at their existing loading values (Table 6).

Table 6. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for Delaware Run

Component	Sediment (lbs/day)
Load Allocation	8,448.9539
Loads not Reduced	103.8904
FOREST	103.8904
Adjusted Load Allocation	8,345.0635

TMDLs

The sediment TMDL established for the Delaware Run Watershed consists of a LA, ALA, and MOS. The individual components of the TMDL are summarized in Table 7.

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

Component	Sediment (lbs/day)
TMDL (Total Maximum Daily Load)	9,387.7266
MOS (Margin of Safety)	938.7727
LA (Load Allocation)	8,448.9539
LNR (Loads not Reduced)	103.8904
ALA (Adjusted Load Allocation)	8,345.0635

CALCULATION OF SEDIMENT LOAD REDUCTIONS

The ALA established in the previous section represents the annual total sediment loads that are available for allocation between contributing sources in the Delaware Run Watershed. The ALA for sediment was allocated between agriculture, developed areas, and streambanks. LA and reduction procedures were applied to the entire Delaware 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 TMDL, the load currently emanating from controllable sources must be reduced (Table 7). This can be achieved through reductions in current sediment loadings from cropland, from hay/pasture, developed areas, and streambanks (Table 8).

Table 8. Sediment Load Allocations and Reductions for Delaware Run Watershed

Pollutant Source	Acres	Unit Area Loading Rate (lbs/ac/day)		Pollutant Loading (lbs/day)		% Reduction
		Current	Allowable	Current	Allowable (LA)	
Sediment						
Hay/Pasture	1,502.4	0.3470	0.2556	521.3699	383.9500	26
Cropland	2,510.6	5.1170	2.4478	12,846.7945	6,145.5156	52
Developed	709.2	0.2256	0.1661	160.0000	117.8280	26
Streambanks	-	-	-	2,305.4205	1,697.7699	26
Total				15,833.5849	8,345.0635	47

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 Delaware Run Watershed TMDL identifies the necessary overall load reductions for sediment 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 reaching Delaware 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 Delaware Run Watershed to help limit sediment 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 Delaware Run Watershed, and it is strongly encouraged to continue.

By developing a sediment TMDL for the Delaware 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 Delaware Run Watershed TMDL was published in the Pa. Bulletin on April 30, 2011, and *The Daily Item* and *Standard Journal* newspaper on April 25, 2011, to foster public comment on the allowable loads calculated. A public meeting was held on May 2, 2011, at the Delaware Township building to discuss the proposed TMDL. The public participation process (which ended on May 30, 2011) was provided for the submittal of comments. Comments and responses are summarized in Attachment H.

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

REFERENCES

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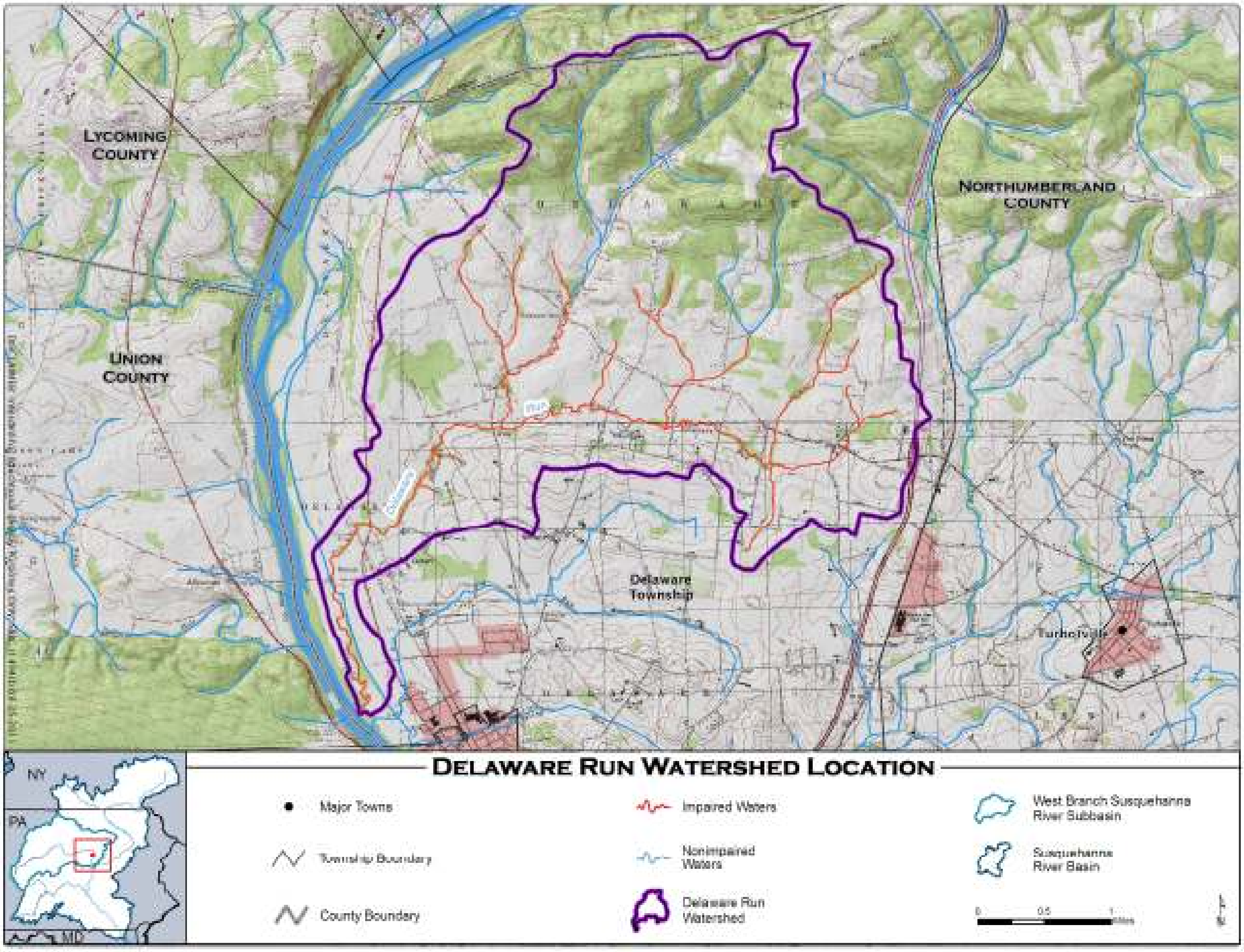
Novotny, V. and H. Olem. 1994. Water Quality: Prevention, Identification, and Management of Diffuse Pollution. Van Nostrand Reinhold, N.Y.

Thomann, R.V. and J.A. Mueller. 1987. Principles of Surface Water Quality Modeling and Control. Harper & Row, N.Y.

Attachment A

Delaware Run Watershed Impaired Waters


LYCOMING COUNTY
UNION COUNTY
NORTHUMBERLAND COUNTY
Delaware Township
Turbotville
NY
PA
MD
DELAWARE RUN WATERSHED LOCATION
Major Towns
Township Boundary
County Boundary
Impaired Waters
Nonimpaired Waters
Delaware Run Watershed
West Branch Susquehanna River Subbasin
Susquehanna River Basin
0
0.5
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Miles

Attachment B

Information Sheet for the Delaware Run Watershed TMDL

What is being proposed?
Total Maximum Daily Load (TMDL) plans have been developed to improve water quality in the Delaware 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 Delaware Run Watershed is impaired due to sediment 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 Delaware Run Watershed selected for TMDL development?
In 2008, PADEP listed segments of the Delaware Run Watershed under Section 303(d) of the federal Clean Water Act as impaired due to causes linked to sediment.

What pollutants do these TMDLs address?
The proposed plans provide calculations of the stream's total capacity to accept sediment.

Where do the pollutants come from?
The sediment related impairments in the Delaware 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 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 wbrown@state.pa.us.

How can I comment on the proposal?

You may provide e-mail or written comments postmarked no later than May 30, 2011 to the above address.

Attachment C

AVGWLF Model Overview & GIS-Based Derivation of Input Data

The TMDL for the Delaware 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 *usew_sept* includes data on conventional systems, and *sew_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 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 *rain_cool* and *rain_warm* 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 *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 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 *aeu_acre* 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 Delaware Run Watershed

Delaware Run Watershed Nutrient Input File

Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	2.9	0.22
Cropland	2.9	0.22
Forest	0.19	0.006
Unpaved_Rd	2.9	0.2
Transition	2.9	0.2
Transition	2.9	0.2
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38

Urban Build-Up	N Kg/ha/d	P Kg/ha/d
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	406	0	17	0
Feb	0.0	0.0	0.0	406	0	17	0
Mar	0.0	0.0	0.0	406	0	17	0
Apr	0.0	0.0	0.0	406	0	17	0
May	0.0	0.0	0.0	406	0	17	0
Jun	0.0	0.0	0.0	406	0	17	0
Jul	0.0	0.0	0.0	406	0	17	0
Aug	0.0	0.0	0.0	406	0	17	0
Sep	0.0	0.0	0.0	406	0	17	0
Oct	0.0	0.0	0.0	406	0	17	0
Nov	0.0	0.0	0.0	406	0	17	0
Dec	0.0	0.0	0.0	406	0	17	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)
2.223	0.027	15	0.1	50	12	2.5	1.6	0.4	3000.0	745.0

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Delaware Run Watershed Transport Input File

Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	608	75	0.262	0.458	0.05	0.68
Cropland	1016	82	0.265	0.462	0.63	0.78
Forest	1121	73	0.248	1.976	0.002	0.45
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Unpaved_Rd	6	87	0.258	0.612	0.1	1
Transition	12	87	0.261	0.262	0.1	0.8
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	269	83	0.26	0.537	0.08	0.2
	0	0	0	0	0	0

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.6	9.3	0	0.12	0	0
Feb	0.65	10.3	0	0.12	0	0
Mar	0.67	11.8	0	0.12	0	0
Apr	0.87	13.2	1	0.3	0	0
May	0.98	14.4	1	0.3	0	0
Jun	1.04	15	1	0.3	0	0
Jul	1.08	14.7	1	0.3	0	0
Aug	1.1	13.7	1	0.3	0	0
Sep	1.11	12.3	1	0.3	0	0
Oct	1.12	10.8	1	0.12	0	0
Nov	0.95	9.6	0	0.12	0	0
Dec	0.85	9	0	0.12	0	0

Init Unsat Stor (cm)	10	**Initial Snow (cm)**	0	**Recess Coefficient**	0.1
Init Sat Stor (cm)	0	**Sed Delivery Ratio**	0.16	**Seepage Coefficient**	0
Unsat Avail Wat (cm)	12.9285	**Tile Drain Ratio**	0.5	**Sediment A Factor**	8.0812E-04
		Tile Drain Density	0	**Sed A Adjustment Factor**	1

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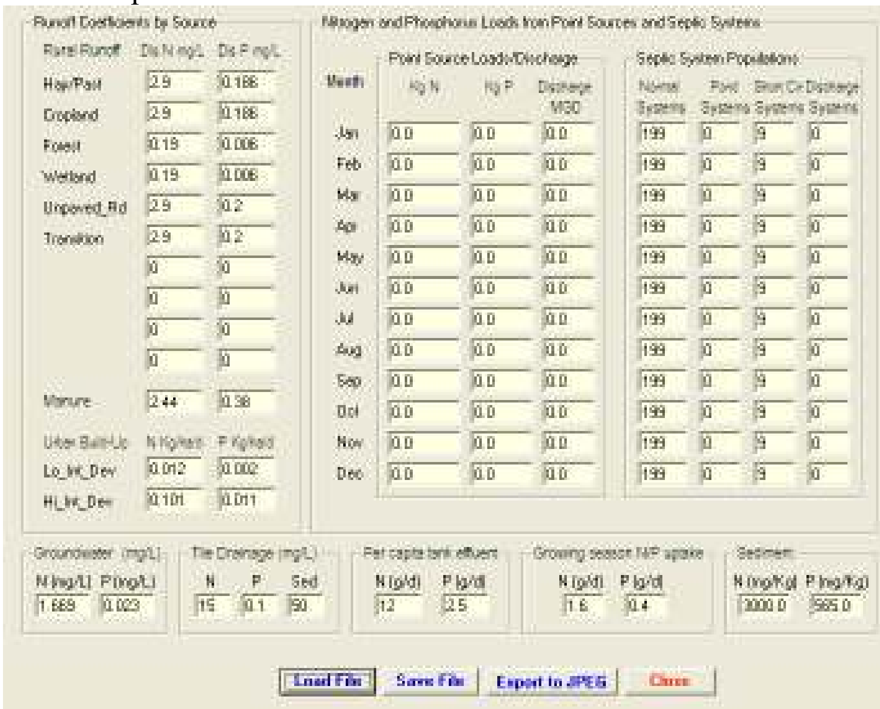
Attachment E

AVGWLF Model Inputs for the Mugser Run Reference Watershed

Mugser Run Nutrient Input File



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	2.9	0.188
Cropland	2.9	0.188
Forest	0.19	0.006
Wetland	0.19	0.006
Unpaved_Rd	2.9	0.2
Transition	2.9	0.2
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Built-Up	N Kg/ha/d	P Kg/ha/d
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	199	0	9	0
Feb	0.0	0.0	0.0	199	0	9	0
Mar	0.0	0.0	0.0	199	0	9	0
Apr	0.0	0.0	0.0	199	0	9	0
May	0.0	0.0	0.0	199	0	9	0
Jun	0.0	0.0	0.0	199	0	9	0
Jul	0.0	0.0	0.0	199	0	9	0
Aug	0.0	0.0	0.0	199	0	9	0
Sep	0.0	0.0	0.0	199	0	9	0
Oct	0.0	0.0	0.0	199	0	9	0
Nov	0.0	0.0	0.0	199	0	9	0
Dec	0.0	0.0	0.0	199	0	9	0

Groundwater (mg/L): N (mg/L)	P (mg/L)	Tile Drainage (mg/L): N	P	Sed	Per capita tank effluent: N (g/d)	P (g/d)	Growing season N/P uptake: N (g/d)	P (g/d)	Sediment: N (mg/Kg)	P (mg/Kg)
1.669	0.023	15	0.1	50	12	2.5	1.6	0.4	3000.0	565.0

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Mugser Run Transport Input File

Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	721	75	0.229	0.829	0.03	0.45
Cropland	682	82	0.231	0.915	0.42	0.45
Forest	1540	73	0.213	5.136	0.002	0.52
Wetland	4	87	0.233	0.246	0.01	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Unpaved_Rd	5	87	0.221	1.446	0.1	1
Transition	8	87	0.216	0.824	0.1	0.8
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	112	83	0.218	2.133	0.08	0.2
Hi_Int_Dev	1	93	0.24	0.127	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.63	9.4	0	0.12	0	0
Feb	0.68	10.3	0	0.12	0	0
Mar	0.71	11.8	0	0.12	0	0
Apr	0.89	13.2	1	0.3	0	0
May	1.0	14.4	1	0.3	0	0
Jun	1.06	14.9	1	0.3	0	0
Jul	1.09	14.6	1	0.3	0	0
Aug	1.11	13.7	1	0.3	0	0
Sep	1.13	12.2	1	0.3	0	0
Oct	1.13	10.8	1	0.12	0	0
Nov	0.97	9.6	0	0.12	0	0
Dec	0.88	9.1	0	0.12	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.16	Seepage Coefficient	0
Unsat Avail Wat (cm)	12.9847	Tile Drain Ratio	0.5	Sediment A Factor	3.4636E-04
		Tile Drain Density	0	Sed A Adjustment Factor	1

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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 the 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 Delaware Run Watershed TMDL

Step 1: TMDL Total Load

Load = loading rate in ref. * Acres in Impaired

9387.7266

Step 2: Adjusted LA = (TMDL total load - MOS) - uncontrollable

8345.0635 8345

SEDIMENT 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.	521.3699	15833.5849	good	521	ADJUST	0.05	137.420	383.950	1502.40	0.256	26%
	Cropland	12846.7945		bad	8345	2987	0.74	2199.548	6145.516	2510.60	2.448	52%
	Developed	160.0000		good	160		0.01	42.172	117.828	709.20	0.166	26%
	Streambank	2305.4205		good	2305		0.20	607.651	1697.770			26%
	Total	15833.5849			11331.85394		1.00		8345.064			

Step 4: All Ag. Loading Rate 1.63

Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.
	Final Hay/Past. LA	1502.40	0.2556	383.9500	0.3470	521.3699	26%
	Final Cropland LA	2510.60	2.4478	6145.5156	5.1170	12846.7945	52%
	Developed	709.20	0.1661	117.8280	0.2256	160.0000	26%
	Streambank			1697.7699		2305.4205	26%
	Total			8345.0635		15833.5849	47%

Delaware Run

Attachment H

Delaware Run Watershed Impaired Segment Listings

Table H1. List of Impaired Stream Segments in Delaware Run Watershed

Segment ID	Year Listed	Stream Name	HUC	Source	Cause	Miles
10453	2002	Delaware Run	02050206	Agriculture	Siltation	8.35
10453	2002	Delaware Run (UNT 19241)	02050206	Agriculture	Siltation	0.19
10453	2002	Delaware Run (UNT 19242)	02050206	Agriculture	Siltation	0.27
10453	2002	Delaware Run (UNT 19243)	02050206	Agriculture	Siltation	1.51
10453	2002	Delaware Run (UNT 19244)	02050206	Agriculture	Siltation	1.05
10453	2002	Delaware Run (UNT 19245)	02050206	Agriculture	Siltation	1.11
10453	2002	Delaware Run (UNT 19246)	02050206	Agriculture	Siltation	0.39
10453	2002	Delaware Run (UNT 19252)	02050206	Agriculture	Siltation	0.54
10453	2002	Delaware Run (UNT 19253)	02050206	Agriculture	Siltation	0.51
10523	2002	Delaware Run (UNT 19253)	02050206	Agriculture Grazing Related	Siltation	0.62
10453	2002	Delaware Run (UNT 19254)	02050206	Agriculture	Siltation	0.96
10453	2002	Delaware Run (UNT 19255)	02050206	Agriculture	Siltation	0.33
10453	2002	Delaware Run (UNT 19257)	02050206	Agriculture	Siltation	0.75
10453	2002	Delaware Run (UNT 19258)	02050206	Agriculture	Siltation	1.21
10453	2002	Delaware Run (UNT 19259)	02050206	Agriculture	Siltation	0.36
10453	2002	Delaware Run (UNT 19260)	02050206	Agriculture	Siltation	0.46

Attachment I

Comment & Response Document for the Delaware Run Watershed TMDL