MUD CREEK
WATERSHED TMDL
Columbia and Montour 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 Derry, West Hemlock, and Madison Townships in Columbia and Montour Counties, Pennsylvania. The stream segments drain approximately 17.5 square miles as part of State Water Plan subbasin 10D. The aquatic life existing uses for Mud Creek, including its tributaries, are warm water fisheries and migratory fishes (25 Pa. Code Chapter 93).

2. Pennsylvania's 2008 303(d) list identified 54.78 miles within the Mud Creek Watershed as impaired by organic enrichment, low dissolved oxygen, and sediment from agricultural land use practices. Organic enrichment is directly associated with livestock deposits in the stream resulting in accelerated oxygen uptake. Phosphorus was used as the surrogate pollutant in this analysis for organic enrichment and low dissolved oxygen listings. 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 Mud Creek Watershed, mean annual loadings for sediment and phosphorus will need to be limited 11,371.5815 pounds per day (lbs/day) and 6.7148 lbs/day, respectively

   The major components of the Mud Creek Watershed TMDL are summarized below.

Mud Creek Watershed Components	**Sediment (lbs/day)**	**Phosphorus (lbs/day)**
TMDL (Total Maximum Daily Load)	11,371.5815	6.7148
WLA (Wasteload Allocation)	-	-
MOS (Margin of Safety)	1,137.1582	0.6715
LA (Load Allocation)	10,234.4233	6.0433

3. Mean annual sediment and phosphorus loadings are estimated at 24,165.5929 lbs/day and 16.6435 lbs/day, respectively. To meet the TMDL, the sediment and phosphorus loadings will require reductions of 58 percent and 64 percent, respectively.

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 and phosphorus TMDL includes a nonpoint source ALA of 10,118.5878 lbs/day and 3.7189 lbs/day, respectively. Sediment and phosphorus loadings from all other sources, such as forested, wetlands, groundwater, and septic systems were maintained at their existing levels. Allocations of sediment and phosphorus to controllable nonpoint sources, or the ALA, for the Mud Creek Watershed TMDL are summarized below.

Mud Creek: Adjusted Load Allocations for Sources of Sediment and Phosphorus			
Pollutant	**Allocated Loading (lbs/day)**	**Adjusted Load Allocation (lbs/day)**	**% Reduction**
Sediment	11,371.5815	10,118.5878	11
Phosphorus	6.7148	3.7189	45

6. Ten percent of the Mud Creek 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 1,137.1582 lbs/day and 0.6715 lbs/day, respectively.

7. The continuous simulation model used for developing the Mud Creek 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 Mud Creek Watershed is approximately 17.5 square miles in area. The headwaters of Mud Creek are located inside the western portion of Columbia County, a few miles northeast of Jerseytown, Pa. The watershed is located on the U.S. Geological Survey (USGS) 7.5 minute quadrangles of Washingtonville and Millville, Pa. The stream flows southwest to its confluence with Chillisquaque Creek. The major tributaries to Mud Creek include several unnamed tributaries (UNTs). Smaller towns include Jerseytown and Washingtonville. State Route 254 travels east/west through the majority of the watershed. Numerous township roads provide access to the Mud Creek 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 southeastern portion of the watershed. The total change in elevation in the watershed is approximately 660 feet from the headwaters to the mouth.

The majority of the rock type in the upland portions of the watershed is shale (80 percent), predominantly associated with the Hamilton Group (Figure 1). The remaining rock types found in the watershed are siltstone and sandstone (20 percent combined), predominantly associated with the Trimmers Rock Formation, and Onondaga and Old Port Formations.

The Watson-Berks-Alvira 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 Berks-Weikert-Bedington 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 63 percent (Figure 3). Forested land uses account for approximately 31 percent of the watershed. Developed areas are 6 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.

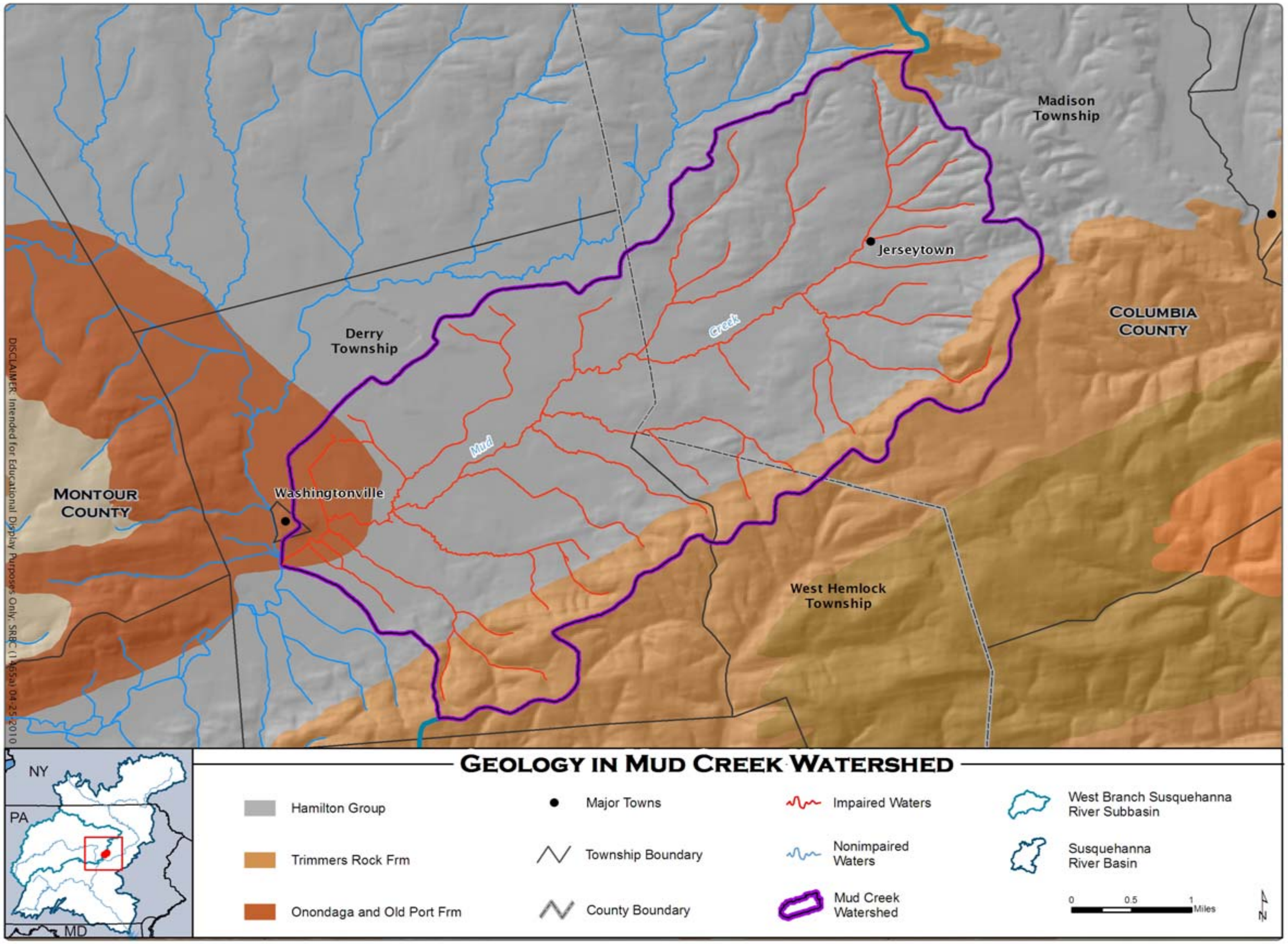

Figure 1. Geology Map of Mud Creek Watershed

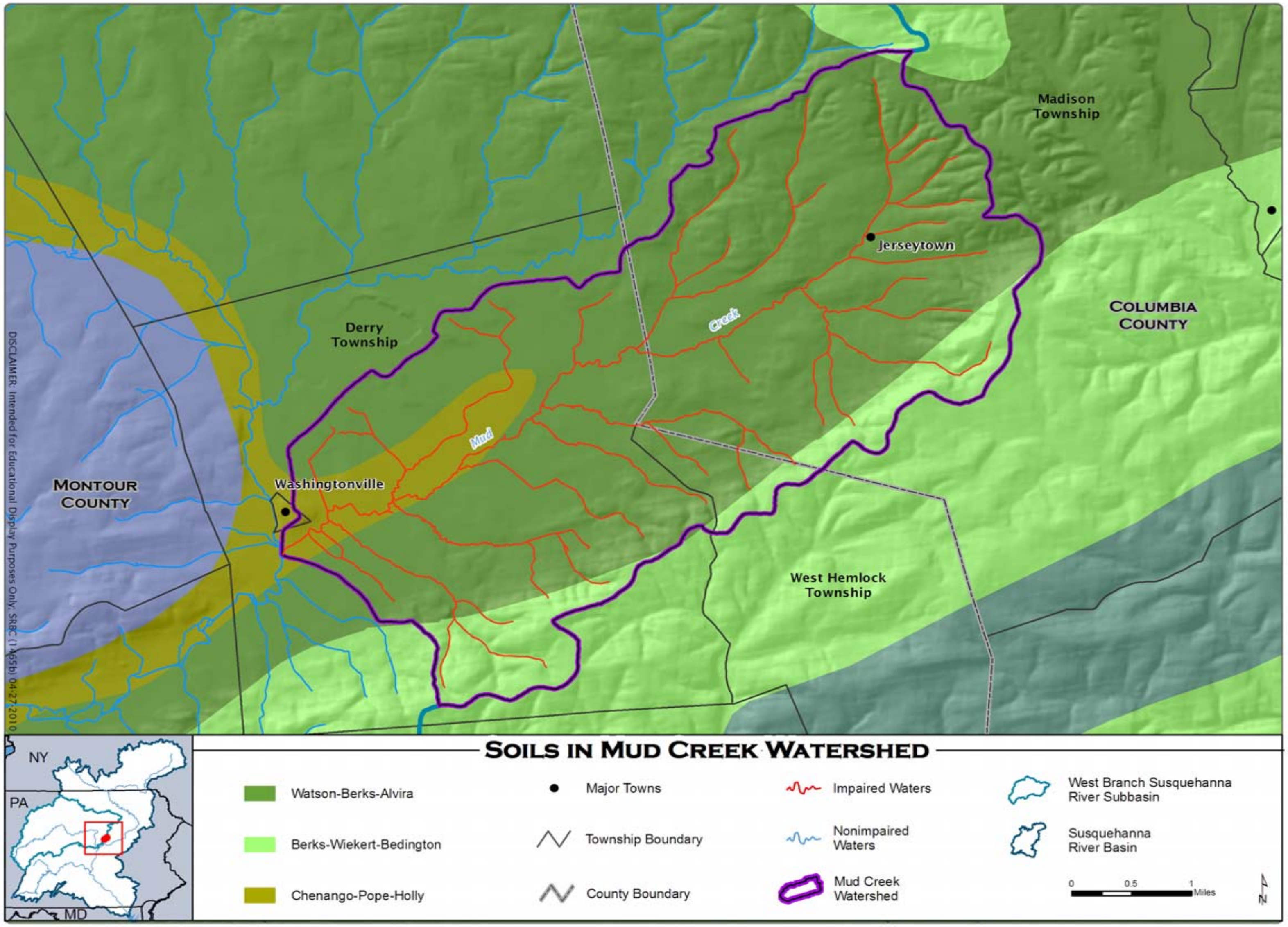

Figure 2. Soils Map of Mud Creek Watershed

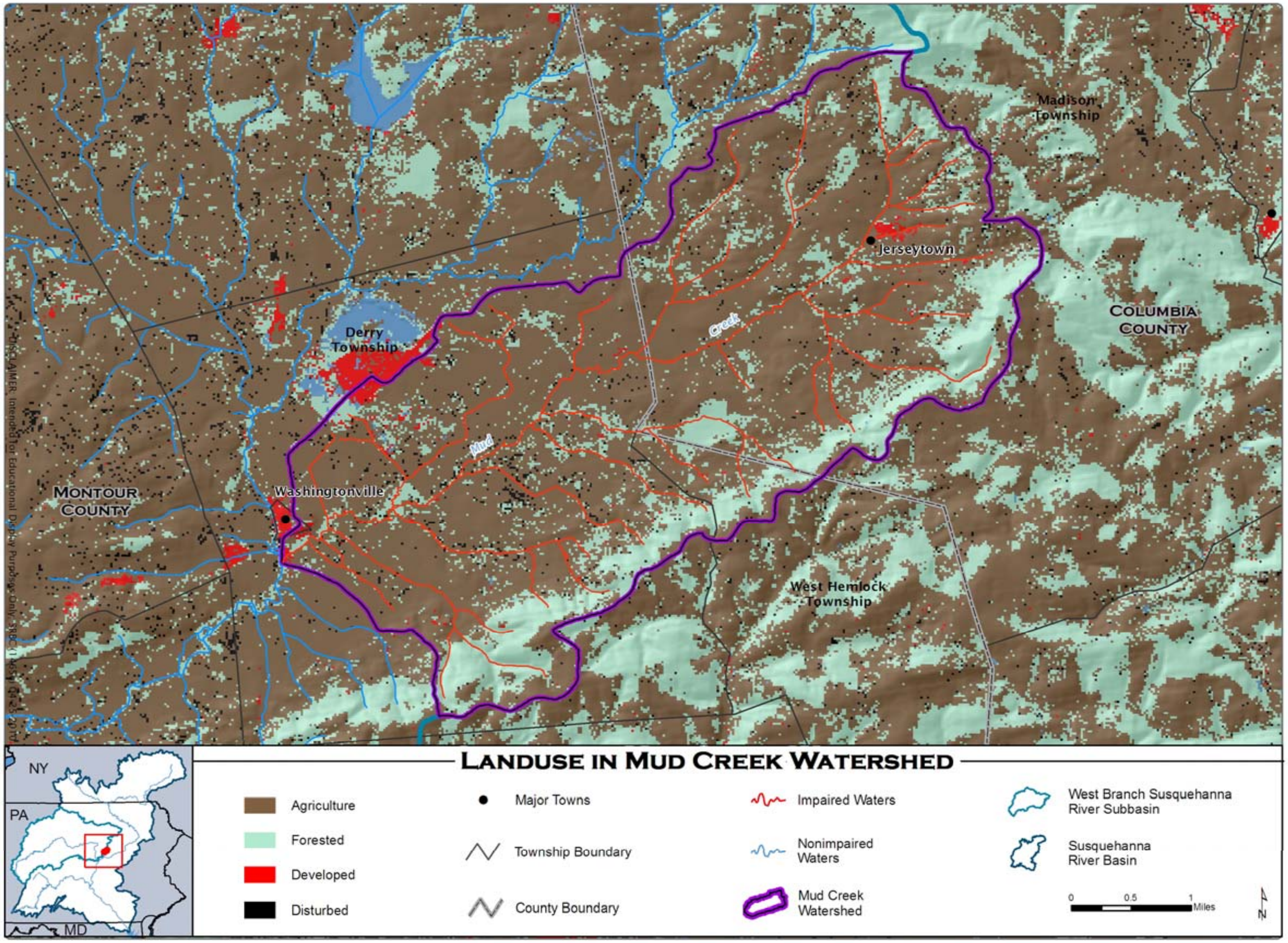

Figure 3. Land Use Map of Mud Watershed

Figure 4. Evidence of Lack of Riparian Vegetation and Streambank Erosion in the Mud Creek Watershed

Surface Water Quality

Pennsylvania's 2008 edition of the 303(d) list(s) identified 54.78 miles of the Mud Creek Watershed as impaired by siltation and organic enrichment/low D.O. emanating from agricultural practices (Table 1).

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

State Water Plan (SWP) Subbasin: 10D				
HUC: 02050305 – Lower Susquehanna-Swatara				
Watershed – Little Swatara Creek Watershed				
Source	**EPA 305(b) Cause Code**	**Miles**	**Designated Use**	**Use Designation**
Agriculture*	Siltation	54.78	WWF, MF	Aquatic Life
Agriculture	Organic Enrichment/ Low D.O.	54.78	WWF, MF	Aquatic Life

* Please refer to Attachment H for more details.

In general, soil erosion is a major problem in the Mud Creek 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. Many of the streams in the subbasin are extremely muddy for several days after summer thunderstorms. 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

Organic enrichment, low dissolved oxygen and sediment have been identified as the pollutants causing designated use impairments in the Mud Creek 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 Mud Creek 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 Mud Creek Watershed, the average N/P ratio is approximately 17, which indicates that phosphorus is the limiting nutrient. Controlling the phosphorus loading to the Mud Creek Watershed will limit plant growth, thereby helping to eliminate use impairments currently being caused by excess nutrients.

Reference Watershed Approach

The TMDL developed for the Mud Creek 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 Mud Creek 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.

Little Buffalo Creek was selected as the reference watershed for developing the Mud Creek Watershed TMDL. Little Buffalo Creek is located just northwest of Lewisburg, in Union County, Pa. (Figure 5). The watershed is located in State Water Plan subbasin 10C, a tributary to Buffalo Creek, and protected uses include aquatic life and recreation. The tributary is currently designated as a Cold Water Fishery (25 Pa. Code Chapter 93). Based on PADEP assessments, Little Buffalo 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 Mud Creek Watershed were compared to the Little Buffalo Creek Watershed (Table 2). Agricultural land is a dominant land use category in the Mud Creek Watershed (63 percent) and Little Buffalo Creek (43 percent). The geology, soils, and precipitation in both are also similar (Table 2).

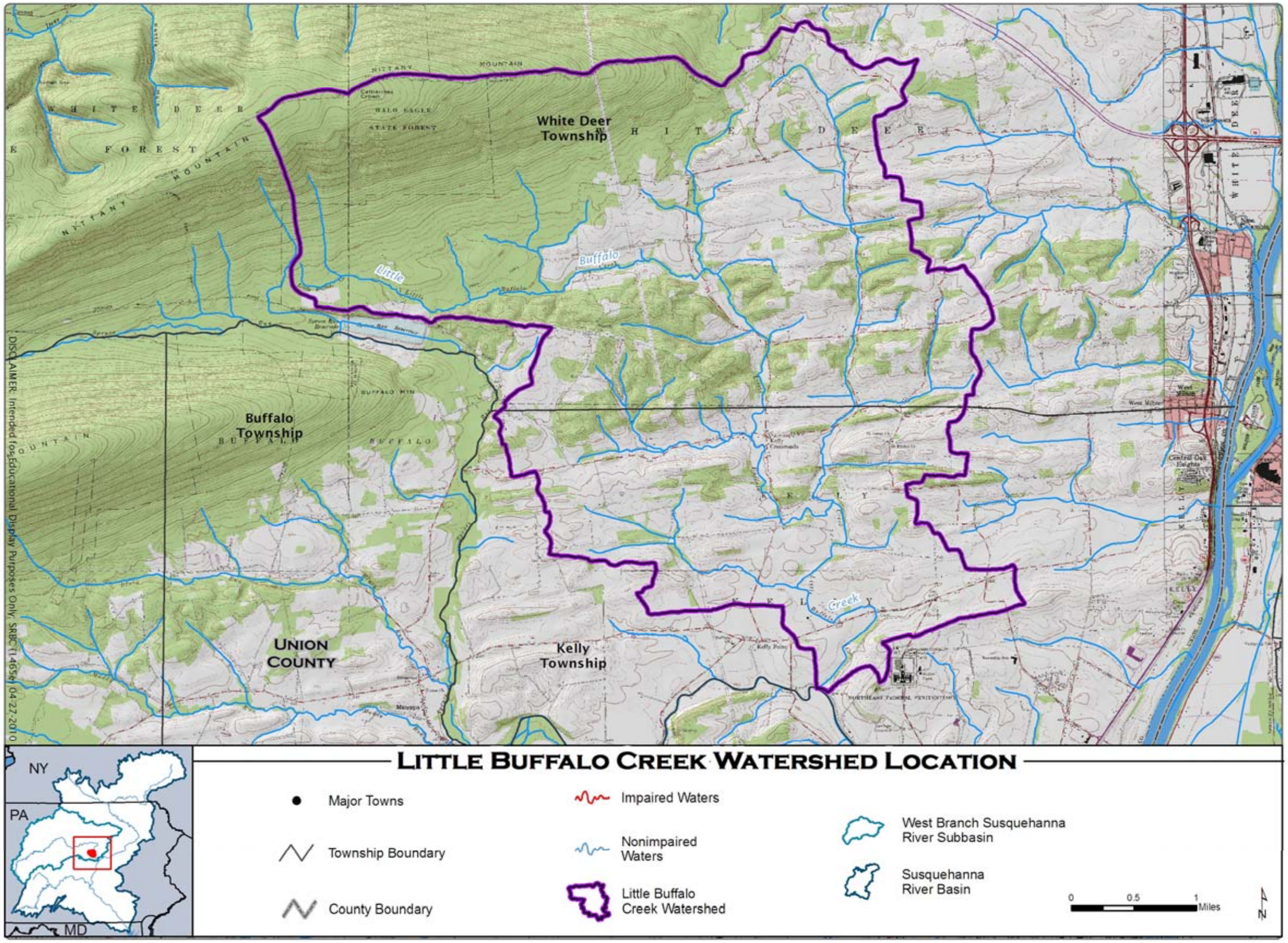

Figure 5. Location Map for Reference Watershed Little Buffalo Creek

Table 2. Comparison Between Mud Creek Watershed and Little Buffalo Creek Watershed

Attribute	Watershed	
	Mud Creek Watershed	**Little Buffalo Creek**
Physiographic Province	Appalachian Mountain Section: Ridge and Valley (100%)	Appalachian Mountain Section: Ridge and Valley (100%)
Area (mi^2)	17.5	19.0
Land Use	Agriculture (62.97%) Development (5.54%) Forested (31.49%)	Agriculture (42.85%) Development (6.70%) Forested (50.46%)
Geology	Hamilton Group (80%) Trimmers Rock Formation (15%) Onondaga and Old Port Formations (5%)	Tuscarora Formation (15%) Clinton Group (30%) Bloomsburg and Mifflintown Formation (30%) Wills Creek Formation (20%) Keyser and Tonoloway Formation (5%)
Soils	Watson-Berks-Alvira (80%) Berks-Weikert-Bedington (12%) Chenango-Pope-Holly (8%)	Berks-Weikert-Bedington (25%) Hazleton-Dekalb-Buchanan (25%) Edom-Millheim-Calvin (30%) Allenwood-Watson-Alvira (15%) Hazleton-Duffield-Clarksburg (5%)
Dominant HSG	Watson-Berks-Alvira A (2%) B (18%) C (58%) D (22%) Berks-Weikert-Bedington A (0%) B (13%) C (52%) D (35%) Chenango-Pope-Holly A (26%) B (37%) C (20%) D (17%)	Berks-Weikert-Bedington A (0%) B (13%) C (52%) D (35%) Hazleton-Dekalb-Buchanan A (2%) B (45%) C (53%) D (0%) Edom-Millheim-Calvin A (0%) B (2%) C (90%) D (8%) Allenwood-Watson-Alvira A (3%) B (55%) C (35%) D (7%) Hazleton-Duffield-Clarksburg A (0%) B (36%) C (60%) D (4%)
K Factor	Watson-Berks-Alvira (0.30) Berks-Weikert-Bedington (0.24) Chenango-Pope-Holly (0.30)	Berks-Weikert-Bedington (0.24) Hazleton-Dekalb-Buchanan (0.18) Edom-Millheim-Calvin (0.28) Allenwood-Watson-Alvira (0.28) Hazleton-Duffield-Clarksburg (0.32)
20-Yr. Ave. Rainfall (in)	44.5	44.5
20-Yr. Ave. Runoff (in)	0.13	0.21

Watershed Assessment and Modeling

The TMDL for the impaired segments of the Mud Creek 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 Mud Creek Watershed and the Little Buffalo Creek reference watershed. All modeling inputs have been attached to this TMDL as Attachments D and E. SRBC staff visited the watershed in the winter and spring of 2010. 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:

<u>Mud Creek Watershed</u>

- Reset P factor for cropland (0.52) and hay/pasture (0.45) land uses to 0.78 and 0.68, while forested (0.45) and wetlands (0.10) 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 0.045, while forested (0.002) and wetlands (0.01) 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, nutrients, and sediment loading. The sediment and nutrient loadings represent an annual average over a 24-year period, from 1975 to 1998, and for the Mud Creek Watershed and Little Buffalo 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 Mud Creek Watershed

		Phosphorus		Sediment	
Pollutant Source	**Acreage**	**Mean Annual Loading (lbs/day)**	**Unit Area Loading (lbs/ac/day)**	**Mean Annual Loading (lbs/day)**	**Unit Area Loading (lbs/ac/day)**
HAY/PAST	2,683.6	1.1005	0.0004	1,016.0548	0.3786
CROPLAND	4,363.9	12.9266	0.0030	19,538.4658	4.4773
FOREST	3,499.0	0.0793	0.0000	115.7808	0.0331
WETLAND	24.7	0.0002	0.0000	0.0548	0.0022
TRANSITION	34.6	0.1493	0.0043	229.8082	6.6419
LO_INT_DEV	585.6	0.0725	0.0001	77.3699	0.1321
Streambank	-	0.0701	-	3,188.0587	-
Groundwater	-	2.1860	-	-	-
Septic System	-	0.0600	-	-	-
TOTAL	11,191.4	16.6435	0.0015	24,165.5929	2.1593

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

		Phosphorus		Sediment	
Pollutant Source	**Acreage**	**Mean Annual Loading (lbs/day)**	**Unit Area Loading (lbs/ac/day)**	**Mean Annual Loading (lbs/day)**	**Unit Area Loading (lbs/ac/day)**
HAY/PAST	2,572.4	1.0609	0.0004	395.8904	0.1539
CROPLAND	2,631.7	6.1927	0.0024	8,038.9041	3.0546
FOREST	6,118.3	0.2034	0.0000	275.8356	0.0451
WETLAND	9.9	0.0002	0.0000	0.0548	0.0055
TRANSITION	42.0	0.1509	0.0036	204.8767	4.8780
LO_INT_DEV	771.0	0.1165	0.0002	120.9863	0.1569
Streambank	-	0.0727	-	3,304.8668	-
Groundwater	-	2.3933	-	-	-
Septic System	-	0.0450	-	-	-
TOTAL	12,145.3	10.2356	0.0008	12,341.4148	1.0161

TMDLS

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

Reducing the loading rate of sediment and phosphorus in the Mud Creek 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 Mud Creek Watershed (11,191.4 acres) by the appropriate unit-area loading rate for the Little Buffalo Creek reference watershed (Table 5). The existing mean annual loading of sediment and phosphorus to Mud Creek Watershed (24,165.5929 lbs/day and 16.6435 lbs/day, respectively) will need to be reduced by 53 and 60 percent, respectively, to meet the targeted TMDL of 11,371.5815 lbs/day and 6.7148 lbs/day, respectively.

Table 5. Targeted TMDL for Mud Creek Watershed

Pollutant	Area (ac)	Unit Area Loading Rate Little Buffalo Creek Reference Watershed (lbs/ac/day)	Targeted TMDL for Mud Creek (lbs/day)
Sediment	11,191.4	1.0161	11,371.5815
Phosphorus	11,191.4	0.0008	6.7148

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

Mud Creek Watershed:
MOS (sediment) = 11,371.5815 lbs/day (TMDL) x 0.1 = 1,137.1582 lbs/day
MOS (phosphorus) = 6.7148 lbs/day (TMDL) x 0.1 = 0.6715 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 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, Groundwater, and Septic Systems) were carried through at their existing loading values (Table 6).

Table 6. Load Allocations, Loads not Reduced, and Adjusted Load Allocation for Mud Creek

Component	Sediment (lbs/day)	Phosphorus (lbs/day)
Load Allocation	10,324.4273	6.0433
Loads not Reduced	115.8395	2.3244
FOREST	115.7808	0.0783
WETLANDS	0.0548	0.0002
Groundwater	-	2.1860
Septic Systems	-	0.0600
Adjusted Load Allocation	10,118.5878	3.7189

TMDLs

The sediment TMDL established for the Mud Creek 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 Mud Creek

Component	Sediment (lbs/day)	Phosphorus (lbs/day)
TMDL (Total Maximum Daily Load)	11,371.5815	6.7148
MOS (Margin of Safety)	1,137.1582	0.6715
LA (Load Allocation)	10,324.4273	6.0433
LNR (Loads not Reduced)	115.8395	2.3244
ALA (Adjusted Load Allocation)	10,118.5878	3.7189

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 Mud Creek Watershed. The ALA for sediment and phosphorus was allocated between agriculture, developed areas, and streambanks. LA and reduction procedures were applied to the entire Mud Creek 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 7). This can be achieved through reductions in current sediment and phosphorus loadings from cropland, from hay/pasture, developed areas, and streambanks (Table 8).

Table 8. Sediment and Phosphorus Load Allocations and Reductions for Mud Creek Watershed

Pollutant Source	Acres	Unit Area Loading Rate (lbs/ac/day)		Pollutant Loading (lbs/day)		% Reduction
		Current	Allowable	Current	Allowable (LA)	
Sediment						
Hay/Pasture	2,683.6	0.3786	0.2619	1,016.0548	702.7426	31
Cropland	4,363.9	4.4773	1.6037	19,538.4658	6,998.4048	64
Developed	620.2	0.4953	0.3426	307.1781	212.4562	31
Streambanks	-	-	-	3,188.0587	2,204.9841	31
Total				24,049.7574	10,118.5877	58
Phosphorus						
Hay/Pasture	2,683.6	0.0004	0.0003	1.1005	0.8007	27
Cropland	4,363.9	0.0030	0.0006	12.9266	2.7058	79
Developed	620.2	0.0004	0.0003	0.2218	0.1614	27
Streambanks	-	-	-	0.0701	0.0510	27
Total				14.3190	3.7189	74

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 Mud Creek 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 Mud Creek 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.

Active groups in the watershed include the Chillisquaque Limestone Run Watershed Association and the Montour County Conservation District. Although significant effort has been made in improving the watershed, they have been limited by lack of interest from residents and have therefore been limited to a few stream bank fencing projects. There is massive potential in this watershed if they are able to break through with connecting to the local population.

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 Mud Creek 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 Mud Creek Watershed, and it is strongly encouraged to continue.

By developing a sediment and phosphorus TMDL for the Mud Creek 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 Mud Creek Watershed TMDL was published in the Pa. Bulletin on June 5, 2010, and *The Daily Item* and *Standard Journal* newspaper on June 1, 2010, to foster public comment on the allowable loads calculated. A public meeting was held on June 21, 2010, at the Montour Preserve Environmental Education Center building to discuss the proposed TMDL. The public participation process (which ended on July 5, 2010) was provided for the submittal of comments. Comments and responses are summarized in Attachment I. There were no public comments received for this TMDL.

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.

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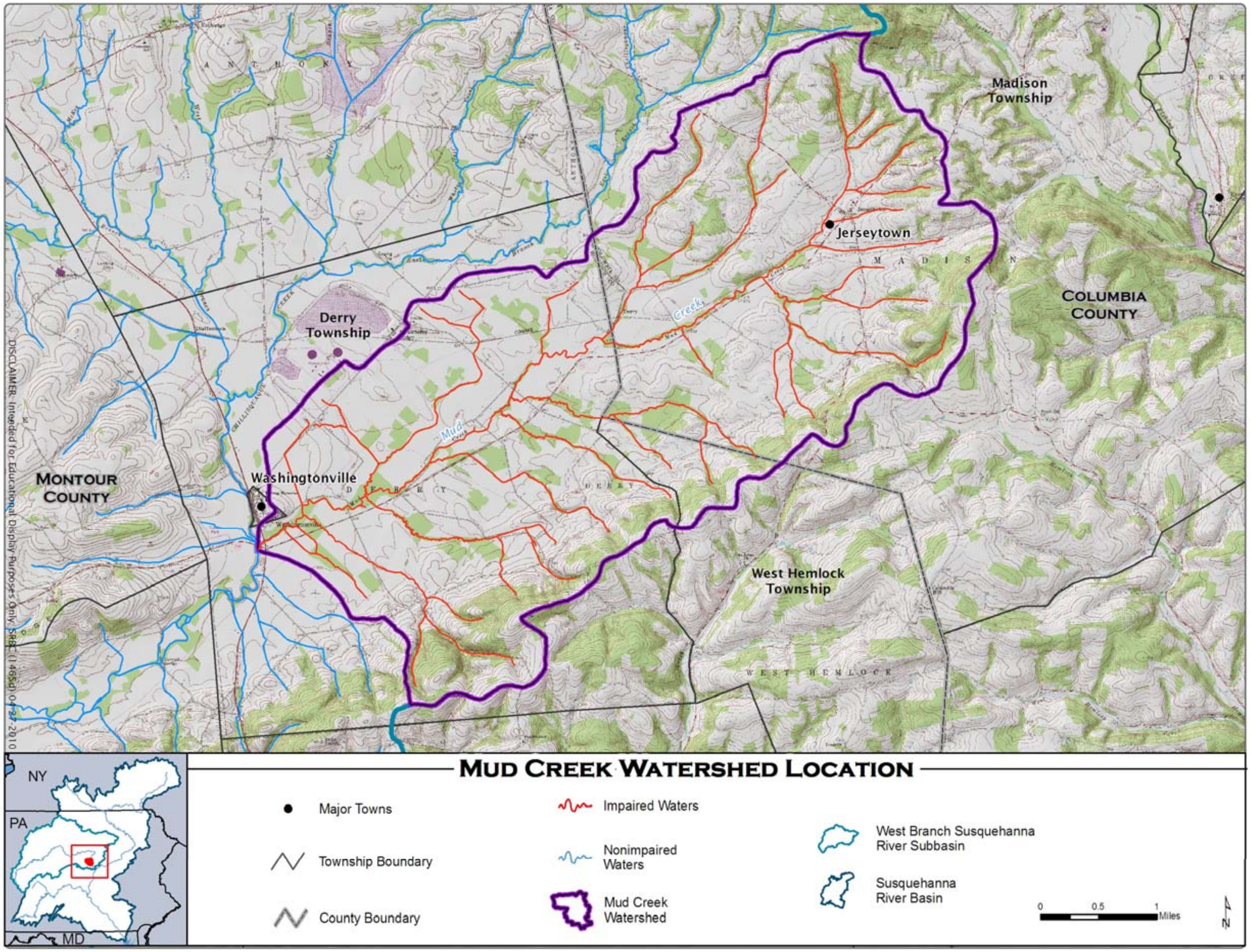
Attachment A

Mud Creek Watershed Impaired Waters


Mud Creek Watershed Location
Madison Township
Jerseytown
Columbia County
Derry Township
Montour County
Washingtonville
West Hemlock Township
Mud
Creek
NY
PA
MD
Major Towns
Township Boundary
County Boundary
Impaired Waters
Nonimpaired Waters
Mud Creek Watershed
West Branch Susquehanna River Subbasin
Susquehanna River Basin
0
0.5
1
Miles
N

Attachment B

Information Sheet for the Mud Creek Watershed TMDL

What is being proposed?

Total Maximum Daily Load (TMDL) plans have been developed to improve water quality in the Mud Creek 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 Mud Creek Watershed is impaired due to sediment and phosphorus emanating from agricultural runoff. The plans include a calculation of the loading for sediment and phosphorus that will correct the problem and meet water quality objectives.

Why was the Mud Creek Watershed selected for TMDL development?

In 2008, PADEP listed segments of the Mud Creek 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 Mud Creek 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 and phosphorus 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 and phosphorus.

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 and phosphorus, 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 and phosphorus 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 wbrown@state.pa.us.

How can I comment on the proposal?
You may provide e-mail or written comments postmarked no later than July 5, 2010 to the above address.

Attachment C

AVGWLF Model Overview & GIS-Based Derivation of Input Data

The TMDL for the Mud Creek 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.

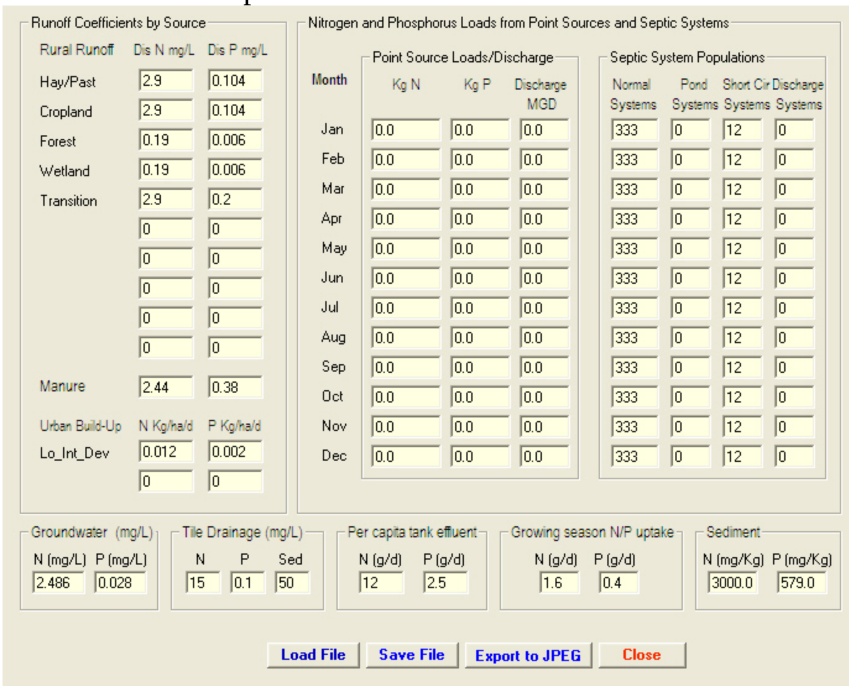
The following table lists the statewide GIS data sets and provides an explanation of how they were used for development of the input files for the GWLF model.

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 Mud Creek Watershed

Mud Creek Watershed Nutrient Input File



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	2.9	0.104
Cropland	2.9	0.104
Forest	0.19	0.006
Wetland	0.19	0.006
Transition	2.9	0.2
	0	0
	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
	0	0

Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

	Point Source Loads/Discharge			Septic System Populations			
Month	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	333	0	12	0
Feb	0.0	0.0	0.0	333	0	12	0
Mar	0.0	0.0	0.0	333	0	12	0
Apr	0.0	0.0	0.0	333	0	12	0
May	0.0	0.0	0.0	333	0	12	0
Jun	0.0	0.0	0.0	333	0	12	0
Jul	0.0	0.0	0.0	333	0	12	0
Aug	0.0	0.0	0.0	333	0	12	0
Sep	0.0	0.0	0.0	333	0	12	0
Oct	0.0	0.0	0.0	333	0	12	0
Nov	0.0	0.0	0.0	333	0	12	0
Dec	0.0	0.0	0.0	333	0	12	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)
2.486	0.028	15	0.1	50	12	2.5	1.6	0.4	3000.0	579.0

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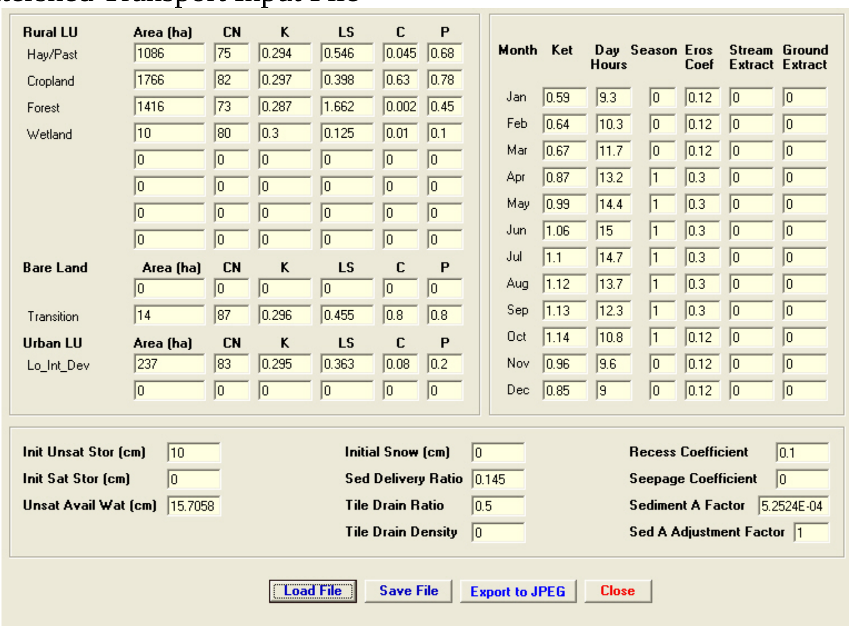
Mud Creek Watershed Transport Input File



Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	1086	75	0.294	0.546	0.045	0.68
Cropland	1766	82	0.297	0.398	0.63	0.78
Forest	1416	73	0.287	1.662	0.002	0.45
Wetland	10	80	0.3	0.125	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**
	0	0	0	0	0	0
Transition	14	87	0.296	0.455	0.8	0.8
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	237	83	0.295	0.363	0.08	0.2
	0	0	0	0	0	0

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.59	9.3	0	0.12	0	0
Feb	0.64	10.3	0	0.12	0	0
Mar	0.67	11.7	0	0.12	0	0
Apr	0.87	13.2	1	0.3	0	0
May	0.99	14.4	1	0.3	0	0
Jun	1.06	15	1	0.3	0	0
Jul	1.1	14.7	1	0.3	0	0
Aug	1.12	13.7	1	0.3	0	0
Sep	1.13	12.3	1	0.3	0	0
Oct	1.14	10.8	1	0.12	0	0
Nov	0.96	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**	0.145	**Seepage Coefficient**	0
Unsat Avail Wat (cm)	15.7058	**Tile Drain Ratio**	0.5	**Sediment A Factor**	5.2524E-04
		Tile Drain Density	0	**Sed A Adjustment Factor**	1

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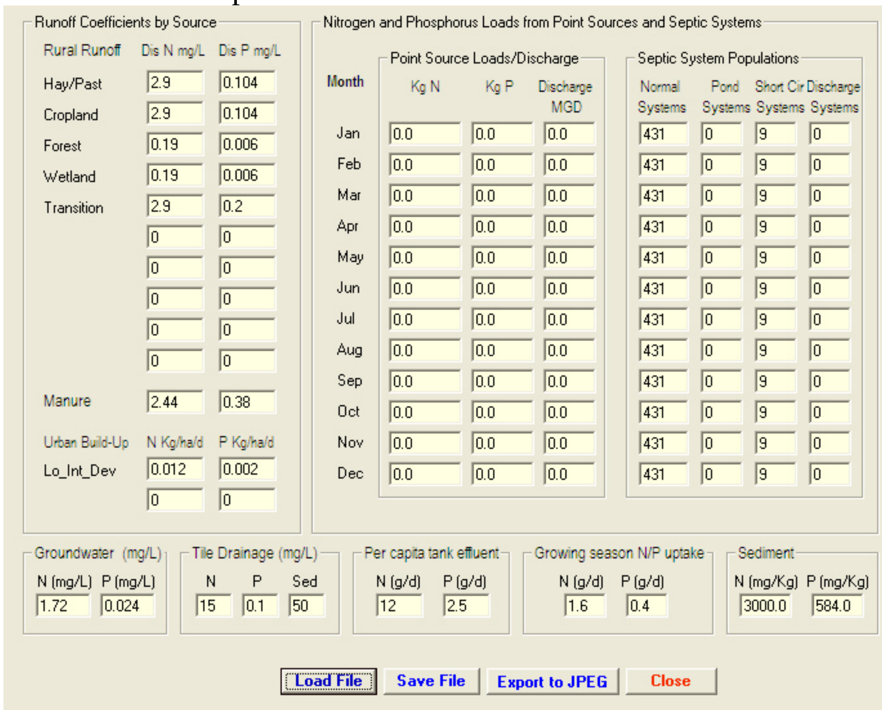
Attachment E

AVGWLF Model Inputs for the Little Buffalo Creek Reference Watershed

Little Buffalo Creek Nutrient Input File



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	2.9	0.104
Cropland	2.9	0.104
Forest	0.19	0.006
Wetland	0.19	0.006
Transition	2.9	0.2
	0	0
	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
	0	0

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	431	0	9	0
Feb	0.0	0.0	0.0	431	0	9	0
Mar	0.0	0.0	0.0	431	0	9	0
Apr	0.0	0.0	0.0	431	0	9	0
May	0.0	0.0	0.0	431	0	9	0
Jun	0.0	0.0	0.0	431	0	9	0
Jul	0.0	0.0	0.0	431	0	9	0
Aug	0.0	0.0	0.0	431	0	9	0
Sep	0.0	0.0	0.0	431	0	9	0
Oct	0.0	0.0	0.0	431	0	9	0
Nov	0.0	0.0	0.0	431	0	9	0
Dec	0.0	0.0	0.0	431	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)
1.72	0.024	15	0.1	50	12	2.5	1.6	0.4	3000.0	584.0

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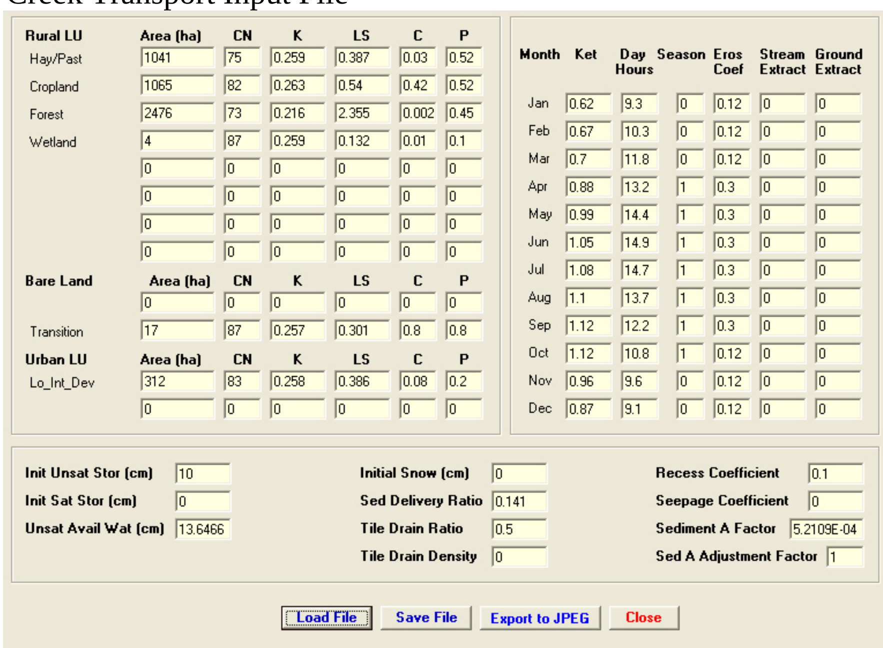
Little Buffalo Creek Transport Input File



Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	1041	75	0.259	0.387	0.03	0.52
Cropland	1065	82	0.263	0.54	0.42	0.52
Forest	2476	73	0.216	2.355	0.002	0.45
Wetland	4	87	0.259	0.132	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**
	0	0	0	0	0	0
Transition	17	87	0.257	0.301	0.8	0.8
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	312	83	0.258	0.386	0.08	0.2
	0	0	0	0	0	0

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.62	9.3	0	0.12	0	0
Feb	0.67	10.3	0	0.12	0	0
Mar	0.7	11.8	0	0.12	0	0
Apr	0.88	13.2	1	0.3	0	0
May	0.99	14.4	1	0.3	0	0
Jun	1.05	14.9	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	1.12	12.2	1	0.3	0	0
Oct	1.12	10.8	1	0.12	0	0
Nov	0.96	9.6	0	0.12	0	0
Dec	0.87	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	0.141	Seepage Coefficient	0
Unsat Avail Wat (cm)	13.6466	Tile Drain Ratio	0.5	Sediment A Factor	5.2109E-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 Mud Creek Watershed TMDL

Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable						
	Load = loading rate in ref. * Acres in Impaired					10,118.5878	10119					
	11371.5815											
	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.	1016.0548	24049.7574	good	1016	ADJUST	0.07	313.312	702.743	2683.60	0.262	31%
	Cropland	19538.4658		bad	10119	4511	0.69	3120.183	6998.405	4363.90	1.604	64%
	Developed	307.1781		good	307		0.02	94.722	212.456	620.20	0.343	31%
	Streambank	3188.0587		good	3188		0.22	983.075	2204.984			31%
	Total	24049.7574			14629.87939		1.00		10118.588			
Step 4:	All Ag. Loading Rate	1.09										
Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.					
	Final Hay/Past. LA	2683.60	0.2619	702.7426	0.3786	1016.0548	31%					
	Final Cropland LA	4363.90	1.6037	6998.4048	4.4773	19538.4658	64%					
	Developed	620.20	0.3426	212.4562	0.4953	307.1781	31%					
	Streambank			2204.9841		3188.0587	31%					
	Total			10118.5878		24049.7574	58%					
	Mud Creek											

Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable						
	Load = loading rate in ref. * Acres in Impaired					3.7189	4					
	6.7148											
	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.	1.1005	14.319	good	1	ADJUST	0.22	0.300	0.801	2683.60	0.000	27%
	Cropland	12.9266		bad	4	1	0.73	1.013	2.706	4363.90	0.001	79%
	Developed	0.2218		good	0		0.04	0.060	0.161	620.20	0.000	27%
	Streambank	0.0701		good	0		0.01	0.019	0.051			27%
	Total	14.319			5.111256		1.00		3.719			
Step 4:	All Ag. Loading Rate	0.00										
Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.					
	Final Hay/Past. LA	2683.60	0.0003	0.8007	0.0004	1.1005	27%					
	Final Cropland LA	4363.90	0.0006	2.7058	0.0030	12.9266	79%					
	Developed	620.20	0.0003	0.1614	0.0004	0.2218	27%					
	Streambank			0.0510		0.0701	27%					
	Total			3.7189		14.3190	74%					
	Mud Creek											

Attachment H

Mud Creek Watershed Impaired Segment Listings

Stream Name / Use Designation (Assessment ID) / Source	Cause	Date Listed	TMDL Date

Hydrologic Unit Code: 02050206 - Lower West Branch Susquehanna

Mud Creek
HUC: 02050206

Aquatic Life (8343) - 8.48 miles; 22 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011

Mud Creek (Unt 18778)
HUC: 02050206

Aquatic Life (8343) - 0.93 miles; 2 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011

Mud Creek (Unt 18779)
HUC: 02050206

Aquatic Life (8343) - 3.13 miles; 5 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011

Mud Creek (Unt 18780)
HUC: 02050206

Aquatic Life (8343) - 0.56 miles; 1 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011

Mud Creek (Unt 18782)
HUC: 02050206

Aquatic Life (8343) - 0.86 miles; 2 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011

Mud Creek (Unt 18784)
HUC: 02050206

Aquatic Life (8343) - 2.87 miles; 7 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011

*Segments are defined as individual COM IDs.

Stream Name Use Designation (Assessment ID) Source	Cause	Date Listed	TMDL Date
Mud Creek (Unt 18785) HUC: 02050206			
Aquatic Life (8343) - 0.59 miles; 1 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18787) HUC: 02050206			
Aquatic Life (8343) - 2.64 miles; 4 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18788) HUC: 02050206			
Aquatic Life (8343) - 0.78 miles; 2 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18789) HUC: 02050206			
Aquatic Life (8343) - 0.32 miles; 2 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18790) HUC: 02050206			
Aquatic Life (8343) - 0.48 miles; 1 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18791) HUC: 02050206			
Aquatic Life (8343) - 1.96 miles; 1 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18793) HUC: 02050206			
Aquatic Life (8343) - 1.86 miles; 2 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011

*Segments are defined as individual COM IDs.

Stream Name Use Designation (Assessment ID) Source	Cause	Date Listed	TMDL Date
Mud Creek (Unt 18793) HUC: 02050206			
Aquatic Life (8343) - 1.86 miles; 2 Segment(s)*			
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18794) HUC: 02050206			
Aquatic Life (8343) - 3.28 miles; 4 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18796) HUC: 02050206			
Aquatic Life (8343) - 0.58 miles; 1 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18797) HUC: 02050206			
Aquatic Life (8343) - 0.83 miles; 1 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18798) HUC: 02050206			
Aquatic Life (8343) - 3.04 miles; 5 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18799) HUC: 02050206			
Aquatic Life (8343) - 1.83 miles; 3 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18800) HUC: 02050206			
Aquatic Life (8343) - 0.67 miles; 2 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18801) HUC: 02050206			
Aquatic Life (8343) - 0.35 miles; 1 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011

*Segments are defined as individual COM IDs.

Stream Name / Use Designation (Assessment ID) / Source	Cause	Date Listed	TMDL Date
Mud Creek (Unt 18801) HUC: 02050206			
Mud Creek (Unt 18802) HUC: 02050206			
Aquatic Life (8343) - 0.49 miles; 1 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18803) HUC: 02050206			
Aquatic Life (8343) - 2.20 miles; 3 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18804) HUC: 02050206			
Aquatic Life (8343) - 1.91 miles; 3 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18806) HUC: 02050206			
Aquatic Life (8343) - 0.91 miles; 2 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18807) HUC: 02050206			
Aquatic Life (8343) - 0.72 miles; 1 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18808) HUC: 02050206			
Aquatic Life (8343) - 1.17 miles; 1 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18810) HUC: 02050206			
Aquatic Life (8343) - 0.77 miles; 2 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011

*Segments are defined as individual COM IDs.

Stream Name / Use Designation (Assessment ID) / Source	Cause	Date Listed	TMDL Date
Mud Creek (Unt 18811)			
HUC: 02050206			
Aquatic Life (8343) - 0.66 miles; 1 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18812)			
HUC: 02050206			
Aquatic Life (8343) - 0.49 miles; 1 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011
Mud Creek (Unt 18813)			
HUC: 02050206			
Aquatic Life (8343) - 0.35 miles; 1 Segment(s)*			
Agriculture	Organic Enrichment/Low D.O.	1998	2011
Agriculture	Siltation	1998	2011

Report Summary

Watershed Summary

	Stream Miles	Assessment Units	Segments (COMIDs)
Watershed Characteristics	46.91	1	95

Impairment Summary

Source	Cause	Miles	Assessment Units	Segments (COMIDs)
Agriculture	Organic Enrichment/Low D.O.	45.86	1	91
Agriculture	Siltation	45.86	1	91
		45.86 **	**1** **	**91** **

**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	45.86	1	91

*Segments are defined as individual COM IDs.

Attachment I

Comment & Response Document for the Mud Creek Watershed TMDL

No official comments were received for this TMDL.