Sediment Total Maximum Daily Load
For

Patterson Creek

Stream Code - 42695

Armstrong County, PA (18-F)

Prepared by

Southwestern Regional Office

Pennsylvania Department of Environmental Protection

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I.   TMDL Overview

The TMDL development process is a nationwide effort to inventory and improve the health of our waters. Each water body in Pennsylvania has water quality standards that define the amount of substances with pollution-potential that can exist therein. The attainment of these standards is essential to ensure that the quality of each water body can support its "protected use." Water quality may be protected to support coldwater fishes, recreational activities, potable water, or many other "protected uses." When the water quality standards of a water body are not met, the water is classified as being "impaired." Section 303(d) of the Clean Water Act requires all impaired waters to be identified and documented. Consequently, the Pennsylvania Department of Environmental Protection is assessing all of its water bodies, and listing those that are impaired on its own 303(d) list. Furthermore, regulations require that a TMDL study must be completed for each impaired water body on this list. The goal of such a study is to determine how to restore impaired water bodies.

Identifying and eliminating all sources of the pollutant would of course be the optimal method of restoration; however, this is rarely feasible or possible. Instead, a TMDL study is directed at determining the total maximum daily load (TMDL) of a pollutant that a water body can assimilate (uptake) and still maintain its water quality standards. Once a TMDL is determined in terms of a pollutant load (e.g., lbs nitrogen/yr), this value is compared to the existing load. In general, the difference between the TMDL and the existing load constitutes the targeted load reduction.

To reach this targeted load, reductions from the loads of both point (e.g., sewage treatment facility discharge) and non-point (e.g., farmland runoff) sources are considered. Pollutant contributions from non-point sources often comprise the majority of the total load. To reduce these loads, Best Management Practices (BMPs) are reviewed and recommended to land owners. Riparian buffer strips (Figure 1) and contour buffers strips (Figure 2) are examples of BMPs. Proper implementation of these land management strategies can cause substantial reductions of pollutants, and consequently can have a meaningful and positive effect on the health of our waters.

Figures 1 and 2 (left to right). Photographs of areas where BMPs have been implemented to reduce nutrient leaching. Fig. 1 – Riparian buffer strip, and Fig 2. – Contour buffer strip.

II. Executive Summary

This TMDL was developed for Patterson Creek, Armstrong County (18-F). This stream was identified on the 2006 Section 303(d) list as being impaired by sediment in the form of siltation.   Sources of sediment pollution were listed to be crop-related and grazing-related agriculture. Specific causes of impairment to the stream were identified as streambank erosion due to 1) grazing of bank vegetation, 2) trampling of the streambank by livestock, and 3) accelerated runoff from steep bordering land. In addition, runoff from cropland and pastureland was found to be directly carrying sediment into the stream.

Using AVGWLF® (Appendix A), a watershed that currently attains its water quality standards, and has several relevant similarities with the impaired watershed was found: Thorn Creek. This watershed is located approximately 10 miles southwest of Patterson Creek, and is similar except that it has vast areas of trees, grasses and shrubs that add stability to streambanks, and buffer the flow of runoff from agriculture areas. Using the GWLF® model, the existing loads of sediment from non-point sources (no point sources present) were determined for both the impaired and reference watersheds. Using this data, the loading rate of the reference watershed was calculated, and used to determine the TMDL for the impaired watershed.

A 10% margin of safety (MOS), and non-point source loads that will not be reduced (LNRs) were then subtracted from the TMDL (Table i). The remaining load (ALA) was then allocated among non-point sources, and required reductions were determined. Reductions can be achieved by implementing Best Land Management Practices (BMP). Based upon the causes of sediment pollution in this watershed, the following BMPs were recommended: 1) Runoff Management System, 2) Stream Channel Stabilization, 3) Streambank and Shoreline Protection, and 4) Fencing. Information sheets about each of these BMPs are included in the appendix G of this report.

Table i. Descriptive parameters and their corresponding values for the Patterson Creek TMDL.

Parameter	Sediment (tons/yr)
TMDL (Total Max Daily Load)	**1665.83**
WLA (Wasteload Allocation)	**0**
ALA (Adjusted Load Allocation)	**1488.59**
LNRs (Loads not reduced)	**10.4**
MOS (Margin of Safety)	**166.55**
TMDL / 365 Days	**4.56 tons/day**

III. Introduction

A. Watershed Description

1. Location and General Description

Patterson Creek (stream code – 42695) is located in northwestern Armstrong County, near Frogtown (Figure 1). Its watershed lies within Sugar Creek Township (USGS quadrangle – Chicora), and borders the watersheds of Buffalo Run, Glade Run, Hart Run, Holder Run, and Huling Run. From its headwaters, it flows south through sub-basin 18-F for about 8 miles before joining with Buffalo Creek (stream code - 42557). Its 16.7 mi^2-watershed encompasses about 44.7 miles of stream.
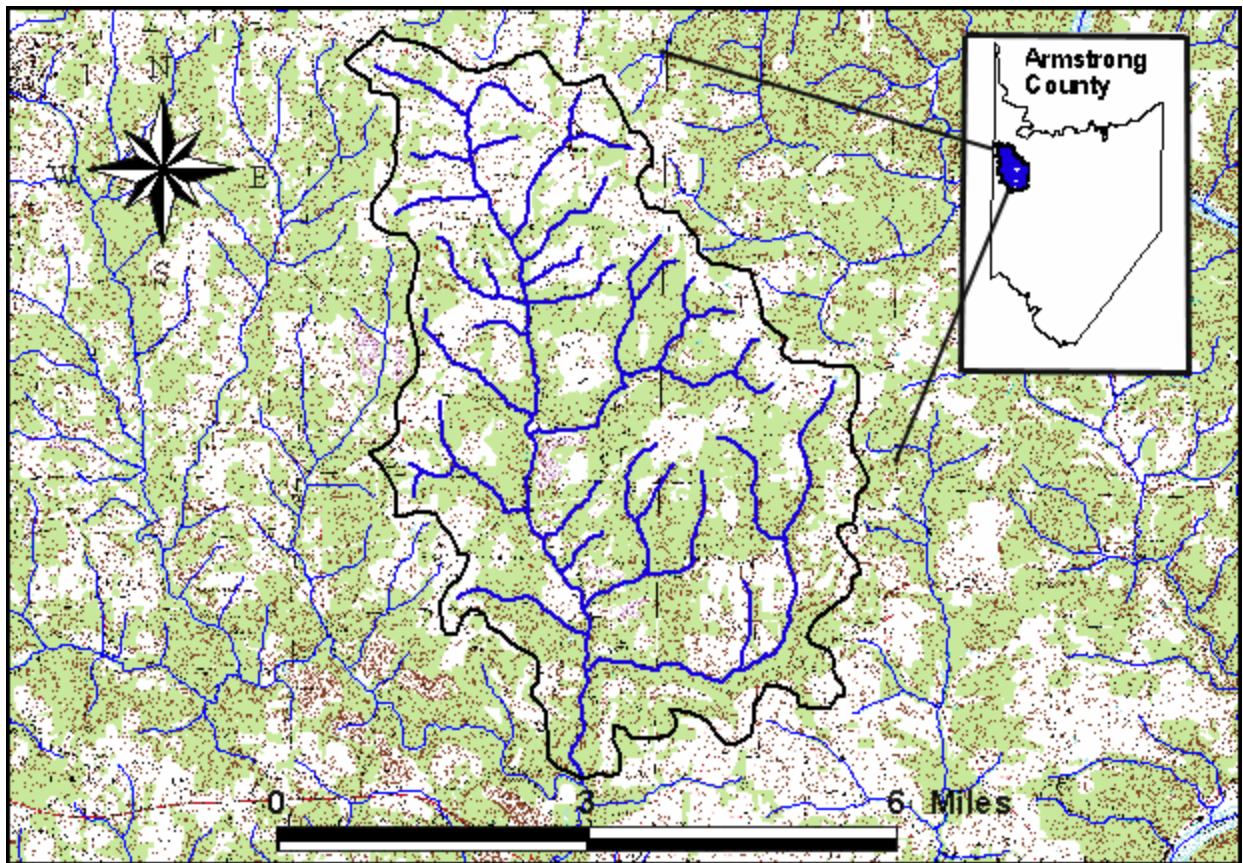
Figure 1. Location of Patterson Creek (Armstrong County, PA).

2. Targeted Area of Watershed

Only the northern region of the watershed (Figure 2) contains impaired stream segments. All segments below this area have been determined to be non-impaired, and therefore were not included in this TMDL analysis. By focusing on this targeted area instead of the entire watershed, 1) a more site-specific reference watershed can be found, and 2) the determination of the total pollutant load will be more site specific, and hence will not be diluted by areas of the watershed that are not impaired. This region of the watershed is 5.5 mi^2, and encompasses about 13.3 miles of stream.
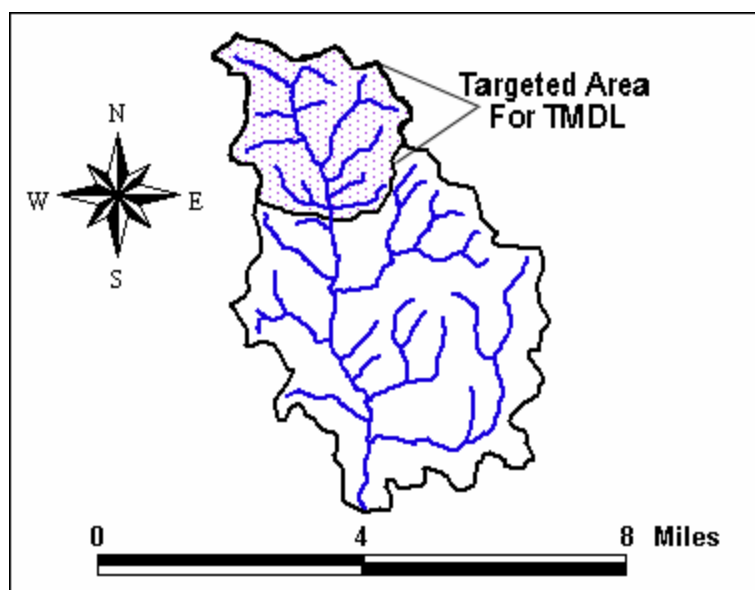
Figure 2. Area of the Patterson Creek watershed that will be included in the TMDL analysis.

3. Topography and Geology

The watershed of Patterson Creek lies within the Pittsburgh Low Plateau Section of the Appalachian Plateau Province. This section consists of a smooth undulating upland surface cut by numerous, narrow, relatively shallow valleys. Elevation ranges from 364 to 452 m above sea level. Rocks within the watershed are entirely interbedded sedimentary, and the two underlying bedrock groups are the Casselman Formation, and Allegheny Group, with the latter being dominant.

The dominant hydrologic soil group is C; this soil group is characterized as having a slow infiltration rate when thoroughly wetted. Soil associations within the watershed are Gilpin-Wharton-Ernest (98%) and Hazelton-Dekalb-Buchanon (2%).

4. Land Use

The ArcView® Generalized Watershed Loading Function (AVGWLF®) model version 5.0.2 (Appendix A) was used to estimate the landuse for the targeted area of the Patterson Creek watershed. Furthermore, a survey (February 2006) was conducted to verify the accuracy. No changes were required. The distribution of dominant landuses is as follows: Cropland – 43%, Forest – 36%, Hay/Pasture – 14%, Transitional Land (currently being developed) – 5%, and Developed Land – 1%.
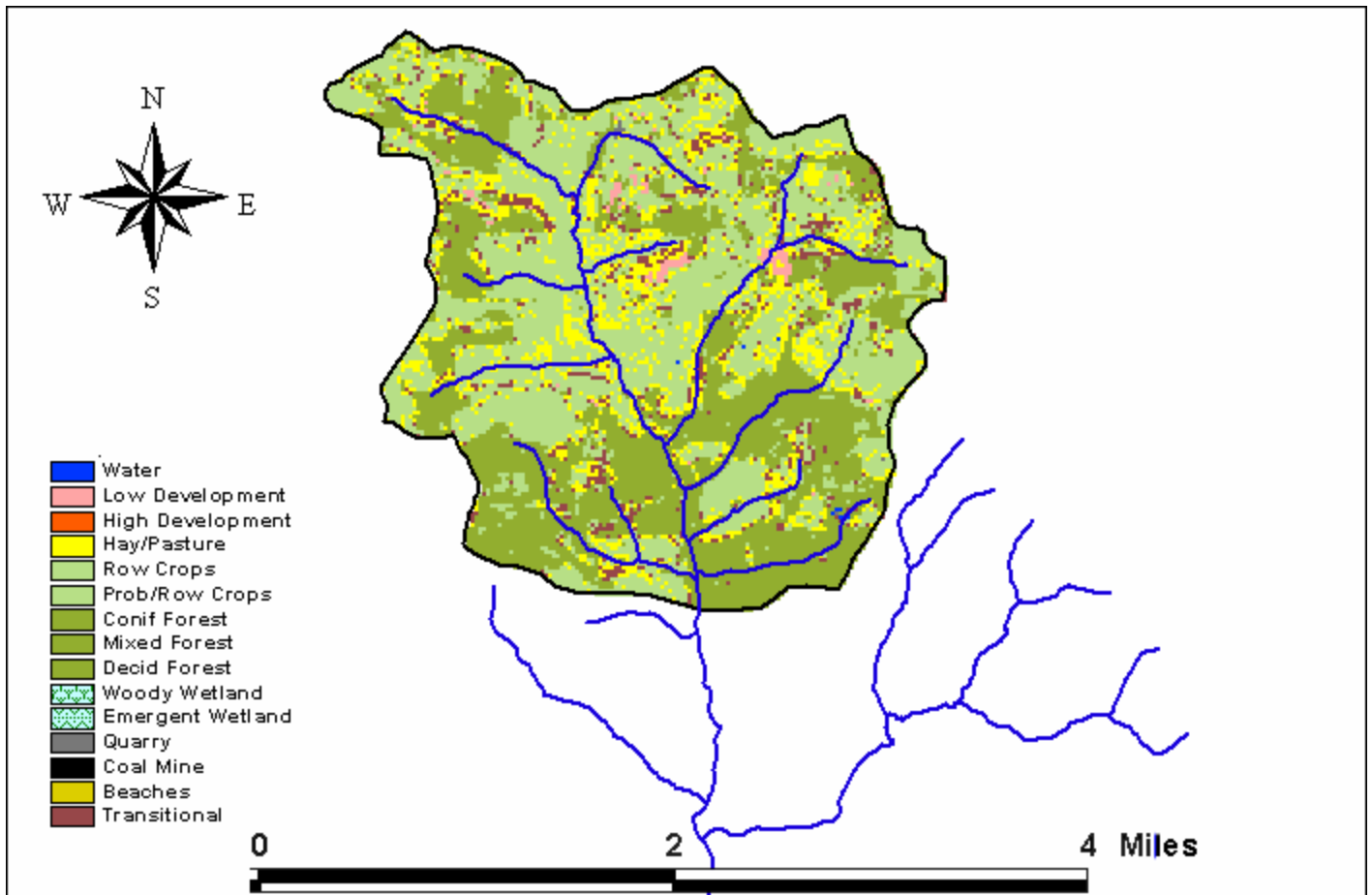
Figure 3. Landuse distribution calculated by AVGWLF for the targeted area of Patterson Creek, Armstrong County. "Transitional land" refers to land that is currently being developed.

B. Nature of Impairments, Water Quality Standards, and Pollutants

Streams within the Patterson Creek watershed were determined to be impaired (Figure 4), which means that they are not meeting their protected use: High Quality Trout-Stocked Fishery. All such fisheries within Pennsylvania must be of sufficient quality to support healthy populations of aquatic life. If it is determined that a stream's aquatic life is degraded, the stream is deemed impaired. The aquatic life, i.e., macro-invertebrate communities, of streams within the Patterson Creek watershed were determined to be degraded by sediment stemming from agriculture, and consequently these streams were placed on Pennsylvania's 2006 Integrated Water Quality Monitoring and Assessment Report (Table 1).
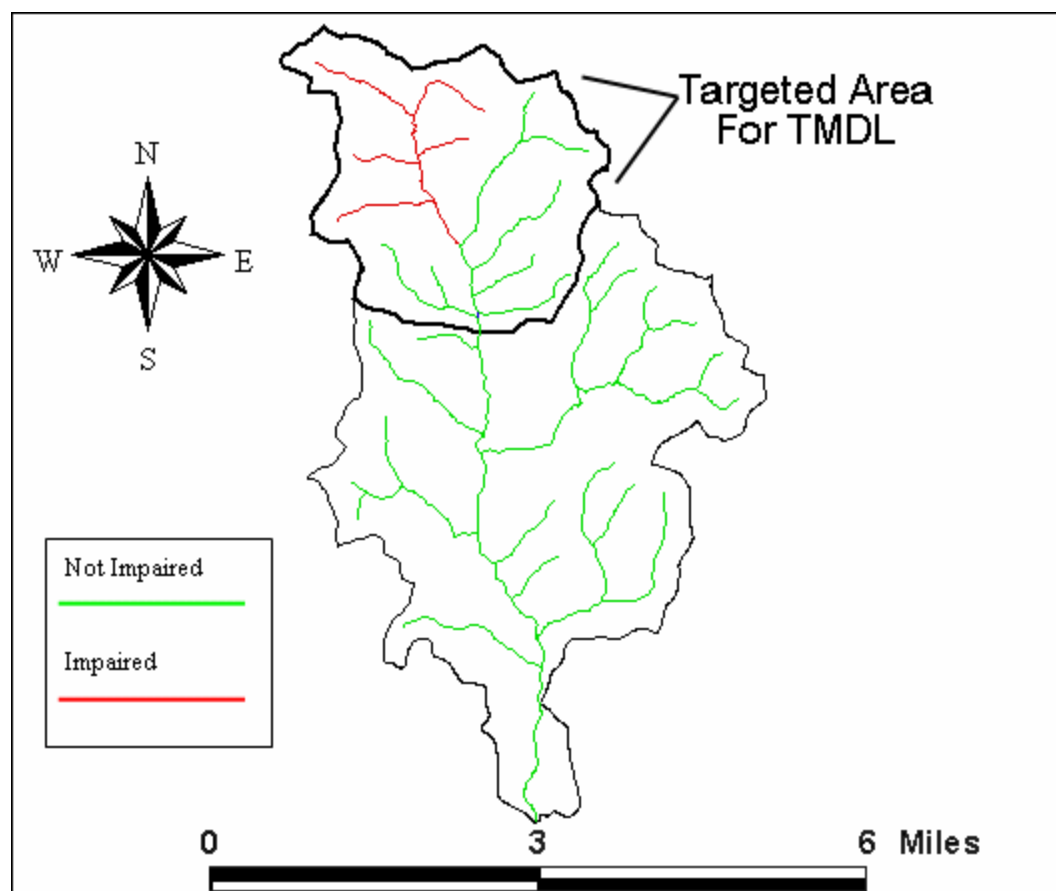
Figure 4. Impaired and non-impaired areas of Patterson Creek (Armstrong County).

The "impaired" status of these streams resulted from assessments conducted as a part of the Surface Water Monitoring Program (SSWAP). During these assessments, a biologist collects data to assess the conditions of water chemistry, in-stream as well as surrounding habitat, and macro-invertebrate life. Based on the findings, a professional decision is made as to whether the stream is impaired, and if so, the biologist determines the source(s) and cause(s) (Table 1). No point sources of pollution are currently contributing to the sediment impairment in the Patterson Creek watershed.

Table 1. Impairment information from 2006 Integrated Water Quality Monitoring and Assessment Report.

Stream Name	Assessment ID	Source	Cause	Miles
Patterson Creek	7324	Crop Related Agriculture	Siltation	0.91
Patterson Creek	7325	Crop Related and Grazing Related Agriculture	Siltation	1.34
Patterson Creek	7327	Crop Related and Grazing Related Agriculture	Siltation	0.09
Unnamed tributaries 42723 to 42726	7324	Crop Related Agriculture	Siltation	3.2

C. Source Assessment

Surveys conducted in 2006 and 2007 revealed that agriculture is impacting the headwater region of the Patterson Creek watershed. The foremost northern reach of Patterson Creek is surrounded by cropland, and some low-density development. In this area, some of the stream is surrounded by thick riparian zones; however, some areas lack this buffer (Figure 5), and sediment from adjacent cropland is entering the stream channel via surface runoff.

Figure 5. Cropland along Patterson Creek (Armstrong County).

The major impact to Patterson Creek begins shortly downstream. Herein, the stream is surrounded by steep, overgrazed land (Figure 6). As a result, large volumes of surface runoff are directed into the stream during rainy events, which consequently overwhelms the stream channel and erodes sediment (Figure 7).

Figure 6. Steep bordering hills surrounding Patterson Creek (Armstrong County).

Figure 7. Decaying streambank of Patterson Creek (Armstrong County).

Bordering cropland in this area also resides on steep hillsides. Because there is little vegetative buffer between the crops and the stream, accelerated runoff generated during rainy events is carrying sediment from these areas into the stream channel (Figures 8 and 9). Channel erosion is also a prevalent problem in this area.

Figure 8. Cropland along Patterson Creek (Armstrong County).

Figure 9. Cropland along Patterson Creek (Armstrong County).

Some of the land directly surrounding Patterson Creek in this area has been trampled by livestock (Figure 10). Streambanks are collapsing into the channel, and loosened soil is being washed in. As a result of the aforementioned impacts, the substrate of Patterson Creek throughout this area consists chiefly of sediment (Figure 11).

Figure 10. Trampled land surrounding Patterson Creek (Armstrong County).

Figure 11. Sediment-dominated substrate of Patterson Creek (Armstrong County).

D. Pollutant Background and Endpoint

Impairments within the watershed were addressed by targeting sediment loading. "Siltation", which is listed as the cause of impairment in the watershed, is the process whereby a stream becomes choked, or covered with sediment.

1. Sediment

Like nutrients, sediment is an essential component of aquatic ecosystems, as it often contains minerals used by many aquatic organisms, and also provides habitat. Sedimentation is a natural process that is caused by the weathering of landscape, whereby wind and water erode the surfaces of rocks and soils creating small particles. When these particles enter streams, they may flow with the current (suspended solids), or be deposited on the streambed. Typically, natural inputs of sediment to streams do not cause problems; however, when landscape is modified whereby soils become unstable, excessive amounts of sediment can enter streams and cause undesirable effects (Bryan and Rutherford 1995).

Agricultural practices such as row cropping involve the tilling of landscapes to make the soil porous and fertile, which consequently loosens soil directly, as well as indirectly by removing plants whose roots once held soil in place. During rainy events, loosened soil is directed toward nearby streams via overland runoff, and depending upon the density of vegetation along the shoreline, sediment enters into the water.

The soil of pasture land is often more stable than that of cropland, yet sedimentation issues inherently arise from this landuse. Vegetation grown within pasture land typically has little water retention ability, and often is not thick enough to impede overland runoff during rainy events. Consequently, large volumes of overland runoff often generate and enter nearby streams. The sudden increase in water volume in a stream raises the velocity of the flow to a point where soil from the streambanks begins to erode into the channel. Runoff volume from this landuse is further increased in areas with steep topography, and areas in which cattle have overgrazed the vegetation. In addition to facilitating hydrology-related sedimentation issues, the overgrazing and trampling of vegetation in riparian zones leads to loosened soil that directly enters streams.

Eroded sediment can cause numerous problems for aquatic organisms. Suspended sediment causes turbidity, which can interfere with predation efficiency; cause respiration problems by clogging gills of aquatic organisms (Horne and Goldman 1994); and also reduces sunlight penetration, which affects plant photosynthesis (Waters 1995). Causing a higher magnitude of problems, deposited sediment can 1) suffocate eggs of fish and other organisms, 2) suffocate small organisms, 3) severely reduce habitat and habitat diversity, and 4) alter flow patterns (USEPA 1999). Therefore, our endpoint was the reduction in sediment required to render the targeted area of the Patterson Creek watershed unimpaired.

IV. TMDL Development Methods

A. Reference Watershed Approach: Setting the Standard

The first step of this approach was to find a non-impaired watershed (reference watershed) that was similar to the impaired watershed in terms of factors such as land-use, soil associations, drainage area, precipitation, physiographic province, and geology. Once found, the model data for this watershed was adjusted to account for BMPs (Best Management Practices) that exist within the watershed, or to account for other reasons why it is not impaired, whereas the similarly natured Patterson Creek watershed is. This process is necessary because the model does not account for land management practices, such as streambank fencing, that may be in place. The sediment loading rate for the reference watershed was then determined, and the general objective then became to reduce the sediment loading of the Patterson Creek watershed to or slightly below that of the reference watershed.

B. Watershed Assessment Approach and Modeling

1. Reference Watershed Loading Rate

The ArcView® Generalized Watershed Loading Function (AVGWLF®) model version 6.2.2 (described in Appendix A) was used to acquire pertinent information about the reference watershed. This model was used to generate the total area as well as non-point sediment loads of the reference watershed. Its loading rate for sediment was then determined by dividing its total sediment load by the total area of its watershed.

Reference Watershed Loading Rate = Total Sed Load (tons/yr) / Total Area (Acres) = Tons/yr/ Acre

2. Total Maximum Daily Load

This resulting value was then multiplied by the total area of the impaired watershed. This value constitutes the "total maximum daily load" (TMDL) that the impaired watershed should be able to uptake and still maintain water quality standards, as it is proportional to the load of the reference watershed relative to total area.

TMDL = Ref Watershed Loading Rate (tons/yr/acre) x Total Area Impaired Watershed (acres) =
        Tons/Year Sediment

3. Margin of Safety and Total Allowable Load

A "margin of safety" is a percent of the TMDL that will not be included in the total load that will be allocated among the various pollutant sources. This step was implemented to recognize and account for any uncertainty that may exist about the relationship between pollutant loads and receiving water quality. Use of a 10% MOS is standard practice in most TMDL reports where water quality criteria are not explicitly defined for the targeted pollutant; this MOS level was used herein. When the MOS is subtracted from the TMDL, the resulting value can be termed the total allowable load (TAL), which essentially is the total load that pollutant sources, as a whole, must be limited to.

MOS (Margin of Safety) = 0.10 x TMDL

TAL (Total Allowable Load) = TMDL - MOS

4. Wasteload Allocation and Load Allocation.

Ultimately the total allowable load is divided between point and non-point sources. The "wasteload allocation" (WLA) is the load that point sources will be allowed to emit, and the "load allocation" (LA) is the load that non-point sources must be limited to. To determine the WLA, the total load from all point sources is determined; this value is obtained using the permitted design flows and monthly average maximum effluent limits. Provided that this load is found to not significantly contribute to the impairment in the watershed, this value is the load that point sources will be allowed to emit, and a reduction will not be mandated. This value is then subtracted from the total allowable load; the resulting value is the load allocation. If there are no point sources in the watershed, the WLA is set to zero. With this, the TMDL is equivalent to the sum of the LA, WLA, and MOS.

LA (load allocation) = TAL (total allowable load) – WLA
or,
LA (load allocation) = TMDL – MOS – WLA

thus, TMDL (total max daily load) = LA + WLA + MOS (margin of safety)

5. Loads Not Reduced and Adjusted Load Allocation

"Loads not reduced" (LNRs) included all loads from non-point sources that were not subjected to a reduction. The loads of some pollution sources are uncontrollable, for example, a load coming from a forest. We also may not reduce a source's load because its contribution to the total load may be minute, and therefore implementing land management practices to achieve a load reduction would not be practical, or meaningful. Because the loads from these sources were not subjected to a reduction, they were subtracted from the load allocation (LA). However, they were accounted for by requiring the

further reduction of loads from other sources. The resulting adjusted load allocation (ALA) is the load that was allocated among the non-point pollutant sources that will receive reductions.

ALA (Adjusted Load Allocation) = Load Allocation (LA) - LNRs
ALA (Adjusted Load Allocation) = TMDL - MOS (margin of safety) – WLA - LNRs

With this, the following equation holds true:

TMDL = ALA + MOS + WLA (Wasteload Allocation) + LNRs (Loads Not Reduced)

6. Overall Load Allocation Distribution and Required Reductions

The adjusted load allocation (ALA) was allocated among the non-point pollutant sources using the Equal Marginal Percent Reduction (EMPR) spreadsheet. The computations within this spreadsheet determine the percentage of the ALA that the load of each non-point source constitutes (percent reduction allocation). Each source's load reduction is then produced by multiplying its percent reduction allocation by the ALA. The source's load reduction is then subtracted from its initial load, and its allocated load is produced. For more detail, see Appendix B

C.   Quality Assurance

1. Consideration of Critical Conditions

The AVGWLF model is a continuous simulation model that uses daily time-steps for weather data and water balance calculations. Monthly calculations are made for sediment loads based upon 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.

2.   Consideration of Seasonal Variations

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

V. TMDL Results

A. Reference Watershed Selection

Using GIS imagery through ArcView®, a closely matched reference watershed was found: Thorn Creek (stream code – 35108), Butler County (Figure 12). For the TMDL analysis, only a portion of the headwaters was used as a reference. This approach resulted in a watershed that was very similar to the targeted area of Patterson Creek. Pennsylvania's 303(d) list indicates that this region of Thorn Creek is not impaired. It is located approximately 10 miles southwest of the Patterson Creek watershed. The boundaries of its watershed lie within Jefferson and Summit townships (USGS quadrangle – Saxonburg). Its watershed is part of State Water Plan 18-F, and has a total drainage area of 5.4 mi^2.
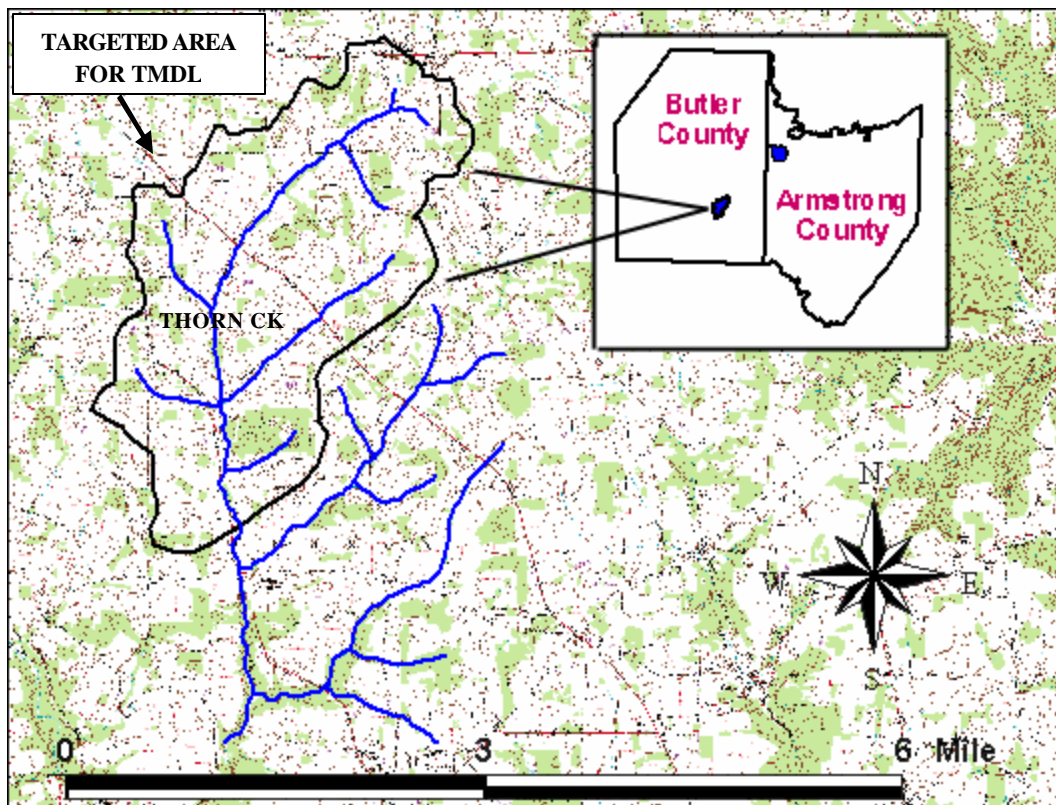

Figure 12. Locations of the targeted region of Thorn Creek used as a reference watershed (Butler County), and the impaired watershed (Patterson Creek), Armstrong County, PA.

Both GIS imagery through ArcView®, and a physical survey indicated that the selected region of the Thorn Creek watershed is similar to that of Patterson Creek. Table 2 illustrates the similarities between the watersheds. Because the watershed of Patterson Creek was determined to be impaired by sedimentation from agricultural activities, it was important to find a reference watershed with a similar amount of agricultural landuse.

Table 2. A comparison of the attributes used to deem Thorn Creek a suitable reference watershed to be used in the TMDL development of Patterson Creek.

ATTRIBUTE	WATERSHED	
	Patterson Creek (Targeted Area) **State Water Plan – 18-F** **Stream Code - 42695**	*Thorn Creek* (Targeted Area) **State Water Plan -18-F** **Stream Code - 35108**
Physiographic Province	Appalachian Plateau Province (Pittsburgh Low Plateau Section)	Appalachian Plateau Province (Pittsburgh Low Plateau Section)
Drainage Area (mi^2)	5.5	5.4
Land-use Distribution	Agriculture – 57% Forested – 37% Transitional – 5% Development – 1%	Agriculture – 70% Forested – 23% Transitional – 5% Development – 2%
Geology	Interbedded Sedimentary (100%)	Interbedded Sedimentary (100%)
Soils	Gilpin-Wharton-Ernest (98%) Hazelton-Dekalb_Buchanon (2%)	Hazelton-Cookport-Ernest (87%) Gilpin-Ernest-Cavode (13%)
Dominant Hydro Soil Group	C	C
23-Year Average Rainfall (in)	41.36	41.36
23-Year Average Runoff (in)	2.83	3.02

Although both the impaired and reference watersheds are similar, differences were found that likely explain why the selected area of the Thorn Creek watershed is not impaired, whereas the targeted area of Patterson Creek is. It should be noted that some areas in the Thorn Creek watershed could be improved; however, there are more areas that are protective of the stream in this watershed relative to the Patterson Creek watershed.

Because most of the sedimentation problems within the Patterson Creek watershed are being caused within agricultural land, attention was given to these areas that exist within the reference watershed. Streams that run along pasture and cropland areas within the Thorn Creek watershed typically have more buffer zones that run contiguously with them (Figures 13 & 14). These buffer zones consist of trees, shrubs, and grasses, all of which appear to slow surface runoff, and reduce sediment from being transported into the streams. In addition, the use of streambank fencing was noticed in several areas throughout the watershed (Figure 15). The streambanks in these areas are not decaying, and the substrate contains a mix of cobble and woody debris (Figure 16).

Figure 13. Buffer zone along Thorn Creek. Stream is centered within buffer strip.

Figure 14. Buffer zone (both sides) along Thorn Creek. Stream is centered within buffer strip.

Figure 15. Streambank fencing along Thorn Creek.

Figure 16. Rocky substrate of area of Thorn Creek bordering livestock area.

B. Pollutant Loads and Reference Watershed Loading Rates

1. Pollutant Loads

Table 3. <u>Non-point</u> pollutant loads of sources within the watersheds of Patterson Creek (Armstrong County), and Thorn Creek (Armstrong and Butler counties).

	Patterson Creek		Thorn Creek	
Pollutant Source	Area (Acres)	Sediment (Tons/yr)	Area (Acres)	Sediment (Tons/yr)
Hay/Pasture	491.7	300.33	565.9	192.66
Cropland	1529.6	862.19	1771.7	584.08
Conif_forest	46.9	0.48	51.9	0.04
Mixed_forest	34.6	0.11	98.8	0.22
Decid_forest	1156.5	4.28	637.5	0.89
Unpaved Road	17.3	0.00	-	-
Quarry	2.5	3.74	-	-
Coal Mines	0	-	-	-
Transitional	207.6	225.17	202.6	221.84
Low_Int_Dev	27.2	1.79	76.6	2.35
High_Int_Dev	-	-	-	-
Streambank	-	1266.67	-	612.16
TOTAL	3513.8	2664.8	3405.1	1614.3

2. Reference Watershed Loading Rate

Reference Watershed Loading Rate = Total Load (tons/yr) / Total Area (Acres) = Tons/yr Sed / Acre

1. (Sediment) = 1614.3 tons / 1 yr / 3405.1 Acres = <u>0.474 tons/yr/acre</u>

C. Total Maximum Daily Load

TMDL = Ref Watershed Loading Rate (lbs/acre) x Total Area Impaired Watershed (acres)

1. (Sediment) = 0.474 tons/yr/acre x 3513.8Acres = <u>1665.541 tons/yr</u>

D.   Margin of Safety

MOS (Margin of Safety) = 0.10 x TMDL

    1. (Sediment) = 0.10 x 1665.541 tons/yr = <u>166.554 tons/yr</u>

E.   Wasteload Allocation and Load Allocation

LA (load allocation) = TMDL (total max daily load) – WLA - MOS (margin of safety)

  1. (Sediment) = 1665.541 tons/yr - 0 tons/yr - 166.554 tons/yr = <u>1498.987 tons/yr</u>

F. Loads Not Reduced and Adjusted Load Allocation

Table 4. Loads of pollutant sources that will not be reduced (LNRs). These loads were either insignificant compared to the major loads, or cannot be controlled.

Loads Not Reduced (LNRs)	Sediment (Tons/yr)
Conif_forest	0.48
Mixed_forest	0.11
Decid_forest	4.28
Quarry	3.74
Low Density Development	1.79
TOTAL	10.4

ALA (adjusted load allocation) = LA – LNRs

    1. (Sediment) = 1498.987 tons/yr – 10.4 tons/yr = <u>1488.59 tons/yr</u>

G. Overall Load-Allocation Distribution and Required Reductions

Table 5. Allowable and existing <u>sediment</u> loads, as well as required reductions for individual pollutant sources.

Pollutant Source	Current Loading Rate (tons/yr/acre)	Current Load (tons/yr)	Allowable Loading Rate (tons/yr/acre)	Allowable Load (tons/yr)	Percent Load Reduction
Hay/Pasture	0.61	300	0.32	159	**47%**
Cropland	0.56	862	0.32	494	**43%**
Transitional	1.08	226	0.61	126	**44%**
Streambank	0.41	1266	0.23	710	**44%**
TOTAL	-	2654	-	1489	Average = **45%**

VI. Reasonable Assurance and Recommendations

Required reductions of sediment loads for non-point pollutant sources in the watershed of Patterson Creek are shown in table 5. If these reductions were attained, the loading level of sediment would become similar to that of the watershed of Thorn Creek, which is currently meeting its water quality standards. Reductions shall be achieved mainly by implementing BMPs (Best Management Practices). BMPs are techniques that can be employed by land owners to either reduce the production of a pollutant, or prevent a pollutant from entering a water body. Each BMP is equipped to handle a unique type of pollutant; although, implementation of a single BMP can sometimes address multiple pollutant problems. Nevertheless, each has its own reduction efficiency, and the optimal BMP is a consideration of its efficiency as well as the feasibility of employing it.

Information sheets describing the implementation procedures of BMPs that could be used in the restoration process of this watershed can be found in appendix G. Because sediment pollution in this watershed is being caused primarily agricultural practices, the following BMPs are suggested: 1) Runoff Management Systems, 2) Stream Channel Stabilization, 3) Streambank and Shoreline Protection, and 4) Fencing.

DEP will support local efforts to develop and implement watershed restoration plans based on the reduction goals specified in this TMDL. Interested parties should contact the appropriate Watershed Coordinator in the Department's Southwestern Regional Office (412-442-4149) for information regarding technical and financial assistance that is currently available. Individuals and/or local watershed groups interested in the reclamation of the watershed of Patterson Creek are strongly encouraged to exploit funding sources available through DEP and other state and federal agencies (e.g., Growing Greener or 319 Program).

VII. Public Participation

TO BE COMPLETED.

VIII. References

USDA (United States Department of Agriculture). 1981. Soil Survey of Allegheny County, Pennsylvania. National Cooperative Soil Survey. 93 p.

USEPA (United States Environmental Protection Agency). 1992. TMDL case study: Sycamore Creek, Michigan. EPA841-F-92-012. U.S. Environmental Protection Agency, Office of Water, Assessment and Watershed Protection Division, Washington, DC

USEPA (United States Environmental Protection Agency). 1999a. Protocol for developing nutrient TMDLS. EPA841-B-99-007. U.S. Environmental Protection Agency, Office of Water, Assessment and Watershed Protection Division, Washington, DC.

USEPA (United States Environmental Protection Agency). 1999b. Protocol for developing sediment TMDLS. EPA841-B-99-004. U.S. Environmental Protection Agency, Office of Water, Assessment and Watershed Protection Division, Washington, DC.

Byran, C.F. and D.A. Rutherford. 1995. Impacts of warmwater streams: Guidelines for evaluation (2nd Edition). Southern Division, American Fisheries Society, Little Rock, Arkansas. 285 p.

Evans, B.M and K.J. Corradini. 2001 (In Review). BMP pollution reduction guidance document. Environmental Resources Research Institute, Pennsylvania State University, State College, PA. 15p.

Horne, A.J. and C.R. Goldman. 1994. Limnology (2nd Edition). McGraw-Hill Inc, New York, New York. 576 p.

Stickney, R.R. 1994. Principles of aquaculture. John Wiley & Sons, Inc, New York, New York. 502 p.

Waters, T.F. 1995. Sediment in streams: Sources, biological effects, and control. American Fisheries Society Monograph 7. American Fisheries Society, Bethesda, Maryland. 251 p.

IX. Appendices

Appendix A. AVGWLF Model Overview & GIS-Based Derivation of Input Data.

TMDLs for the watershed of Patterson Creek were developed using the Generalized Watershed Loading Function or GWLF model. The GWLF model provides the ability to simulate runoff and sediment loadings from 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 sub-surface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for sub-surface flow contributions. Daily water balances are computed for an unsaturated zone as well as a saturated sub-surface 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 and transport capacities based on average daily runoff are applied to the calculated erosion to determine sediment yield for each source area. Surface nutrient losses are determined by applying dissolved N and P coefficients to surface runoff and a sediment coefficient to the yield portion for each agricultural source area. Point source discharges can also 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. Sub-surface losses are calculated using dissolved N and P coefficients for shallow groundwater contributions to stream nutrient loads, and the sub-surface sub-model 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 Manuel, available from the Department's Bureau of Watershed Conservation, Division of Assessment and Standards.

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 N and P concentrations and cropping practices. Complete GWLF-formatted weather files are also included for eighty 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.
Land-use5	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. This used to calculate landslope and slope length.
Palumrlc	A satellite image derived land cover grid that is classified into 15 different landcover categories. This dataset provides landcover 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 N and P 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 the 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 DEP 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.

Appendix B. 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 non-point sources. The load allocation and EMPR procedures were performed using MS Excel and results are presented in Appendix E. The 5 major steps identified in the spreadsheet are summarized below:

Step 1: Calculation of the TMDL based on impaired watershed size and unit area loading rate of reference watershed.

Step 2: Calculation of Adjusted Load Allocation based on TMDL, Margin of Safety, and existing loads not reduced.

Step 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 water-body. 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 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.

Step 4: Calculation of total loading rate of all sources receiving reductions.

Step 5: Summary of existing loads, final load allocations, and % reduction for each pollutant source.

Appendix C. GWLF Output for Patterson Creek.

Average Loads by Source

GWLF Total Loads for Patterson_Creek_Final

Period of analysis: 23 years, from Apr 1975 to Mar 1998

Source	(Acres) Area	(in) Runoff	(Tons) Erosion	(Tons) Sediment	Total Loads (Pounds) Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos.
HAY/PAST	491.7	3.60	1677.80	300.33	1061.39	2863.34	120.45	327.67
CROPLAND	1529.6	3.60	4816.73	862.19	3301.50	8474.66	374.66	969.58
CONIF_FOR	46.9	1.66	2.66	0.48	3.36	6.22	0.11	0.43
MIXED_FOR	34.6	1.66	0.64	0.11	2.47	3.16	0.08	0.16
DECID_FOR	1156.5	1.66	23.91	4.28	82.72	108.41	2.61	5.57
UNPAVED_RD	17.3	5.78	0.00	0.00	65.75	65.75	4.53	4.53
QUARRY	2.5	7.12	20.88	3.74	0.05	22.47	0.01	2.59
TRANSITION	207.6	5.78	1257.93	225.17	789.03	2140.05	54.42	209.78
LO_INT_DEV	27.2	3.94	9.98	1.79	0.00	0.13	0.00	0.02
Stream Bank				1266.67		126.67		55.73
Groundwater					24255.39	24255.39	335.45	335.45
Point Sources					0.00	0.00	0.00	0.00
Septic Syst.					1140.43	1140.43	16.90	16.90
Totals	3513.8	3.10	7810.5	2664.8	30702.10	39206.68	909.22	1928.41

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Appendix D. GWLF Output for Thorn Creek.

Average Loads by Source

GWLF Total Loads for Thorn_creek

Period of analysis: 23 years, from Apr 1975 to Mar 1998

Source	(Acres) Area	(in) Runoff	(Tons) Erosion	(Tons) Sediment	Total Loads (Pounds) Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos.
HAY/PAST	565.9	1.96	1070.31	192.66	667.08	1823.02	75.30	182.80
CROPLAND	1771.7	3.60	3244.90	584.08	3824.19	7328.68	433.98	759.90
CONIF_FOR	51.9	1.66	0.24	0.04	3.71	3.97	0.12	0.14
MIXED_FOR	98.8	1.66	1.22	0.22	7.07	8.39	0.22	0.35
DECID_FOR	637.5	1.66	4.93	0.89	45.60	50.93	1.44	1.94
TRANSITION	202.6	5.78	1232.45	221.84	770.25	2101.29	53.12	176.91
LO_INT_DEV	76.6	3.94	13.05	2.35	0.00	0.48	0.00	0.06
Stream Bank				612.16		61.22		26.93
Groundwater					29289.25	29289.25	350.62	350.62
Point Sources					0.00	0.00	0.00	0.00
Septic Syst.					2773.53	2773.53	20.66	20.66
Totals	3405.1	3.00	5567.1	1614.3	37380.68	43440.76	935.46	1520.31

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Appendix E. Equal Marginal Percent Reduction Calculations for Patterson Creek.

SEDIMENT (See Appendix B. for methodology)

Step 1: TMDL Total Load

Load = T loading rate in ref. * Acres in Impaired

| 1665 |

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

| 1489 | 1489 |

Step 3:

Source	Annual Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reduction	Initial LA	Acres
Hay/Past.	300.3	1162.49	good	300	ADJUST	0.11	132	168	492
Cropland	862		good	862	1165	0.32	378	484	1530
Transitional Land	225		good	225		0.08	99	126	208
Streambank	1266		good	1266		0.48	556	710	3067
				2654		1		1489	

Step 4:

| All Ag. Loading Rate | 0.32 |

Step 5:

	Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.
Final Hay/Past. LA	492	0.32	159	0.61	300	47%
Final Cropland LA	1530	0.32	494	0.56	862	43%
Transitional Land	208	0.61	126	1.08	225	44%
Streambank	3067	0.23	710	0.41	1266	44%
			1489		2654	

Appendix F. TMDL Information Sheet for Patterson Creek.

What is being proposed?
Total Maximum Daily Load (TMDL) plans have been developed to improve water quality in the watershed of Patterson Creek, Armstrong County (stream code – 42695).

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 (U.S. EPA) for review and approval as required by federal regulation. In 1995, U.S. EPA was sued for not developing TMDLs when Pennsylvania failed to do so. PADEP has entered into an agreement with U.S. EPA to develop TMDLs for certain specified waters over the next several years. These TMDLs have been developed in compliance with the state/U.S. EPA agreement.

What is a TMDL?
A TMDL sets a ceiling on the pollutant loads that can enter a water-body 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 sources of the pollutant on that water body. A TMDL plan includes waste load allocations for point sources, load allocations for non-point sources, and a margin of safety. The Clean Water Act requires states to submit their TMDLs to U.S. EPA for approval. Also, if a state does not develop the TMDL, the Clean Water Act states that U.S. EPA must do so.

What is a water quality standard?
The Clean Water Act sets a national minimum goal that all waters are to 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 in-stream 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?
Patterson Creek is impaired by excess sediment. These TMDL plans include a calculation of sediment loading that will meet water quality objectives.

Why was this watershed selected for TMDL development?
In 2006, PADEP listed Patterson Creek under Section 303(d) of the federal Clean Water Act as impaired due to excess sediment.

What pollutants do these TMDLs address? The proposed plans provide calculations of the stream's total capacity to accept sediment. Sediment loading is being used to address siltation impairments.

Where do the pollutants come from?
Sediment related impairments in the watershed of Patterson Creek come from non-point sources (NPS) of pollution, primarily from streambank decay caused by agricultural activities.

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 non-impaired 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 non-impaired 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 non-impaired watershed. The reference stream approach was used to set allowable loading rates in the affected watershed because neither Pennsylvanian nor U.S. EPA has water quality criteria for sediment.

How much pollution is too much?
The allowable amount of pollution in a water body 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 non-point source pollution loading of sediment, the TMDL is expressed as an annual loading. This accounts for pollution contributions over all stream flow conditions. PADEP established the water quality objectives for sediment by using the reference watershed approach. This approach assumes that the impairment is eliminated when the impaired watershed achieves loadings similar to the reference watershed. Reducing the current loading rates for sediment and 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 Joseph Boylan at 412-442-4049 during the business hours of 8:00 a.m. to 4:00 p.m., Monday through Friday. One may also contact Mr. Boylan by e-mail at joboylan@state.pa.us, or mail at: Pennsylvania Department of Environmental Protection; Water Management Program; Southwest Regional Office; 400 Waterfront Drive; Pittsburgh, PA 15222-4745

How can I comment on the proposal? You may provide e-mail or written comments postmarked no later than April 4, 2008 to the above address.

Appendix G. Best Management Practices (BMPs) Information Sheets.

1. Runoff Management System

DEFINITION

A system for controlling excess runoff caused by construction operations at development sites, changes in land use, or other land disturbances.

SCOPE

This standard applies to the planning, design, installation, operation, and maintenance of runoff management systems, including adequate outlet facilities and components required for adequate management of storm runoff, as determined by site conditions.

PURPOSE

Mainly to regulate the rate and amount of runoff and sediment from development sites during and after construction operations to minimize such undesirable effects as flooding, erosion, and sedimentation.

CONDITIONS WHERE PRACTICE APPLIES

The practice applies if there is a need to control runoff, erosion, and sedimentation to compensate for increased peak discharges and erosion resulting from construction operations at development sites or from other changes in land use. The discharges may be caused by such factors as increased runoff, reduced time of concentration, reduced natural storage.

PLANNING CONSIDERATIONS

Water Quantity

1. Effects of onsite detention on decreased runoff volume and peak flow, potentially increased infiltration, and the effectiveness of infiltration devices and controlled outlets.
2. Potential changes in evapotranspiration of vegetation in the infiltration areas and changes in soil moisture storage and volume of deep percolation.

Water Quality

1. Effects of reduction in erosion and sediment yield, with reductions in construction related pollutants adsorbed on sediments, such as fields and oils.
2. Effects of increases in dissolved nutrients and other chemicals through increased infiltration and deep percolation.
3. Effects on the visual quality of decreased sediment in downstream water resources.

DESIGN CRITERIA

Overall. A runoff management system must be compatible with the flood plain management program of the local jurisdiction and with local regulations for controlling sediment, erosion, and runoff. The system, a single component or a combination of components, must properly regulate storm discharges from a site to a safe, adequate outlet. Consideration shall be given to the duration of flow as well as the peak discharge. Adequate erosion-control measure and other water-quality practices must be provided. The components must be planned and designed to insure minimal impact on visual quality and human enjoyment of the landscape. Structures and materials must harmonize with surrounding areas.

The peak discharge from the 2-year and 100-year, 24-hour storms shall be analyzed. No increase in peak from these storms shall be allowed unless downstream increases are compatible with the overall flood plain management system.

Components. Components include but are not limited to dams, excavated ponds, infiltration trenches, parking lot storage, rooftop storage, and underground tanks.

Each component shall be designed according to sound engineering principles to insure that the system achieves its intended purpose. Design criteria for individual components shall be based on the following:

1. Dams shall meet the requirements, specified in 40 - part 520, subpart C of the National Engineering Manual
2. Excavated ponds shall meet the requirements specified for Ponds (378).
3. The design of infiltration trenches shall be based on such factors as soil permeability, soil depth, seepage, quality of water to be temporarily stored, foundations for adjacent buildings and structures, drainage conditions, and vegetation. Other considerations are:
    a. Only relatively clean water shall enter the trench to insure that oils, grease, and sediments do not seal trench walls and bottom and thus reduce the effectiveness of the practice. At parking lots and at other areas having a similar contamination potential, filter strips; sediment traps; grease traps or filter traps, or both, shall be installed to remove objectionable materials from the water before it reaches the infiltration device. A strip of close growing grasses at least 25 ft wide must be properly placed and maintained to insure the effectiveness of the trench. Water must move through the grass as sheet flow. If local site conditions warrant, a wider filter strip can be used.
    b. Trenches shall be located above the seasonally high water table.
    c. The size of the trench shall depend on the volume of storage required and the void ratio of the stones in the excavation. The volume of water infiltrating the walls and bottom of the trench during a storm shall be assumed to be zero in calculating the required volume. The permeability rate of the soil is used in determining the dewatering time, which shall not exceed 5 days.
    d. The soils used for installing an infiltration trench must be well drained. If permeability of the surrounding soils is less than about 0.6 in./h, suitability of the site for an infiltration trench may not be practicable.
    e. An infiltration trench must not adversely affect nearby foundations for buildings, roads, and parking lots and must not impair the growth of significant woody vegetation.
    f. Stone used in the excavation must be poorly graded and about 1 to 2 in. in size.
    g. In areas where spring runoff from snowmelt is likely to occur before the trench thaws, provisions shall be made for removing the excess water.
    h. Provisions shall be made to insure that salts or other soluble pollutants entering the trench do not contaminate local water supplies.
    i. The trench bottom and the stone surface must be level to insure adequate storage capacity and uniform infiltration.
4. Parking lot storage areas can be used to help control runoff from impervious paving. Most parking lot storage area include small ponding areas that have an increased curb height and an outlet control structure. The following factors shall be considered in designing these areas:

a. The practice generally used to control runoff from areas less than 3 acres in size.
b. The parking lot design and installation grades must insure positive flow to the storage area. The storage area must be nearly level, but the slope must be steep enough to facilitate drainage.
c. Trash guards must be provided to prevent clogging of the outlet control device.
d. Generally, ponding on the parking lot must not exceed 6 in. in areas where cars and light trucks are to be parked or 10 in. where heavy trucks are to be parked.
e. Emergency overflow outlets must be provided.
f. Such auxiliary practices as porous pavement and vegetative strips may be used in or adjacent to parking lots to permit infiltration.

5. For rooftop storage, the following requirements are applicable:
a. The roof shall be structurally capable of holding detained storm water and of withstanding the effects of high winds and snow. Requirements for structural stability are outside the scope of this standard and shall be determined by the building designer.
b. An adequate number of roof drains shall be provided.
c. Emergency overflow measures shall be provided to prevent overloading if roof drains become plugged.
d. Detention rings shall be placed around all roof drains in areas to be used for storage. The required number of holes or the size of openings in the rings shall be computed on the basis of the area of roof drainage per detention ring and the runoff criteria.
e. Maximum time of storage on the roof shall not exceed 24 hours.

6. The design of underground tanks shall be based on the following criteria:
a. The tank must be structurally capable of handling the anticipated loadings and be suited to the soils. Requirements for structural stability are outside the scope of this standards and must be based on sound engineering principles.
b. The outlet from the tank shall not be less than 5 in. in diameter. Provisions shall be made to prevent debris from entering the tank. Debris collectors shall be placed so that the need for maintenance can be readily detected and cleaning operations easily performed.
c. The bottom of the tank shall be on a slight grade to insure complete drainage of the tank.
d. Access must be provided to the tank to permit removal of sediment and other debris.
e. The maximum time of storage shall not exceed 5 days.

Sequence of installation. Components shall be designed and installed in a sequence that permits each to function as intended without causing a hazard. Single components shall not be installed until plans for the entire runoff management system are completed.

Safety. Appropriate safety features and devices shall be installed to protect humans and animals from such accidents as falling or drowning. Temporary fencing can be used until barrier plantings are established. Such protective measures as guard-rails and fences shall be used on spillways and impoundments as needed.

Visual resource. Landscape architectural practices must insure that all measures are visually compatible with the surrounding landscape.

Protection. A protective cover of grasses shall be established on exposed surfaces and other disturbed areas. Other protective measures, such as mulches, also can be used. Seedbed preparation, seeding, fertilizing, and mulching shall comply with recommendations in technical guides for the area.

OPERATION AND MAINTENANCE.

A plan of operation and maintenance shall be prepared for use by the owner or others responsible for the system to insure that each component functions properly. This plan shall provide requirements for inspection, operation, and maintenance of individual components, including outlets. It shall be prepared before the system is installed and shall specify who is responsible for maintenance. Adequate rights-of-way must be provided for maintenance access.

2. Stream Channel Stabilization

DEFINITION

Stabilizing the channel of a stream with suitable structures.

SCOPE

This standard applies to the structural work done to control aggradation or degradation in a stream channel. It does not include work done to prevent bank cutting or meander.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to stream channels undergoing damaging aggradation or degradation that cannot be feasibly controlled by clearing or snagging, by the establishment of vegetative protection, or by the installation of upstream water control facilities.

PLANNING CONSIDERATIONS

Water Quantity

1. Stage-discharge and flow velocity relative to the water budget components, geologic materials comprising the stream channel, and objectives of the channel modification.
2. Effects on water tables, soil moisture storage, and rooting depths and transpiration of vegetation.

Water Quality

1. Temporary and long-term effects on erosion and sedimentation.
2. Changes in stream water temperature that may result from the clearing of vegetation or alteration of water sources to the channel.
3. Effects on the visual quality of the water resource.

DESIGN CRITERIA

It is recognized that channels may aggrade or degrade during a given storm or over short periods. A channel is considered stable if over long periods the channel bottom remains essentially at the same elevation.

In the design of a channel for stability, consideration shall be given to the following points:

1. The character of the materials comprising the channel bottom.
2. The quantity and character of the sediments entering the reach of channel under consideration. This shall be analyzed on the basis of both present conditions and projected changes caused by changes in land use or land treatment and upstream improvements or structural measures.
3. Streamflow peaks, velocities, and volumes at various flow frequencies.
4. The effects of changes in velocity of the stream produced by the structural measures.

Structures installed to stabilize stream channels shall be designed and installed to meet SCS standards for the particular structure and type of construction.

3. Streambank and Shoreline Protection

DEFINITION

Treatment(s) used to stabilize and protect banks of streams or constructed channels, and shorelines of lakes, reservoirs, or estuaries.

PURPOSE

- To prevent the loss of land or damage to land uses, or other facilities adjacent to the banks, including the protection of known historical, archeological, and traditional cultural properties.
- To maintain the flow or storage capacity of the water body or to reduce the offsite or downstream effects of sediment resulting from bank erosion.
- To improve or enhance the stream corridor for fish and wildlife habitat, aesthetics, recreation.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to streambanks of natural or constructed channels and shorelines of lakes, reservoirs, or estuaries where they are susceptible to erosion. It applies to controlling erosion where the problem can be solved with relatively simple structural measures, vegetation, or upland erosion control practices. It does not apply to erosion problems on main oceanfronts and similar areas of complexity not normally within the scope of NRCS authority or expertise.

CRITERIA

General Criteria Applicable to All Purposes

Measures must be installed according to a site-specific plan and in accordance with all applicable local, state, and federal laws and regulations.

Protective measures to be applied shall be compatible with improvements planned or being carried out by others.

Protective measures shall be compatible with the bank or shoreline materials, water chemistry, channel or lake hydraulics, and slope characteristics both above and below the water line.

End sections shall be adequately bonded to existing measures, terminate in stable areas, or be otherwise stabilized.

Protective measures shall be installed on stable slopes. Bank or shoreline materials and type of measure installed shall determine maximum slopes.

Designs will provide for protection from upslope runoff.

Internal drainage for bank seepage shall be provided when needed. Geotextiles or properly designed filter bedding shall be used on structural measures where there is the potential for migration of material from behind the measure.
Measures applied shall not adversely affect threatened and endangered species nor species of special concern as defined by the appropriate state and federal agencies.

Measures shall be designed for anticipated ice action and fluctuating water levels.

All disturbed areas around protective measures shall be protected from erosion. Disturbed areas that are not to be cultivated shall be protected as soon as practical after construction.11.

Vegetation shall be selected that is best suited for the soil/moisture regime.

Additional Criteria for Streambanks

The channel grade shall be stable based on a field assessment before any permanent type of bank protection can be considered feasible, unless the protection can be constructed to a depth below the anticipated lowest depth of streambed scour.

A protective toe shall be provided based on an evaluation of stream bed and bank stability.

Channel clearing to remove stumps, fallen trees, debris, and bars shall only be done when they are causing or could cause detrimental bank erosion or structural failure. Habitat forming elements that provide cover, food, and pools, and water turbulence shall be retained or replaced to the extent possible.

Changes in channel alignment shall not be made unless the changes are based on an evaluation that includes an assessment of both upstream and downstream fluvial geomorphology. The current and future discharge-sediment regime shall be based on an assessment of the watershed above the proposed channel alignment.

Measures shall be functional for the design flow and sustainable for higher flow conditions based on acceptable risk.

Measures shall be designed to avoid an increase in natural erosion downstream.

Measures planned shall not limit stream flow access to the floodplain.

Stream segments to be protected shall be classified according to a system deemed appropriate by the state. Segments that are incised or contain the 5-year return period (20 percent probability) or greater flows shall be evaluated for further degradation or aggradation.

When water surface elevations are a concern, the effects of protective measures shall not increase flow levels above those that existed prior to installation.

Additional Criteria for Shorelines

All revetments, bulkheads, or groins are to be no higher than 3 feet (1 meter) above mean high tide, or mean high water in non-tidal areas

Structural shoreline protective measures shall be keyed to a depth to prevent scour during low water.

For the design of structural measures, the site characteristics below the waterline shall be evaluated for a minimum of 50 ft (15 meters) horizontal distance from the shoreline measured at the design water surface.

The height of the protection shall be based on the design water surface plus the computed wave height and freeboard. The design water surface in tidal areas shall be mean high tide.
When vegetation is selected as the protective treatment, a temporary breakwater shall be used during establishment when wave run up would damage the vegetation.

Additional Criteria for Stream Corridor Improvement

Stream corridor vegetative components shall be established as necessary for ecosystem functioning and stability. The appropriate composition of vegetative components is a key element in preventing excess long-term channel migration in re-established stream corridors.

Measures shall be designed to achieve any habitat and population objectives for fish and wildlife species or communities of concern as determined by a site-specific assessment or management plan. Objectives are based on the survival and reproductive needs of populations and communities, which include habitat diversity, habitat linkages, daily and seasonal habitat ranges, limiting factors and native plant communities. The type, amount, and distribution of vegetation shall be based on the requirements of the fish and wildlife species or communities of concern to the extent possible.

Measures shall be designed to meet any aesthetic objectives as determined by a site-specific assessment or management plan. Aesthetic objectives are based on human needs, including visual quality, noise control, and microclimate control. Construction materials, grading practices, and other site development elements shall be selected and designed to be compatible with adjacent land uses.

Measures shall be designed to achieve any recreation objectives as determined by a site-specific assessment or management plan. Recreation objectives are based on type of human use and safety requirements.

CONSIDERATIONS

An assessment of streambank or shoreline protection needs should be made in sufficient detail to identify the causes contributing to the instability (e.g. watershed alterations resulting in significant modifications of discharge or sediment production). Due to the complexity of such an assessment an interdisciplinary team should be utilized.

When designing protective measures, consider the changes that may occur in the watershed hydrology and sedimentation over the design life of the measure.

Consider utilizing debris removed from the channel or streambank into the treatment design.

Use construction materials, grading practices, vegetation, and other site development elements that minimize visual impacts and maintain or complement existing landscape uses such as pedestrian paths, climate controls, buffers, etc. Avoid excessive disturbance and compaction of the site during installation.

Utilize vegetative species that are native and/or compatible with local ecosystems. Avoid introduced or exotic species that could become nuisances. Consider species that have multiple values such as those suited for biomass, nuts, fruit, browse, nesting, aesthetics and tolerance to locally used herbicides. Avoid species that may be alternate hosts to disease or undesirable pests. Species diversity should be considered to avoid loss of function due to species-specific pests. Species on noxious plant lists should not be used.

Livestock exclusion should be considered during establishment of vegetative measures and appropriate grazing practices applied after establishment to maintain plant community integrity. Wildlife may also need to be controlled during establishment of vegetative measures. Temporary and local population control methods should be used with caution and within state and local regulations.

Measures that promote beneficial sediment deposition and the filtering of sediment, sediment-attached, and dissolved substances should be considered.

Consider maintaining or improving the habitat value for fish and wildlife, including lowering or moderating water temperature, and improving water quality.

Consideration should be given to protecting side channel inlets and outlets from erosion.

Toe rock should be large enough to provide a stable base and graded to provide aquatic habitat.

Consider maximizing adjacent wetland functions and values with the project design and minimize adverse effects to existing wetland functions and values.

When appropriate, establish a buffer strip and/or diversion at the top of the bank or shoreline protection zone to help maintain and protect installed measures, improve their function, filter out sediments, nutrients, and pollutants from runoff, and provide additional wildlife habitat.

Consider conservation and stabilization of archeological, historic, structural and traditional cultural properties when applicable.

Measures should be designed to minimize safety hazards to boaters, swimmers, or people using the shoreline or streambank.

Protective measures should be self-sustaining or require minimum maintenance.

PLANS AND SPECIFICATIONS

Plans and specifications for streambank and shoreline protection shall be prepared for specific field sites and based on this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be prepared for use by the owner or others responsible for operating and maintaining the system. The plan shall provide specific instructions for operating and maintaining the system to insure that it functions properly. It shall also provide for periodic inspections and prompt repair or replacement of damaged components or erosion.

4. Fencing

DEFINITION

A constructed barrier to livestock, wildlife or people.

PURPOSES

This practice may be applied as part of a conservation management system to facilitate the application of conservation practices that treat the soil, water, air, plant animal and human resource concerns.

CONDITIONS WHERE THIS PRACTICE APPLIES

This practice may be applied on any area where livestock and/or wildlife control is needed, or where access to people is to be regulated. Fences are not needed where natural barriers will serve the purpose.

CRITERIA

Fencing materials shall be of a high quality and durability, and the construction performed to meet the intended management objectives.

Fences shall be positioned to facilitate management requirements.

Standard or conventional (barbed or smooth wire), suspension, woven wire, or electric fences shall consist of acceptable fencing designs to control the animal(s) or people of concern and meet the intended life of the practice.

Height, number, and spacing of wires will be installed to facilitate control and management of the animal(s) and people of concern.

Height, size, spacing and type of posts will be used that best provides the needs for the style of fence required and is best suited for the topography of the landscape.

CONSIDERATIONS

Consider installing fences in locations that will facilitate maintenance avoiding irregular terrain and/or water crossings.

Consider wildlife movement needs when locating fences.

Consider livestock management, handling, watering and feeding when locating fences.

Boundary fences shall comply with state laws and standards for construction.

Where applicable, clear right-of-ways will be established which will facilitate fence construction and maintenance.

Consider soil erosion potential when planning and constructing a fence on steep slopes.

PLANS AND SPECIFICATIONS

Plans and specifications are to be prepared for specific field sites based on the NRCS National and State Fence Standards and appropriate state or local statutes or laws.

OPERATION AND MAINTENANCE

Regular inspection of fences should be part of an on-going management program. Inspection of fences after storm events is needed to facilitate the function of the intended use of the fence.

Maintenance and repairs will be performed as needed to facilitate the intended operation of the installed fence.