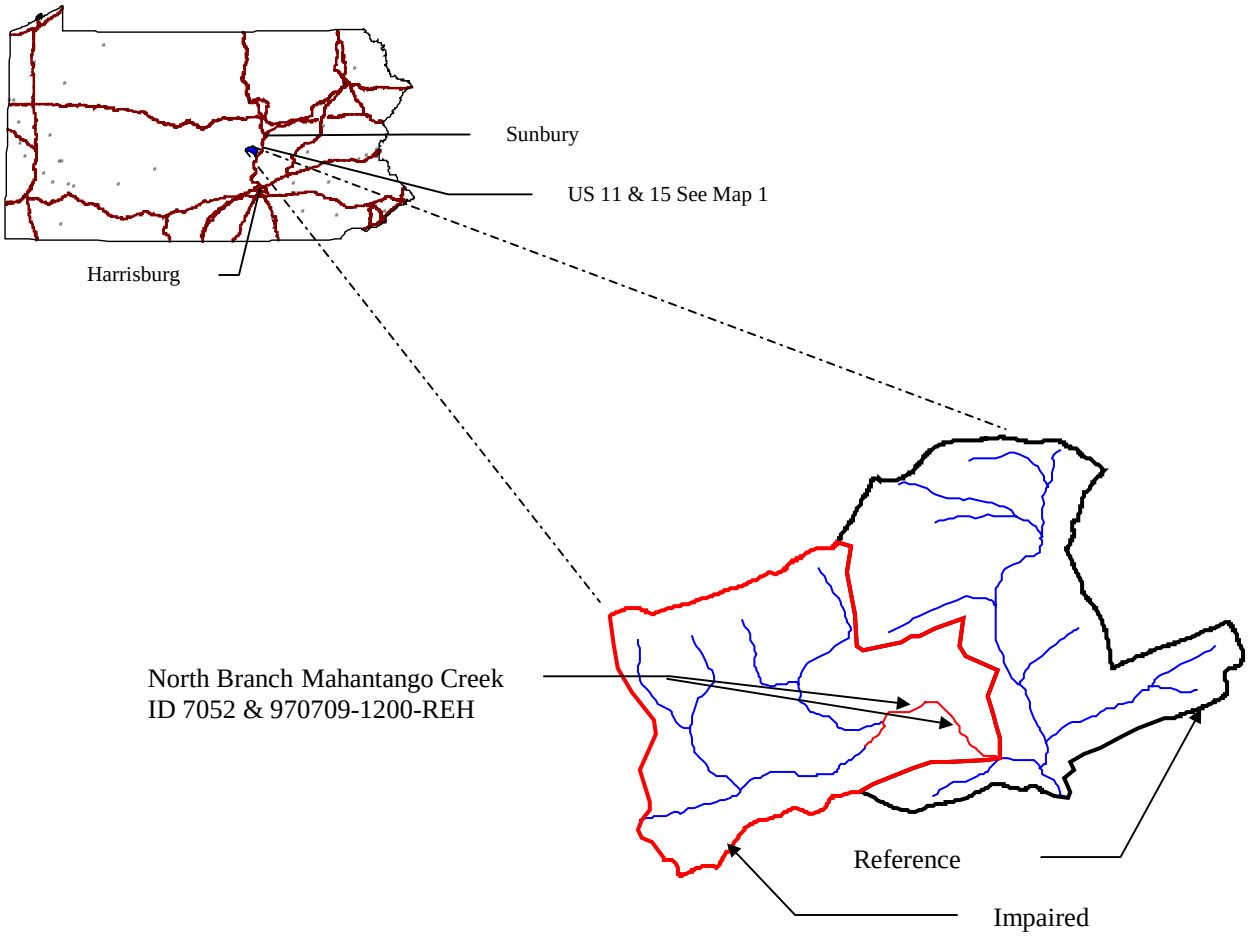
# Proposed Phosphorus and Sediment Total Maximum Daily Load (TMDL) North Branch Mahantango Watershed

*Pennsylvania, Snyder County*




**Impaired Watershed & Stream Segments**

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## EXECUTIVE SUMMARY

The North Branch Mahantango Creek watershed encompasses approximately 37 square miles in a predominantly rural portion of Snyder County. It is a tributary of Mahantango Creek, which flows into the Susquehanna River at a point approximately 27 miles above Harrisburg. The designated aquatic use in Chapter 93 of the Department's Regulations for the main stem North Branch Mahantango Creek is trout stocking. This aquatic use, in portions of the watershed, has been determined to be impaired, based on biological surveys. The impaired watershed and the two impaired stream segments which are the subject of this TMDL are shown on the cover.

This total maximum daily load (TMDL) report addresses impaired segments on Pennsylvania's 1996 and 1998 Clean Water Act Section 303(d) lists. Biological surveys of the aquatic life in the stream identified stream segments which were impaired by organic enrichment from agricultural sources. The impairments were documented in assessments conducted by the Department in 1992 and 1997. Excessive sedimentation and nutrients often characterize impairments caused by organic enrichment from agriculture. Therefore, a TMDL was developed to address the pollutants sediment and nutrients. The TMDL for nutrients focuses on phosphorus because it is the "limiting", or critical, nutrient on the watershed. The TMDL addresses two impaired segment lengths of 0.69 miles and 0.71 miles on the North Branch Mahantango, with a tributary watershed area of approximately 5 square miles.

Pennsylvania does not have water quality criteria for sediment or phosphorus. Therefore, PADEP uses a reference watershed approach to determine the TMDL endpoints for the impaired uses. The endpoints are phosphorus and sediment allowable loads that have been shown to meet water quality objectives in a reference watershed. The approach uses a generalized watershed loading function (GWLF) computer model to compare loads in the impaired and reference watershed. The comparison of North Branch Mahantango to the reference watershed is shown in Table 1. The endpoints in Table 2 show the maximum allowable phosphorus and sediment load to meet the TMDL endpoints.

**Table 1. Watershed Comparison**

| Comparison | Acres | Sediment lb/yr/acre | Total N lb/yr/acre | Total P lb/yr/acre |
|---|---|---|---|---|
| Reference | 3205 | 707.74 | 8.99 | 0.4427 |
| **North Branch Mahantango** | 3195 | 927.4 | 10.03 | 0.5656 |

**Table 2. TMDL Endpoints for the North Branch Mahantango Watershed**

| Pollutant | Allowable Pollutant Load lb/yr | Load Allocation lb/yr | Waste Load Allocation lb/yr | Margin of Safety lb/yr |
|---|---|---|---|---|
| **Sediment** | 2261234 | 2035111 | 0 | 226123 |
| **Phosphorus** | 1414 | 1273 | 0 | 141 |

The TMDL establishes agricultural non-point source load allocations (LAs), with 10% reserve for a margin of safety (MOS) for the total watershed. There are no waste load allocations (WLAs) for point sources of phosphorus and sediments, because there are no point source dischargers in the

impaired portion of the watershed. Livestock farming is the major source of the pollutants phosphorus and sediments.

## INTRODUCTION

Total Maximum Daily Loads (TMDLs) have been developed for the North Branch Mahantango Creek watershed to address impaired segments on the 1996 and 1998 CWA Section 303(d) list. Aquatic surveys conducted by the Department, which included kick screen analysis and habitat surveys, determined that North Branch Mahantango Creek is not meeting its designated water quality use for protection of aquatic life. As a consequence of the surveys, two segments of North Branch Mahantango Creek were included on the Year 1996 and 1998 Section 303(d) list of impaired waters (Table 3). Actually, as shown in Table 3, the original listing in 1996 considered only one general zone of impairment. On the 1998 list, however, the same general zone of impairment was refined into two distinct stream segments. Therefore, this TMDL will address the two segments identified on the 1998 303(d) list, and will, at the same time, satisfy regulatory requirements to address impaired segments on the 1996 list.

The lists indicate organic enrichment from agricultural sources as the primary cause of the impairments. Organic enrichments generally involves the impact of nutrients and sedimentation, tending to yield a depressed aquatic community characterized by a tolerance to low dissolved oxygen. The most probable source of these problems is livestock with free access to the impaired stream segments. They defecate in the stream, trample the natural vegetation and make the stream bank unstable. Location of livestock herds gathered from a PADEP September 14, 2000 site visit are plotted on Map 2.

North Branch Mahantango Creek and its impaired tributaries discharge to Mahantango Creek, which in turn discharges to the Susquehanna River at a point approximately 1.5 miles downstream of McKees Half Falls and approximately 27 miles north of Harrisburg, Pennsylvania. The impaired portion of the watershed, which is the subject of this TMDL, is approximately 12.5 miles upstream of the Susquehanna River. Map 1 shows the local roads for finding the impaired stream segments.

The method which PADEP has employed to develop the TMDL compares the impaired portion of the North Branch Mahantango watershed to a non-impaired reference portion of the watershed. This method determines the pollutant loading rate (pounds/acre/yr) for nutrients and sediment in each watershed. The TMDL reduces the phosphorus and sediment loading rate in the impaired portion of the North Branch Mahantango watershed to the rates shown in the reference watershed. Because of the similarities in land use and characteristics, the TMDL will ensure North Branch Mahantango watershed achieves and maintains its aquatic life use, as evidenced by the healthy aquatic life in the reference watershed.

**Table 3.** Section 303(d) Listings for North Branch Mahantango Creek Watershed

| Year Listed | Segment ID | Stream Code | Stream | Source | Cause | Miles |
|---|---|---|---|---|---|---|
| 1996 (original listing) | N/A | 17370 | North Branch Mahantango Creek | Agriculture | Organic Enrichment/ Low DO | Approx 1 mile |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1998 (continued listing – defined one segment ) | 7052 | 17370 | North Branch Mahantango Creek | Agriculture | Organic Enrichment/ Low DO | 0.71 |
| 1998 (continued listing – defined a second segment) | 970709-1200-REH | 17370 | North Branch Mahantango Creek | Agriculture | Siltation | 0.69 |

PADEP uses a modification of EPA's Rapid Bio-assessment Protocol II (RPB-II) to assess streams. This method requires selecting sampling sites that reflect impacts from surrounding land use that are representative of the stream segment. Department biologists evaluating the stream segment select as many sites as necessary to establish an accurate assessment. At each site, a biological assessment using the modified RBP II method is conducted. The length of stream that is assessed per site varies. The site location and the length of an assessed segment depend on several factors. Some of these factors are:

- Distinct changes in stream characteristics,
- Surface geology,
- Riparian land use,
- Point source and non-point-source discharge locations,
- The pollutant(s) causing the impairment.

To develop this TMDL it was necessary to aggregate 303(d) listed stream segments together, because of the common representative land use above the impairments and common source of the impairments. The primary data source for non-point source TMDLs is Geographic Information System (GIS) layers derived from data on land use and other watershed characteristics. The land use data sets for this analysis are 30 by 30 *meter* grids from satellite imagery. Aggregation of segments and sources on a watershed scale effectively ensures that the level of precision of the analysis matches that of the GIS data. For this reason, the TMDL employs an aggregated analysis of the watershed above the impaired segments.

The TMDL developed for the impaired segments on the North Branch Mahantango address nutrients and sediment as the representative pollutants from non-point agricultural sources. Controlling nutrients and sediments to allowable levels will prevent organic enrichment and any dissolved oxygen depletion in the water column or benthic environment.

The nutrient portion of the TMDL addresses phosphorus, because it is the limiting nutrient on the watershed. Phosphorus is generally held to be the limiting nutrient in a waterbody when the nitrogen to phosphorus ratio exceeds 10/1. The ratio on the North Branch Mahantango is 18/1.

## REFERENCE WATERSHED APPROACH

Neither PADEP nor EPA currently has adopted in-stream water quality criteria for phosphorus and sediments. Therefore, PADEP has developed a reference watershed approach to develop TMDL endpoints or water quality objectives. The reference watershed approach uses an unimpaired watershed with similar land use to determine allowable loading rates for phosphorus and sediments. This is done by mathematically modeling the loads that enter the stream system, using precipitation and land use data. The approach uses the AVGWLF model to determine these rates (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). The rates in the unimpaired watershed are the goal for loading rate reductions in the impaired watershed. The model of the impaired watershed determines the current loading rates. The model of the unimpaired watershed determines target loading rates and the reductions necessary to meet the goal.

AVGWLF models surface runoff using the Soil Conservation Service Curve Number (SCS-CN) approach with daily weather (temperature and precipitation) inputs. All of the equations used by the model can be viewed in Attachment C, AVGWLF Users Manual.

Attachments A and B provide information on the method Pennsylvania uses to establish a TMDL for stream segments impaired by nutrients and sediment. They also include information on watershed hydrology and pollutant transport.

## WATERSHED HISTORY

The impaired North Branch Mahantango watershed in Snyder County is 5.1 square miles, located in the Ridge and Valley Physiographic Province. The protected uses of the watershed are water supply, recreation and aquatic life. Pennsylvania Code Title 25 Chapter 93, § 93.9 m designates the aquatic life use for the main stem North Branch Mahantango Creek as trout stocking.

In 1992, the PADEP conducted an aquatic biological survey on North Branch Mahantango Creek, to collect information on the macro-invertebrate community, and to determine the water quality of the stream. The survey identified degradation due to agricultural activities, notably livestock herds which have access to the stream. These herds cause severe stream bank erosion and are the source of phosphorus and sediments in the impaired stream segments. Map 2 shows the relationship between impairment, land use and the location of livestock herds. PADEP biologists concluded in the 1992 aquatic report that water quality would remain poor until buffer zones are established to protect the streams.

The primary land use on the watershed is agriculture, with areas of row crops and pasture lands which are directly adjacent to the stream banks. Livestock have free access to the stream. The 1992 survey indicated the majority of the stream had no protected riparian zone.

The follow-up survey in 1997 survey showed manure sedimentation as a continuing problem. Manure deposited in the streambed degrades the habitat for macro-invertebrates and adds nutrients

that cause algae blooms. A site visit conducted by the Department in September 2000 confirmed that the impaired stream still has no protected riparian zone.

## TMDL ENDPOINTS

The TMDL endpoints are the allowable pollutant loads (sediment and phosphorus) for the impaired portion of the watershed. These pollutants are mostly from livestock operations. PADEP determines the allowable pollutant load using the reference watershed approach and the AVGWLF model.

The objective of this TMDL is to reduce the loading rates of phosphorus and sediment in the impaired watersheds to a level that will restore the macro-invertebrate community, and to control, to acceptable levels, the impact of organic enrichment from agriculture. Although low dissolved oxygen is listed along with organic enrichment in the 303(d) listing as a cause of the impairment, the Department does not have data to support low D.O. as an actual cause. The inclusion of low D.O. on the 303(d) listing occurred because the Department's custom, when developing the 305(b) lists through the mid-1990s, was to automatically include low D.O. as an assumed cause of impairment whenever organic enrichment was the observed cause. Department biologists have since found that organic enrichment, by itself, can be the sole cause of a shift in the aquatic insect community, even in situations where D.O. is not depressed. Accordingly, because there is no data to indicate that the organic enrichment observed in the North Branch Mahantango is also accompanied by low D.O., this TMDL will focus on organic enrichment as the cause of impairment. As noted above, the phosphorus and sediment loads, mostly from agricultural non-point sources, will be analyzed as the pertinent pollutants characterizing the observed organic enrichment The computation of these pollutant loads is discussed in detail in the TMDL computations for phosphorus and sediment section.

These endpoints will serve as references to guide the implementation of best management practices (BMPs) for the livestock operations. These operations are the major sources of phosphorus and sediments. The livestock operations contributing these pollutants is shown on Map 2. PADEP will determine compliance with these endpoints using the same biological assessment that impaired the North Branch Mahantango watershed.

Pennsylvania's Growing Greener initiative provides funding for installing BMP that will restore the aquatic use of the North Branch Mahantango watershed. The recent organization of PADEP into watershed teams will facilitate funding and technical assistance to implement this TMDL.

## SELECTION OF THE REFERENCE WATERSHED

The reference watershed is a portion of the North Branch Mahantango that has similar characteristics as the impaired watershed. The location of the reference watershed, as shown on the front cover map of this TMDL report, is directly adjacent, in a northeasterly direction, to the impaired watershed. Department biologists have assessed the streams in the reference watershed over the same time period in which the assessments of the impaired segments were conducted. Those assessments show that the streams in the reference watershed fully support their designated aquatic uses.

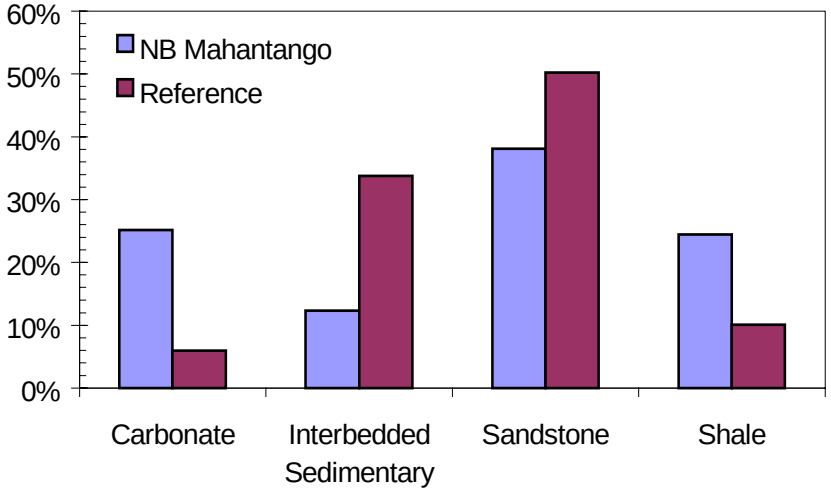
The charts below show similarity in the land use and geology between the impaired and reference watersheds. The land use and geology charts are derived from GIS database files that describe these attributes for the two watersheds. The charts show the distribution of land use and rock type for both watersheds. These charts and the model inputs (see page 19) show that the reference is viable, because of the physical similarities to the impaired watershed. The model outputs show that both watersheds have similar ground water and surface water flow. Maps 2 and 3 also show that their land use and geology are similar. Also, because the impaired watershed and reference watershed are so close to each other geographically, precipitation characteristics, soil characteristics, and other physical characteristics which can influence runoff quantity and quality are the same or similar. Because of this, coefficients used for the hydraulic and soil loss equations within the GWLF analysis model are essentially the same for both the impaired and reference watersheds.

The September 14, 2000 site visit also verified the land use shown in Map 2. This visit did result in the identification of one small area on the impaired watershed which was stored in the land-use data base as "high development", but which was actually a quarry. The quarry uses a sedimentation basin to control storm water run-off, and the discrepancy is not critical to the analysis. The quarry constitutes only 17 acres (or approximately 0.5 %) of 3195 acres on the entire impaired watershed. Also, information provided by the quarry operator, as well as visual observations, confirm that the sedimentation basin was designed to control all of the accelerated runoff from the entire 17-acre site and overflows into a wetland. With such controls in place, there should be no reason to assume that the unit area sediment load developed in the model for "high intensity development" would be substantively different for the controlled runoff from this quarry. To model this land as a quarry would drastically overestimate the sediment/nutrient loads from this area and obscure the true cause of impairment in the stream. Furthermore, as stated above, the acreage, and therefore the potential total pollutant load, is small compared to other land-use categories and sources on the watershed. Accordingly, the Department has determined that the analysis of pollutant loads (both sediment and phosphorus) in the model is neither inaccurate nor critical to the evaluation of the important sources of pollutant loads, namely the agricultural lands.

CHART 1: COMPARISON OF LAND USE DISTRIBUTION

| Land Use | NB Mahantango | Reference |
|---|---|---|
| Low Intensity Development | 0.1 % | 0.5% |
| High Intensity Development | (quarry) 0.5% | 0.2% |
| Hay/Pasture | 17.3% | 11.9% |
| Cropland | 19.4% | 21.1% |
| Coniferous Forest | 2.5% | 4.6% |
| Mixed Forest | 3.7% | 3.2% |
| Deciduous Forest | 55.5% | 58.5% |

CHART 2: COMPARISON OF GEOLOGY/ROCK-TYPE DISTRIBUTION




| Rock Type | NB Mahantango | Reference |
|---|---|---|
| Carbonate | 25% | 6% |
| Interbedded Sedimentary | 12% | 34% |
| Sandstone | 38% | 50% |
| Shale | 24% | 10% |

The land use, geology, and meteorology of these watersheds are similar enough that changes to the model input are not necessary.

**DATA COMPILATION AND MODEL OVERVIEW**

The Generalized Watershed Loading Function (GWLF) model outputs were used in the development of the TMDL. The GWLF model provides the ability to simulate runoff, sediment, nitrogen (N) and phosphorus (P) loading from watershed-specific source areas ( e.g. agricultural, forested, developed, etc). 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 that uses

daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values.

GWLF is a combined distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use scenarios. Each area is assumed to be homogeneous 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 the 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 a transport capacity based on average daily runoff are applied to the calculated erosion to determine sediment yield for each source area. Surface nutrient losses are determined by applying dissolved 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 loading. 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 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 Attachment E, 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.

## GIS BASED DERIVATION OF INPUT DATA

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 Cornell University GWLF model. 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 (see Attachment B). For use in Pennsylvania, AVGWLF has been linked with statewide GIS data layers such as land use, 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-eight weather stations around the state. Table 5 lists the GIS data sets and provides explanation of how they were used for development of the input files for the GWLF model.

**Table 4. State-Wide GIS Data Sets**

| | |
|---|---|
| Physprov | A shape file of physiographic provinces. Attributes *rain_cool* and *rain_warm* are used to set recession coefficient |
| Statsgo | A shape file of generalized soil boundaries. The attribute *mu_k* sets the k factor in the USLE. The attribute *mu_awc* is the unsaturated available capacity. and the *muhsg_dom* is used with land use cover to derive curve numbers. |
| Basin | A shape file of the boundary for North Branch Mahantango watershed |
| County | The County boundaries coverage lists data on conservation practices, which provides C and P values in the Universal Soil Loss Equation (USLE). |
| Zipcode | Coverage of animal densities. Attribute *aeu_acre* helps estimate N & P concentrations in runoff in agricultural lands and over manured areas. |
| Pointsrc | Major point source discharges with permitted N and P loads. |
| Censustr | Coverage of Census data including information on individual homes septic systems. The attribute *susew_sept* includes data on conventional systems, and *su_other* provides data on short-circuiting and other systems. |
| Pasingle | The 1:24,000 scale single line stream coverage of Pennsylvania. Provides a complete network of streams with coded stream segments. |
| Weather | A shape file for stations around Pennsylvania to simulate flow. |
| Padem | 100-meter digital elevation model. This is used to calculate land slope and slope length. |
| Palumrlc | A satellite image derived land ues grid, which is classified into 15 different land use, categories. This data set provides land use loading rate for the different categories in the model. |
| Gwnback | A grid of background concentrations of N in groundwater derived from water well sampling. |

| | |
|---|---|
| Soilphos | A grid of soil phosphorous loads, which has been generated from soil sample data. Used to help set phosphorus and sediment values. |
| 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 | Coverage of permitted point discharges. Provides background information and cross check for the point source coverage. |
| Refwater | Shape file of reference watersheds for which nutrient and sediment loads have been calculated. |
| Smallsheds | Coverage of watersheds at the 1:24,000 scale set a name stream level. This coverage is used with the stream network to delineate the desired level watershed. |
| Strm305 | Coverage of stream water quality as reported in the Pennsylvania's 305(b) report. Current status of assessed streams. |
| Surfgeol | A shape file 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. |

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

In the GWLF model, the non-point source load calculated is affected by terrain conditions, such as the amount of agricultural land, land slope, and inherent soil erosion. It is also affected by farming methods, as well as by background concentrations of N and P in soil and groundwater. The model includes parameters to account for these conditions and practices. Some of the more important parameters are summarized below:

- *Areal extent of different land use categories:* This is calculated directly from a GIS layer of land use.

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

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

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

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

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

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

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

- *Dissolved nitrogen in runoff:* This varies according to land use type, and reasonable values have been established in the literature. This rate, reported in mg/l, can be re-adjusted based on local conditions such as rates of fertilizer application and farm animal populations.

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

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

- *Nutrient build-up in non-urban areas:* In GWLF, rates of build-up for both N and P have to be specified. In Pennsylvania, this is estimated using historical information on atmospheric deposition.

- *Background N and P concentrations in groundwater:* Subsurface concentrations of nutrients (primarily N) contribute to the nutrient loads in streams. In Pennsylvania, these concentrations are estimated using recently published data from USGS.

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

Other less important factors that can affect sediment and nutrient loads in a watershed are also included in the model. More detailed information about these parameters and those outlined above can be obtained from the GWLF Users Guide provided in Appendix C of this document.

## WATERSHED ASSESSMENT AND MODELING

Existing conditions for nitrogen, phosphorus, and sediment loads were estimated with GWLF for the impaired portion of the North Branch Mahantango and reference watersheds. The 22-year statistical means for these parameters for each watershed are shown Tables 7 and 8. The Unit Area Load for each pollutant in each watershed was estimated by dividing the mean annual loading (lbs/year) by the total area (acres) resulting in an approximate loading per unit area for the watershed. Table 5 presents an explanation of the header information contained in Tables 7 and 8.

**Table 5. Header information for Tables 6 and 7.**

| | |
|---|---|
| Source | The pollutant Source heading from the GWLF summary output |
| Area (acres) | The area of the specific land use category found in the watershed. |
| Total P | The estimated total phosphorus loading that reaches the outlet point of the watershed that is being modeled. Expressed in lbs./year. |
| Unit Area P Load | The estimated loading rate for phosphorus for a specific land cover/land use category. Loading rate is expressed in lbs/acre/year |
| Total N | The estimated total nitrogen loading that reaches the outlet point of the watershed that is being modeled. Expressed in lbs./year. |
| Unit Area N Load | The estimated loading rate for nitrogen for a specific land cover/land use category. Loading rate is expressed in lbs/acre/year |
| Total Sed | The estimated total sediment loading that reaches the outlet point of the watershed that is being modeled. Expressed in lbs./year. |
| Unit Area Sed Load | The estimated loading rate for sediment for a specific land cover/land use category. Loading rate is expressed in lbs/acre/year |

**Table 6. Existing Loading Values for North Branch Mahantango Watershed**

| Source | Area (acres) | Total P (lbs/yr) | Unit Area P Load (lbs/acre/ yr) | Total N (lbs/yr) | Unit Area N Load (lbs/acre/ yr) | Sed Load (lbs/year) | Unit Area Sed Load (lbs/acre/yr) |
|---|---|---|---|---|---|---|---|
| "Hay/Past" | 551 | 206 | 0.37 | 2093 | 3.80 | 316361 | 574 |
| "Cropland" | 620 | 1120 | 1.81 | 8352 | 13.47 | 2017752 | 3253 |
| "Conif_For" | 79 | 1 | 0.01 | 12 | 0.15 | 1192 | 15 |
| "Mixed_For" | 119 | 2 | 0.02 | 22 | 0.18 | 2899 | 24 |
| "Decid_For" | 1806 | 316 | 0.17 | 2011 | 1.11 | 604497 | 335 |
| "Lo_Int_Dev" | 2 | 0.2 | 0.09 | 2 | 0.71 | 13128 | 5313 |
| "Hi_Int_Dev" | 17 | 21 | 1.20 | 188 | 10.85 | 10458 | 605 |
| Groundwater | | 130 | | 18606 | | | |
| Point Source | | 0 | | 0 | | 0 | |
| Septic Systems | | 11 | | 748 | | | |
| **Total** | **3195** | **1807** | **0.5656** | **32033** | **10.03** | **2966348** | **928.4** |

The "Hi_Int_Dev" in the above is a quarry. This quarry uses a sedimentation basin that would have smaller loads than the above. Since, the above loads for "Hi_Int_Dev" are small it was not necessary to adjust the model.

**Table 7. Loading Values for Reference Watershed**

| Source | Area (acres) | Total P (lbs/yr) | Unit Area P Load (lbs/acre/ yr) | Total N (lbs/yr) | Unit Area N Load (lbs/acre/ yr) | Sed Load (lbs/year) | Unit Area Sed Load (lbs/acre/yr) |
|---|---|---|---|---|---|---|---|
| "Hay/Past" | 381 | 95 | 0.25 | 1172 | 3.08 | 127451 | 335 |
| "Cropland" | 677 | 1041 | 1.54 | 8115 | 11.99 | 1868600 | 2760 |
| "Conif_For" | 146 | 2 | 0.01 | 23 | 0.16 | 2445 | 17 |
| "Mixed_For" | 101 | 1 | 0.01 | 15 | 0.14 | 1166 | 12 |
| "Decid_For" | 1875 | 131 | 0.07 | 940 | 0.50 | 244970 | 131 |
| "Lo_Int_Dev" | 17 | 1.5 | 0.09 | 12 | 0.70 | 13128 | 759 |
| "Hi_Int_Dev" | 7 | 9 | 1.19 | 80 | 10.85 | 10458 | 1411 |
| Groundwater | | 123 | | 17511 | | | |
| Point Source | | 0 | | 0 | | 0 | |
| Septic Systems | | 17 | | 949 | | | |
| **Total** | **3205** | **1419** | **0.4427** | **28817** | **8.99** | **2268300** | **707.74** |

## TMDL COMPUTATIONS FOR PHOSPHORUS AND SEDIMENT

The TMDL establishes a load allocation (LA) and a margin of safety (MOS) for both phosphorus and sediment in the North Branch Mahantango Creek. There are no point discharges of phosphorus in the impaired or reference watershed; therefore, no waste load allocation (WLA).

The TMDL does not include nitrogen because the stream is phosphorus limited. If the ratio of nitrogen to phosphorus is greater than 10 to 1, it means that phosphorus will be the limiting nutrient in the stream. The North Branch Mahantango Creek nitrogen to phosphorus ratio is **32,033** pounds of nitrogen to **1,807** pounds of phosphorus, or 18 to 1.

The current loading rates for phosphorus and sediment in the reference watershed are the basis for the load reduction calculations in North Branch Mahantango watershed in this analysis. The reference watershed is meeting its designation for trout stocking (TSF). The phosphorus and sediment loading rates were computed for the reference watershed using the AVGWLF model. These loading rates were then used to determine the TMDL for North Branch Mahantango Creek.

The TMDL equation is as follows: Allowable Pollutant Loading = WLA + LA + MOS

The WLA (wasteload allocation) portion of this equation is the total loading that is assigned to point sources. The LA (load allocation) is the portion of this equation that is assigned to non-point sources for the total watershed. The MOS (margin of safety) is the portion of loading that is reserved to account for any uncertainty in the data and computation method used for the analysis. Table 8 presents the TMDL for North Branch Mahantango Creek.

**Table 8. TMDL for North Branch Mahantango Watershed**

| Pollutant | Allowable Pollutant Load (lb/yr) | LA (lb/yr) | WLA (lb/yr) | MOS (lb/yr |
|---|---|---|---|---|
| **Sediment** | 2261234 | 2035111 | 0 | 226123 |
| **Phosphorus** | 1414 | 1273 | 0 | 141 |

The individual components of the TMDL are discussed in detail below.

TMDL COMPUTATION

The TMDLs for both pollutants were computed in the same manner. The reference watershed area loading rate for each pollutant was multiplied by the total area of North Branch Mahantango watershed to give the TMDL value. Table 10 presents this information.

**Table 9. TMDL Computation**

| Pollutant | Area Loading Rate in Reference Watershed (lbs/acre/year) | Total Watershed Area in North Branch Mahantango Creek (acres) | TMDL Value (lbs/year) |
|---|---|---|---|
| **Phosphorus** | 0.4427 | 3195 | 1414 |
| **Sediment** | 707.7415 | 3195 | 2261234 |

MARGIN OF SAFETY

The Margin of Safety (MOS) for this analysis reserves ten percent of each TMDL. The MOS will provide an additional level of protection to the uses of the waterbody.

Phosphorus – 1414 x 0.1 = 141 lbs/year
Sediment - 2261234 x 0.1 = 226123 lbs/year

LOAD ALLOCATION

The load allocation (LA) for the entire watershed is computed by subtracting the margin of safety value and the WLA from the allowable pollutant load. Individual load allocations shown in Table 10 are assigned to hay/pasture and cropland for the entire watershed. The load allocation for the other land uses is set at their existing loads. The following section shows the allocation process in detail.

Phosphorus

1. The margin of safety and the WLA values subtracted from the allowable pollutant load equals the LA.

   LA = 1414– 141 = 1273 lbs/year

2. The loads that will not be managed are subtracted from the LA value. These loads are: coniferous forest, mixed forest, deciduous forest, low intensity development (Lo Int Dev), high intensity development (Hi Int Dev), groundwater, and septic systems. The total load for these land uses/sources is 481 lbs. This quantity is subtracted from the LA.

   Adjusted LA = 1273 – 481 = 792 lbs/year

3. The adjusted LA is the allocation for the hay/pasture and cropland sources of phosphorus and sediments. Equal Marginal Percent Reduction (EMPR) is the allocation method. Attachment D describes EMPR.

4. The results of the LA are presented in Table 10.

Sediment

1. The margin of safety value subtracted from the allowable pollutant load equals the LA.

   LA = 2261234– 226123 = 2035111 lbs/year

2. The loads that will not be managed are subtracted from the LA value. These are the loads: Coniferous Forest, Mixed Forest, and Deciduous Forest, low intensity development (Lo Int Dev) and high intensity development (Hi Int Dev). The total load for these land uses/sources is 632175 lbs. This quantity was subtracted from the LA.

Adjusted LA = 2035111 – 632175= 1402935 lbs/year

3. The adjusted LA is the allocation for the hay/pasture and cropland sources of phosphorus and sediments. Equal Marginal Percent Reduction (EMPR) is the allocation method. The allocation method is discussed above in the phosphorus section.

4. The results of the LA are presented in Table 10.

**Table 10. North Mahantango Watershed Land Use Load Allocation**

| | | Phosphorus | | | | | Sediment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source** | **Acres** | **lbs/acre/yr** | **lbs/yr** | **Baseline** | **LA lbs/yr** | **% Red** | **lbs/acre/yr** | **lbs/yr** | **Baseline** | **LA lbs/yr** | **% Red** |
| "Hay/Past" | 551 | 0.37 | 206 | 206 | 164 | 21% | 574 | 316361 | 316361 | 258150 | 18% |
| "Cropland" | 620 | 1.81 | 1120 | 792 | 628 | 44% | 3253 | 2017752 | 1402935 | 1144787 | 43% |
| "Conif_For" | 79 | 0.01 | 1 | | 1 | | 15 | 1192 | | 1192 | |
| "Mixed_For" | 119 | 0.02 | 2 | | 2 | | 24 | 2899 | | 2899 | |
| "Decid_For" | 1806 | 0.17 | 316 | | 316 | | 335 | 604497 | | 604497 | |
| "Lo_Int_Dev" | 2 | 0.09 | 0.2 | | 0 | | 5313 | 13128 | | 13128 | |
| "Hi_Int_Dev" | 17 | 1.20 | 21 | | 21 | | 605 | 10458 | | 10458 | |
| Groundwater | | | 130 | | 130 | | | | | | |
| Point Source | | | 0 | | | | | 0 | | | |
| Septic Systems | | | 11 | | 11 | | | | | | |
| Total | 3195 | 0.5656 | 1807 | 998 | 1273 | 30% | 928.4 | 2966348 | 1719296 | 2035111 | 31% |

The lbs/yr is from the model output Total Loads by Land Use Category English Unit. The Unit Area Loading Rate is the annual average load divided by the acres. Table 11 below shows the comparison of the existing loads to the allocated loads

**Table 11 Comparison of Exiting to Allocated Loads**

| | Phosphorus | | | | | | Sediment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source** | **Acres** | **Existing lbs/yr** | **Existing lbs/acre/yr** | **Allocated lbs/yr** | **Allocated lbs/acre/yr** | **% Red** | **Existing lbs/yr** | **Existing lbs/acre/yr** | **Allocated lbs/yr** | **Allocated lbs/acre/yr** | **% Red** |
| "Hay/Past" | 551 | 206 | 0.37 | 164 | 0.30 | 21% | 316361 | 574 | 258150 | 469 | 18% |
| "Cropland" | 620 | 1120 | 1.81 | 628 | 1.01 | 44% | 2017752 | 3253 | 1144787 | 1846 | 43% |

## CONSIDERATION OF CRITICAL CONDITIONS

The AVGWLF model is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. These daily steps are from the 1976 to 1998 time period for 22 years of simulation that accounts for severe weather events. Monthly calculations made for phosphorus and sediment loads, are based on daily water balance accumulated to monthly values that account for seasonal variability. Therefore, all flow conditions are taken into account for loading calculations. Because of the lag time between introducing phosphorus and sediments to a water body and their impact on beneficial uses, establishing the TMDL using average annual conditions is protective of the waterbody.

## CONSIDERATION OF SEASONAL VARIATIONS

The continuous simulation model used for this analysis considers seasonal variation through the following mechanisms.

- The model uses daily time steps for weather data and water balance calculations.
- This model input is for May to September growing season.
- The model accounts for the application of manure to farm fields from February to May and September to November.
- The model computes hours of daylight for each month.

The combination of these actions by the model accounts for seasonal variability.

## RECOMMENDATIONS

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

## ASSESSMENT OF MEASURES AND FOLLOW-UP MONITORING

Monitoring will begin prior to the installation of BMPs and includes biota, water chemistry and bank stability. The PADEP will conduct follow-up assessment and determinations regarding the stream's recovery, after BMPs have been implemented. Based on the results of follow-up analysis, further targeted BMPs may be identified as being necessary to further reduce pollutant loads and impairments.

## PUBLIC PARTICIPATION

The Department published this TMDL in the Pennsylvania Bulletin on December 16, 2000, in the Sunbury Daily Item (local newspaper) on December 17, 2000, and on the Department's web-site to provide opportunity for public comment on the pollutant load analysis. The official comment period was from December 16, 2000, to February 13, 2001. A public meeting was scheduled for January 30, 2001, and was advertised/noticed in the above-mentioned publications. No public comments were received during the comment period or at the scheduled meeting. EPA comments are addressed in Attachment E – Comment and Response Document. Notice of the final TMDL, upon approval by EPA, will be published in the Pennsylvania Bulletin.

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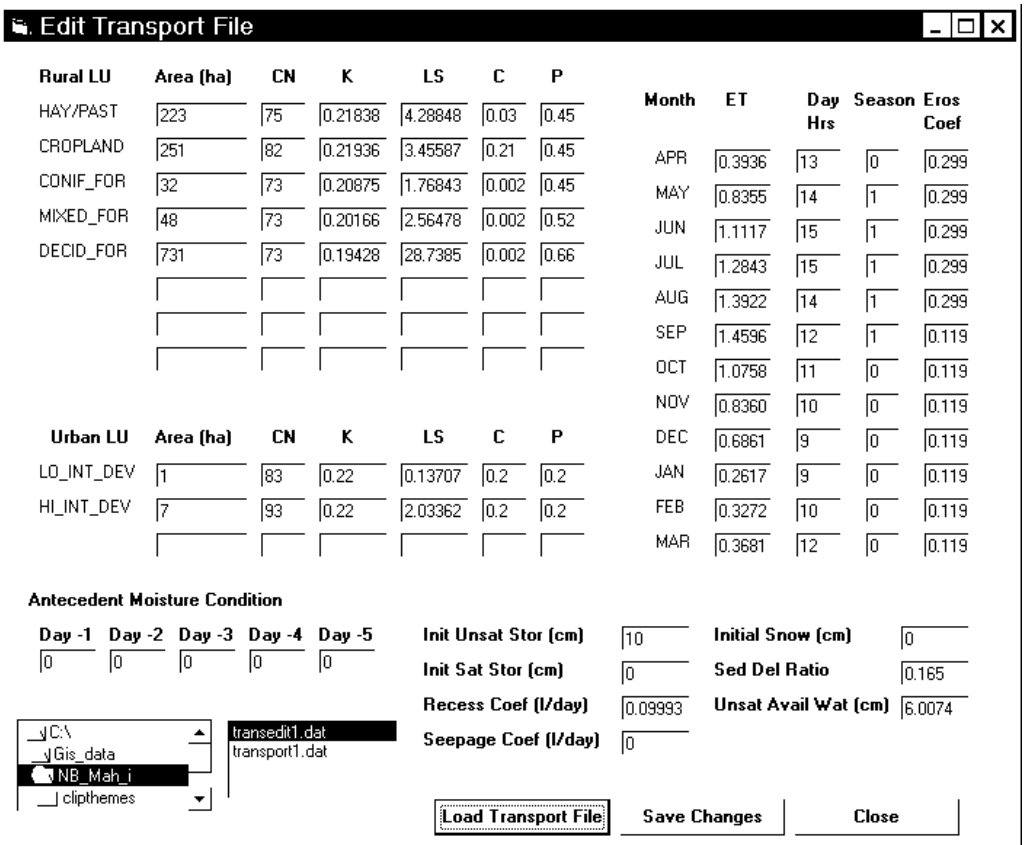
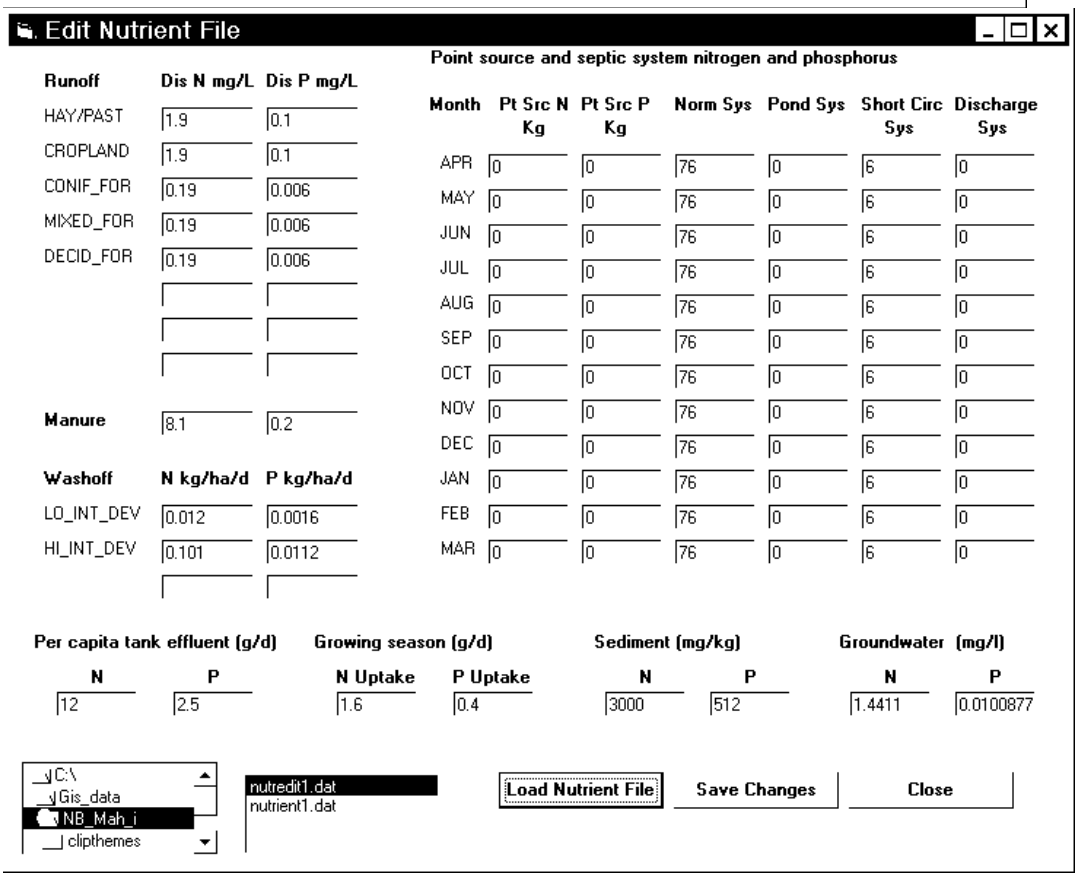
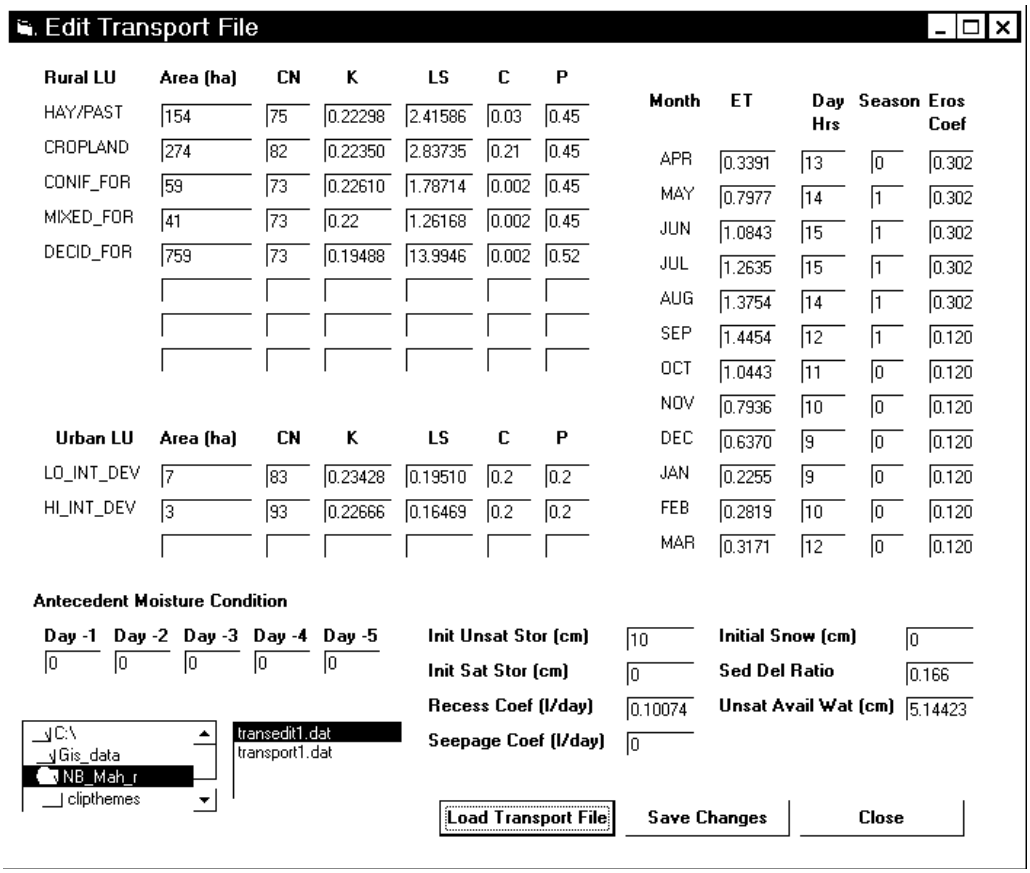
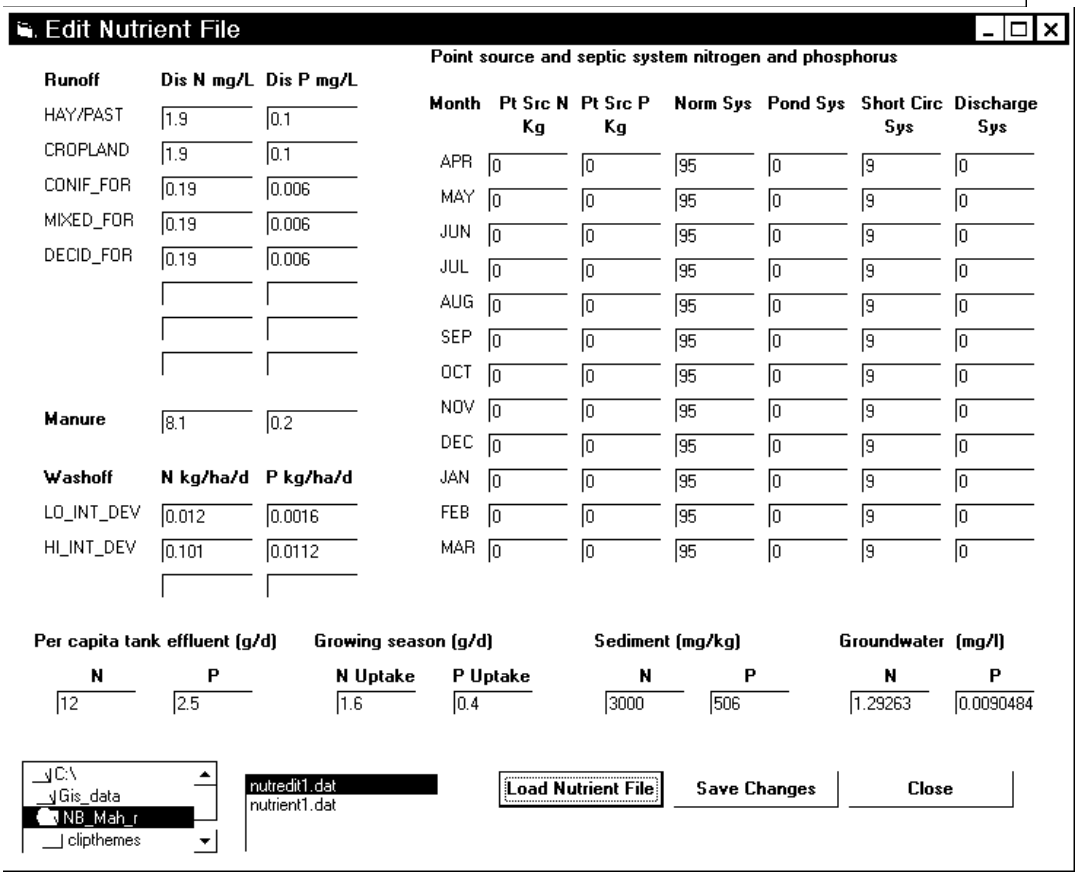
**GWLF INPUT SCREENS**
North Branch Mahantango Watershed




Edit Transport File
Rural LU | Area (ha) | CN | K | LS | C | P
HAY/PAST | 154 | 75 | 0.22298 | 2.41586 | 0.03 | 0.45
CROPLAND | 274 | 82 | 0.22350 | 2.83735 | 0.21 | 0.45
CONIF_FOR | 59 | 73 | 0.22610 | 1.78714 | 0.002 | 0.45
MIXED_FOR | 41 | 73 | 0.22 | 1.26168 | 0.002 | 0.45
DECID_FOR | 759 | 73 | 0.19488 | 13.9946 | 0.002 | 0.52
Urban LU | Area (ha) | CN | K | LS | C | P
LO_INT_DEV | 7 | 83 | 0.23428 | 0.19510 | 0.2 | 0.2
HI_INT_DEV | 3 | 93 | 0.22666 | 0.16469 | 0.2 | 0.2
Month | ET | Day Hrs | Season | Eros Coef
APR | 0.3391 | 13 | 0 | 0.302
MAY | 0.7977 | 14 | 1 | 0.302
JUN | 1.0843 | 15 | 1 | 0.302
JUL | 1.2635 | 15 | 1 | 0.302
AUG | 1.3754 | 14 | 1 | 0.302
SEP | 1.4454 | 12 | 1 | 0.120
OCT | 1.0443 | 11 | 0 | 0.120
NOV | 0.7936 | 10 | 0 | 0.120
DEC | 0.6370 | 9 | 0 | 0.120
JAN | 0.2255 | 9 | 0 | 0.120
FEB | 0.2819 | 10 | 0 | 0.120
MAR | 0.3171 | 12 | 0 | 0.120
Antecedent Moisture Condition
Day -1 | Day -2 | Day -3 | Day -4 | Day -5
0 | 0 | 0 | 0 | 0
Init Unsat Stor (cm) 10
Init Sat Stor (cm) 0
Recess Coef (l/day) 0.10074
Seepage Coef (l/day) 0
Initial Snow (cm) 0
Sed Del Ratio 0.166
Unsat Avail Wat (cm) 5.14423
C:\
Gis_data
NB_Mah_r
clipthemes
transedit1.dat
transport1.dat
Load Transport File
Save Changes
Close


Edit Nutrient File
Runoff | Dis N mg/L | Dis P mg/L
HAY/PAST | 1.9 | 0.1
CROPLAND | 1.9 | 0.1
CONIF_FOR | 0.19 | 0.006
MIXED_FOR | 0.19 | 0.006
DECID_FOR | 0.19 | 0.006
Manure | 8.1 | 0.2
Washoff | N kg/ha/d | P kg/ha/d
LO_INT_DEV | 0.012 | 0.0016
HI_INT_DEV | 0.101 | 0.0112
Point source and septic system nitrogen and phosphorus
Month | Pt Src N Kg | Pt Src P Kg | Norm Sys | Pond Sys | Short Circ Sys | Discharge Sys
APR | 0 | 0 | 95 | 0 | 9 | 0
MAY | 0 | 0 | 95 | 0 | 9 | 0
JUN | 0 | 0 | 95 | 0 | 9 | 0
JUL | 0 | 0 | 95 | 0 | 9 | 0
AUG | 0 | 0 | 95 | 0 | 9 | 0
SEP | 0 | 0 | 95 | 0 | 9 | 0
OCT | 0 | 0 | 95 | 0 | 9 | 0
NOV | 0 | 0 | 95 | 0 | 9 | 0
DEC | 0 | 0 | 95 | 0 | 9 | 0
JAN | 0 | 0 | 95 | 0 | 9 | 0
FEB | 0 | 0 | 95 | 0 | 9 | 0
MAR | 0 | 0 | 95 | 0 | 9 | 0
Per capita tank effluent (g/d)
N 12
P 2.5
Growing season (g/d)
N Uptake 1.6
P Uptake 0.4
Sediment (mg/kg)
N 3000
P 506
Groundwater (mg/l)
N 1.29263
P 0.0090484
C:\
Gis_data
NB_Mah_r
clipthemes
nutredit1.dat
nutrient1.dat
Load Nutrient File
Save Changes
Close

**GWLF OUTPUT SUMMARY FOR NORTH BRANCH MAHANTANGO WATERSHED**

# Transport Information

| | Units in Centimeters | | | | |
|---|---|---|---|---|---|
| **MONTH** | **PRECIP** | **EVAPOTRANS** | **GR.WAT. FLOW** | **RUNOFF** | **STREAMFLOW** |
| "APR" | 8.79 | 1.78 | 7.5 | 0.4 | 8 |
| "MAY" | 9.26 | 6.41 | 5.2 | 0.2 | 5.4 |
| "JUN" | 10.83 | 10.78 | 2 | 0.5 | 2.5 |
| "JUL" | 10 | 10.93 | 0.4 | 0.3 | 0.6 |
| "AUG" | 9.73 | 8.99 | 0.2 | 0.4 | 0.6 |
| "SEP" | 9.03 | 6.51 | 0.4 | 0.2 | 0.6 |
| "OCT" | 8.82 | 3.8 | 2 | 0.8 | 2.8 |
| "NOV" | 9.59 | 1.55 | 4.3 | 0.6 | 5 |
| "DEC" | 7.44 | 0.5 | 6.4 | 0.7 | 7 |
| "JAN" | 7.79 | 0.11 | 4.7 | 1.6 | 6.2 |
| "FEB" | 6.25 | 0.21 | 5.1 | 1.1 | 6.2 |
| "MAR" | 8.1 | 0.81 | 7.1 | 1.4 | 8.5 |
| **ANNUAL:** | 105.62 | 52.38 | 45.3 | 8.1 | 53.4 |

# Nutrient Information

| | Mg (1000 Kg) | | Kg | | | |
|---|---|---|---|---|---|---|
| **MONTH** | **EROSION** | **SEDIMENT** | **DIS. NITR.** | **TOT. NITR.** | **DIS. PHOS.** | **TOT. PHOS** |
| "APR" | 911.5 | 150.4 | 1516.8 | 1574.7 | 13.3 | 22.8 |
| "MAY" | 1043.5 | 172.2 | 1040.2 | 1086 | 8.8 | 16.3 |
| "JUN" | 1452.1 | 239.6 | 447.2 | 673.2 | 6.1 | 44.2 |
| "JUL" | 1194.3 | 197.1 | 108.3 | 213.1 | 2.8 | 20.3 |
| "AUG" | 1372.9 | 226.5 | 99.6 | 275.8 | 3.3 | 32.9 |
| "SEP" | 445.5 | 73.5 | 181.2 | 283.5 | 3.4 | 20.5 |
| "OCT" | 462.7 | 76.3 | 773.2 | 1194.2 | 12.7 | 84.2 |
| "NOV" | 461.4 | 76.1 | 1184.8 | 1564.7 | 14.6 | 79 |
| "DEC" | 233.4 | 38.5 | 1319.8 | 1632.5 | 13 | 65.9 |
| "JAN" | 120.2 | 19.8 | 1094.5 | 1838.3 | 16.1 | 142.5 |
| "FEB" | 131.5 | 21.7 | 1126.9 | 1748.7 | 14.1 | 119.7 |
| "MAR" | 260.8 | 43 | 1547 | 2445.2 | 18.6 | 171.4 |
| **ANNUAL:** | 8089.9 | 1334.8 | 10439.6 | 14529.9 | 126.8 | 819.8 |

# Total Loads by Land Use Category

| | (ha) | (cm) | (Kg/ha) | | Total Loads (Kg) | | | |
|---|---|---|---|---|---|---|---|---|
| **SOURCE** | **AREA** | **RUNOFF** | **EROSION** | **SEDIMENT** | **DIS. NITR** | **TOT. NITR** | **DIS. PHOS** | **TOT. PHOS** |
| "HAY/PAST" | 223 | 7.52 | 3900.2 | 643.5 | 518.8 | 949.4 | 20 | 93.5 |
| "CROPLAND" | 251 | 13.03 | 22099.4 | 3646.4 | 1042.8 | 3788.5 | 39.5 | 508.1 |
| "CONIF_FOR" | 32 | 6.43 | 102.5 | 16.9 | 3.9 | 5.5 | 0.1 | 0.4 |
| "MIXED_FOR" | 48 | 6.43 | 165.9 | 27.4 | 5.9 | 9.8 | 0.2 | 0.9 |
| "DECID_FOR" | 731 | 6.43 | 2273.5 | 375.1 | 89.4 | 912 | 2.8 | 143.2 |
| "LO_INT_DEV" | 1 | 14.13 | 36090.5 | 5954.9 | 0 | 0.8 | 0 | 0.1 |
| "HI_INT_DEV" | 7 | 35.6 | 4107.2 | 677.7 | 0 | 85.1 | 0 | 9.4 |
| GROUNDWATER | | | | | 8439.5 | 8439.5 | 59.1 | 59.1 |
| POINT SOURCE | | | | | 0 | 0 | 0 | 0 |
| SEPTIC SYSTEMS | | | | | 339.3 | 339.3 | 5.1 | 5.1 |
| **TOTAL** | 1293 | 8.06 | 6306.811 | 1040.624 | 10439.6 | 14529.9 | 126.8 | 819.8 |

# Total Loads by Land Use Category English Unit

acre = (ha) x 2.471  inches = (cm) / 2.54  pounds/acre = (kg/ha) x 0.8924  pound = (kg) x 2.2046

| | acre | inches | pounds/acre | | | | Total Load (pounds) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **SOURCE** | **AREA** | **RUNOFF** | **EROSION** | **SEDIMENT** | **TOTAL NITROGEN** | **TOTAL PHOS** | **DIS. NITR** | **TOT. NITR** | **DIS. PHOS** | **TOT. PHOS** |
| "HAY/PAST" | 551 | 3.0 | 3479.7 | 574.1 | 3.80 | 0.37 | 1144 | 2093 | 44 | 206 |
| "CROPLAND" | 620 | 5.1 | 19716.9 | 3253.3 | 13.47 | 1.81 | 2299 | 8352 | 87 | 1120 |
| "CONIF_FOR" | 79 | 2.5 | 91.4 | 15.1 | 0.15 | 0.01 | 9 | 12 | 0 | 1 |
| "MIXED_FOR" | 119 | 2.5 | 148.0 | 24.4 | 0.18 | 0.02 | 13 | 22 | 0 | 2 |
| "DECID_FOR" | 1806 | 2.5 | 2028.4 | 334.7 | 1.11 | 0.17 | 197 | 2011 | 6 | 316 |
| "LO_INT_DEV" | 2 | 5.6 | 32199.6 | 5312.9 | 0.71 | 0.09 | 0 | 2 | 0 | 0 |
| "HI_INT_DEV" | 17 | 14.0 | 3664.4 | 604.6 | 10.85 | 1.20 | 0 | 188 | 0 | 21 |
| GROUNDWATER | | | | | | | 18606 | 18606 | 130 | 130 |
| POINT SOURCE | | | | | | | 0 | 0 | 0 | 0 |
| SEPTIC SYSTEMS | | | | | | | 748 | 748 | 11 | 11 |
| **TOTAL** | 3195 | 3.2 | 5627 | 928 | 10.03 | 0.57 | 23015 | 32033 | 280 | 1807 |

**GWLF OUTPUT SUMMARY FOR REFERENCE WATERSHED**

# Transport Information

| | Units in Centimeters | | | | |
|---|---|---|---|---|---|
| **MONTH** | **PRECIP** | **EVAPOTRANS** | **GR.WAT. FLOW** | **RUNOFF** | **STREAMFLOW** |
| "APR" | 8.79 | 1.54 | 7.7 | 0.4 | 8.2 |
| "MAY" | 9.26 | 6.07 | 5.4 | 0.2 | 5.6 |
| "JUN" | 10.83 | 10.31 | 2.1 | 0.5 | 2.6 |
| "JUL" | 10 | 10.51 | 0.5 | 0.3 | 0.7 |
| "AUG" | 9.73 | 8.92 | 0.4 | 0.4 | 0.7 |
| "SEP" | 9.03 | 6.38 | 0.6 | 0.2 | 0.8 |
| "OCT" | 8.82 | 3.7 | 2.4 | 0.8 | 3.1 |
| "NOV" | 9.59 | 1.47 | 4.7 | 0.6 | 5.4 |
| "DEC" | 7.44 | 0.46 | 6.6 | 0.7 | 7.2 |
| "JAN" | 7.79 | 0.09 | 4.7 | 1.6 | 6.2 |
| "FEB" | 6.25 | 0.18 | 5.1 | 1.1 | 6.2 |
| "MAR" | 8.1 | 0.7 | 7.1 | 1.4 | 8.6 |
| **ANNUAL:** | 105.62 | 50.33 | 47.4 | 8.1 | 55.4 |

# Nutrient Information

| | Mg (1000 Kg) | | Kg | | | |
|---|---|---|---|---|---|---|
| **MONTH** | **EROSION** | **SEDIMENT** | **DIS. NITR.** | **TOT. NITR.** | **DIS. PHOS.** | **TOT. PHOS** |
| "APR" | 691.1 | 114.7 | 1423.4 | 1465.6 | 12.7 | 19.7 |
| "MAY" | 791.2 | 131.3 | 987.6 | 1020.9 | 8.5 | 14 |
| "JUN" | 1100.9 | 182.7 | 439.1 | 609.4 | 6.1 | 34.6 |
| "JUL" | 905.5 | 150.3 | 123.6 | 201.6 | 3 | 16 |
| "AUG" | 1040.9 | 172.8 | 119.7 | 252.3 | 3.5 | 25.7 |
| "SEP" | 337.8 | 56.1 | 212 | 288.2 | 3.8 | 16.5 |
| "OCT" | 350.8 | 58.2 | 791.8 | 1111.1 | 12.7 | 66.4 |
| "NOV" | 349.8 | 58.1 | 1164.6 | 1452.1 | 14.4 | 62.7 |
| "DEC" | 176.9 | 29.4 | 1234.5 | 1471.2 | 12.4 | 52.1 |
| "JAN" | 91.2 | 15.1 | 1009.7 | 1574.9 | 15.2 | 110.4 |
| "FEB" | 99.7 | 16.6 | 1038.2 | 1510.4 | 13.4 | 92.8 |
| "MAR" | 197.7 | 32.8 | 1430.8 | 2113.7 | 17.6 | 132.6 |
| **ANNUAL:** | 6133.5 | 1018.2 | 9975 | 13071.5 | 123.5 | 643.5 |

# Total Loads by Land Use Category

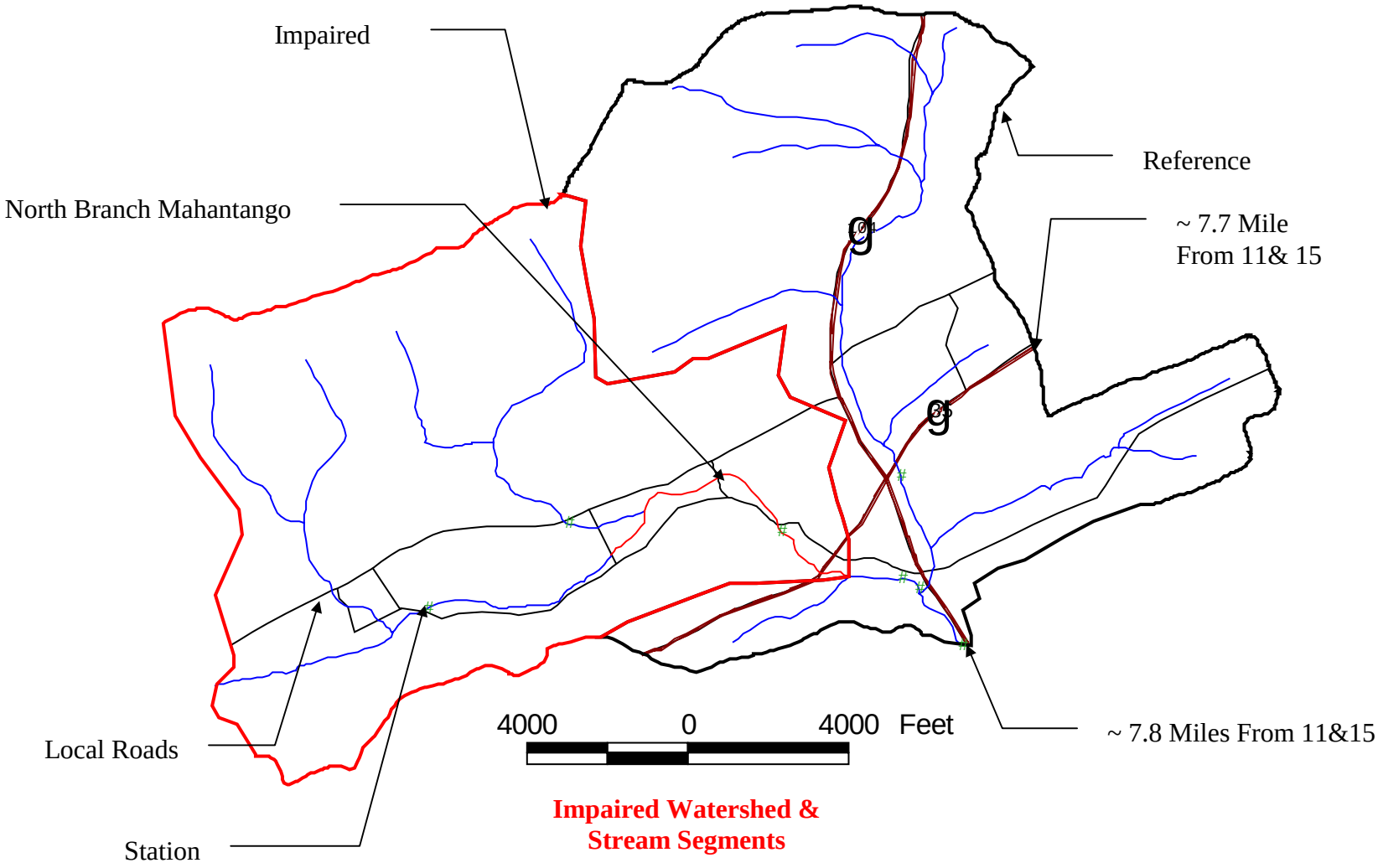
| | (ha) | (cm) | (Kg/ha) | | Total Loads (Kg) | | | |
|---|---|---|---|---|---|---|---|---|
| SOURCE | AREA | RUNOFF | EROSION | SEDIMENT | DIS. NITR | TOT. NITR | DIS. PHOS | TOT. PHOS |
| "HAY/PAST" | 154 | 7.52 | 2261.4 | 375.4 | 358.3 | 531.7 | 13.8 | 43.1 |
| "CROPLAND" | 274 | 13.03 | 18634.9 | 3093.4 | 1138.4 | 3681.1 | 43.1 | 472 |
| "CONIF_FOR" | 59 | 6.43 | 113.1 | 18.8 | 7.2 | 10.5 | 0.2 | 0.8 |
| "MIXED_FOR" | 41 | 6.43 | 77.7 | 12.9 | 5 | 6.6 | 0.2 | 0.4 |
| "DECID_FOR" | 759 | 6.43 | 882 | 146.4 | 92.8 | 426.2 | 2.9 | 59.2 |
| "LO_INT_DEV" | 7 | 14.13 | 5124.7 | 850.7 | 0 | 5.5 | 0 | 0.7 |
| "HI_INT_DEV" | 3 | 35.6 | 9525.8 | 1581.3 | 0 | 36.5 | 0 | 4 |
| GROUNDWATER | | | | | 7943 | 7943 | 55.6 | 55.6 |
| POINT SOURCE | | | | | 0 | 0 | 0 | 0 |
| SEPTIC SYSTEMS | | | | | 430.3 | 430.3 | 7.7 | 7.7 |
| **TOTAL** | 1297 | 8.06 | 4778.693 | 793.263 | 9975 | 13071.5 | 123.5 | 643.5 |

# Total Loads by Land Use Category English Unit

acre = (ha) x 2.471  inches = (cm) / 2.54  pounds/acre = (kg/ha) x 0.8924  pound = (kg) x 2.2046

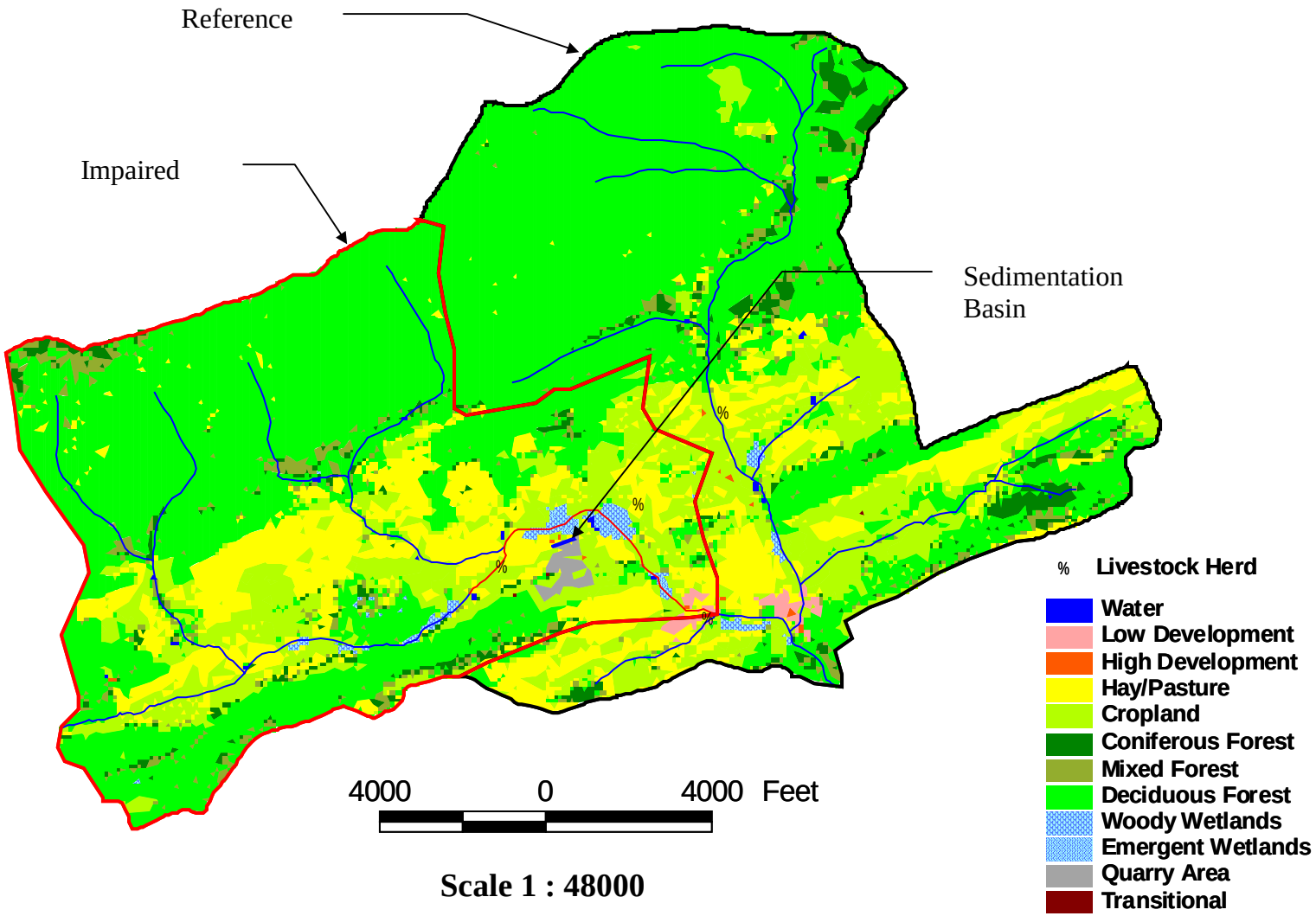
| | acre | inches | pounds/acre | | | | Total Load (pounds) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SOURCE | AREA | RUNOFF | EROSION | SEDIMENT | TOTAL NITROGEN | TOTAL PHOS | DIS. NITR | TOT. NITR | DIS. PHOS | TOT. PHOS |
| "HAY/PAST" | 381 | 3.0 | 2017.6 | 334.9 | 3.08 | 0.25 | 790 | 1172 | 30 | 95 |
| "CROPLAND" | 677 | 5.1 | 16625.9 | 2759.9 | 11.99 | 1.54 | 2510 | 8115 | 95 | 1041 |
| "CONIF_FOR" | 146 | 2.5 | 100.9 | 16.8 | 0.16 | 0.01 | 16 | 23 | 0 | 2 |
| "MIXED_FOR" | 101 | 2.5 | 69.3 | 11.5 | 0.14 | 0.01 | 11 | 15 | 0 | 1 |
| "DECID_FOR" | 1875 | 2.5 | 786.9 | 130.6 | 0.50 | 0.07 | 205 | 940 | 6 | 131 |
| "LO_INT_DEV" | 17 | 5.6 | 4572.2 | 759.0 | 0.70 | 0.09 | 0 | 12 | 0 | 2 |
| "HI_INT_DEV" | 7 | 14.0 | 8498.8 | 1410.8 | 10.85 | 1.19 | 0 | 80 | 0 | 9 |
| GROUNDWATER | | | | | | | 17511 | 17511 | 123 | 123 |
| POINT SOURCE | | | | | | | 0 | 0 | 0 | 0 |
| SEPTIC SYSTEMS | | | | | | | 949 | 949 | 17 | 17 |
| **TOTAL** | 3205 | 3.2 | 4263.5 | 707.7 | 8.99 | 0.442655 | 21991 | 28817 | 272 | 1419 |

**MAP 1. IMPAIRED SEGMENT LOCATION**



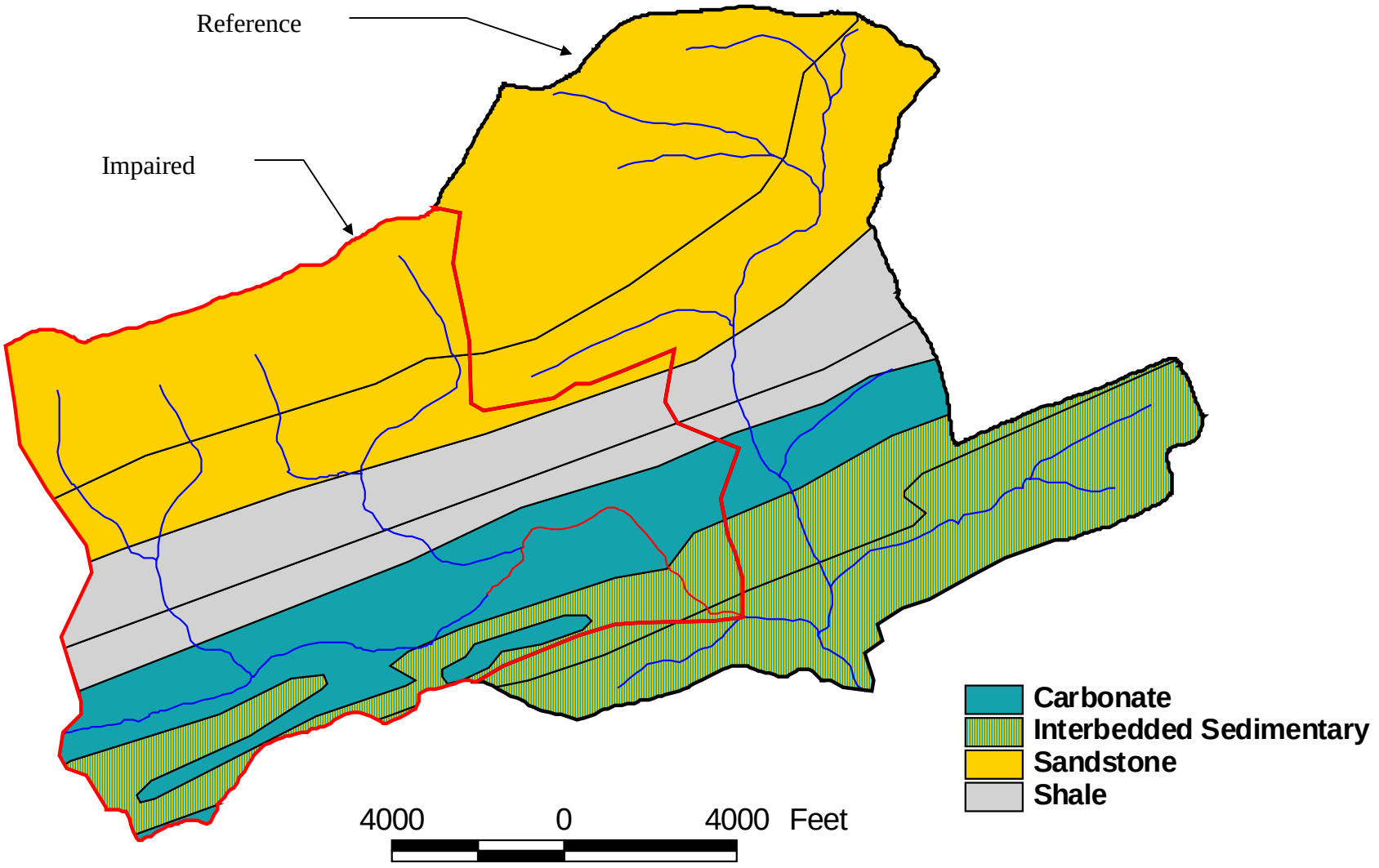

**Scale 1 : 48,000**

**MAP 2 LAND USE NORTH BRANCH MAHANTANGO WATERSHED**




**Scale 1 : 48000**

**MAP 3 GEOLOGY**




**Scale 1 : 48,000**

| Information Sources for GWLF Model Parameterization. | |
|---|---|
| **WEATHER.DAT file** | Historical weather data from National Weather Service monitoring stations |
| **TRANSPORT.DAT file** | |
| Basin size | GIS/derived from basin boundaries |
| Land use distribution | GIS/derived from land use map |
| Curve numbers by source area | GIS/derived from land cover and soil maps |
| USLE (KLSCP) factors by source area | GIS/derived from soil, DEM, and land use |
| ET cover coefficients | GIS/derived from land use |
| Erosion coefficients | GIS/ derived from physiography map |
| Daylight hrs. by month | Computed automatically for state |
| Growing season months | Input by user |
| Initial saturated storage | Default value of 10 cm (GWLF Manual) |
| Initial unsaturated storage | Default value of 0 cm (GWLF Manual) |
| Recession coefficient | Default value of .1 (GWLF Manual) |
| Seepage coefficient | Default value of 0 (GWLF Manual) |
| Initial snow amount (cm water) | Default value of 0 (GWLF Manual) |
| Sediment delivery ratio | GIS/based on basin size |
| Soil water (available water capacity) | GIS/derived from soil map |
| **NUTRIENT.DAT file** | |
| Dissolved N in runoff by land cover type | Default values (GWLF Manual) |
| Dissolved P in runoff by land cover type | Default values (GWLF Manual) |
| N/P concentrations in manure runoff | Default values (GWLF Manual) |
| N/P buildup in urban areas | Statewide atmospheric deposition layer |
| N and P point source loads | GIS/derived from NPDES point coverage |
| Background N/P concentrations in GW | GIS layer derived from USGS sample data |
| Background N/P concentrations in soil | GIS layer derived from soil test data |
| Months of manure spreading | Input by user |
| Population on septic systems | GIS/derived from census tract map |
| Per capita septic system loads (N/P) | Default values (GWLF Manual) |

**Attachment F**
**North Branch Mahantango Creek TMDL**
**Snyder County, Pennsylvania**

**Comment and Response Document**
**March 2001**

## Introduction Section

**Comment:** The document refers to the year 2000 303(d) list, even though that list is a draft document at this point in time. (EPA Region III)

> **Response:** The Department has eliminated references to the draft year 2000 303(d) list, both in text and in Table 3. The document has now been written to clearly indicate that the TMDL addresses one segment on the 1996 list which became two separate segments when carried over to the 1998 list.

**Comment:** Only the original year of the listing for impaired waters should be given in Table 3. Please clarify what the original year of listing was for each segment and identify how the segments were carried through to subsequent 303(d) listings. (EPA Region III)

> **Response:** The Department has annotated Table 3 of TMDL document to clearly show which segments were listed on the 1996 list and how they were carried through in the 1998 list.

## TMDL End Points Section

**Comment:** The TMDL document does not discuss low dissolved oxygen (D.O.) as being a cause of the impairment as listed on the 1996 and 1998 303(d) listings. Text should be provided to establish why dissolved oxygen was included under "cause," and how it is addressed in the TMDL. (EPA Region III)

> **Response:** The Department has added text in the TMDL Endpoints section to explain that dissolved oxygen was automatically included, in the mid-1990s, as an accompanying cause of impairment on 305(b) lists, whenever organic enrichment was observed by Department biologists. The added discussion in this section explains that the Department does not have actual data indicating that low dissolved oxygen is a cause of impairment on this watershed, and that accordingly, the TMDL will focus only on organic enrichment.

## Selection of the Reference Watershed

**Comment:** Please support the assertion in the TMDL document that the 17 acres of quarry land, evaluated in the TMDL analysis as "high intensity development," is accurate in terms of pollutant loads and does not substantially effect the pollutant load evaluation. (EPA Region III)

**Response:** The Department has added text to this section of the TMDL document confirming that the sediment and phosphorus loads from the 17 acres of quarry land would be more consistent with the pollutant loads from a "high intensity development" land use. The discussion also documents that because of the small acreage involved, the pollutant loads do not become an important part of the load allocation process.

**Comment:** Chart 1 indicates that there is 0.7% high intensity development and 0.7% quarry. Table 6, however, shows 17 acres of high intensity development representing quarry lands which would account for 0.5% of the acreage. Please clarify. (EPA Region III)

**Response:** The Department has reformatted Chart 1 and has revised text in this section of the TMDL document to clearly indicate that there are only 17 acres of quarry lands (and no additional high intensity development), and that this acreage constitutes 0.5% of the total acreage on the impaired watershed.

**Comment:** Please clarify that the streams in the portion of the North Branch Mahantango Watershed that is being used as the reference watershed have been assessed and have been found to not be impaired. (EPA Region III)

**Response:** The Department has added text to this section of the TMDL document confirming that the streams in the referenced watershed have been assessed and fully meet all aquatic uses.

**Comment:** The TMDL document should mention the similarities or differences in precipitation characteristics, hydraulic characteristics and soil loss characteristics between the impaired watershed and the referenced watershed. The document should explain how these parameters compare in the two watershed and how they are accounted for in the model. (EPA Region III)

**Response:** The Department has added a discussion in this section of the TMDL document which highlights the similarities in these model coefficients within the impaired and referenced watershed and references the model input screens included in the report.

## TMDL Computations for Phosphorus and Sediment Section

**Comment:** The computations presented in Table 9 of the TMDL document for total allowable pounds per year of phosphorus and sediment are not consistent, to extended significant digits, with the aerial loading rates and total watershed areas given in Tables 6 and 7. Please explain the reasons for the differences.

**Response:** The inconsistency in the tables was due to the rounding of aerial loading rates, after calculation from the specific land use loading rates in Tables 6 and 7. The Department has revised the unit aerial loading rates to increase the precision to several significant figures in Table 6, 7 and 9 to attain the necessary consistency.

# Attachment F

# Comment and Response Document