Total Maximum Daily Loads (TMDLs) Development Plan for Chickies Creek Watershed

Prepared for Pennsylvania Department of Environmental Protection

by

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TMDLs for Chickies Creek Watershed

EXECUTIVE SUMMARY

The Chickies Creek watershed in Lancaster County is 65.0 square miles in size. The protected uses of the watershed are water supply, recreation, and aquatic life. The aquatic use for the main stem of Chickies Creek, its unnamed and named tributaries (Boyers Run, Rife Run, and Dellinger run) is warm water fishes. It is cold water fishes for Shearers Creek, another tributary of Chickies Creek. The latter is also protected due to the high quality of its waters.

Total Maximum Daily Loads (TMDLs) apply to the main stem of Chickies Creek (Stream Code 7919) from about a 1.5 miles north of the town of Manheim to the mouth, the Rife Run and an unnamed tributary located North East of Manheim. They were developed to address the impairments noted on Pennsylvania's 1996 and 1998 Clean Water act Section 303(d) Lists. The impairments are primarily caused by excess nutrient and sediment loads from agriculture activities. The TMDL focuses on control of the nutrient phosphorus and sediments. Phosphorus is generally considered to be the limiting nutrient in a waterbody when the nitrogen/phosphorus ratio exceeds 10 to 1. In Chickies Creek, this ratio is 17 to 1.

Pennsylvania does not currently have water quality criteria for nutrients and sediments. For this reason, we developed a reference watershed approach to identify the TMDL endpoints or water quality objectives for nutrients and sediments in the impaired segments of the Chickies Creek watershed. Based upon comparison to a similar, non-impaired watershed, it was estimated that the amount of phosphorus loading that will meet the water quality objectives for Chickies Creek is 39,956 pounds per year. Sediment loading must be limited to 8,194,278 pounds per year. Chickies Creek will support its aquatic life uses when these values are met. The TMDLs for Chickies Creek are allocated as shown in the table below.

Summary of TMDLs for Chickies Creek (lbs/yr)							
Pollutant	**TMDL**	**MOS**	**WLA**	**LA**	**LNR**	**ALA**	**% Reduction**
Phosphorus	39,956	3,996	8,809	27,151	6,032	21,119	42
Sediments	8,194,278	819,428	-	7,374,850	387,037	6,987,813	72

The TMDLs are allocated to non-point source from agricultural activities, with 10% of the TMDL total load reserved as a margin of safety (MOS). The Wasteload Allocation (WLA) is that portion of the total load that is assigned to point sources. The allowable loading, or adjusted loading allocation (ALA), is that load attributed to agricultural land use and is computed by subtracting loads that do not need to be reduced (LNR) from the TMDL total values. The TMDLs cover a total of 30.6 miles of the main stem of Chickies Creek, its tributary Rife Run, and an unnamed tributary. The TMDL establishes a reduction for phosphorus loading from agricultural activities of 42% from the current annual loading of 61,530 pounds, and a reduction in sediment loading of 72% from the current annual loading of 26,093,711pounds. A more complete discussion of Chickies Creek TMDLs and TMDLs in general are contained in the attached Information Sheet (Appendix A).

I. INTRODUCTION

Total Maximum Daily Loads or TMDLs were developed for the Chickies Creek watershed to address the impairments noted on Pennsylvania's 1996 and 1998 Clean Water Act Section 303(d) Lists. It was first determined that Chickies Creek was not meeting its designated water quality uses for protection of aquatic life based on a 1994 aquatic biological survey, which included kick screen analysis and habitat surveys. In 1997, the Department again surveyed the stream and found the stream to still be impaired. As a consequence of the surveys, Pennsylvania listed Chickies Creek on the 1996 and 1998 Section 303(d) Lists of Impaired Waters. The 1996 303 (d) List reported 10 miles of the main stem (Stream Code 7919) to be impaired by agricultural nutrients. The 1998 list includes the original main stem impairment (Segment ID 1247 on 1998 List and decreased from 10 to 9.39 miles based on GIS measurement of stream miles) and added new segments (IDs 970729-1415-SAW and 970812-1045-SAW). The final impaired stream mile total on the 1998 Section 303(d) list is 30.6 miles (Table 1). These segments were listed on the 1998 303 (d) List because of impacts by nutrients and siltation due to agriculture. The Segment ID 970812-1045-SAW was also listed as impaired by urban Runoff/storm sewers but the cause of the impairment was "unknown". Upon field verification, we acknowledged the presence of an industrial site and railroad tract in the sub-watershed corresponding to this stream segment. Despite stagnant water due to gentle slopes and algae in the steam near this site, there is no apparent upland runoff and sediment production originating from the industrial site. In addition, this part of the stream is protected by stream buffers. Therefore, no TMDL was conducted for "unknown" causes of impairments from urban runoff/storm sewers.

The Pennsylvania approach to TMDL development involves comparing nutrient and sediment loads of the impacted watershed to those of a reference watershed. Based on the predominance of agricultural land use, nutrients and sediments are the most likely pollutants causing Chickies Creek to violate the aquatic life use. Therefore, the TMDLs propose reducing the phosphorus and sediment loadings in Chickies Creek watershed to levels consistent with Conococheague watershed, the reference watershed. Because of the similarities in size, land use, and geology existing between the two watersheds, achieving nutrient and sediment loadings in the Chickies Creek TMDL will ensure that the aquatic life use is achieved and maintained as evidenced in the Conococheague watershed.

Pennsylvania presently does not have water quality criteria for nutrients and sediments. It is for this reason, we developed a reference watershed approach to identify the TMDL endpoints or water quality objectives for nutrients and sediments in the impaired segments of the Chickies Creek watershed. The nutrient loading for this watershed only addresses phosphorus because it was determined that phosphorus was the limiting nutrient. Phosphorus is generally held to be the limiting nutrient in a waterbody when the nitrogen/phosphorus ratio exceeds 10 to 1. This ratio in Chickies Creek is 17 to 1.

Table 1. 303(d) Sub-List								
State Water Plan (SWP) Subbasin:					**7-Chickies Creek Watershed**			
Year	SWP	Miles	Segment ID	DEP Stream Code	Stream Name	Designated Use	Data Source	EPA 305(b) Cause Code
1996	07-G	10.0	------	07919	Chickies	WWF	305(b) Report	Nutrients
1998*		9.4	1247	07919	Chickies		305(b) Report	Nutrients
1998	07-G	7.7	970812-1045-SAW	07919	Chickies	WWF	305(b) Report	Nutrients/Siltation, Unknown
1998	07-G	13.5	970729-1415-SAW	07919	Chickies	WWF	305(b) Report	Siltation

Warm Water Fishes=WWF

The Chickies Creek watershed TMDL Information Sheet that is attached to this document (Appendix A) provides a primer for TMDLs (What are they and why are we doing them?) and water quality standards (What makes up a water quality standard?). Appendixes B and C provide information on watershed hydrology and pollutant transport, and the method being used by Pennsylvania for establishing TMDLs for stream segments impaired by nutrients and sediments.

II. BACKGROUND

The Chickies Creek watershed is located almost entirely in Lancaster County and in the Piedmont Physiographic Province. It covers an area of 65.0 square miles. Chickies Creek drains in the Susquehanna River at about 1.2 miles South of the Town of Marietta. Its headwaters are in the Furnace Hills Mountains in the southern part of Lebanon County. The watershed is bounded by Pennsylvania Route 23 to the south and US Interstate 76 (Pennsylvania Turnpike) to the north. It can also be accessed from Lancaster via Route 23. Figure 1 shows the watershed boundary, its location, and the state of water quality of stream segments as reported from the 1998 303(d) List. The protected uses of the watershed are water supply, recreation and aquatic life. As listed in the Title 25 PA Code Department of Environmental Protection Chapter 93, Section 93.o (Commonwealth of PA, 1999), the designated aquatic life use for the main stem of Chickies Creek, its tributaries (Boyers Run, Rife Run, and Dellinger run), and several unnamed tributaries is warm water fishes. It is cold water fishes for Shearers Creek, another tributary of Chickies Creek. The latter is also specially protected due to the high quality of its waters.

The primary land use in the Chickies Creek Watershed is agriculture (73%), with areas adjacent to the stream used for Cropland and pasture. It was found also from a field survey of the watershed that cattle generally have free access to the stream. The majority of the streams had no protected riparian zone. The

1997 survey showed that nutrients from agricultural activities were causing increased algae growths. It also found that sediment deposited in large quantities on the streambed was degrading the habitat of bottom-dwelling macroinvertebrates.

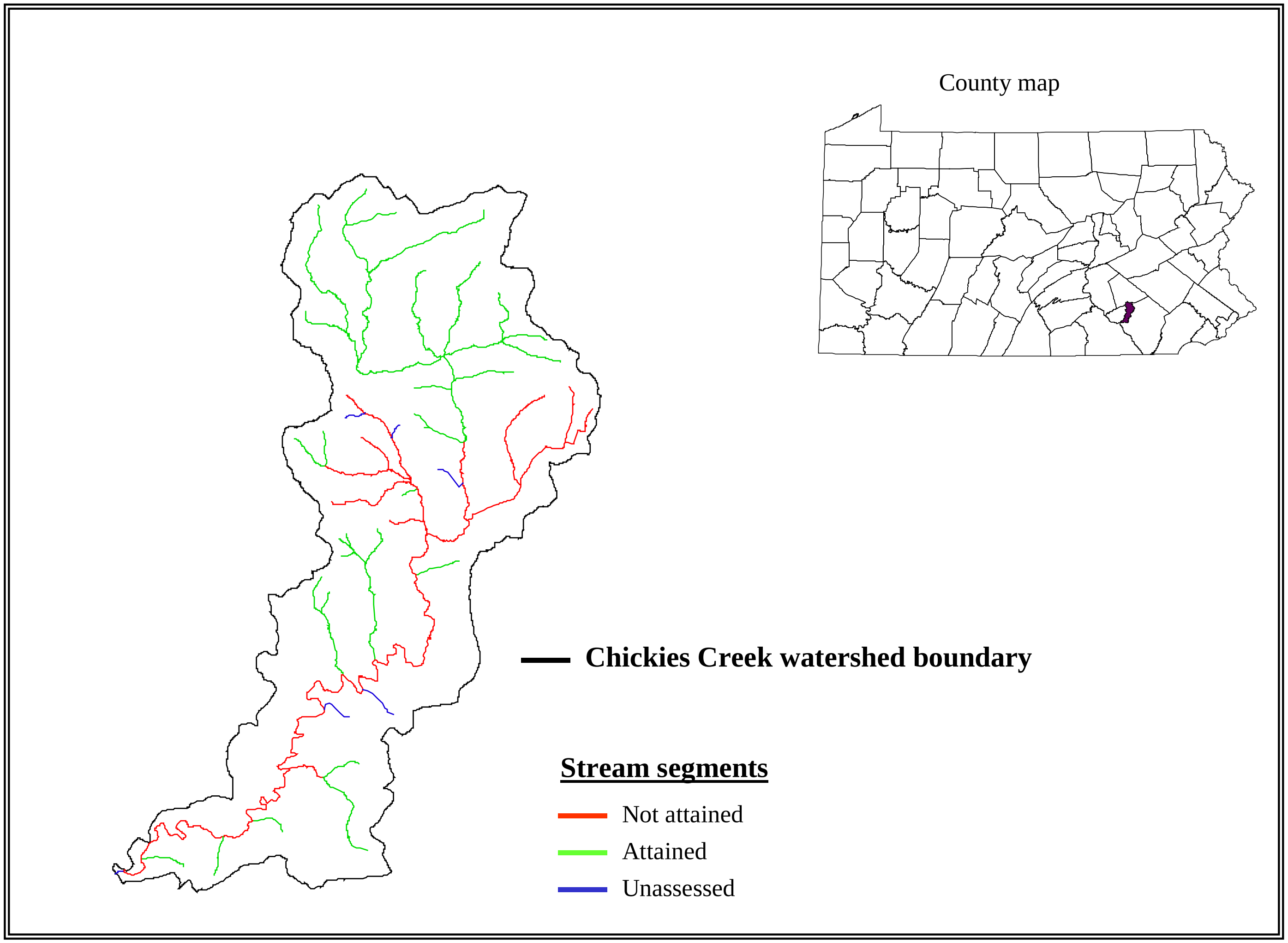

Figure 1. Chickies Creek Watershed.

III. TMDL ENDPOINTS

The TMDLs address phosphorus and sediments. Phosphorus was determined to be the nutrient limiting plant growth in Chickies Creek. Because neither Pennsylvania nor EPA has water quality criteria for phosphorus or sediments, we had to develop a method to determine water quality objectives for these parameters that would result in the impaired stream segments attaining their designated uses. The method employed for these TMDLs is termed the "Reference Watershed Approach."

The Reference Watershed Approach pairs two watersheds, one attaining its uses and one that is impaired based on biological assessment. Both watersheds must have similar land use/cover distributions. Other features such as base geologic formation should be matched to the extent possible; however, most variations can be adjusted in the model. The objective of the process is to reduce the loading rate of nutrients and sediments in the impaired stream segment to a level equivalent to or slightly lower than the loading rate in the non-impaired, reference stream segment. This load reduction will allow the biological community to return to the impaired stream segments.

The TMDL endpoints established for this analysis were determined using Conococheague watershed as the reference watershed. These endpoints are discussed in detail in the TMDL section. The listing for impairment caused by nutrients and siltation is addressed through reduction to the phosphorus load. A detailed explanation of this process is included in the following section.

Nutrient Loads and Organic Enrichment in Stream Systems

As indicated earlier, Chickies Creek was listed as being impaired due to problems associated with nutrient loads and siltation. In stream systems, elevated nutrient loads (nitrogen and phosphorus in particular) can lead to increased productivity of plants and other organisms (Novotny and Olem, 1994).

Typically in aquatic ecosystems the quantities of trace elements are plentiful; however, nitrogen and phosphorus may be in short supply. The nutrient that is in the shortest supply is called the *limiting nutrient* because its relative quantity affects the rate of production (growth) of aquatic biomass. If the nutrient load to a water body can be reduced, the available pool of nutrients that can be utilized by plants and other organisms will be reduced and, in general, the total biomass can subsequently be decreased as well (Novotny and Olem, 1994). In most efforts to control eutrophication processes in water bodies, emphasis is placed on the limiting nutrient. This is not always the case, however. For example, if nitrogen is the limiting nutrient, it still may be more efficient to control phosphorus loads if the nitrogen originates from difficult to control sources such as nitrates in ground water.

In most fresh water bodies, phosphorus is the limiting nutrient for aquatic growth. In some cases, however, the determination of which nutrient is the most limiting is difficult. For this reason, the ratio of the amount of N to the amount of P is often used to make this determination (Thomann and Mueller, 1987). If the N/P ratio is less than 10, nitrogen is limiting. If the N/P ratio is greater than 10, phosphorus is the limiting nutrient. In the case of Chickies Creek, the N/P ratio is approximately 17, which points to phosphorus as the limiting nutrient. Controlling the phosphorus loading to Chickies Creek will limit plant growth and result in raising the dissolved oxygen level.

IV. SELECTION OF THE REFERENCE WATERSHED

In general, three factors should be considered when selecting a suitable reference watershed. The first factor is to use a watershed that has been assessed by the Department using the Unassessed Waters Protocol and has been determined to attain water quality standards. The second factor is to find a watershed that closely resembles Chickies Creek watershed in physical properties such as land cover/land use, physiographic province, and geology. Finally, the size of the reference watershed should be within 20-30% of the impaired watershed area. The search for a reference watershed that would satisfy the above characteristics was done by means of a desktop screening using several GIS coverages including the Multi-Resolution Land Characteristics (MRLC) Landsat-derived land cover/use grid, the Pennsylvania's 305(b) assessed streams database, and geologic rock types.

A watershed that would satisfy all the characteristics mentioned above could not be found in the same physiographic province as Chickies Creek due to the following reasons:

1) Not all stream segments in the Piedmont Physiographic Province where Chickies Creek watershed is located have been assessed.

2) All watersheds that have similar levels of agricultural land use and geologic rock type distributions as Chickies Creek watershed are also impacted.

The watershed used as a reference for the Chickies Creek Watershed was obtained by screen-digitizing a subwatershed of the Conococheague Creek watershed. Stream segments in Conococheague watershed have been assessed and were found to be attaining standards. This watershed is located in the Ridge and Valley Province in State Water Plan (SWP) Basin 13C. The digitized (reference) watershed is referred in this report as "Conococheague watershed". Table 3 compares the two watersheds in terms of their size, location, and other physical characteristics. This watershed is also within the size range for reference watersheds, 62.6 square miles or 93% of the Chickies Creek Watershed area. Figure 2 shows its boundary and location in Franklin County.

The Conococheague watershed is still appropriate for use as a reference watershed for Chickies Creek watershed despite differences in point source loadings. The Conococheague watershed has significantly higher point source phosphorus load contribution, 90% higher, than that of Chickies Creek watershed. However, Conococheague watershed is still suitable for use as a reference because it continues to meet water quality criteria based on biological assessment.

The analysis of value counts for each pixel of the MRLC grid revealed that land cover/use distributions in both watersheds are similar. The agricultural land use, which is the source of impairment in Chickies Creek watershed, accounts for 73% of the total land area as compared to 84% in Conococheague watershed. The surficial geologies of the Chickies Creek and Conococheague watersheds were also compared and appear to produce reasonably a good match. The geology of Chickies Creek Watershed consists primarily of carbonate (67%) and conglomerate (25%), while Conococheague watershed is made of carbonate (63%) and shale (37%). The bedrock geology affects primarily surface runoff and background nutrient loads through its influences on soils and landscape as well as fracture density and directional permeability. A look at these attributes in Table 2 indicates that these watersheds compare very well in terms of average runoff, precipitation, and soil K factor.

Table 2. Comparison Between Chickies Creek and Conococheague Watersheds

Attribute	**Chickies Creek**	**Conococheague**
Physiographic Province	Piedmont	Ridge and Valley
Area (square miles)	65.0	62.6
Predominant Land Use		
	Agriculture (73%)	Agriculture (84%)
Predominant Geology		
	Carbonate (67%	Carbonate (63%)
	Conglomerate (25%)	Shale (37%)
Soils		
Dominant HSG	B (60%), C (40%)	B(13%), C (87%)
K Factor	0.30	0.28
20-Year Average Rainfall (in)	42.6	39.3
20-Year Average Runoff (in)	4.1	4.3

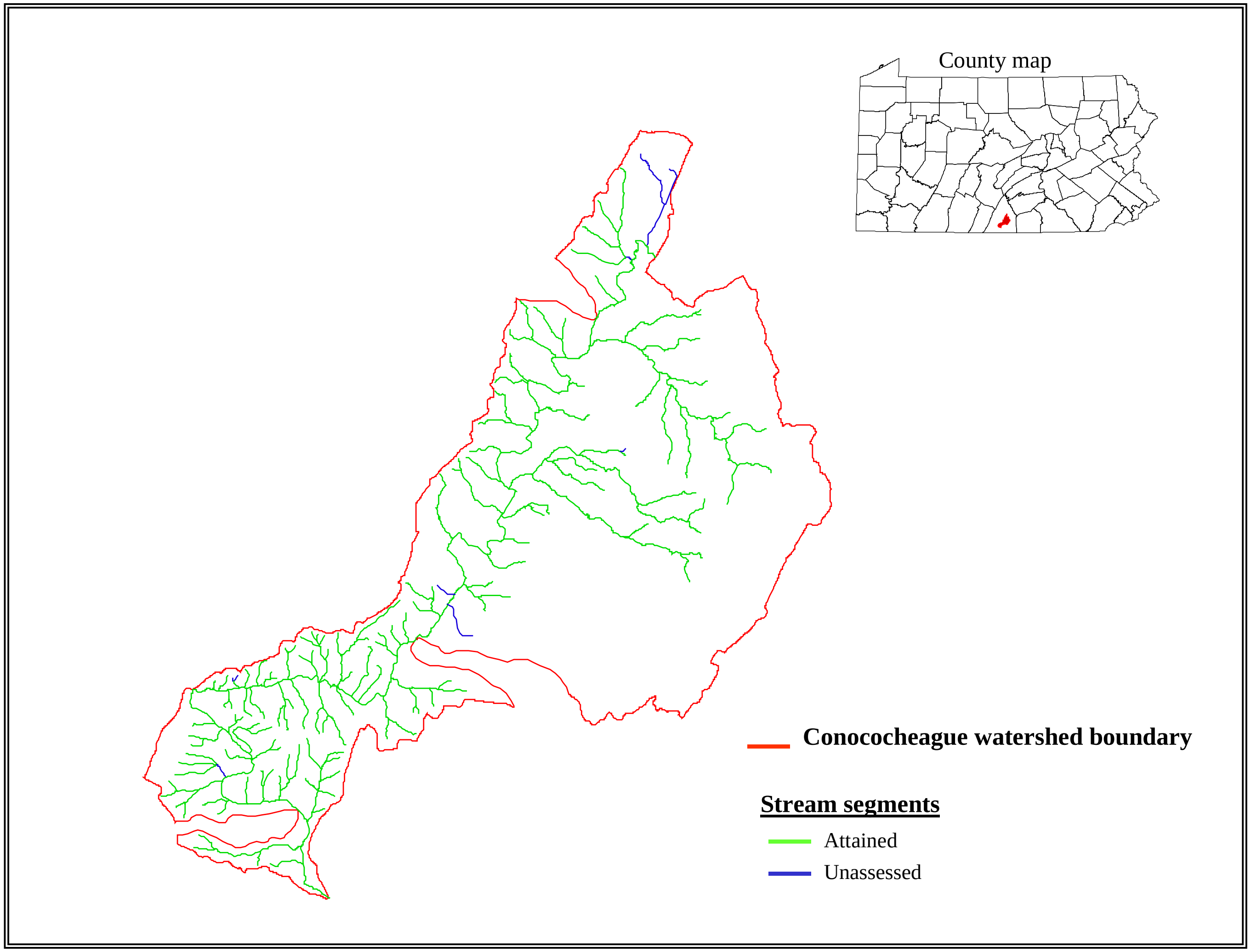

Figure 2. Conococheague (Reference) Watershed.

V. HYDROLOGIC/WATER QUALITY MODELING

5.1. Data Compilation and Model Overview

The TMDLs were developed using the Generalized Watershed Loading Function or GWLF model. The GWLF model provides the ability to simulate runoff, sediment, and nutrient (N and P) 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 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/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 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 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 Attachment D, the GWLF Users Guide.

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.

5.2. 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 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 (see Appendix B). 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. Table 3 lists the statewide GIS data sets and provides explanation of how they were used for development of the input files for the GWLF model.

Table 3. GIS Data Sets

Censustr	Coverage of Census data including information on individual homes septic systems. The attribute*usew_sept* includes data on conventional systems, and *sew_other* provides data on short circuiting and other systems.
County	The County boundaries coverage lists data on conservation practices which provides C and P values in the Universal Soil Loss Equation (USLE).
Gwnback	A grid of background concentrations of N in groundwater derived from water well sampling.
Landuse5	Grid of the MRLC that has been reclassified into five categories. This is used primarily as a background.
Majored	Coverage of major roads. Used for reconnaissance of a watershed.
MCD	Minor civil divisions (boroughs, townships and cities).
Npdespts	A coverage of permitted point discharges. Provides background information and cross check for the point source coverage.
Padem	100 meter digital elevation model. This used to calculate landslope and slope length.
Palumrlc	A satellite image derived land cover grid which 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 phosphorous 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 landuse 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.

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/cover, and soil type. In essence, the model is used to estimate surface runoff and nonpoint 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 nonpoint source load calculated is affected by terrain conditions such as amount of agricultural land, land slope, and inherent soil erodibility. It is also affected by farming practices utilized in the area, as well as by background concentrations of nutrients (i.e., N and P) in soil and groundwater. Various parameters are included in the model to account for these conditions and practices. Some of the more important parameters are summarized below:

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

Curve number: This determines the amount of precipitation that infiltrates into the ground or enters surface water as runoff. It is based on specified combinations of land use/cover and hydrologic soil type, and is calculated directly using digital land use/cover 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/cover 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/cover 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 D of this document. Specific details in this guide that describe equations and typical parameter values used can be found on pages 15 through 41.

5.3. Watershed Assessment and Modeling

The AVGWLF model was run for both the Chickies Creek Watershed and Conococheague watershed to establish existing loading conditions under existing land cover use conditions in each watershed.

General observations of watershed characteristics:

- Chickies Creek watershed has less topographic relief, shallower streambed, more continuous corn crops and less hay/pasture, more animals (particularly dairy and poultry operations), dominated by carbonate rocks, less evidence of conservation practices.

- Conococheague watershed has more topographic relief than Chickies, deeper streambed, more hay/pasture and cover crops, more crop residue left, more use of strip cropping and forest buffers along streams, dominated by carbonate rocks, more evidence of conservation practices, fewer animals.

Adjustments to Specific GWLF-related parameters

Conococheague:

Reset “C” factor to 0.16 for Cropland land to account for use of continuous cover crop.

Reset “P” factor to 0.30 for Hay/Pasture and Cropland land uses to account for use of riparian forest and grasses along streams, strip cropping, and buffer strips.

Point Sources for Chickies and Conococheague:

Total P point source contributions to the watershed for use in determining the loading rate in the Conococheague (reference) watershed, and serving as the target loading rate for Chickies (the impaired) watershed, were determined using the Discharge Monitoring Records (DMR) data for each facility. DMR data were also used in assessing the existing point source contributions to the impaired watershed. These values, 1,947 and 33,727 lbs/year for Chickies Creek (Table 4) and Conococheague (Table 5) watersheds, respectively, are averages for Year 1999.

Table 4. Permitted and Actual Point Source Total P Loads Discharged in Chickies Creek

Facility	NPDES Permit	Location (City)	Flow (mgd)		Total P (lbs/year)	
			Permit Limit	Avg. from 1999 DMR	Permit Limit	Avg. from 1999 DMR
Manheim STP	PA0020893	Lancaster	1.14	1.14	6938	1597
Model Enterprise Inc.	PA0081299	Lancaster	0.02	0.02	122	55
Northwestern Lancaster Co.	PA0084026	Manheim	0.25	0.25	1521	207
Penn Valley Mobile Home Village	PA0034860	Lititz	0.01	0.01	67	54
Telco Developers Inc.	PA0081787	Stevens	0.03	0.03	161	34
Total P					8809	1947

Table 5. Actual Point Source Total P Loads Discharged in Conococheague Watershed

Facility	NPDES Permit	Location (City)	Average Flow from 1999 DMR (mgd)	Avg. from 1999 DMR Total P (lbs/year)
Chambersburg Boro STP	PA0026051	Chambersburg	4.6	33,712
Martin's Famous Pastry Shoppe, Inc.	-	-	0.0006	15
Total				33,727

Since there is no in-stream module in the GWLF model, in-stream P losses must be accounted for externally in order to accurately represent the load at the watershed outlet. In-stream P losses from point sources were estimated according to an algorithm available in the USGS SPARROW (**SPA**tially **R**eferenced **R**egressions **o**n **W**atershed Attributes) model (Preston, 2000; personal communication). SPARROW estimates in-stream nutrient losses using a decay function based on travel time and stream flow. Travel time to the watershed outlet is calculated for each facility using flow velocity, as determined by flow volume and a representative cross-sectional area of the stream based on field measurements at several sites along the reach, and distance traveled. Phosphorus data resulting from adjusting for in-stream losses are 1,447 and 23,000 lbs/year for Chickies Creek and Conococheague watersheds, respectively (See Tables 6 and 7).

The 20-year (1979-1998) means for these parameters for each watershed are shown Tables 6 and 7. The Unit Area Load for each pollutant in each watershed was estimated by dividing the mean annual loading (lbs/yr) by the total area (acres) resulting in an approximate loading per unit area for the watershed. The point source   Table 8 presents an explanation of the header information contained in Tables 6 and 7. Modeling output for Chickies Creek and Conococheague watersheds are presented in Appendices E and F, respectively.

Table 6. Existing Loading Values for Chickies Creek Watershed

Land Use Category	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	9,027	4,408	0.49	64,821	7.18	1,278,781	141.66
Cropland	20,598	49,143	2.39	322,832	15.67	24,356,865	1,182.52
Coniferous For	341	5	0.01	55	0.16	1,733	5.08
Mixed For	585	9	0.02	83	0.14	3,915	6.69
Deciduous For	8,363	591	0.07	1,415	0.17	357,347	42.75
Transition	2	0	0.00	0	0	0	0
Lo Int Dev	1,195	107	0.09	801	0.67	13,962	11.69
Hi Int Dev	661	723	1.09	6,523	9.87	10,080	15.25
Groundwater		4,396		627,990			
Point Source		1,447		7,092			
Septic Systems		201		34,374			
Total	40,772	61,030	1.50	1,065,987	26.15	26,093,711	640.00

Table 7. Existing Loading Values for Conococheague Watershed

Land Use Category	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	12,404	1,651	0.13	30,532	2.46	731,691	58.99
Cropland	19,511	8,897	0.46	94,926	4.87	7,070,707	362.40
Coniferous For	324	2	0.01	36	0.11	924	2.86
Mixed For	823	6	0.01	95	0.12	3,157	3.84
Deciduous For	2,711	23	0.01	330	0.12	15,965	5.89
Transition	49	67	1.36	408	8.26	57,782	1,169.21
Lo Int Dev	2,024	174	0.09	1,309	0.65	12,461	6.16
Hi Int Dev	1,470	1,663	1.13	14,993	10.20	8,791	5.98
Groundwater		2,983		426,194			
Point Source		23,000		115,272			
Septic Systems		83		17,912			
Total	39,316	38,549	0.98	702,008	17.86	7,901,478	200.98

Table 8. Header Information for Tables 6 and 7.	
Land Use Category	The land cover classification that was obtained by from the MRLC database
Area (acres)	The area of the specific land cover/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

VI. LOAD ALLOCATION PROCEDURE FOR PHOSPHORUS AND SEDIMENT TMDLS

The load allocation and reduction procedures will be applied to the entire Chickies Creek watershed and its subwatersheds. These subwatersheds (Subwatersh_1415, Subwatersh_1247, and Subwater_1045) were obtained by delineating contributing areas to each of the impacted segments shown in Tables 1 and 2. The subwatershed boundaries are shown in Figure 3. In addition to subwatershed delineations, a GIS analysis was performed to determine land use distributions in each subwatershed. This data is needed for load reduction analyses.

The load reduction calculations in Chickies Creek watershed are based on the current loading rates for phosphorus and sediments in Conococheague watershed, the reference watershed for this analysis. Based on biological assessment, it was determined that Conococheague was attaining its designated uses. The phosphorus and sediment loading rates were computed for Conococheague watershed using the AVGWLF model. These loading rates were then used as the basis for establishing the TMDLs for Chickies Creek watershed. The equations defining TMDLs for Chickies are as follows:

$$TMDL = MOS + LA + WLA \qquad (1)$$

$$LA = ALA - LNR \qquad (2)$$

TMDL is the TMDL total load. The LA (load allocation) is the portion of Equation (1) that is assigned to non-point sources. The MOS (margin of safety) is the portion of loading that is reserved to account for any uncertainty in the data and computational methodology used for the analysis. The WLA (Waste Load Allocation) is the portion of this equation that is assigned to point sources. The adjusted load allocation (ALA) is load that originates from nonpoint sources (Equation 2) that need to be reduced for the Chickies Creek watershed to meet water quality standards. Therefore, it is the load that originates from agricultural sources for water quality problems encountered in the watershed. Details of TMDL, MOS, LA, and ALA computations are presented below.

6.1. TMDL Total Load

The TMDL loads for both pollutants of concern were computed in the same manner. The first step is to determine the TMDL total target load for Chickies Creek, the impaired watershed. This value was obtained by multiplying each pollutant unit loading rate in Conococheague watershed by the total watershed area of Chickies Creek. This information is presented in Table 9.

Table 9. TMDL Total Load Computation

Type of Pollutant	Unit Area Loading Rate in Conococheague Crk (lbs/acre/yr)	Total Watershed Area in Chickies Creek (acres)	TMDL Total Load (lbs/yr)
Phosphorus	0.98	40,772	39,956
Sediment	200.98	40,772	8,194,278

6.2. Margin of Safety

The Margin of Safety (MOS) for this analysis is explicit. Ten percent of each of the TMDLs was reserved as the MOS.

Phosphorus - *39,956 lbs/yr x 0.1 = 3,996 lbs/yr* (3)
Sediment - *8,194,278 lbs/yr x 0.1 = 819,428 lbs/yr* (4)

6.3. Load Allocation

The Load allocation (LA), consisting of all nonpoint sources in the watershed, was computed as by subtracting the margin of safety and the wasteload allocation (WLA) from the TMDL total load. The WLA is the total loading that is assigned to point sources within Chickies Creek watershed. The WLA for the watershed is set to the sum of the permitted loads (8,809 lbs/year) for all dischargers in the watershed (see Table 4). Notice that in-stream losses are not applied to the permitted loads in setting the WLA.

LA (Phosphorus) = 39,956 lbs/yr – 3,996 lbs/yr – 8,809 lbs/yr= 27,151 lbs/yr (5)
LA (Sediments) = 8,194,278 lbs/yr - 819,428 lbs/yr = 7,374,850 lbs/yr (6)

6.4. Adjusted Load Allocation

The adjusted load allocation (ALA) is the actual load allocation for sources that will need reductions. It is computed by subtracting loads from non-point sources that are not considered in the reduction scenario (LNR). These are loads from all non-point sources in Table 6 except those from agricultural land uses (Hay/Past, Row_Crops). Therefore, using data in Table 6,

LNR (Phosphorus) = 5 lbs/yr + 9 lbs/yr + 591 lbs/yr + 0 lb/yr + 107 lb/yr + 723 lbs/yr + 4,396 lbs/yr + 201 lbs/yr = 6,032 lbs/yr (7)
ALA (Phosphorus) = 27,151 lbs/yr - 6,032 lbs/yr= 21,119 lbs/yr (8)

LNR (Sediments) = 1,733 lbs/yr + 3,915 lbs/yr + 357,347 lb/yr + 0 lb/yr + 13,962 lbs/yr + 10,080 lbs/yr = 387,037 lbs/yr (9)
ALA (Sediments) = 7,374,850 lbs/yr - 387,037 lbs/yr = 6,987,813 lbs/yr. (10)

Table 10 below presents TMDLs for Chickies Creek watershed.

Table 10. Summary of TMDLs for Chickies Creek (lbs/yr)

Pollutant	TMDL	MOS	WLA	LA	LNR	ALA
Phosphorus	39,956	3,996	8,809	27,151	6,032	21,119
Sediments	8,194,278	819,428	-	7,374,850	387,037	6,987,813

The ALA computed above is the portion of the load that is available to allocate among contributing sources (Hay/Past, Cropland) as described in the next step. Not all land use/source categories were included in the allocation because they are difficult to control, or provide an insignificant portion of the total load (e.g., transition land use). The following section shows the allocation process in detail for the entire watershed and subwatersheds.

6.5. Load Reduction Procedures

The P and sediment loads obtained in the previous step were allocated among the remaining land use/sources of the impaired watershed according to the Equal Marginal Percent Reduction (EMPR) method. EMPR is carried out using an Excel Worksheet in the following manner:

1) Each land use/source load is compared with the total allocable load to determine if any contributor would exceed the allocable load by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load to the receiving waterbody. If the contributor exceeds the allocable load, that contributor would be reduced to the allocable load. This is the baseline portion of EMPR.

2) After any necessary reductions have been made in the baseline the multiple analysis is run. The multiple analyses will sum all of the baseline loads and compare them to the total allocable load. If the allocable load 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.

3) Now that the load allocation for each land use in the Chickies Creek has been calculated, portions of the whole watershed load can be allocated to each subwatershed. The TMDL total load for each subwatershed was computed as the product of the unit area load for that land use determined in the watershed analysis and the area covered by the land use/source in the subwatershed. The load allocation for each land use was determined by multiplying the allowable unit area loading rate for that land use (after EMPR) and the area of the land use in the impaired subwatersheds. Results of the load reduction procedure are load allocations to agricultural activities and associated percent reductions needed to reach water quality standards in the watershed and subwatersheds (see Tables 11 and 12). The load allocation and EMPR procedures were performed using an Excel Worksheet and results are presented in Appendices G and H for P and sediments, respectively. Table 13 provides load allocation by considering all land uses in Chickies Creek Watershed. In this case, land uses/sources that were not part of the allocation are carried through at their existing loading values.

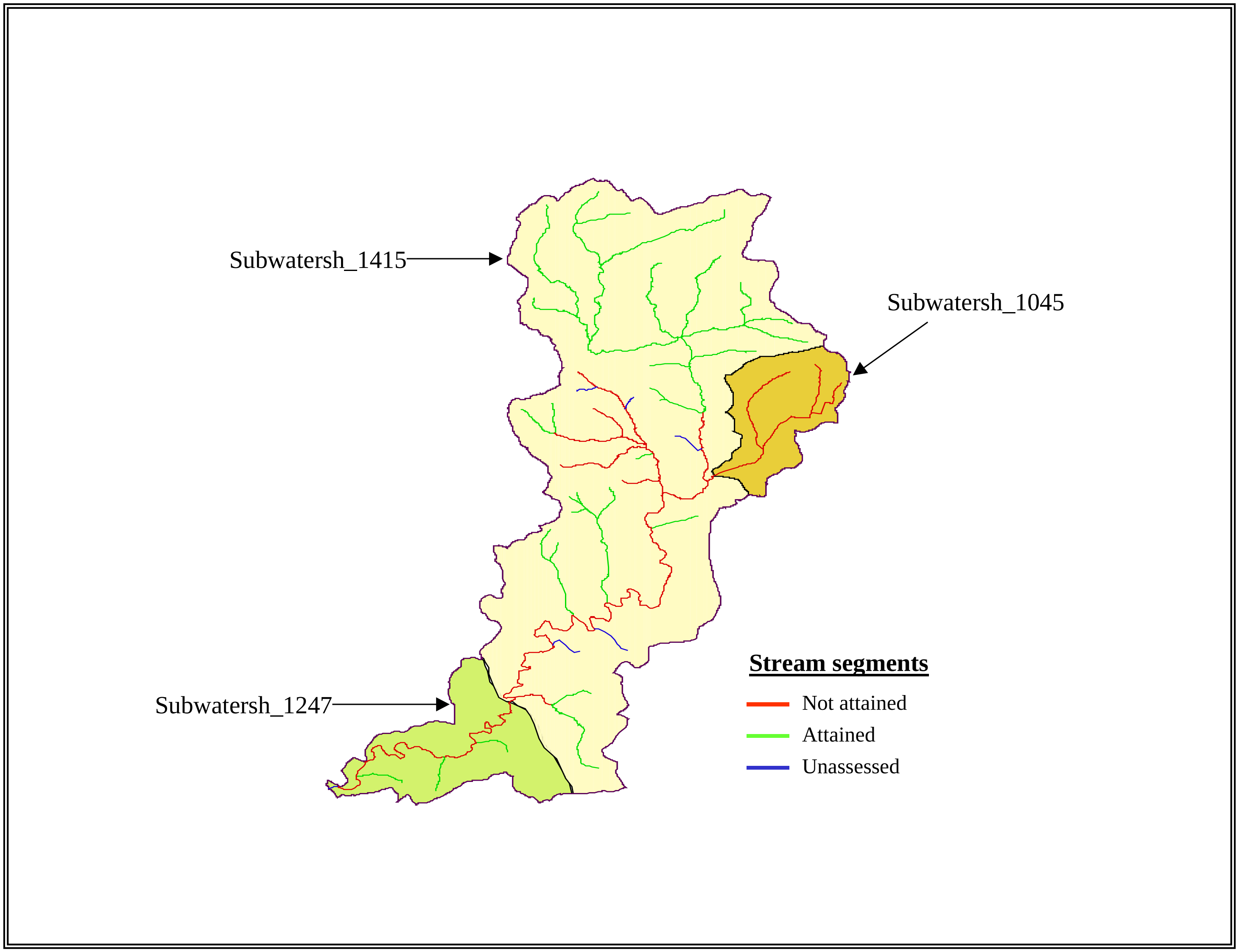

Figure 3. Subwatersheds of Chickies Creek Watershed.

Table 11. Load Allocation for Phosphorus by Each Agricultural Source.

Stream Segment ID	Land Use/ Source	Area	Phosphorus				
			Current Loading Rate	Allowable Loading Rate	Current Load	Load Allocation (ALA)	Reduction
		Acres	lbs/ac/yr	lbs/ac/yr	lbs/yr	lbs/yr	- % -
970729-1415-SAW	Hay/Past	6,785	0.49	0.40	3,313	2,741	17
	Cropland	16,000	2.39	0.85	38,174	13,572	64
Sub-total		22,785	1.82	0.72	41,487	16,314	61
1247	Hay/Past	1,106	0.49	0.40	540	447	17
	Cropland	2,494	2.39	0.85	5,950	2,115	64
Sub-total		3,600	1.80	0.71	6,490	2,562	62
97082-1045-SAW	Hay/Past	1,136	0.49	0.40	555	459	17
	Cropland	2,104	2.40	0.85	5,019	1,784	64
Sub-total		3,240	1.72	0.69	5,574	2,243	60
Watershed	Hay/Past	9,027	0.49	0.40	4,408	3,647	17
	Cropland	20,598	2.39	0.85	49,143	17,472	64
TOTAL		29,625	1.81	0.71	53,551	21,119	61

Table 12. Load Allocation of Sediment by Each Agricultural Source.

Stream Segment ID	Land Use/ Source	Area	Sediments				
			Current Loading Rate	Allowable Loading Rate	Current Load	Load Allocation (ALA)	Reduction
		Acres	lbs/ac/yr	lbs/ac/yr	lbs/yr	lbs/yr	- % -
970729-1415-SAW	Hay/Past	6,785	141.66	119.75	916,185	812,497	15
	Cropland	16,000	1,182.52	286.78	18,920,250	4,588,402	76
Sub-total		22,785	872.56	237.04	19,881,435	5,400,899	73
1247	Hay/Past	1,106	141.66	119.76	156,699	132,459	15
	Cropland	2,494	1,182.52	286.74	2,948,981	715,165	76
Sub-total		3,600	862.69	235.45	3,105,680	847,625	73
97082-1045-SAW	Hay/Past	1,136	141.66	119.72	160,957	136,007	15
	Cropland	2,104	1,182.52	286.73	2,487,634	603,283	76
Sub-total		3,240	817.58	228.18	2,648,531	739,290	72
Watersh	Hay/Past	9,027	141.66	119.75	1,278,781	1,080,963	15
	Cropland	20,598	1,182.52	286.77	24,356,865	5,906,850	76
TOTAL		29,625	865.35	235.88	25,635,646	6,987,813	73

Table 13. Load Allocation by Each Land Use/Source.

		Phosphorus					Sediment				
Source	Area	Current Loading Rate	Allowable Loading Rate	Current Load	Load Allocation (ALA)	Reduction	Current Loading Rate	Allowable Loading Rate	Current Load	Load Allocation (ALA)	Reduction
	acres	lbs/ac./yr	lbs/ac./yr	lbs/yr	lbs/year	- % -	lbs/ac/yr	lbs/ac/yr	lbs/yr	lbs/yr	- % -
Hay/Past	9,027	0.49	0.40	4,408	3,647	17	141.66	119.75	1,278,781	1,080,963	15
Cropland	20,598	2.39	0.85	49,143	17,472	64	1,182.52	288.77	24,356,865	5,906,850	76
Coniferous	341	0.01		5	5	0	5.08		1,733	1,733	0
Mixed For	585	0.02		9	9	0	6.69		3,915	3,915	0
Deciduous	8,363	0.07		591	591	0	42.75		357,347	357,347	0
Transition	3	0.00		0	0	0	0.00		0	0	0
Lo Int Dev	1,195	0.09		107	107	0	11.69		13,962	13,962	0
Hi Int Dev	661	1.09		723	723	0	15.25		10,080	10,080	0
Groundwater				4,396	4,396	0					
Point Source				1,447	8,809	0					
Septic Systems				201	201	0					
Total	**40,772**	**1.51**	**0.88**	**61,030**	**35,960**	**41**	**640.00**	**180.88**	**26,093,711**	**7,374,850**	**72**

VII. CONSIDERATION OF CRITICAL CONDITIONS

The AVGWLF model is a continuous simulation model which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values. Therefore, all flow conditions are taken into account for loading calculations. Because there is generally a significant lag time between the introduction of sediment and nutrients to a waterbody and the resulting impact on beneficial uses, establishing these TMDLs using average annual conditions is protective of the waterbody.

VIII. 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.

IX. RECOMMENDATIONS

The pollutant reductions in the TMDLs 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 TMDLs. 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 and stone ford cattle crossings. 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 to meet the nutrient and sediment reductions outlined in this report.

X. PUBLIC PARTICIPATION

A public meeting to discuss and accept comments on proposed TMDLs was held on January 25, 2001 beginning at 7:00 p.m., in the main auditorium of the Farm and Home Center in Lancaster . Public notice of the draft TMDL and the public meeting was published in the *Pennsylvania Bulletin* and the *Lancaster Intelligencer*. Notice of final plan approval will be published in the *Pennsylvania Bulletin.*

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Total Maximum Daily Loads (TMDLs) Development Plan for Chickies Creek Watershed

Prepared for Pennsylvania Department of Environmental Protection

by

Pennsylvania State University
Environmental Resources Research Institute
March 2, 2001

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TMDLs for Chickies Creek Watershed

EXECUTIVE SUMMARY

The Chickies Creek watershed in Lancaster County is 65.0 square miles in size. The protected uses of the watershed are water supply, recreation, and aquatic life. The aquatic use for the main stem of Chickies Creek, its unnamed and named tributaries (Boyers Run, Rife Run, and Dellinger run) is warm water fishes. It is cold water fishes for Shearers Creek, another tributary of Chickies Creek. The latter is also protected due to the high quality of its waters.

Total Maximum Daily Loads (TMDLs) apply to the main stem of Chickies Creek (Stream Code 7919) from about a 1.5 miles north of the town of Manheim to the mouth, the Rife Run and an unnamed tributary located North East of Manheim. They were developed to address the impairments noted on Pennsylvania's 1996 and 1998 Clean Water act Section 303(d) Lists. The impairments are primarily caused by excess nutrient and sediment loads from agriculture activities. The TMDL focuses on control of the nutrient phosphorus and sediments. Phosphorus is generally considered to be the limiting nutrient in a waterbody when the nitrogen/phosphorus ratio exceeds 10 to 1. In Chickies Creek, this ratio is 17 to 1.

Pennsylvania does not currently have water quality criteria for nutrients and sediments. For this reason, we developed a reference watershed approach to identify the TMDL endpoints or water quality objectives for nutrients and sediments in the impaired segments of the Chickies Creek watershed. Based upon comparison to a similar, non-impaired watershed, it was estimated that the amount of phosphorus loading that will meet the water quality objectives for Chickies Creek is 39,956 pounds per year. Sediment loading must be limited to 8,194,278 pounds per year. Chickies Creek will support its aquatic life uses when these values are met. The TMDLs for Chickies Creek are allocated as shown in the table below.

Summary of TMDLs for Chickies Creek (lbs/yr)							
Pollutant	**TMDL**	**MOS**	**WLA**	**LA**	**LNR**	**ALA**	**% Reduction**
Phosphorus	39,956	3,996	8,809	27,151	6,032	21,119	42
Sediments	8,194,278	819,428	-	7,374,850	387,037	6,987,813	72

The TMDLs are allocated to non-point source from agricultural activities, with 10% of the TMDL total load reserved as a margin of safety (MOS). The Wasteload Allocation (WLA) is that portion of the total load that is assigned to point sources. The allowable loading, or adjusted loading allocation (ALA), is that load attributed to agricultural land use and is computed by subtracting loads that do not need to be reduced (LNR) from the TMDL total values. The TMDLs cover a total of 30.6 miles of the main stem of Chickies Creek, its tributary Rife Run, and an unnamed tributary. The TMDL establishes a reduction for phosphorus loading from agricultural activities of 42% from the current annual loading of 61,530 pounds, and a reduction in sediment loading of 72% from the current annual loading of 26,093,711pounds. A more complete discussion of Chickies Creek TMDLs and TMDLs in general are contained in the attached Information Sheet (Appendix A).

I. INTRODUCTION

Total Maximum Daily Loads or TMDLs were developed for the Chickies Creek watershed to address the impairments noted on Pennsylvania's 1996 and 1998 Clean Water Act Section 303(d) Lists. It was first determined that Chickies Creek was not meeting its designated water quality uses for protection of aquatic life based on a 1994 aquatic biological survey, which included kick screen analysis and habitat surveys. In 1997, the Department again surveyed the stream and found the stream to still be impaired. As a consequence of the surveys, Pennsylvania listed Chickies Creek on the 1996 and 1998 Section 303(d) Lists of Impaired Waters. The 1996 303 (d) List reported 10 miles of the main stem (Stream Code 7919) to be impaired by agricultural nutrients. The 1998 list includes the original main stem impairment (Segment ID 1247 on 1998 List and decreased from 10 to 9.39 miles based on GIS measurement of stream miles) and added new segments (IDs 970729-1415-SAW and 970812-1045-SAW). The final impaired stream mile total on the 1998 Section 303(d) list is 30.6 miles (Table 1). These segments were listed on the 1998 303 (d) List because of impacts by nutrients and siltation due to agriculture. The Segment ID 970812-1045-SAW was also listed as impaired by urban Runoff/storm sewers but the cause of the impairment was "unknown". Upon field verification, we acknowledged the presence of an industrial site and railroad tract in the sub-watershed corresponding to this stream segment. Despite stagnant water due to gentle slopes and algae in the steam near this site, there is no apparent upland runoff and sediment production originating from the industrial site. In addition, this part of the stream is protected by stream buffers. Therefore, no TMDL was conducted for "unknown" causes of impairments from urban runoff/storm sewers.

The Pennsylvania approach to TMDL development involves comparing nutrient and sediment loads of the impacted watershed to those of a reference watershed. Based on the predominance of agricultural land use, nutrients and sediments are the most likely pollutants causing Chickies Creek to violate the aquatic life use. Therefore, the TMDLs propose reducing the phosphorus and sediment loadings in Chickies Creek watershed to levels consistent with Conococheague watershed, the reference watershed. Because of the similarities in size, land use, and geology existing between the two watersheds, achieving nutrient and sediment loadings in the Chickies Creek TMDL will ensure that the aquatic life use is achieved and maintained as evidenced in the Conococheague watershed.

Pennsylvania presently does not have water quality criteria for nutrients and sediments. It is for this reason, we developed a reference watershed approach to identify the TMDL endpoints or water quality objectives for nutrients and sediments in the impaired segments of the Chickies Creek watershed. The nutrient loading for this watershed only addresses phosphorus because it was determined that phosphorus was the limiting nutrient. Phosphorus is generally held to be the limiting nutrient in a waterbody when the nitrogen/ phosphorus ratio exceeds 10 to 1. This ratio in Chickies Creek is 17 to 1.

Table 1. 303(d) Sub-List								
State Water Plan (SWP) Subbasin:					**7-Chickies Creek Watershed**			
Year	SWP	Miles	Segment ID	DEP Stream Code	Stream Name	Designated Use	Data Source	EPA 305(b) Cause Code
1996	07-G	10.0	------	07919	Chickies	WWF	305(b) Report	Nutrients
1998*		9.4	1247	07919	Chickies		305(b) Report	Nutrients
1998	07-G	7.7	970812-1045-SAW	07919	Chickies	WWF	305(b) Report	Nutrients/Siltation, Unknown
1998	07-G	13.5	970729-1415-SAW	07919	Chickies	WWF	305(b) Report	Siltation

Warm Water Fishes=WWF

The Chickies Creek watershed TMDL Information Sheet that is attached to this document (Appendix A) provides a primer for TMDLs (What are they and why are we doing them?) and water quality standards (What makes up a water quality standard?). Appendixes B and C provide information on watershed hydrology and pollutant transport, and the method being used by Pennsylvania for establishing TMDLs for stream segments impaired by nutrients and sediments.

II. BACKGROUND

The Chickies Creek watershed is located almost entirely in Lancaster County and in the Piedmont Physiographic Province. It covers an area of 65.0 square miles. Chickies Creek drains in the Susquehanna River at about 1.2 miles South of the Town of Marietta. Its headwaters are in the Furnace Hills Mountains in the southern part of Lebanon County. The watershed is bounded by Pennsylvania Route 23 to the south and US Interstate 76 (Pennsylvania Turnpike) to the north. It can also be accessed from Lancaster via Route 23. Figure 1 shows the watershed boundary, its location, and the state of water quality of stream segments as reported from the 1998 303(d) List. The protected uses of the watershed are water supply, recreation and aquatic life. As listed in the Title 25 PA Code Department of Environmental Protection Chapter 93, Section 93.o (Commonwealth of PA, 1999), the designated aquatic life use for the main stem of Chickies Creek, its tributaries (Boyers Run, Rife Run, and Dellinger run), and several unnamed tributaries is warm water fishes. It is cold water fishes for Shearers Creek, another tributary of Chickies Creek. The latter is also specially protected due to the high quality of its waters.

The primary land use in the Chickies Creek Watershed is agriculture (73%), with areas adjacent to the stream used for Cropland and pasture. It was found also from a field survey of the watershed that cattle generally have free access to the stream. The majority of the streams had no protected riparian zone. The

1997 survey showed that nutrients from agricultural activities were causing increased algae growths. It also found that sediment deposited in large quantities on the streambed was degrading the habitat of bottom-dwelling macroinvertebrates.

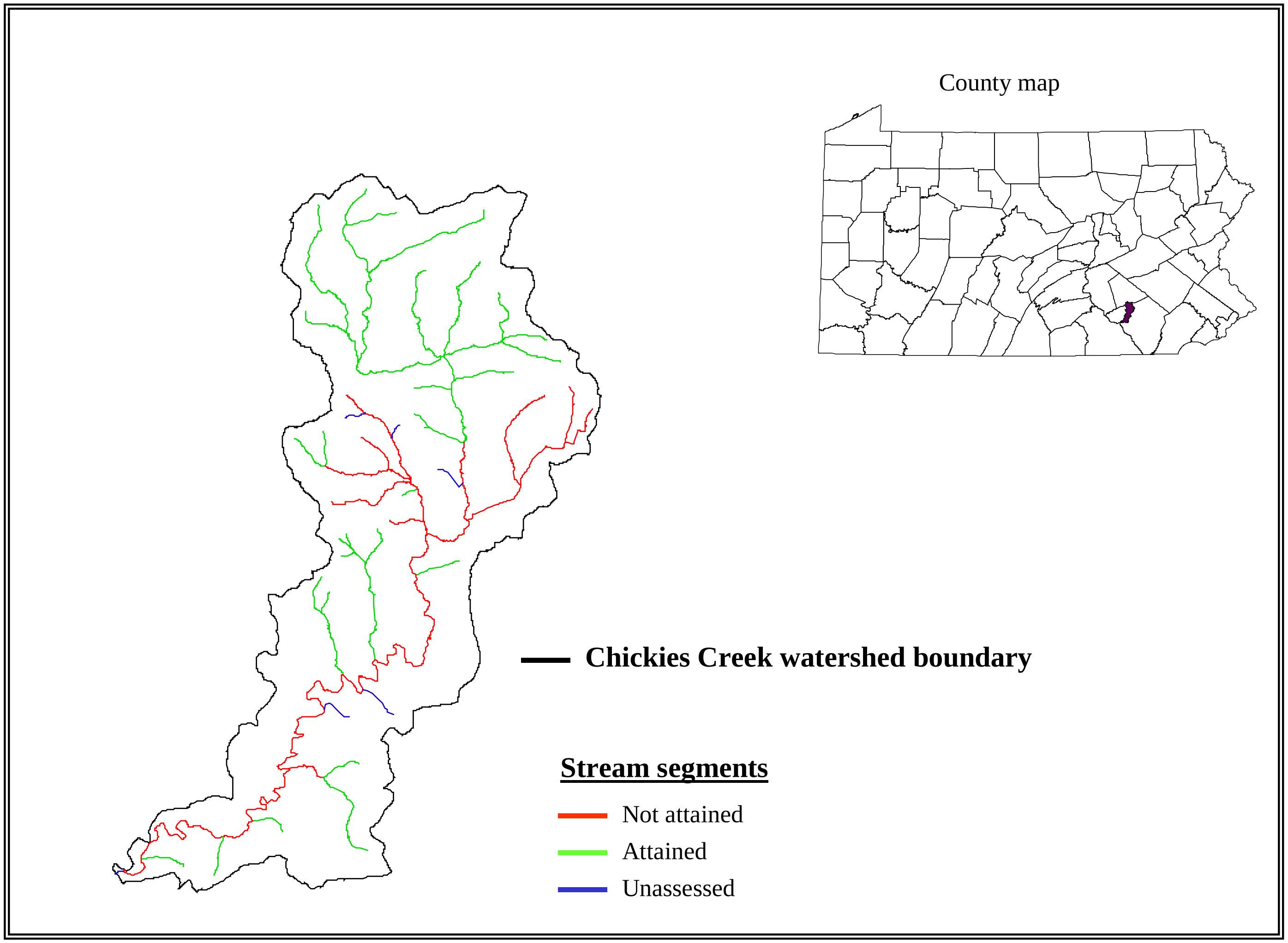

Figure 1. Chickies Creek Watershed.

III. TMDL ENDPOINTS

The TMDLs address phosphorus and sediments. Phosphorus was determined to be the nutrient limiting plant growth in Chickies Creek. Because neither Pennsylvania nor EPA has water quality criteria for phosphorus or sediments, we had to develop a method to determine water quality objectives for these parameters that would result in the impaired stream segments attaining their designated uses. The method employed for these TMDLs is termed the "Reference Watershed Approach."

The Reference Watershed Approach pairs two watersheds, one attaining its uses and one that is impaired based on biological assessment. Both watersheds must have similar land use/cover distributions. Other features such as base geologic formation should be matched to the extent possible; however, most variations can be adjusted in the model. The objective of the process is to reduce the loading rate of nutrients and sediments in the impaired stream segment to a level equivalent to or slightly lower than the loading rate in the non-impaired, reference stream segment. This load reduction will allow the biological community to return to the impaired stream segments.

The TMDL endpoints established for this analysis were determined using Conococheague watershed as the reference watershed. These endpoints are discussed in detail in the TMDL section. The listing for impairment caused by nutrients and siltation is addressed through reduction to the phosphorus load. A detailed explanation of this process is included in the following section.

Nutrient Loads and Organic Enrichment in Stream Systems

As indicated earlier, Chickies Creek was listed as being impaired due to problems associated with nutrient loads and siltation. In stream systems, elevated nutrient loads (nitrogen and phosphorus in particular) can lead to increased productivity of plants and other organisms (Novotny and Olem, 1994).

Typically in aquatic ecosystems the quantities of trace elements are plentiful; however, nitrogen and phosphorus may be in short supply. The nutrient that is in the shortest supply is called the *limiting nutrient* because its relative quantity affects the rate of production (growth) of aquatic biomass. If the nutrient load to a water body can be reduced, the available pool of nutrients that can be utilized by plants and other organisms will be reduced and, in general, the total biomass can subsequently be decreased as well (Novotny and Olem, 1994). In most efforts to control eutrophication processes in water bodies, emphasis is placed on the limiting nutrient. This is not always the case, however. For example, if nitrogen is the limiting nutrient, it still may be more efficient to control phosphorus loads if the nitrogen originates from difficult to control sources such as nitrates in ground water.

In most fresh water bodies, phosphorus is the limiting nutrient for aquatic growth. In some cases, however, the determination of which nutrient is the most limiting is difficult. For this reason, the ratio of the amount of N to the amount of P is often used to make this determination (Thomann and Mueller, 1987). If the N/P ratio is less than 10, nitrogen is limiting. If the N/P ratio is greater than 10, phosphorus is the limiting nutrient. In the case of Chickies Creek, the N/P ratio is approximately 17, which points to phosphorus as the limiting nutrient. Controlling the phosphorus loading to Chickies Creek will limit plant growth and result in raising the dissolved oxygen level.

IV. SELECTION OF THE REFERENCE WATERSHED

In general, three factors should be considered when selecting a suitable reference watershed. The first factor is to use a watershed that has been assessed by the Department using the Unassessed Waters Protocol and has been determined to attain water quality standards. The second factor is to find a watershed that closely resembles Chickies Creek watershed in physical properties such as land cover/land use, physiographic province, and geology. Finally, the size of the reference watershed should be within 20-30% of the impaired watershed area. The search for a reference watershed that would satisfy the above characteristics was done by means of a desktop screening using several GIS coverages including the Multi-Resolution Land Characteristics (MRLC) Landsat-derived land cover/use grid, the Pennsylvania's 305(b) assessed streams database, and geologic rock types.

A watershed that would satisfy all the characteristics mentioned above could not be found in the same physiographic province as Chickies Creek due to the following reasons:

1) Not all stream segments in the Piedmont Physiographic Province where Chickies Creek watershed is located have been assessed.

2) All watersheds that have similar levels of agricultural land use and geologic rock type distributions as Chickies Creek watershed are also impacted.

The watershed used as a reference for the Chickies Creek Watershed was obtained by screen-digitizing a subwatershed of the Conococheague Creek watershed. Stream segments in Conococheague watershed have been assessed and were found to be attaining standards. This watershed is located in the Ridge and Valley Province in State Water Plan (SWP) Basin 13C. The digitized (reference) watershed is referred in this report as "Conococheague watershed". Table 3 compares the two watersheds in terms of their size, location, and other physical characteristics. This watershed is also within the size range for reference watersheds, 62.6 square miles or 93% of the Chickies Creek Watershed area. Figure 2 shows its boundary and location in Franklin County.

The Conococheague watershed is still appropriate for use as a reference watershed for Chickies Creek watershed despite differences in point source loadings. The Conococheague watershed has significantly higher point source phosphorus load contribution, 90% higher, than that of Chickies Creek watershed. However, Conococheague watershed is still suitable for use as a reference because it continues to meet water quality criteria based on biological assessment.

The analysis of value counts for each pixel of the MRLC grid revealed that land cover/use distributions in both watersheds are similar. The agricultural land use, which is the source of impairment in Chickies Creek watershed, accounts for 73% of the total land area as compared to 84% in Conococheague watershed. The surficial geologies of the Chickies Creek and Conococheague watersheds were also compared and appear to produce reasonably a good match. The geology of Chickies Creek Watershed consists primarily of carbonate (67%) and conglomerate (25%), while Conococheague watershed is made of carbonate (63%) and shale (37%). The bedrock geology affects primarily surface runoff and background nutrient loads through its influences on soils and landscape as well as fracture density and directional permeability. A look at these attributes in Table 2 indicates that these watersheds compare very well in terms of average runoff, precipitation, and soil K factor.

Table 2. Comparison Between Chickies Creek and Conococheague Watersheds		
Attribute	**Chickies Creek**	**Conococheague**
Physiographic Province	Piedmont	Ridge and Valley
Area (square miles)	65.0	62.6
Predominant Land Use		
	Agriculture (73%)	Agriculture (84%)
Predominant Geology		
	Carbonate (67%	Carbonate (63%)
	Conglomerate (25%)	Shale (37%)
Soils		
Dominant HSG	B (60%), C (40%)	B(13%), C (87%)
K Factor	0.30	0.28
20-Year Average Rainfall (in)	42.6	39.3
20-Year Average Runoff (in)	4.1	4.3

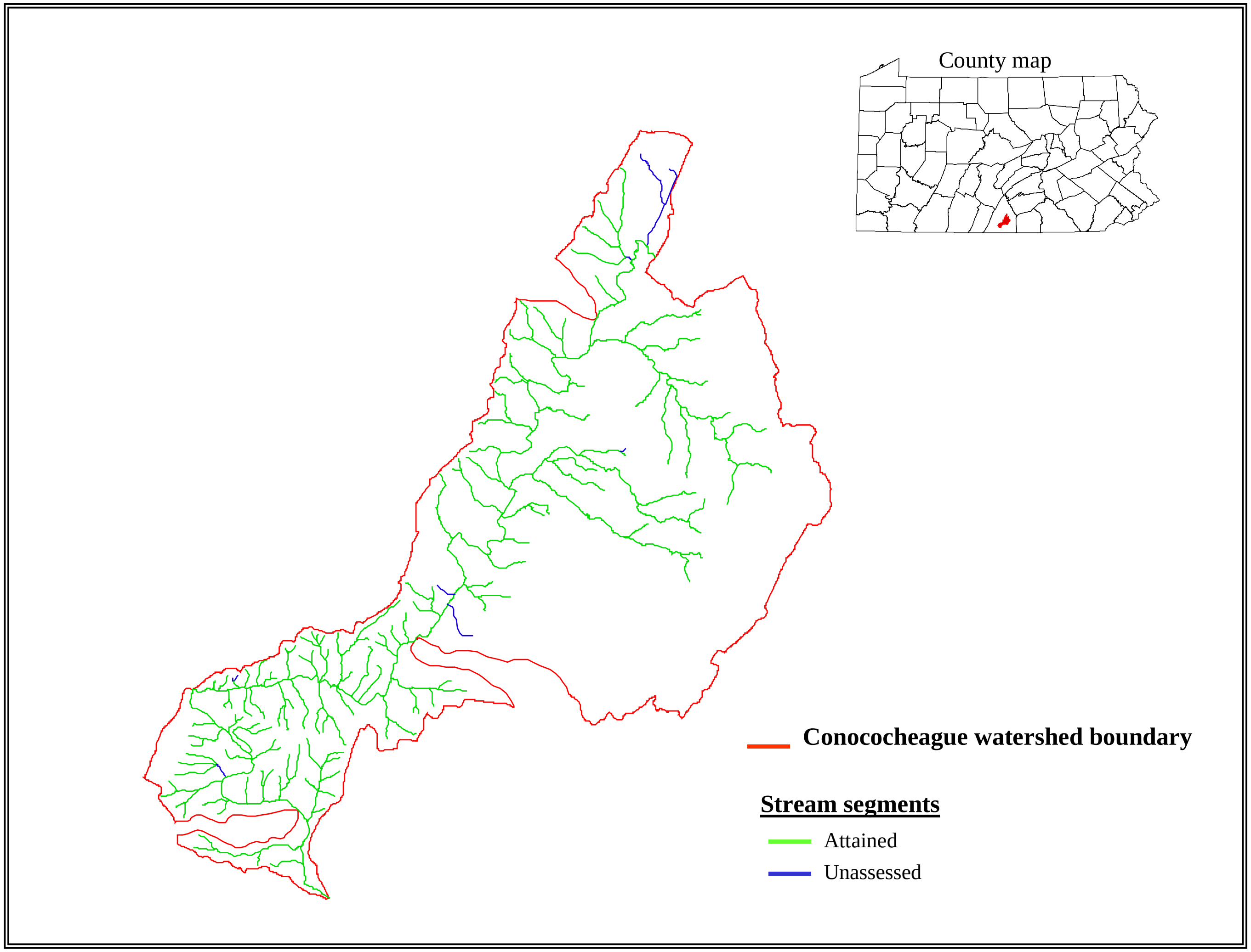

Figure 2. Conococheague (Reference) Watershed.

V. HYDROLOGIC/WATER QUALITY MODELING

5.1. Data Compilation and Model Overview

The TMDLs were developed using the Generalized Watershed Loading Function or GWLF model. The GWLF model provides the ability to simulate runoff, sediment, and nutrient (N and P) 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 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/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 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 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 Attachment D, the GWLF Users Guide.

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.

5.2. 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 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 (see Appendix B). 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. Table 3 lists the statewide GIS data sets and provides explanation of how they were used for development of the input files for the GWLF model.

Table 3. GIS Data Sets	
Censustr	Coverage of Census data including information on individual homes septic systems. The attribute*usew_sept* includes data on conventional systems, and *sew_other* provides data on short circuiting and other systems.
County	The County boundaries coverage lists data on conservation practices which provides C and P values in the Universal Soil Loss Equation (USLE).
Gwnback	A grid of background concentrations of N in groundwater derived from water well sampling.
Landuse5	Grid of the MRLC that has been reclassified into five categories. This is used primarily as a background.
Majored	Coverage of major roads. Used for reconnaissance of a watershed.
MCD	Minor civil divisions (boroughs, townships and cities).
Npdespts	A coverage of permitted point discharges. Provides background information and cross check for the point source coverage.
Padem	100 meter digital elevation model. This used to calculate landslope and slope length.
Palumrlc	A satellite image derived land cover grid which 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 phosphorous 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 landuse 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.

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/cover, and soil type. In essence, the model is used to estimate surface runoff and nonpoint 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 nonpoint source load calculated is affected by terrain conditions such as amount of agricultural land, land slope, and inherent soil erodibility. It is also affected by farming practices utilized in the area, as well as by background concentrations of nutrients (i.e., N and P) in soil and groundwater. Various parameters are included in the model to account for these conditions and practices. Some of the more important parameters are summarized below:

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

Curve number: This determines the amount of precipitation that infiltrates into the ground or enters surface water as runoff. It is based on specified combinations of land use/cover and hydrologic soil type, and is calculated directly using digital land use/cover 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/cover 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/cover 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 D of this document. Specific details in this guide that describe equations and typical parameter values used can be found on pages 15 through 41.

5.3. Watershed Assessment and Modeling

The AVGWLF model was run for both the Chickies Creek Watershed and Conococheague watershed to establish existing loading conditions under existing land cover use conditions in each watershed.

General observations of watershed characteristics:

-Chickies Creek watershed has less topographic relief, shallower streambed, more continuous corn crops and less hay/pasture, more animals (particularly dairy and poultry operations), dominated by carbonate rocks, less evidence of conservation practices.

- Conococheague watershed has more topographic relief than Chickies, deeper streambed, more hay/pasture and cover crops, more crop residue left, more use of strip cropping and forest buffers along streams, dominated by carbonate rocks, more evidence of conservation practices, fewer animals.

Adjustments to Specific GWLF-related parameters

Conococheague:

Reset "C" factor to 0.16 for Cropland land to account for use of continuous cover crop.

Reset "P" factor to 0.30 for Hay/Pasture and Cropland land uses to account for use of riparian forest and grasses along streams, strip cropping, and buffer strips.

Point Sources for Chickies and Conococheague:

Total P point source contributions to the watershed for use in determining the loading rate in the Conococheague (reference) watershed, and serving as the target loading rate for Chickies (the impaired) watershed, were determined using the Discharge Monitoring Records (DMR) data for each facility. DMR data were also used in assessing the existing point source contributions to the impaired watershed. These values, 1,947 and 33,727 lbs/year for Chickies Creek (Table 4) and Conococheague (Table 5) watersheds, respectively, are averages for Year 1999.

Table 4. Permitted and Actual Point Source Total P Loads Discharged in Chickies Creek

Facility	NPDES Permit	Location (City)	Flow (mgd)		Total P (lbs/year)	
			Permit Limit	Avg. from 1999 DMR	Permit Limit	Avg. from 1999 DMR
Manheim STP	PA0020893	Lancaster	1.14	1.14	6938	1597
Model Enterprise Inc.	PA0081299	Lancaster	0.02	0.02	122	55
Northwestern Lancaster Co.	PA0084026	Manheim	0.25	0.25	1521	207
Penn Valley Mobile Home Village	PA0034860	Lititz	0.01	0.01	67	54
Telco Developers Inc.	PA0081787	Stevens	0.03	0.03	161	34
Total P					8809	1947

Table 5. Actual Point Source Total P Loads Discharged in Conococheague Watershed				
Facility	**NPDES Permit**	**Location (City)**	**Average Flow from 1999 DMR (mgd)**	**Avg. from 1999 DMR Total P (lbs/year)**
Chambersburg Boro STP	PA0026051	Chambersburg	4.6	33,712
Martin's Famous Pastry Shoppe, Inc.	-	-	0.0006	15
Total				33,727

Since there is no in-stream module in the GWLF model, in-stream P losses must be accounted for externally in order to accurately represent the load at the watershed outlet. In-stream P losses from point sources were estimated according to an algorithm available in the USGS SPARROW (**SPA**tially **R**eferenced **R**egressions **o**n **W**atershed Attributes) model (Preston, 2000; personal communication). SPARROW estimates in-stream nutrient losses using a decay function based on travel time and stream flow. Travel time to the watershed outlet is calculated for each facility using flow velocity, as determined by flow volume and a representative cross-sectional area of the stream based on field measurements at several sites along the reach, and distance traveled. Phosphorus data resulting from adjusting for in-stream losses are 1,447 and 23,000 lbs/year for Chickies Creek and Conococheague watersheds, respectively (See Tables 6 and 7).

The 20-year (1979-1998) means for these parameters for each watershed are shown Tables 6 and 7. The Unit Area Load for each pollutant in each watershed was estimated by dividing the mean annual loading (lbs/yr) by the total area (acres) resulting in an approximate loading per unit area for the watershed. The point source Table 8 presents an explanation of the header information contained in Tables 6 and 7. Modeling output for Chickies Creek and Conococheague watersheds are presented in Appendices E and F, respectively.

Table 6. Existing Loading Values for Chickies Creek Watershed

Land Use Category	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	9,027	4,408	0.49	64,821	7.18	1,278,781	141.66
Cropland	20,598	49,143	2.39	322,832	15.67	24,356,865	1,182.52
Coniferous For	341	5	0.01	55	0.16	1,733	5.08
Mixed For	585	9	0.02	83	0.14	3,915	6.69
Deciduous For	8,363	591	0.07	1,415	0.17	357,347	42.75
Transition	2	0	0.00	0	0	0	0
Lo Int Dev	1,195	107	0.09	801	0.67	13,962	11.69
Hi Int Dev	661	723	1.09	6,523	9.87	10,080	15.25
Groundwater		4,396		627,990			
Point Source		1,447		7,092			
Septic Systems		201		34,374			
Total	40,772	61,030	1.50	1,065,987	26.15	26,093,711	640.00

Table 7. Existing Loading Values for Conococheague Watershed

Land Use Category	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	12,404	1,651	0.13	30,532	2.46	731,691	58.99
Cropland	19,511	8,897	0.46	94,926	4.87	7,070,707	362.40
Coniferous For	324	2	0.01	36	0.11	924	2.86
Mixed For	823	6	0.01	95	0.12	3,157	3.84
Deciduous For	2,711	23	0.01	330	0.12	15,965	5.89
Transition	49	67	1.36	408	8.26	57,782	1,169.21
Lo Int Dev	2,024	174	0.09	1,309	0.65	12,461	6.16
Hi Int Dev	1,470	1,663	1.13	14,993	10.20	8,791	5.98
Groundwater		2,983		426,194			
Point Source		23,000		115,272			
Septic Systems		83		17,912			
Total	39,316	38,549	0.98	702,008	17.86	7,901,478	200.98

Table 8. Header Information for Tables 6 and 7.	
Land Use Category	The land cover classification that was obtained by from the MRLC database
Area (acres)	The area of the specific land cover/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

VI. LOAD ALLOCATION PROCEDURE FOR PHOSPHORUS AND SEDIMENT TMDLS

The load allocation and reduction procedures will be applied to the entire Chickies Creek watershed and its subwatersheds. These subwatersheds (Subwatersh_1415, Subwatersh_1247, and Subwater_1045) were obtained by delineating contributing areas to each of the impacted segments shown in Tables 1 and 2. The subwatershed boundaries are shown in Figure 3. In addition to subwatershed delineations, a GIS analysis was performed to determine land use distributions in each subwatershed. This data is needed for load reduction analyses.

The load reduction calculations in Chickies Creek watershed are based on the current loading rates for phosphorus and sediments in Conococheague watershed, the reference watershed for this analysis. Based on biological assessment, it was determined that Conococheague was attaining its designated uses. The phosphorus and sediment loading rates were computed for Conococheague watershed using the AVGWLF model. These loading rates were then used as the basis for establishing the TMDLs for Chickies Creek watershed. The equations defining TMDLs for Chickies are as follows:

$$TMDL = MOS + LA + WLA \qquad (1)$$

$$LA = ALA - LNR \qquad (2)$$

TMDL is the TMDL total load. The LA (load allocation) is the portion of Equation (1) that is assigned to non-point sources. The MOS (margin of safety) is the portion of loading that is reserved to account for any uncertainty in the data and computational methodology used for the analysis. The WLA (Waste Load Allocation) is the portion of this equation that is assigned to point sources. The adjusted load allocation (ALA) is load that originates from nonpoint sources (Equation 2) that need to be reduced for the Chickies Creek watershed to meet water quality standards. Therefore, it is the load that originates from agricultural sources for water quality problems encountered in the watershed. Details of TMDL, MOS, LA, and ALA computations are presented below.

6.1. TMDL Total Load

The TMDL loads for both pollutants of concern were computed in the same manner. The first step is to determine the TMDL total target load for Chickies Creek, the impaired watershed. This value was obtained by multiplying each pollutant unit loading rate in Conococheague watershed by the total watershed area of Chickies Creek. This information is presented in Table 9.

Table 9. TMDL Total Load Computation

Type of Pollutant	Unit Area Loading Rate in Conococheague Crk (lbs/acre/yr)	Total Watershed Area in Chickies Creek (acres)	TMDL Total Load (lbs/yr)
Phosphorus	0.98	40,772	39,956
Sediment	200.98	40,772	8,194,278

6.2. Margin of Safety

The Margin of Safety (MOS) for this analysis is explicit. Ten percent of each of the TMDLs was reserved as the MOS.

Phosphorus - *39,956 lbs/yr x 0.1 = 3,996 lbs/yr* (3)
Sediment - *8,194,278 lbs/yr x 0.1 = 819,428 lbs/yr* (4)

6.3. Load Allocation

The Load allocation (LA), consisting of all nonpoint sources in the watershed, was computed as by subtracting the margin of safety and the wasteload allocation (WLA) from the TMDL total load. The WLA is the total loading that is assigned to point sources within Chickies Creek watershed. The WLA for the watershed is set to the sum of the permitted loads (8,809 lbs/year) for all dischargers in the watershed (see Table 4). Notice that in-stream losses are not applied to the permitted loads in setting the WLA.

LA (Phosphorus) = 39,956 lbs/yr – 3,996 lbs/yr – 8,809 lbs/yr= 27,151 lbs/yr (5)
LA (Sediments) = 8,194,278 lbs/yr - 819,428 lbs/yr = 7,374,850 lbs/yr (6)

6.4. Adjusted Load Allocation

The adjusted load allocation (ALA) is the actual load allocation for sources that will need reductions. It is computed by subtracting loads from non-point sources that are not considered in the reduction scenario (LNR). These are loads from all non-point sources in Table 6 except those from agricultural land uses (Hay/Past, Row_Crops). Therefore, using data in Table 6,

LNR (Phosphorus) = 5 lbs/yr + 9 lbs/yr + 591 lbs/yr + 0 lb/yr + 107 lb/yr + 723 lbs/yr + 4,396 lbs/yr + 201 lbs/yr = 6,032 lbs/yr (7)
ALA (Phosphorus) = 27,151 lbs/yr - 6,032 lbs/yr= 21,119 lbs/yr (8)

LNR (Sediments) = 1,733 lbs/yr + 3,915 lbs/yr + 357,347 lb/yr + 0 lb/yr + 13,962 lbs/yr + 10,080 lbs/yr = 387,037 lbs/yr (9)
ALA (Sediments) = 7,374,850 lbs/yr - 387,037 lbs/yr = 6,987,813 lbs/yr. (10)

Table 10 below presents TMDLs for Chickies Creek watershed.

Table 10. Summary of TMDLs for Chickies Creek (lbs/yr)

Pollutant	TMDL	MOS	WLA	LA	LNR	ALA
Phosphorus	39,956	3,996	8,809	27,151	6,032	21,119
Sediments	8,194,278	819,428	-	7,374,850	387,037	6,987,813

The ALA computed above is the portion of the load that is available to allocate among contributing sources (Hay/Past, Cropland) as described in the next step. Not all land use/source categories were included in the allocation because they are difficult to control, or provide an insignificant portion of the total load (e.g., transition land use). The following section shows the allocation process in detail for the entire watershed and subwatersheds.

6.5. Load Reduction Procedures

The P and sediment loads obtained in the previous step were allocated among the remaining land use/sources of the impaired watershed according to the Equal Marginal Percent Reduction (EMPR) method. EMPR is carried out using an Excel Worksheet in the following manner:

1) Each land use/source load is compared with the total allocable load to determine if any contributor would exceed the allocable load by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load to the receiving waterbody. If the contributor exceeds the allocable load, that contributor would be reduced to the allocable load. This is the baseline portion of EMPR.

2) After any necessary reductions have been made in the baseline the multiple analysis is run. The multiple analyses will sum all of the baseline loads and compare them to the total allocable load. If the allocable load 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.

3) Now that the load allocation for each land use in the Chickies Creek has been calculated, portions of the whole watershed load can be allocated to each subwatershed. The TMDL total load for each subwatershed was computed as the product of the unit area load for that land use determined in the watershed analysis and the area covered by the land use/source in the subwatershed. The load allocation for each land use was determined by multiplying the allowable unit area loading rate for that land use (after EMPR) and the area of the land use in the impaired subwatersheds. Results of the load reduction procedure are load allocations to agricultural activities and associated percent reductions needed to reach water quality standards in the watershed and subwatersheds (see Tables 11 and 12). The load allocation and EMPR procedures were performed using an Excel Worksheet and results are presented in Appendices G and H for P and sediments, respectively. Table 13 provides load allocation by considering all land uses in Chickies Creek Watershed. In this case, land uses/sources that were not part of the allocation are carried through at their existing loading values.

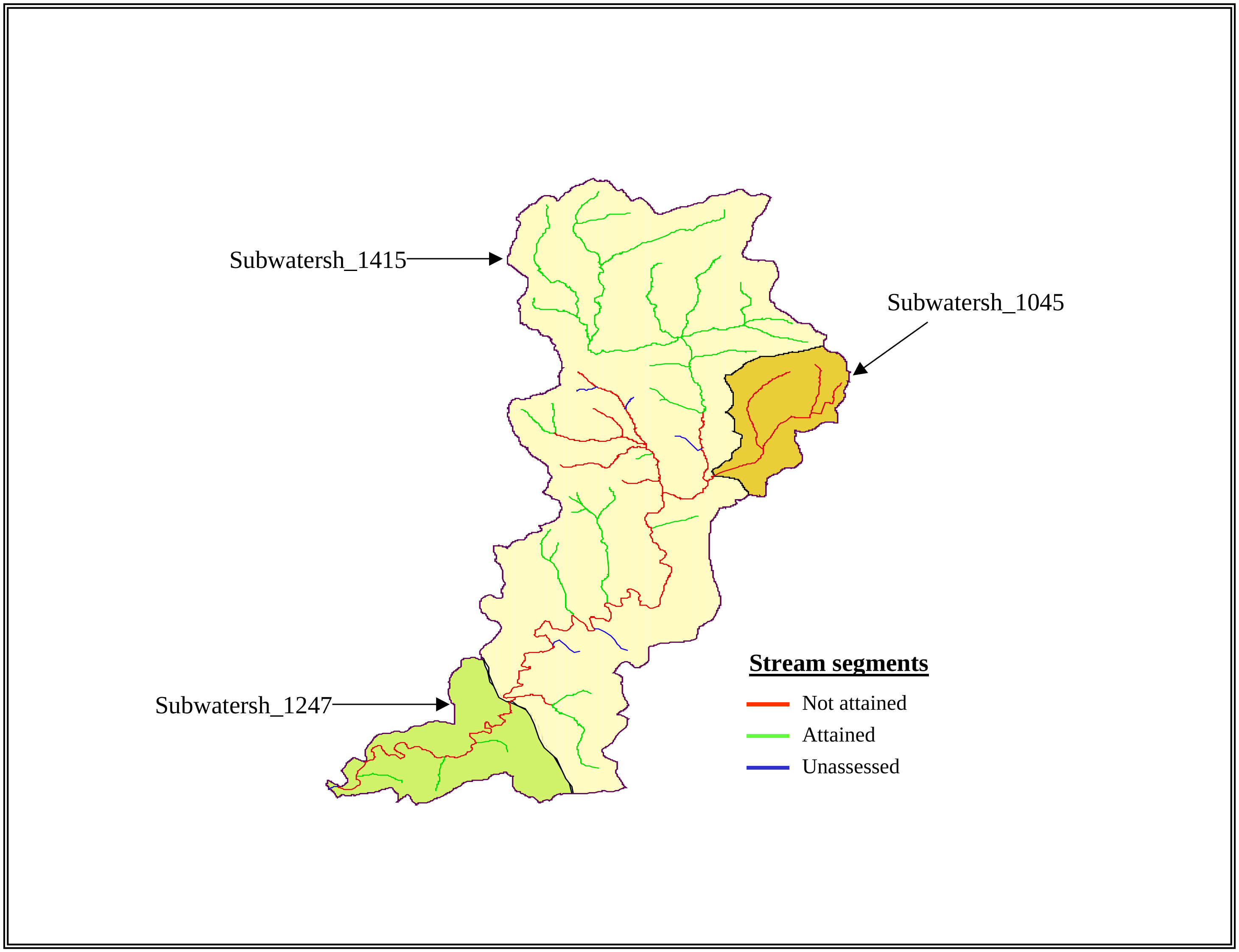

Figure 3. Subwatersheds of Chickies Creek Watershed.

Table 11. Load Allocation for Phosphorus by Each Agricultural Source.

Stream Segment ID	Land Use/ Source	Area	Phosphorus				
			Current Loading Rate	Allowable Loading Rate	Current Load	Load Allocation (ALA)	Reduction
		Acres	lbs/ac/yr	lbs/ac/yr	lbs/yr	lbs/yr	- % -
970729-1415-SAW	Hay/Past	6,785	0.49	0.40	3,313	2,741	17
	Cropland	16,000	2.39	0.85	38,174	13,572	64
Sub-total		22,785	1.82	0.72	41,487	16,314	61
1247	Hay/Past	1,106	0.49	0.40	540	447	17
	Cropland	2,494	2.39	0.85	5,950	2,115	64
Sub-total		3,600	1.80	0.71	6,490	2,562	62
97082-1045-SAW	Hay/Past	1,136	0.49	0.40	555	459	17
	Cropland	2,104	2.40	0.85	5,019	1,784	64
Sub-total		3,240	1.72	0.69	5,574	2,243	60
Watershed	Hay/Past	9,027	0.49	0.40	4,408	3,647	17
	Cropland	20,598	2.39	0.85	49,143	17,472	64
TOTAL		29,625	1.81	0.71	53,551	21,119	61

Table 12. Load Allocation of Sediment by Each Agricultural Source.

Stream Segment ID	Land Use/ Source	Area	Sediments				
			Current Loading Rate	Allowable Loading Rate	Current Load	Load Allocation (ALA)	Reduction
		Acres	lbs/ac/yr	lbs/ac/yr	lbs/yr	lbs/yr	- % -
970729-1415-SAW	Hay/Past	6,785	141.66	119.75	916,185	812,497	15
	Cropland	16,000	1,182.52	286.78	18,920,250	4,588,402	76
Sub-total		22,785	872.56	237.04	19,881,435	5,400,899	73
1247	Hay/Past	1,106	141.66	119.76	156,699	132,459	15
	Cropland	2,494	1,182.52	286.74	2,948,981	715,165	76
Sub-total		3,600	862.69	235.45	3,105,680	847,625	73
97082-1045-SAW	Hay/Past	1,136	141.66	119.72	160,957	136,007	15
	Cropland	2,104	1,182.52	286.73	2,487,634	603,283	76
Sub-total		3,240	817.58	228.18	2,648,531	739,290	72
Watersh	Hay/Past	9,027	141.66	119.75	1,278,781	1,080,963	15
	Cropland	20,598	1,182.52	286.77	24,356,865	5,906,850	76
TOTAL		29,625	865.35	235.88	25,635,646	6,987,813	73

Table 13. Load Allocation by Each Land Use/Source.

		Phosphorus					Sediment				
Source	Area	Current Loading Rate	Allowable Loading Rate	Current Load	Load Allocation (ALA)	Reduction	Current Loading Rate	Allowable Loading Rate	Current Load	Load Allocation (ALA)	Reduction
	acres	lbs/ac./yr	lbs/ac./yr	lbs/yr	lbs/year	- % -	lbs/ac/yr	lbs/ac/yr	lbs/yr	lbs/yr	- % -
Hay/Past	9,027	0.49	0.40	4,408	3,647	17	141.66	119.75	1,278,781	1,080,963	15
Cropland	20,598	2.39	0.85	49,143	17,472	64	1,182.52	288.77	24,356,865	5,906,850	76
Coniferous	341	0.01		5	5	0	5.08		1,733	1,733	0
Mixed For	585	0.02		9	9	0	6.69		3,915	3,915	0
Deciduous	8,363	0.07		591	591	0	42.75		357,347	357,347	0
Transition	3	0.00		0	0	0	0.00		0	0	0
Lo Int Dev	1,195	0.09		107	107	0	11.69		13,962	13,962	0
Hi Int Dev	661	1.09		723	723	0	15.25		10,080	10,080	0
Groundwater				4,396	4,396	0					
Point Source				1,447	8,809	0					
Septic Systems				201	201	0					
Total	**40,772**	**1.51**	**0.88**	**61,030**	**35,960**	**41**	**640.00**	**180.88**	**26,093,711**	**7,374,850**	**72**

VII. CONSIDERATION OF CRITICAL CONDITIONS

The AVGWLF model is a continuous simulation model which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values. Therefore, all flow conditions are taken into account for loading calculations. Because there is generally a significant lag time between the introduction of sediment and nutrients to a waterbody and the resulting impact on beneficial uses, establishing these TMDLs using average annual conditions is protective of the waterbody.

VIII. 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.

IX. RECOMMENDATIONS

The pollutant reductions in the TMDLs 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 TMDLs. 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 and stone ford cattle crossings. 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 to meet the nutrient and sediment reductions outlined in this report.

X. PUBLIC PARTICIPATION

A public meeting to discuss and accept comments on proposed TMDLs was held on January 25, 2001 beginning at 7:00 p.m., in the main auditorium of the Farm and Home Center in Lancaster . Public notice of the draft TMDL and the public meeting was published in the *Pennsylvania Bulletin* and the *Lancaster Intelligencer*. Notice of final plan approval will be published in the *Pennsylvania Bulletin.*

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Comment Response Document
Chickies Creek Watershed TMDL

Commentor :
U.S. Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Point Sources:

Comment: Please use permit limits and not DMR limits to determine the waste load allocation (WLA).
Response: Permit limits, not DMR data, were used to determine WLA. The following sentences were added on Page 22 to make it more clear:

> "The WLA for the watershed is set to the sum of the permitted loads (8,809 lbs/year) for all dischargers in the watershed (see Table 4). Notice that in-stream losses are not applied to the permitted loads in setting the WLA."

Comment: Please properly identify the point sources. Including the type, name, and location of each facility. The permit number, DMR data and design flows and concentrations should also be included for each facility.
Response: Two tables, Tables 4 and 5 for Chickies and Conococheague Watersheds, respectively, have been added.

Comment: Please adequately explain the methodology used to determine the point source contributions to the watershed.
Response: Two paragraphs that explain the methodology used to determine the point sources contributions to the watershed ware included on Pages 18 and 19.

Comment: Please make any model parameter adjustments consistent with other PA TMDLs using the same reference condition.
Response: The modeling results for Conococheague (reference watershed) in this report are the same as those obtained by the SRBC (see TMDL report for the Pequea Creek watershed). Therefore, the same model adjustments were made. The SRBC did reset C and P values (as we did) but did not report having made this change in the Pequea Creek TMDL document.

Comment: As written, the TMDL does not adequately discuss the existence of point sources in the watershed, and how the WLA was determined. Table 8 denotes that 8,809lbs/yr has been determined to be the WLA for phosphorus, however there is no discussion on WLA other than to define it as representing the point source contributions.
Response: Same responses as to above comments regarding documentation of point sources.

Comment: In section IV, (The selection of the Reference Watershed), the GWLF parameters were adjusted from 'permitted levels to actual' based on discharge monitoring reports, for both the impaired and the reference watersheds. Table 4 also indicates the

existing load for phosphorus is 1,947lbs/yr for Chickees Creek watershed and 23,000lbs/yr for the Conococheague watershed. The TMDL does state that 1,947lb/yr of phosphorus is the ‘actual value of total P loading for the Chickees watershed. However, it does not indicate whether this number represents an averaged value, or for what period of time it represents, or if it is a cumulative load from several dischargers or a singe discharge. The TMDL does not discuss the source of the 8,809lbs/yr value assigned as the WLA.
Response: See Tables 4 and 5 for response. It is indicated in these tables that Permit and DMR limit loads are 1999 average values.

Comment: It is important to clearly explain how the point source contributions are determined. It is not acceptable to use the DMRs to estimate the existing load and not the permitted loads to determine allocations. If the discharger is discharging below the permit limits at a certain level, then the allocation should also consider that. If the WLA is set to equal the actual effluent load, then permit should reflect that reduced loading when reissued. Otherwise the permittee could increase load to permit level and the TMDL would be invalid.
Response: The Department uses DMR loads to estimate existing loads in the watershed and permitted loads for WLA. The use of permitted loads, rather than actual DMR calculated loads, to estimate existing conditions in the reference and impaired watersheds would be inaccurate. The numbers in the Current/Existing conditions tables are to reflect the nutrient loads responsible for the current state of the water body; therefore, DMR loads must be used. The use of permitted loads in the WLA was addressed above.

Comment: EPA notes that the Conococheague watershed has been used as a reference for other impaired watersheds. In the Pequea Watershed TMDL, no adjustments were made to the GWLF model parameters for point source contributions. The TMDLs must be consistent in the modifications made and any adjustments should be clearly explained in detail.
Response: The response is the same as for 5). We used the same adjustments as SRBC for the Pequea Creek TMDL. In the Pequea Watershed TMDL, SRBC used point source loads from DMRs (23,000 lbs/year) after adjustment for losses occurring within the stream. The total permitted loads in this watershed were 33,727 lbs TP/yr. A paragraph will be added to include how losses were determined (see Page 19).

Section IV. The selection of the Reference Watershed
Comment: Please clarify that all of the Conococheague reference watershed is assessed and has been found to not be impaired. Please specifically discuss the status of the PS discharge receiving streams.

This section states that "most" of the stream segments in the Conococheague reference watershed have been assessed and found to be attaining. If there are sections that are not assessed, or sections that have been assessed and were found to be impaired, then those portions of the watershed cannot be used to determine loadings. For use as a reference condition, all streams must be assessed by the Department and found to be attaining standards.

Response: The sentence *"Most of the Conococheague stream segments have been assessed and were found to be impaired."* has been modified (see Page 10) to read: Stream segments in Conococheague watershed have been assessed and were found to be attaining standards.

Comment: The TMDL discusses the impaired Chickies Creek watershed and the reference Conococheague watershed as having similar attributes in terms of landuse type, geology, precipitation, and K factor. However, the Conococheague has a significantly higher point source phosphorus load contribution, 90% higher, than that of the Chickies Creek watershed. It would be helpful to include a discussion explaining that although there is a difference in PS contributions of phosphorus in the watersheds, the Conococheague is still suitable as a reference condition because it continues to meet standards in all segments.
Response: Regardless of the source, Conococheague has been determined to be attaining standards/uses based on the target loading rate which includes both point and nonpoint sources. With agricultural land uses being a close match for the Conococheague and Chickies Creek Watersheds (84% and 73% respectively), both would be influenced similarly by precipitation/runoff events with respect to nonpoint-generated pollutant loadings (See GWLF manual in the attachments section). Since Conococheague has been determined to be attaining its water-quality standards/designate use, its unit-area loading rate generated by the model provides an adequate reference target for computing the TMDLs for Chickies Creek.

Comment: Please add a list of the definitions, similar to that found in other reference condition based TMDLs, of parameters such as LS factor, p factor, c factor, sediment delivery ratio etc.
Response: The definitions were added (see Pages 16-17)

Comment: Please modify Tables 9 and 10 to clearly identify the current loads, current loading rates, the allowable loads and TMDL load allocations, as in done in similar TMDLs.

The column headers in these Tables of 'loading rate' and 'average load' should be more accurately identified as the current loading rate and the current load. Additionally, since the purpose of the TMDL is to reduce loads and loading rate to that of the reference Conococheague watershed, columns illustrating the allowable loading rate and the allowable load should also be added and clearly labeled in these Tables. This will help to illustrate the reductions and the sources of information for the values found in these Tables.
Response: Tables 9 and 10 were modified as suggested.

Commentors:
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Reference Watershed Approach

Comment: The Commentor is generally supportive of the "reference watershed approach" that the Department of Environmental Protection ("DEP") used to develop the proposed TMDLs.
Response: Thanks for the comment

Reference Watershed Selection and Comparison

Comment: The TMDL needs to more fully discuss whether the differences that exist between the target and reference watersheds (such as the differences in topographic relief, soil type, and pollution sources) are compensated for in the model used or by the TMDL that results from the watershed comparisons.
Response: The AVGWLF model does take into account differences in topographic relief, geology, and 20-year average runoff. Topography and stream density are used in derivation of Universal Soil Loss Equation (USLE) parameters assigned to model soil erosion. Geologic similarity is used as one of the criteria for choosing a reference watershed and model parameters such as the groundwater recession coefficient are adjusted based on the underlying geology in each watershed. Loading rates discussed in the TMDL are delivered loading rates, not edge-of-stream loading rates. AVGWLF models surface runoff using the SCS-CN approach with daily weather (temperature and precipitation) inputs.

Comment: The Commentor is concerned that the two watersheds are not well matched in the types of pollution sources. Specifically, Conococheague Creek (reference watershed) has one or more point sources that contribute 60% of the phosphorus pollution in the watershed (Table 5), whereas Chickies Creek has only a relatively minor point source contribution of phosphorus (3%; Table 4). Because point sources add pollutants on a daily basis throughout the year, and surface non-point sources add pollutants only during periods of precipitation and runoff, the pollution loads in a watershed with significant point sources (such as Conococheague Creek) would be distributed much more evenly through the year than the pollution loads in a watershed dominated by non-point sources (such as Chickies Creek). The differences in pollution sources could be expected to result in differences in water quality impacts. As a result, the Commentor suggests that a watershed with a similar point source contribution would be a more appropriate reference.
Response: The Department agrees that the two watersheds are dissimilar in terms of

sources of phosphorus pollution. As mentioned by the Commentor, 60% of the phosphorus in the Conococheague watershed is contributed by point sources, whereas the percent contributed by point sources in Chickies Creek is only 3%. Given this scenario, one might expect that the evenly distributed point source load in the former watershed could be problematic during low flow periods. Based on the stream assessment completed as part of the Unassessed Waters Program, however, this does not appear to be the case. The lack of impairments noted for the Conococheague during the assessment suggests that the "assimilative capacity" of the stream is sufficient to prevent recurring problems in this watershed. This concept of assimilative capacity is one of the underlying bases for the reference watershed approach used in DEP's TMDL assessment process. Specifically with reference to this TMDL, it is assumed that both watersheds have similar inherent assimilative capacities, and that if mean annual pollutant loads in Chickies Creek are reduced to levels presently found in the Conocoheague watershed, then similar levels of water quality and overall stream heath will be achieved.

Comment: The TMDL also fails to discuss whether the water quality standards, and the biological assessments made to determine compliance with those standards, differ between the target and reference watersheds.
Response: The water quality standard for both watersheds is the combination of designated uses and the criteria developed to protect those uses. Portions of the Chickies Creek watershed were placed on the 1996 303(d) list due to documented water quality criteria violations from instream water samplings and non-support of designated uses based on qualitative sampling of the benthic macroinvertebrate community. The 1998 303(d) list includes additional impairments that were documented with qualitative sampling of the benthic macroinvertebrate community. As mentioned in the report, the Conococheague Creek watershed has been assessed under the UW protocol and was determined to be supporting all its designated uses.

Comment: The TMDL needs to discuss the differences in these designations and why they do or do not affect the appropriateness of choosing Conococheague Creek as the reference watershed. For example, if Conococheague Creek is a significantly lower temperature than Chickies Creek, the nutrient loads in Conococheague Creek may not produce as many negative effects, such as algae blooms, as the same nutrients loads would in the warmer waters of Chickies Creek.
Response: The reference watershed used for developing these TMDLs includes waters with designated aquatic life uses that include Cold Water Fishes (CWF), Trout Stocking (TSF), and Warm Water Fishes (WWF). The most downstream of Conococheague reference watershed (i.e., the point at which annual loadings were calculated) is designated as WWF. All the impaired stream segments of Chickies Creek watershed are currently designated as WWF. The reference watershed used in the development of these nutrient TMDLs had the exact same aquatic life use designation (WWF) as the impaired stream segments in the Chickies Creek watershed. During any time of the year, instream temperature at the mouth of Chickies Creek (WWF) is protected at the same levels compared to the downstream portion of the Conococheague Creek (WWF).

Comment: The draft document fails to discuss whether the differences in agricultural practices and condition of riparian buffers and streambanks (p. 15) reasonably account

for Conococheague Creek meeting water quality standards while Chickies Creek does not.
Response: The 1996 and 1998 303(d) lists specifically identify agriculture as the source of use impairment in the Chickies Creek watershed. Nutrients and siltation are identified as the causes of impairments. The portion of the Conococheague Creek watershed used in this report has been assessed using the Department's Unassessed Waters Program protocol and was determined to be supporting its designated uses. These two watersheds are a fairly close match in terms of land cover/land use, physiographic province, geology, and size. The extent of agricultural land uses in each watershed is similar. The primary difference between the two watersheds at the time of the section 303(d) listing of Chickes Creek was the presence of agricultural Best Management Practices (BMPs) in the Conococheague Creek watershed. The differences in BMP implementation identified by the commentor appear to be the reason for nonsupport of designated uses in the Chickies Creek watershed at the time of the original listing survey.

<u>Failure to Establish Daily Loads</u>

Comment: The proposed TMDLs fail to establish total maximum daily loads. They establish only a yearly limit, whereas the Clean Water Act requires total maximum daily loads. DEP has not explained why setting a yearly limit, which presumably allows for daily, weekly, or monthly fluctuations in loads as long as the yearly totals are not exceeded, adequately protect water quality on a daily basis.
Response: The Clean Water Act requirement for total maximum daily loads allows for the expression of a TMDL in units of mass per time, toxicity, or other appropriate measures. DEP in consultation with EPA has determined that annual loadings are more appropriate for expression of nonpoint source TMDLs for nutrients and sediment.

Comment: Setting only annual loads is inadequate for performance monitoring and regulatory enforcement. For these purposes, daily loadings and streamflows should be calculated for one or several critical or frequently encountered seasonal weather conditions. Such daily loading and streamflow values could be easily extracted from mass and water balance calculations already performed internally by ArcView Version of the Generalized Watershed Loading Function (AVGWLF). They would be more readily useful measures for monitoring of loads and enforcement of the TMDL.
Response: See previous response

<u>Failure to Establish Nitrogen TMDLs</u>

Comment: The TMDLs fail to establish nitrogen limits without sufficient justification for not doing so. If the N:P ratio is calculated from total yearly loads including groundwater as a source, the ratios are above the 10:1 threshold on which DEP bases its limiting nutrient determination. If the N:P ratio is calculated from nutrient loads from surface sources alone, the ratios become significantly lower. Nitrogen may be the rate-limiting nutrient rather than phosphorus when surface runoff becomes the major source of stream flow and nutrient loadings. Because of the uncertainty over which nutrient is limiting at any given time during the year, the commentor strongly urges DEP to

establish nitrogen TMDLs in addition to the phosphorus TMDLs.
Response: Although ground water contributions of N will be highest relative to overland runoff contributions during the summer months (May through September), total nitrogen loads will normally be lowest in these months due to low flows and increased plant uptake. Phosphorus does enter the stream through overland flow (runoff); however, periods of high P exports correspond to periods of high soil loss. During the wet winter months, there is normally enough ground cover to dissipate the erosive energy of precipitation. Total P loads, on a unit area basis, are typically highest in the fall (after harvest when more bare soil is exposed) and in the spring (more intense rainfall events on fields being prepared for planting). However, TN loads are also higher in the fall and spring such that the N:P ratio remains greater than 10.

Failure to Account for Seasonal Variations

Comment: The TMDL fails to meet the Clean Water Act requirement for establishing a maximum daily load for impaired waters that reflects seasonal variations
Response: The continuous simulation model used for this analysis considers seasonal variations 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.

Calculation of TMDL

Comment: In calculating the TMDL, DEP is inadequately accounting for the differences between the reference watershed and Chickies Creek Watershed. Although the subject and reference watershed are similar in some ways, there may be differences besides watershed size, e.g., topographic relief, stream density (stream miles/mi^2), geology, annual water yield, animal densities, crops, and cropping practices, that influence the pollutant loads that can be accommodated by the streams.
Response: The TMDLs developed for the Chickies Creek watershed did account for differences in many of the factors listed. Topography and stream density are used in the derivation of the Universal Soil Loss Equation (USLE) parameters used to model soil erosion. Differences in these factors are reflected in the LS factor in the USLE for each watershed. Differences in animal density are accounted for in the model using a GIS coverage of animal populations by zip code as obtained from the U.S. Census of Agriculture. This data layer is used in determining the amount, and nutrient content, of manure applied to cropland in each watershed. Differences in crops and cropping practices are also accounted for both through GIS generation and manual manipulation of the C and P factors in the USLE. Using GIS coverages with typical county-based cropping and BMP implementation practices, C and P factors are generated for each watershed. These factors were further adjusted for Chickies Creek and reference watersheds based on specific information obtained during site visits and discussions with district conservationists working in these watersheds. The adjustments made to the GIS generated C and P values are documented in the Watershed Assessment and Modeling

section of this report. Geologic similarity is used as one of the criteria for choosing a reference watershed. Model parameters such as the groundwater recession coefficient are adjusted based on the underlying geology in the watershed. Therefore, differences in groundwater contributions due to dissimilar geology are accounted for in the analysis.
Comment: The calculation of point source loads for the maximum daily WLA needs to be done from the maximum permit limit, not average permit limit. It is not clear from the footnote to Section 6.3 whether the permit limit used as a basis for the WLA is an average or a maximum.
Response: The WLA for Chickies Creek watershed, although expressed as an annual load, was calculated from maximum permit limits.

Failure to Require Reduction in Point Source Loads

Comment: While the current phosphorus pollution attributable to point sources is a small percentage of the current total phosphorus loading, the permit limits make the point sources potentially much more significant in the future, especially at the significantly reduced total phosphorus load dictated by the TMDL.
Response: Point sources were not identified as a source of impairment on the 303(d) list and are currently contributing less than 3% of the total phosphorus loading to Chickies Creek watershed. If the reductions called for under the Chickies Creek TMDL cannot be met, additional considerations will be used to update the TMDL.

Allocation of TMDLs Among Non-Point Sources

Comment: DEP has made a reasonable allocation of the loads among non-point sources in the watershed. The Commentor commends DEP for making this allocation in the TMDLs, as the TMDLs established by other states often fail to do so.
Response: Thank you.

Implementation Plans

Comment: The Commentor does not believe the TMDLs provide reasonable assurance that the required reductions in phosphorus and sediment loadings will be met. In addition, the document does not specify if Best Management Practice (BMP) implementation is planned for the whole watershed or just for impaired areas, and the document fails to consider the expected BMP compliance rate for landowners.
Response: TMDLs developed under section 303(d) of the CWA are not intended to be a step-by-step description of how to restore an impaired watershed. Federal law requires establishment of a pollutant load that will ensure attainment of water quality standards and an allocation of that load among point and nonpoint sources. These TMDLs have established pollutant loads, along with allocations of those loads, which will ensure attainment of water quality standards. Implementation plans, including assurances of specified load reductions, are not currently required as part of the TMDL under section 303(d). Information on potential remediation activities, including BMPs, was provided as an indication that the identified load reductions were achievable. The information should prove helpful to those developing plans to meet the specified reductions. While the Department insures compliance with all applicable laws and regulations, the most

effective and achievable means of meeting the goals set forth in these TMDLs will come from the local level. The Department will also provide organizational, technical and financial assistance to watershed groups who undertake implementation. Please contact the Department if you want further information.

Comment: A significant problem with the implementation plan is the failure to reduce the waste load allocation to the point sources on the watershed. With the large reductions required in non-point source loads, and the uncertain effectiveness of BMPs, it seems prudent to first look at reductions possible at the point sources, which can be implemented and enforced via permits.
Response: Point sources were not identified as a source of impairment on the 303(d) list and are currently contributing less than 3% of the total phosphorus loading to Chickies Creek watershed. If the reductions called for under the Chickies Creek TMDL cannot be met, additional considerations will be used to update the TMDL.

Comment: The Commentor urges DEP to make appropriate use of the AVGWLF model in developing site-specific implementation plans.
Response: The model does not allow for the direct input of BMPs on the landscape to predict reduction values. GWLF is a lumped parameter model; therefore, assessment of nutrient/sediment reductions due to BMP implementation in impaired watersheds are best done external to the model. The Department will provide information and documentation on the AVGWLF model upon request.

Comment: The Commentor recommends that a monitoring program be part of any implementation plans to determine if the BMPs are having their intended effect on water quality or if other remedial measures are required.
Response: The Department agrees with this comment. The Department will continue to assess water quality and designated use attainment in the Chickies Creek watershed through its ongoing assessment and regulatory activities.

Margin of Safety

Comment: DEP fails to provide a rationale for selecting 10% as the margin of safety. The margin of safety should be based on the inherent uncertainty of the models used rather than the undefined "best professional judgment."
Response: The margin of safety used in these TMDLs does take into consideration the inherent uncertainty of the AVGWLF model. The "best professional judgment" referred to in the report includes information from those individuals who developed, calibrated, and currently maintain the AVGWLF model. Inclusion of the 10% margin of safety provides an additional level of protection to designated uses.

Commentor:
Mark Maurer
Assistant Director of Governmental Affairs
Pennsylvania Builders Association
600 N. Twelfth Street
Lemoyne, PA 17043

Comment: TMDL proposals should cite the specific use of water that is impaired, thereby requiring the TMDL's development. This is especially the case when the impairing pollutants have no numerical water quality criteria. In the case of Trindle Spring Run and Conowingo Creek, these streams are considered impaired by sediment and nutrients when, in a separate Department of Environmental Protection action, they are acknowledged as supporting Class A Wild Trout Fisheries. If the impairment is not sufficient to prevent the stream from supporting the top functional fishery classification, is the use of the stream as a Cold Water Fishery really impaired?

Response: It is possible for a stream to have a very good fish population and at the same time demonstrate impairments to other aquatic life, water supply, or recreational uses. Most of the entries on the PA 303(d) list are the result of biological surveys conducted as part of the Department's Unassessed Waters Program. A rapid biological screening protocol is used to evaluate numerous aspects of in-stream or riparian physical habitat and macroinvertebrate community structure, and make a determination of attainment or non-attainment of water quality standards.

The section of Trindle Spring Run that was added recently to the list of Class A wild trout streams is currently on the 303(d) list because of impairment from priority organics. This will result in a fish consumption advisory for that stream segment. The un-named tributary and upper section of the main stem of Trindle Spring Run as well as Conowingo Creek are currently on the 303(d) list for impairment related to sediment and nutrients based on physical habitat and benthic macroinvertebrate community impacts.

Comment: The PBA appreciates the efforts of the Department in translating narrative water quality criteria into a quantitative TMDL. Further, PBA conceptually approves of the modeling techniques used to develop the TMDL. PBA further recommends that the Department consider developing numeric water quality criteria for phosphorus and sediment.

Response: We are currently working with EPA to develop nutrient criteria.

Comment: PBA is very concerned about the use of reference watersheds to establish TMDLs. Under federal requirements, loading capacity represents the maximum concentration of a pollutant at which a stream can remain in attainment of water quality standards. A TMDL should equal loading capacity plus a quantitative margin of safety. In establishing the TMDL for the streams in question, DEP fails to establish their respective loading capacities. Additionally, the specific selection of reference streams seems to be significantly flawed. Warm Water Fisheries are referenced against Cold Water Fisheries (Mains and Gum Runs compared to Griers Hollow, et.al. as well as Pequea and Chickies Creeks compares to Conococheague Creek). Of even greater concern is the issue that numerous impaired streams are compared against High Quality (HQ) streams (Yellow Breeches Creek, Letort Spring Run). Since a HQ stream (Pennsylvania equivalent to federal Tier II) represents a condition where ambient water quality exceeds the water quality necessary to support existing uses, the use of HQ streams as referenced for non-HQ streams will result in a TMLD that is overly restrictive. Finally, the ad-hoc subdivision of a watershed for use as a reference is highly subjective, and to PBA's understanding, is not supported by any forma scientific review.

Response: In order to establish a loading capacity for an impaired stream segment where no numerical water quality criteria exist, Pennsylvania has developed a reference watershed approach. The allowable loading rate for an impaired stream is established by evaluating the loading rate of a non-impaired watershed selected based on matching the land use distribution, surface geology, and size of the impaired watershed. The modeling methods used for these analyses are sensitive to land use characteristics, geology, known nutrient soil concentrations, rainfall and drainage area. A good match for a reference watershed based on these characteristics over-rides concerns about matching use classifications of the streams in making our selections. The important common feature of the reference watersheds is that their biological communities are unimpaired. The reduction in loads projected in the TMDL should, therefore, restore the biological condition of the impaired water to an unimpaired level. However, the degree of recovery will be controlled, and in some cases limited, by numerous physical habitat issues. Impaired, non-HQ or EV waters, will not be expected to "recover" to antidegradation levels as the result of TMDL implementation.

As far as selecting portions of a watershed to use as a reference the following rule was applied; only upstream headwater stream segments could be cut out for the purpose of a reference (this means that no downstream impaired segment could be cut out, also that no portion of the reference watershed should drain into any section where an impairment is present). There could be exceptions to this practice, however, there must be very good justification in order to deviate from the rule.

Commentor:
U.S. Fish & Wildlife Service

Comment: Any remediation measures to address identified water quality problems may benefit certain threatened and endangered species in certain watersheds by improving water quality. However, in some instances, these measures have the potential to adversely affect federally listed species; therefore, further consultation will be necessary to identify and address these cases as described above.
Response: Detailed remediation and implementation plans are not required as part of the TMDL submittal and have not been completed at this time. All current regulations will be followed and threatened and endangered species will be protected in developing a remediation plan for the watershed.