# <u>Nutrient</u>
# Total Maximum Daily Load
# For

## <u>Wells Creek</u>

**Stream Code - 45675**

**Somerset County, PA (18-E)**


**Prepared by**

**Southwestern Regional Office**

**Pennsylvania Department of Environmental Protection**



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# I. TMDL Overview

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

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

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

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

# II. Executive Summary

This TMDL was developed for Wells Creek, Somerset County (18-E). A section of this stream was identified on the 1996 Section 303(d) list as being impaired by nutrients stemming from agriculture. In addition, the Wells Creek Sewage Treatment Plant was identified as being a significant contributor to the nutrient load in the watershed. Because phosphorus was determined to be the limiting nutrient in the watershed, its reduction was used as the end point for this TMDL.

Using AVGWLF® (Appendix A), a watershed that currently attains its water quality standards, and has several relevant similarities with the impaired watershed was found: Beaverdam Creek. This watershed is adjacent to Wells Creek, and has a similar amount of agricultural landuse. Using the GWLF® model, the existing loads of phosphorus from non-point sources were determined for both the impaired and reference watersheds. The phosphorus load from the Wells Creek Sewage Treatment Plant was determined based upon its maximum design flow, and a mandated 2-mg/l average monthly concentration of phosphorus. This concentration was set forth in accordance with Title 25 PA Code Chapter 96.5(c)

Based upon this data, the phosphorus loading rate of the reference watershed was used to determine the TMDL for the Wells Creek watershed. The TMDL was then reduced by a 10% margin of safety (MOS), the wasteload allocation (WLA) for the Wells Creek Sewage Treatment Plant, and non-point source loads that will not be reduced (LNRs) (Table i). The remaining load (ALA) was then allocated among non-point sources, and required reductions were determined. Reductions can be achieved by implementing Best Land Management Practices (BMP). Proper implementation of BMPs can cause substantial reductions of pollutants.

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

| Parameter | Phosphorus (tons/yr) |
|---|---|
| **WLA (Wasteload Allocation) for Wells Creek STP** | **4873.48** |
| **ALA (Adjusted Load Allocation)** | **1721.7** |
| **LNRs (Loads not reduced)** | **58.1** |
| **MOS (Margin of Safety)** | **739.26** |
| **TMDL (Total Max Daily Load)** | **7392.54** |

# III. Introduction

## A. Watershed Description

### 1. Location and General Description

Wells Creek (stream code – 45675) is located in mid-central Somerset County. Its watershed boundaries lie within Somerset, Stonycreek, and Quemahoning townships (USGS quadrangles – Berlin, Murdock, Somerset, and Stoystown) (Figure 1). From its headwaters, it flows northeasterly through sub-basin 18-E for about 10 miles before joining with the Stonycreek River (stream code – 45084). Its 17 $mi^2$ watershed encompasses about 31 miles of stream.

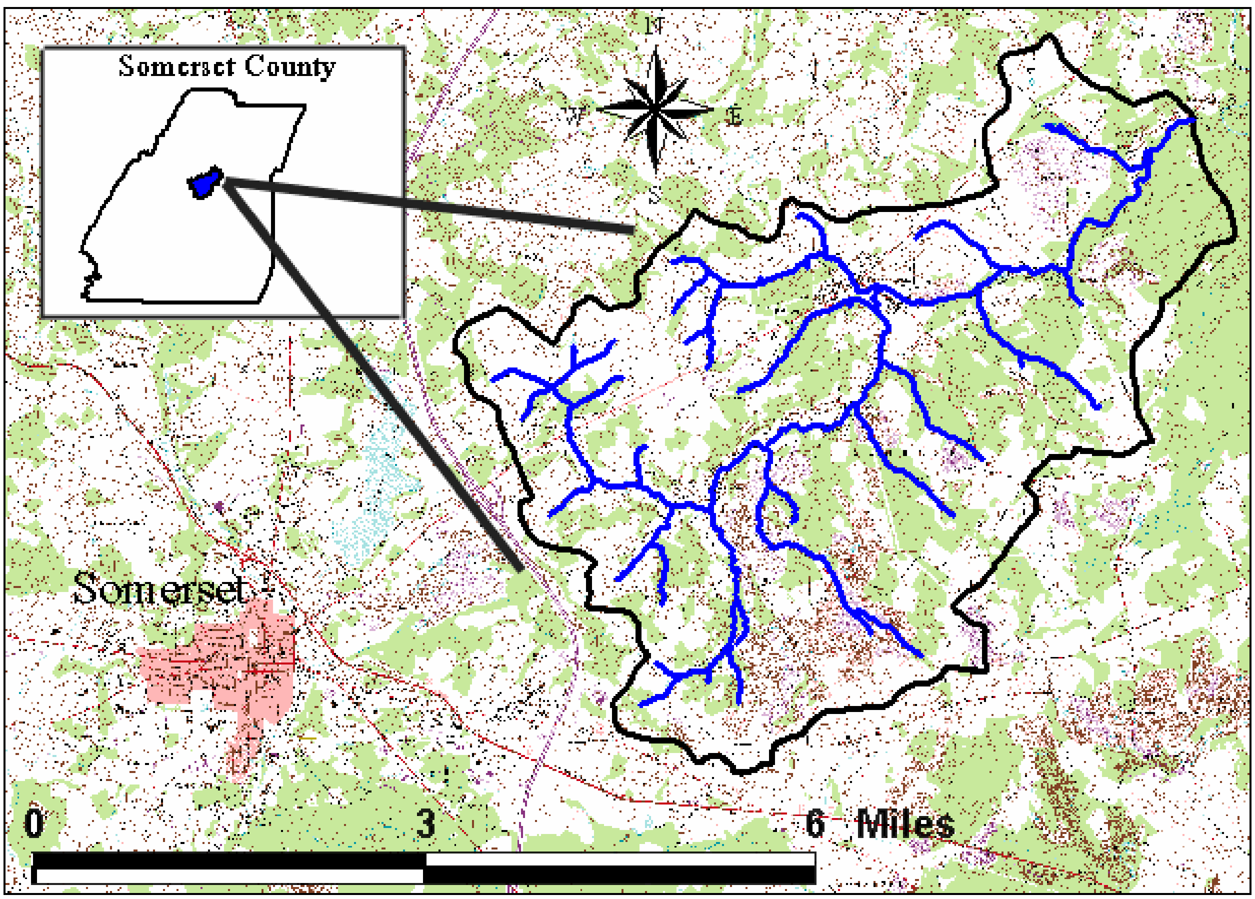


Figure 1. Wells Creek (Somerset County, PA).

## 2. Topography and Geology

The Wells Creek watershed lies within the Allegheny Mountain Section of the Appalachian Plateau Province. Elevation ranges from 600 to 761 m above sea level (Figure 2). Rocks within the watershed are entirely interbedded sedimentary, and the two underlying bedrock groups are the Allegheny Group and the Glenshaw Formation, with the latter being dominant. The strata of the Glenshaw Formation consist predominantly of sandstones and mudrocks with thin limestones and coals. The sole soil association is Gilpin-Wharton-Ernest, and the dominant hydrologic soil group is C; this soil group is characterized as having a slow infiltration rate when thoroughly wetted.

## 3. Land Use

The ArcView® Generalized Watershed Loading Function (AVGWLF®) model version 6.3.3 (described in Appendix A) was used to estimate the landuse for the Wells Creek watershed. Furthermore, a survey (December 2006) was conducted to verify its accuracy. Although the model indicated that the southwestern region of the watershed contained quarry, it was determined that most of this land is currently old mining areas that have reforested. The current landuse distribution of dominant categories is as follows: Agriculture – 53%, Forest – 41%, and Development – 6%.

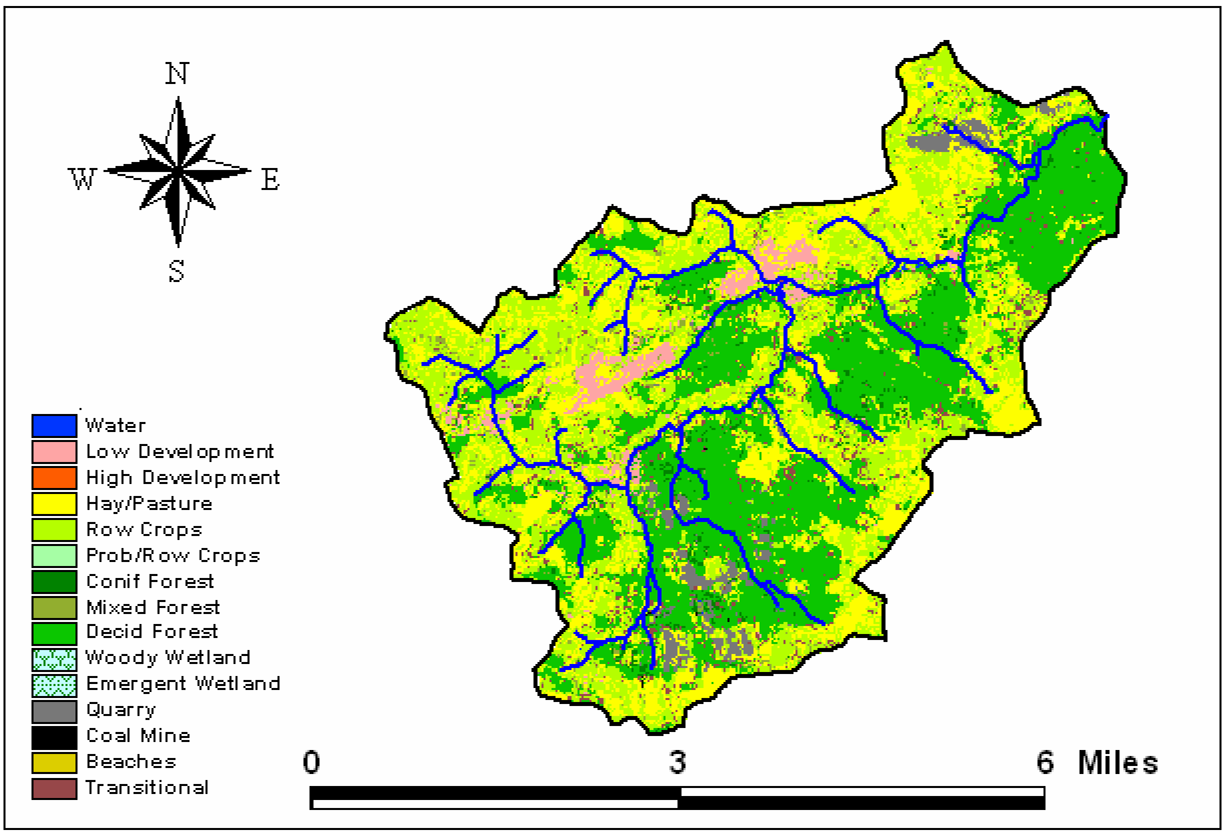


Figure 3. Current landuse distribution for the Wells Creek watershed, Somerset County. Transitional refers to land that is currently being developed.

## B. Nature of Impairment, Water Quality Standards, and Pollutants

A section of Wells Creek was found to be impaired (Figure 4), which means that its water quality is not suitable for its protected use: Cold Water Fishery. All cold-water fisheries within Pennsylvania are protected to support indigenous aquatic life, and if it is determined that aquatic life is degraded, the stream is deemed impaired. This section was determined to be impaired by nutrients, and subsequently was placed on Pennsylvania's 1996 303-d list (Table 1).

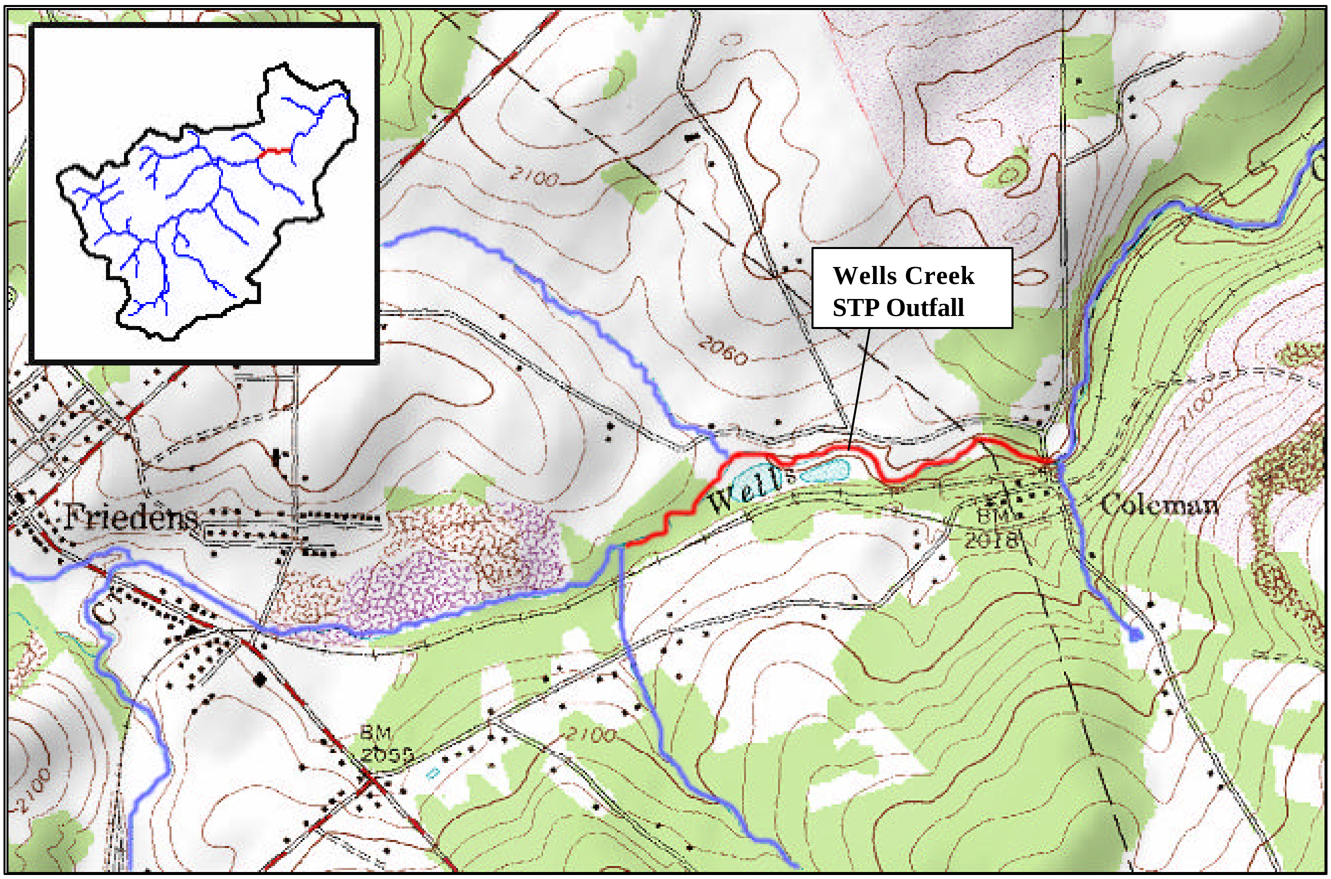


Figure 4. 1) Location of the section of Wells Creek impaired by nutrients (red), and 2) location of Wells Creek Sewage Treatment Plant's outfall (Somerset County).

Table 1. Data from PA's 1996 303(d) list showing impairments of Wells Creek (Somerset County).

| Stream Name | Stream Code | Source | Cause | Miles |
|---|---|---|---|---|
| Wells Creek | 45675 | Agriculture | Nutrients | 0.6 |

Pennsylvania's 1996 303(d) list indicates that the nutrient impairment stems from agricultural practices. Field visits conducted from August to December 2006 verified this. Runoff from fertilized cropland appears to be carrying high concentrations of nutrients into the stream. In addition, Wells Creek Sewage Treatment Plant (PA0041441) is currently discharging into this impaired section (Figure 4). Its permitted discharge currently has no limit for nutrients, specifically for phosphorus. As a result of these two sources, periphyton (attached algae) has covered much of the available substrate within the impaired reach. According to Title 25 PA Code Chapter 96.5(c), "When it is determined that the discharge of phosphorus, alone or in combination with the discharge of other pollutants, contributes or threatens to impair existing or designated uses in a free flowing surface water, phosphorus discharges from point source discharges shall be limited to an average monthly concentration of 2 mg/l. More stringent controls on point source discharges may be imposed, or may be otherwise adjusted as a result of a TMDL which has been developed". No other point sources of pollution, including MS4s (municipal separate storm sewer systems) and CSOs (Combined Sewer Overflows) currently exist within the watershed.

## C. Pollutant Background, Linkage Analysis, and Endpoints

Nutrients are essential components of any aquatic ecosystem. The two most recognized nutrients are nitrogen (N) and phosphorus (P), which fuel photosynthetic growth of aquatic vegetation such as aquatic plants and algae. The existence of aquatic vegetation is crucial, as it provides food and habitat for animals such as aquatic insects, fish, frogs, and waterfowl. More importantly, it provides (via photosynthesis) the key substance that most aquatic organisms must have to survive: dissolved oxygen.

Among other elements, N and P play a direct role in governing growth of aquatic plants; a shortage of either can impede growth, and an excess can accelerate growth to undesirable proportions (Stickney 1994). Because of their ability to proliferate and out-compete aquatic plants, infestations of algae are typically more problematic and receive more attention than do aquatic plants. In most circumstances, however, algae are not problematic, but when nutrients become over-abundant, problems result.

Nitrogen and phosphorus also fuel growth of farm crops and lawn grasses, and therefore are often used to increase crop production and produce fertile lawns. Unfortunately, it is difficult to retain these nutrients, and they often are washed into nearby water bodies during rainy events. Moreover, agricultural land is typically comprised of short grasses or no grasses at all; therefore, little buffer exists to impede the flow of water across the land. Resultantly, dissolved nutrients or nutrients bound to soil are washed into streams uninterruptedly. Algae in the receiving waters exploit these nutrients, and their populations often explode sometimes engulfing all available substrate.

Although they produce oxygen during the day via photosynthesis, algae uptake oxygen from the water during the night; this process is termed *respiration*. If the algal population becomes dense, dissolved oxygen levels can fall below the requirements of fish and other aquatic inhabitants during the night. Organisms that can directly withstand low levels of oxygen may survive temporarily; however face a constant diurnal fluctuation of dissolved oxygen that may prove to be lethal. In addition to directly causing dissolved oxygen shortages, dense aquatic plant establishments can also render habitat unsuitable for indigenous organisms by slowing the movement of water, which consequently increases thermal loading and decreases dissolved oxygen renewal.

Although many short-term methods exist for controlling algae, the only true solution is to limit their food supply: nutrients. A reduction in both N and P can impede algal growth; however, a more practical approach is to reduce the nutrient that most limits growth. Phosphorus is often the most growth-limiting element in freshwater ecosystems due to its limited supply (Horne and Goldman 1994). Unlike nitrogen, phosphorus has no gaseous phase, and therefore rainwater carries little or no phosphorus. Furthermore, the little P that is weathered from rocks is quickly absorbed by the root zone on land, or is adsorbed onto particles making it unavailable for uptake by aquatic plant. Although in some circumstances P may not be the limiting nutrient, our analysis shows that it is for this watershed. A common N:P ratio is 10:1, and an increase in this ratio indicates a limitation of P (Horne and Goldman 1994). The ratio for this watershed was determined to be 24:1, which indicates a limitation of P. When phosphorus is limited, a direct and linear relationship exists between the concentrations of P and algae (Horne and Goldman 19964). Therefore, our endpoint was the reduction in P required to render the watershed unimpaired.

# IV. TMDL Development Methods

## A. Reference Watershed Approach: Setting the Standard

The first step of this approach was to find a non-impaired watershed (reference watershed) that was similar to the impaired watershed in terms of factors such as land-use, soil associations, drainage area, precipitation, physiographic province, and geology. Once found, its phosphorus loading rate was determined, and the general objective then became to reduce the phosphorus load of the impaired watershed to or slightly below that of the reference watershed.

## B. Watershed Assessment Approach and Modeling

### 1. Reference Watershed Loading Rate

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

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

## 2. Total Maximum Daily Load

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

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

## 3. Margin of Safety and Total Allowable Load

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

*MOS (Margin of Safety) = 0.10 x TMDL*

*TAL (Total Allowable Load) = TMDL - MOS*

## 4. Wasteload Allocation and Load Allocation.

Ultimately the total allowable load was divided between point and non-point sources. The "wasteload allocation" (WLA) is the load that point sources will be allowed to emit, and the "load allocation" (LA) is the load that non-point sources should be limited to. To determine the WLA, the total load from all point sources was determined; this value was obtained using the permitted design flows and monthly average maximum effluent limits, or in this case, 2 mg/l phosphorus [see section III(B)]. This value was then subtracted from the total allowable load; the resulting value constituted the load allocation. With this, the TMDL is equivalent to the sum of the LA, WLA, and MOS.

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

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

## 5. Loads Not Reduced and Adjusted Load Allocation

"Loads not reduced" (LNRs) included all loads from non-point sources that were not subjected to a reduction. The loads of some pollution sources are uncontrollable, for example, a load coming from a forest. We also may not reduce a load because its contribution to the total load may be minute, and therefore implementing land management practices to this source to achieve a load reduction would not be practical, or meaningful. Because these loads were not reduced, they were subtracted from the load allocation (LA). The resulting adjusted load allocation (ALA) is the load that was allocated among the non-point pollutant sources that will receive reductions.

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

With this, the following equation holds true:

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

## 6. Adjusted Load Allocation Distribution and Required Reductions

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

# C. Quality Assurance

## 1. Consideration of Critical Conditions

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

### 2. Consideration of Seasonal Variations

The continuous simulation model used for this analysis considered seasonal variation through a number of mechanisms. Daily time steps were 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 considered the months of the year when manure is applied to the land. The combination of these actions by the model accounted for seasonal variability.

## V. TMDL Results

### A. Reference Watershed Selection

Using GIS imagery through ArcView®, a closely matched reference watershed was found: Beaverdam Creek (stream code – 45634), Somerset County (Figure 5). Pennsylvania's 303(d) list indicates that this stream is not impaired. Its watershed is adjacent to the Wells Creek watershed, and lies within Jenner, Lincoln, Quemahoning, and Somerset townships (USGS quadrangles – Somerset, and Stoystown). Its watershed is part of State Water Plan 18-E, and has a total drainage area of 18.6 $mi^2$. Beaverdam Creek consists of about 38 miles of stream, and drains into the Stonycreek River (stream code – 45084).

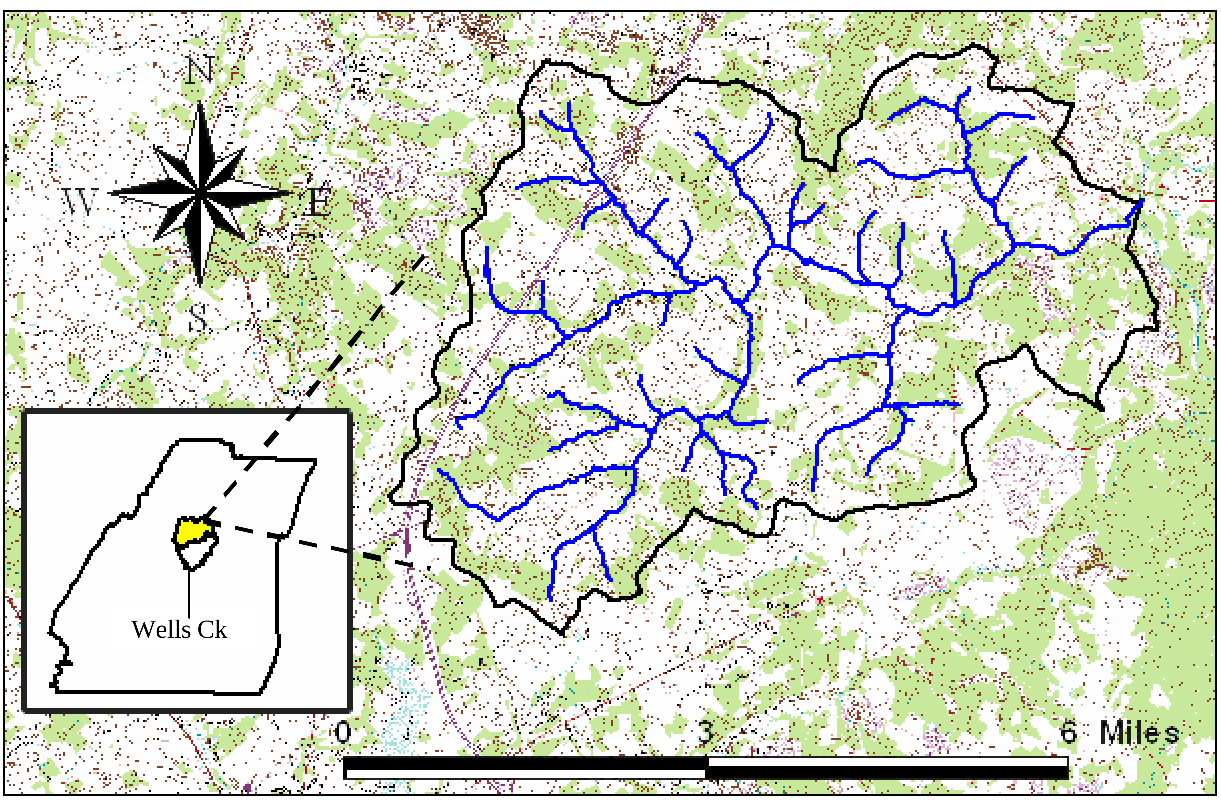


Figure 5. Location of reference watershed: Beaverdam Creek (Somerset County).

Both GIS imagery through ArcView®, and a physical survey (September 2006) indicate that the Beaverdam Creek watershed is similar to that of the Wells Creek watershed. Table 2 illustrates the similarities between the watersheds. Because the impaired watershed was determined to be impaired by nutrients from agricultural activities, it was important to find a reference watershed with a similar amount of agricultural landuse.

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

| **ATTRIBUTE** | **WATERSHED** | |
|---|---|---|
| | ***Wells Creek*** **State Water Plan – 17-E Stream Code - 42342** | ***Beaverdam Creek*** **State Water Plan -17-E Stream Code - 46216** |
| Physiographic Province | Appalachian Plateau Province (Allegheny Mountain Section) | Appalachian Plateau Province (Allegheny Mountain Section ) |
| Drainage Area ($mi^2$) | 17.1 | 18.6 |
| Land-use Distribution | Agriculture – 53%<br>Forested – 41%<br>Development – 6% | Agriculture – 68%<br>Forested – 25%<br>Development – 6% |
| Geology | Interbedded Sedimentary (100%) | Interbedded Sedimentary (100%) |
| Soils | Gilpin-Wharton-Ernest (100%) | Gilpin-Wharton-Ernest (100%) |
| Dominant Hydro Soil Group | C | C |
| 23-Year Average Rainfall (in) | 43.31 | 43.31 |
| 23-Year Average Runoff (in) | 3.37 | 3.41 |

# B. Pollutant Loads and Reference Watershed Loading Rates

## 1. Pollutant Loads

### a. Non-Point Source Pollutant Loads

Table 3. Non-point phosphorus loads of sources within the watersheds of Wells Creek, and Beaverdam Creek (Somerset County).

| | **Wells Creek** | | **Beaverdam Creek (Reference)** | |
|---|---|---|---|---|
| Pollutant Source | Area (Acres) | Total P (Pounds/yr) | Area (Acres) | Total P (Pounds/yr) |
| | | | | |
| Hay/Pasture | 2480.9 | 286.9 | 3479.2 | 476.5 |
| Cropland | 3254.4 | 2279.6 | 4433.1 | 4789.4 |
| Forest | 4438.0 | 33.0 | 2928.2 | 25.3 |
| Coal Mine | 7.4 | 1.5 | - | - |
| Unpaved Rd | 24.7 | 55.6 | 37.1 | 148.0 |
| Transitional | 46.9 | 154.7 | 395.4 | 1293.7 |
| Quarry | 4.9 | 2.0 | 2.5 | 0.5 |
| Low_Dev | 630.1 | 4.7 | 630.1 | 4.7 |
| Streambank | - | 27.8 | - | 32.7 |
| Groundwater | - | 898.4 | - | 1057.0 |
| Septic Sys | - | 16.9 | - | 45.1 |
| TOTAL | 10887.4 | 3761.2 | 11594.2 | 7874.2 |

### b. Point Source Pollutant Load

Wells Creek Sewage Treatment Plant – Permit# - PA0041441

Maximum Design Flow – 0.8 million gallons/day
Average Daily Phosphorus Concentration – Shall be set at 2 mg/l [see section III(B)]

*0.8 million gallons/day * 8.345 lbs/million gallons * 2 mg/l * 365 days*

*= 4873.48 lbs phosphorus/yr*

## 2. Reference Watershed Loading Rate

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

1. (Phosphorus) = 7874.2 lbs / 1 yr / 11594.2 Acres = 0.679 lbs/yr/acre

## C. Total Maximum Daily Load

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

1. (Phosphorus) = 0.679 lbs/yr/acre x 10887.4 Acres = 7392.54 lbs/yr

## D. Margin of Safety

*MOS (Margin of Safety) = 0.10 x TMDL*

1. (Phosphorus) = 0.10 x 7392.545 lbs/yr/acre = 739.255 lbs/yr

## E. Wasteload Allocation and Load Allocation

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

1. WLA = 4873.48 lbs/phosphorus (P)/yr; [SEE SECTION V [B (1b)]] for calculation.
2. LA (P) = 7392.54 lbs/yr - 4873.48 lbs/yr - 739.255 lbs/yr/acre = 1779.80 lbs/yr

## F. Loads Not Reduced and Adjusted Load Allocation

Table 4. Loads of pollutant sources that will not be reduced (LNRs). These loads were determined to have an insignificant impact relative to other loads, or, they cannot feasibly be controlled.

| Loads Not Reduced (LNRs) | Phosphorus (lbs/yr) |
|---|---|
| | |
| Forest | 33.0 |
| Coal Mine | 1.5 |
| Quarry | 2.0 |
| Low Density Development | 4.7 |
| Septic System | 16.9 |
| TOTAL | 58.1 |

*ALA (adjusted load allocation) = LA – LNRs*

1. (Phosphorus) = 1779.8 lbs/yr – 58.1 tons/yr = <u>1721.7 lbs/yr</u>

## G. Adjusted Load Allocation Distribution and Required Reductions

Table 5. Allowable and existing **phosphorus** loads, as well as required reductions for individual non-point pollutant sources.

| Pollutant Source | Current Loading Rate (lbs/yr/acre) | Allowable Loading Rate (lbs/yr/acre) | Current Load (lbs/yr) | Allowable Load (lbs/yr) | Percent Load Reduction |
|---|---|---|---|---|---|
| Hay/Pasture | 0.12 | 0.06 | 287 | 157 | **45%** |
| Cropland | 0.71 | 0.29 | 2280 | 943 | **59%** |
| Unpaved Roads | 2.25 | 1.23 | 56 | 30 | **45%** |
| Transitional | 3.30 | 1.81 | 155 | 85 | **45%** |
| Groundwater | 0.08 | 0.05 | 898 | 492 | **45%** |
| Streambank | 0.00 | 0.00 | 28 | 15 | **45%** |
| TOTAL | - | - | 3703 | 1722 | - |

### H. Summary Table

Table 6. Summary of major calculations.

| Parameter | Phosphorus (tons/yr) |
|---|---|
| **WLA (Wasteload Allocation)** | **4873.48** |
| **ALA (Adjusted Load Allocation)** | **1721.7** |
| **LNRs (Loads not reduced)** | **58.1** |
| **MOS (Margin of Safety)** | **739.26** |
| **TMDL (Total Max Daily Load)** | **7392.54** |

## VI. Reasonable Assurance and Recommendations

Required reductions of phosphorus loads from non-point pollutant sources in the watershed of Wells Creek are shown in table 5. If these reductions were attained, and the Wells Creek Sewage Treatment Plant's discharge was limited to an average monthly concentration of 2 mg/l phosphorus, the loading levels of Wells Creek would become similar to that of the watershed of Beaverdam Creek, which is currently meeting its water quality standards. Non-point source reductions shall be achieved mainly by implementing BMPs (Best Management Practices). BMPs are techniques that can be employed by land owners to either reduce the production of a pollutant, or prevent a pollutant from entering a water body. Each BMP is equipped to handle a unique type of pollutant; although, implementation of a single BMP can sometimes address multiple pollutant problems. Nevertheless, each has its own reduction efficiency, and the optimal BMP is a consideration of its efficiency as well as feasibility of employing it.

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

# VII. Public Participation

TO BE COMPLETED.

# VIII. References

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# IX. Appendices

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

The TMDL for the watershed of Wells Creek was developed using the Generalized Watershed Loading Function or GWLF model. The GWLF model provides the ability to simulate runoff and phosphorus loadings from watershed given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. It is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for nutrient loads, based on the daily water balance accumulated to monthly values.

GWLF is a combined distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios. Each area is assumed to be homogenous in regard to various attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but aggregates the loads from each area into a watershed total. In other words, there is no spatial routing. For sub-surface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for sub-surface flow contributions. Daily water balances are computed for an unsaturated zone as well as a saturated sub-surface zone, where infiltration is computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

GWLF models surface runoff using the Soil Conservation Service Curve Number (SCS-CN) approach with daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the Universal Soil Loss Equation (USLE) algorithm (with monthly rainfall-runoff coefficients) and a monthly composite of KLSCP values for each source area (e.g., land cover/soil type combination). The KLSCP factors are variables used in the calculations to depict changes in soil loss erosion (K), the length slope factor (LS) the vegetation cover factor (C) and conservation practices factor (P). A sediment delivery ratio based on watershed size and transport capacities based on average daily runoff are applied to the calculated erosion to determine sediment yield for each source area. Surface nutrient losses are determined by applying dissolved N and P coefficients to surface runoff and a sediment coefficient to the yield portion for each agricultural source area. Point source discharges can also contribute to dissolved losses to the stream and are specified in terms of kilograms per month. Manured areas, as well as septic systems, can also be considered. Urban nutrient inputs are all assumed to be solid-phase, and the model uses an exponential accumulation and washoff function for these loadings. Sub-surface losses are calculated using dissolved N and P coefficients for shallow groundwater contributions to stream nutrient loads, and the sub-surface sub-model only considers a single, lumped-parameter contributing area. Evapotranspiration is determined using daily weather data and a cover factor dependent upon land use/cover type. Finally, a water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and evapotranspiration values.

All of the equations used by the model can be viewed in GWLF Users Manuel, available from the Department's Bureau of Watershed Conservation, Division of Assessment and Standards.

For execution, the model requires three separate input files containing transport-, nutrient-, and weather-related data. The transport (TRANSPRT.DAT) file defines the necessary parameters for each source area to be considered (e.g., area size, curve number, etc.) as well as global parameters (e.g., initial storage, sediment delivery ratio, etc.) that apply to all source areas. The nutrient (NUTRIENT.DAT) file specifies the various loading parameters for the different source areas identified (e.g., number of septic systems, urban source area accumulation rates, manure concentrations, etc.). The weather (WEATHER.DAT) file contains daily average temperature and total precipitation values for each year simulated.

The primary sources of data for this analysis were geographic information system (GIS) formatted databases. A specially designed interface was prepared by the Environmental Resources Research Institute of the Pennsylvania State University in ArcView (GIS software) to generate the data needed to run the GWLF model, which was developed by Cornell University. The new version of this model has been named AVGWLF (ArcView Version of the Generalized Watershed Loading Function).

In using this interface, the user is prompted to identify required GIS files and to provide other information related to "non-spatial" model parameters (e.g., beginning and end of the growing season, the months during which manure is spread on agricultural land and the names of nearby weather stations). This information is subsequently used to automatically derive values for required model input parameters, which are then written to the TRANSPRT.DAT, NUTRIENT.DAT and WEATHER.DAT input files needed to execute the GWLF model. For use in Pennsylvania, AVGWLF has been linked with statewide GIS data layers such as land use/cover, soils, topography, and physiography; and includes location-specific default information such as background N and P concentrations and cropping practices. Complete GWLF-formatted weather files are also included for eighty weather stations around the state. The following table lists the statewide GIS data sets and provides an explanation of how they were used for development of the input files for the GWLF model.

| GIS Data Sets | |
|---|---|
| **DATASET** | **DESCRIPTION** |
| **Censustr** | Coverage of Census data including information on individual homes septic systems. The attribute *usew_sept* includes data on conventional systems, and *sew_other* provides data on short-circuiting and other systems. |
| **County** | The County boundaries coverage lists data on conservation practices, which provides C and P values in the Universal Soil Loss Equation (USLE). |
| **Gwnback** | A grid of background concentrations of N in groundwater derived from water well sampling. |
| **Land-use5** | Grid of the MRLC that has been reclassified into five categories. This is used primarily as a background. |
| **Majored** | Coverage of major roads. Used for reconnaissance of a watershed. |
| **MCD** | Minor civil divisions (boroughs, townships and cities). |
| **Npdespts** | A coverage of permitted point discharges. Provides background information and cross check for the point source coverage. |
| **Padem** | 100-meter digital elevation model. This used to calculate landslope and slope length. |
| **Palumrlc** | A satellite image derived land cover grid that is classified into 15 different landcover categories. This dataset provides landcover loading rate for the different categories in the model. |
| **Pasingle** | The 1:24,000 scale single line stream coverage of Pennsylvania. Provides a complete network of streams with coded stream segments. |
| **Physprov** | A shapefile of physiographic provinces. Attributes *rain_cool* and *rain_warm* are used to set recession coefficient |
| **Pointsrc** | Major point source discharges with permitted N and P loads. |
| **Refwater** | Shapefile of reference watersheds for which nutrient and sediment loads have been calculated. |
| **Soilphos** | A grid of soil Phosphorus loads, which has been generated from soil sample data. Used to help set phosphorus and sediment values. |
| **Smallsheds** | A coverage of watersheds derived at 1:24,000 scale. This coverage is used with the stream network to delineate the desired level watershed. |
| **Statsgo** | A shapefile of generalized soil boundaries. The attribute *mu_k* sets the k factor in the USLE. The attribute *mu_awc* is the unsaturated available capacity., and the *muhsg_dom* is used with land-use cover to derive curve numbers. |
| **Strm305** | A coverage of stream water quality as reported in the Pennsylvania's 305(b) report. Current status of assessed streams. |
| **Surfgeol** | A shapefile of the surface geology used to compare watersheds of similar qualities. |
| **T9sheds** | Data derived from a DEP study conducted at PSU with N and P loads. |
| **Zipcode** | A coverage of animal densities. Attribute *aeu_acre* helps estimate N & P concentrations in runoff in agricultural lands and over manured areas. |
| **Weather Files** | Historical weather files for stations around Pennsylvania to simulate flow. |

# Appendix B. Equal Marginal Percent Reduction Method

The Equal Marginal Percent Reduction (EMPR) allocation method was used to distribute Adjusted Load Allocations (ALAs) between the appropriate contributing non-point sources. The load allocation and EMPR procedures were performed using MS Excel and results are presented in Appendix E. The 5 major steps identified in the spreadsheet are summarized below:

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

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

**Step 3**: Actual EMPR Process.

a. Each land use/source load is compared with the total ALA to determine if any contributor would exceed the ALA by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load of the receiving water-body. If the contributor exceeds the ALA, that contributor would be reduced to the ALA. If a contributor is less than the ALA, it is set at the existing load. This is the baseline portion of EMPR.

b. After any necessary reductions have been made in the baseline, the multiple analyses are run. The multiple analyses will sum all of the baseline loads and compare them to the ALA. If the ALA is exceeded, an equal percent reduction will be made to all contributors' baseline values. After any necessary reductions in the multiple analyses, the final reduction percentage for each contributor can be computed.

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

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

# Appendix C. GWLF Output for Wells Creek.

GWLF Total Loads for Wells_Creek_2

Period of analysis: 17 years, from Apr 1975 to Mar 1992

| Source | Area (Acres) | Runoff (in) | Tons: Erosion | Tons: Sediment | Total Loads (Pounds): Dis N | Total N | Dis P | Total P |
|---|---|---|---|---|---|---|---|---|
| HAY/PAST | 2480.9 | 2.5 | 1174.4 | 171.5 | 4031.5 | 5060.3 | 185.4 | 286.9 |
| CROPLAND | 3254.4 | 4.6 | 21072.9 | 3076.6 | 9582.3 | 28042.1 | 458.3 | 2279.6 |
| FOREST | 4438.0 | 2.1 | 233.8 | 34.1 | 405.9 | 610.6 | 12.8 | 33.0 |
| QUARRY | 4.9 | 8.6 | 23.0 | 3.4 | 0.1 | 20.3 | 0.0 | 2.0 |
| COAL_MINES | 7.4 | 7.1 | 16.5 | 2.4 | 0.2 | 14.6 | 0.0 | 1.5 |
| UNPAVED_RD | 24.7 | 7.1 | 551.1 | 80.5 | 115.9 | 598.7 | 8.0 | 55.6 |
| TRANSITION | 46.9 | 7.1 | 1613.9 | 235.6 | 220.3 | 1634.0 | 15.2 | 154.7 |
| LO_INT_DEV | 630.1 | 5.0 | 121.6 | 11.9 | 0.0 | 35.5 | 0.0 | 4.7 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Tile Drainage** | | | | 0.0 | | 0.0 | | 0.0 |
| **Stream Bank** | | | | 633.0 | | 63.3 | | 27.8 |
| **Groundwater** | | | | | 55414.5 | 55414.5 | 898.4 | 898.4 |
| **Point Sources** | | | | | 0.0 | 0.0 | 0.0 | 0.0 |
| **Septic Systems** | | | | | 60.4 | 60.4 | 16.9 | 16.9 |
| **Totals** | 10887.4 | 3.20 | 24807.1 | 4249.0 | 69830.9 | 91554.2 | 1595.0 | 3761.2 |

# Appendix D. GWLF Output for Beaverdam Creek

GWLF Total Loads for Beaverdam_Creek_2

Period of analysis: 17 years, from Apr 1975 to Mar 1992

| | | | Tons | | Total Loads (Pounds) | | | |
|---|---|---|---|---|---|---|---|---|
| **Source** | **Area (Acres)** | **Runoff (in)** | **Erosion** | **Sediment** | **Dis N** | **Total N** | **Dis P** | **Total P** |
| HAY/PAST | 3479.2 | 2.5 | 2727.4 | 387.3 | 5653.7 | 7977.4 | 258.9 | 476.5 |
| CROPLAND | 4433.1 | 4.6 | 52225.0 | 7416.0 | 13052.8 | 57548.6 | 621.6 | 4789.4 |
| FOREST | 2928.2 | 2.1 | 211.1 | 30.0 | 267.8 | 447.6 | 8.5 | 25.3 |
| QUARRY | 2.5 | 8.6 | 5.8 | 0.8 | 0.1 | 5.0 | 0.0 | 0.5 |
| UNPAVED_RD | 37.1 | 7.1 | 1703.8 | 241.9 | 173.9 | 1625.5 | 12.0 | 148.0 |
| TRANSITION | 395.4 | 7.1 | 14608.2 | 2074.4 | 1854.8 | 14301.0 | 127.9 | 1293.7 |
| LO_INT_DEV | 318.8 | 5.0 | 310.8 | 29.7 | 0.0 | 44.7 | 0.0 | 6.0 |
| **Tile Drainage** | | | | 0.0 | | 0.0 | | 0.0 |
| **Stream Bank** | | | | 744.2 | | 74.4 | | 32.7 |
| **Groundwater** | | | | | 80167.2 | 80167.2 | 1057.0 | 1057.0 |
| **Point Sources** | | | | | 0.0 | 0.0 | 0.0 | 0.0 |
| **Septic Systems** | | | | | 114.4 | 114.4 | 45.1 | 45.1 |
| **Totals** | 11594.2 | 3.50 | 71792.1 | 10924.2 | 101284.7 | 162305.9 | 2131.0 | 7874.2 |

# Appendix E. Equal Marginal Percent Reduction Calculations for Wells Creek.

## Phosphorus

Step 1: TMDL Total Load
Load = T loading rate in ref. * Acres in Impaired

| |
|---|
| 7393 |

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

| | |
|---|---|
| 1722 | 1722 |

Step 3:

| Source | Annual Average Load | Load Sum | Check | Initial Adjust | Recheck | % reduction allocation | Load Reduction | Initial LA | Acres |
|---|---|---|---|---|---|---|---|---|---|
| Hay/Past. | 286.9 | 2566.5 | good | 287 | ADJUST | 0.09 | 130 | 157 | 2481 |
| Cropland | 2280 | | bad | 1722 | 1423 | 0.55 | 779 | 943 | 3225 |
| Unpaved Roads | 56 | | good | 56 | 0 | 0.02 | 25 | 30 | 25 |
| Transition | 155 | | good | 155 | 0 | 0.05 | 70 | 85 | 47 |
| Groundwater | 898 | | good | 898 | 0 | 0.29 | 406 | 492 | 10887 |
| Streambank | 28 | | good | 28 | 0 | 0.01 | 13 | 15 | 10887 |
| | | | | 3145 | | 1 | | 1722 | |

Step 4:

| All Ag. Loading Rate | 0.19 |
|---|---|

Step 5:

| | Acres | Allowable (Target) Loading Rate | Final LA | Current Loading Rates | Current Load | % Red. |
|---|---|---|---|---|---|---|
| Final Hay/Past. LA | 2481 | 0.06 | 157 | 0.12 | 287 | 45% |
| Final Cropland LA | 3225 | 0.29 | 943 | 0.71 | 2280 | 59% |
| Unpaved Roads | 25 | 1.23 | 30 | 2.25 | 56 | 45% |
| Transition | 47 | 1.81 | 85 | 3.30 | 155 | 45% |
| Groundwater | 10887 | 0.05 | 492 | 0.08 | 898 | 45% |
| Streambank | 10887 | 0.00 | 15 | 0.00 | 28 | 45% |
| | | | 1722 | | 3703 | |

# Appendix F. TMDL Information Sheet for Wells Creek.

***What is being proposed?***
Total Maximum Daily Load (TMDL) plans have been developed to improve water quality in the watershed of Wells Creek, Somerset County (stream code – 45675).

***Who is proposing the plans? Why?***
The Pennsylvania Department of Environmental Protection (PADEP) is proposing to submit the plans to the U.S. Environmental Protection Agency (U.S. EPA) for review and approval as required by federal regulation. In 1995, U.S. EPA was sued for not developing TMDLs when Pennsylvania failed to do so. PADEP has entered into an agreement with U.S. EPA to develop TMDLs for certain specified waters over the next several years. These TMDLs have been developed in compliance with the state/U.S. EPA agreement.

***What is a TMDL?***
A TMDL sets a ceiling on the pollutant loads that can enter a waterbody so that it will meet water quality standards. The Clean Water Act requires states to list all waters that do not meet their water quality standards even after pollution controls required by law are in place. For these waters, the state must calculate how much of a substance can be put in the water without violating the standard, and then distribute that quantity to all sources of the pollutant on that water body. A TMDL plan includes waste load allocations for point sources, load allocations for non-point sources, and a margin of safety. The Clean Water Act requires states to submit their TMDLs to U.S. EPA for approval. Also, if a state does not develop the TMDL, the Clean Water Act states that U.S. EPA must do so.

***What is a water quality standard?***
The Clean Water Act sets a national minimum goal that all waters are to be "fishable" and "swimmable." To support this goal, states must adopt water quality standards. Water quality standards are state regulations that have two components. The first component is a designated use, such as "warm water fishes" or "recreation." States must assign a "use" or several uses to each of their waters. The second component relates to the in-stream conditions necessary to protect the designated use(s). These conditions or "criteria" are physical, chemical, or biological characteristics such as temperature and minimum levels of dissolved oxygen, and maximum concentrations of toxic pollutants. It is the combination of the "designated use" and the "criteria" to support that use that make up a water quality standard. If any criteria are being exceeded, then the use is not being met and the water is said to be in violation of water quality standards.

***What is the purpose of the plans?***
Wells Creek is impaired by excess nutrients. This TMDL plan includes a calculation of the phosphorus loading that will meet water quality objectives.

***Why was this watershed selected for TMDL development?***
In 1996, PADEP listed Wells Creek under Section 303(d) of the federal Clean Water Act as impaired due to excessive nutrients.

***What pollutants do these TMDLs address?*** The proposed plans provide calculations of the stream's total capacity to accept nutrients. Phosphorus loading is being used to address this impairment.

***Where do the pollutants come from?***
Phosphorus entering Wells Creek is coming from surface runoff from agriculture, as well as from the Wells Creek Sewage Treatment Plant.

***How was the TMDL developed?***
PADEP used a reference watershed approach to estimate the necessary loading reduction of phosphorus that would be needed to restore a healthy aquatic community. The reference watershed approach is based on selecting a non-impaired watershed that has similar land use characteristics and determining the current loading rates for the pollutants of interest. This is done by modeling the loads that enter the stream, using precipitation and land use characteristic data. For this analysis, PADEP used the AVGWLF model (the Environmental Resources Research Institute of the Pennsylvania State University's ArcView based version of the Generalized Watershed Loading Function model developed by Cornell University). This modeling process uses loading rates in the non-impaired watershed as a target for load reductions in the impaired watershed. The impaired watershed is modeled to determine the current loading rates and determine what reductions are necessary to meet the loading rates of the non-impaired watershed. The reference stream approach was used to set allowable loading rates in the affected watershed because neither Pennsylvanian nor U.S. EPA has water quality criteria for phosphorus.

***How much pollution is too much?***
The allowable amount of pollution in a water body varies depending on several conditions. TMDLs are set to meet water quality standards at the critical flow condition. For a free flowing stream impacted by non-point source pollution loading of phosphorus, the TMDL is expressed as an annual loading. This accounts for pollution contributions over all stream flow conditions. PADEP established the water quality objectives for phosphorus by using the reference watershed approach. This approach assumes that the impairment is eliminated when the impaired watershed achieves loadings similar to the reference watershed. Reducing the current loading rates in the impaired watershed to the current loading rates in the reference watershed will result in meeting the water quality objectives.

***How will the loading limits be met?***
Best Management Practices (BMPs) will be encouraged throughout the watershed to achieve the necessary load reductions. In addition, the Wells Creek Sewage Treatment Plant's discharge shall be limited to a monthly average phosphorus concentration of 2 mg/l.

***How can I get more information on the TMDL?***
To request a copy of the full report, contact Joseph Boylan at 412-442-4049 during the business hours of 8:00 a.m. to 4:00 p.m., Monday through Friday. One may also contact Mr. Boylan by e-mail at joboylan@state.pa.us, or mail at: Pennsylvania Department of Environmental Protection; Water Management Program; Southwest Regional Office; 400 Waterfront Drive; Pittsburgh, PA 15222-4745

***How can I comment on the proposal?*** You may provide e-mail or written comments postmarked no later than February 25, 2007 to the above address.