Decision Rationale
Total Maximum Daily Load
for Nutrients
Unnamed Tributary 09655 to Bow Creek
Dauphin County, Pennsylvania

I. Introduction

This document will set forth the Environmental Protection Agency's (EPA) rationale for approving the Total Maximum Daily Load (TMDL) for nutrients (phosphorus) for Unnamed Tributary (UNT) 09655 to Bow Creek in Dauphin County, Pennsylvania. The document was submitted by the Pennsylvania Department of Environmental Protection (PADEP) for final Agency review and received by EPA on July 12, 2004. Our rationale is based on the TMDL document and supporting information contained in Appendices to the document to determine if the TMDL meets the following eight regulatory conditions pursuant to 40 CFR §130.

1. The TMDL is designed to implement applicable water quality standards.
2. The TMDL includes a total allowable load as well as individual waste load allocations (WLA) and load allocations (LA).
3. The TMDL considers the impacts of background pollutant contributions.
4. The TMDL considers critical environmental conditions.
5. The TMDL considers seasonal environmental variations.
6. The TMDL includes a margin of safety (MOS).
7. There is reasonable assurance that the TMDL can be met.
8. The TMDL has been subject to public participation.

II. Summary

The UNT 09655 to Bow Creek Watershed is part of State Water Plan subbasin 07-D (Swatara Creek) and is located in eastern Dauphin County. The unnamed tributary originates north of I-81 in East Hanover Township and flows in a southeasterly direction for approximately 0.9 miles before its confluence with Bow Creek southeast of Grantville, Pennsylvania. The 0.4 square-mile watershed contains a total of 1.1 miles of stream. Landuse in the watershed is dominated by agriculture (78%), followed by forested land (11%) and low intensity development (10%). Approximately 0.8 miles of streams in the watershed flow through agricultural landuse. Other landuses including waterbodies and transitional lands account for less than 2% of the watershed area.

Protected uses of the UNT Bow Creek Watershed include aquatic life, water supply, and recreation. The entire basin is currently designated as a Warm Water Fishery[1]. A total of 0.7 miles of UNT 09655 to Bow Creek appeared on Pennsylvania's 1996 Section 303(d) list of impaired waters due to excess nutrients emanating from agricultural activities in the watershed. Pennsylvania's 1998 Section 303(d) list included an erroneous listing for UNT 09655, identifying 0.92 miles as being impaired by priority organics, and the error was not noticed until some time after EPA had approved the list. The error was later corrected and did not appear on any subsequent 303(d) list. The 2002 Section 303(d) list includes the 0.9 miles of impairment to UNT 09655 under the Bow Creek listing (segment 6438). The segment also appears in

[1] Title 25 Pennsylvania Code, Department of Environmental Protection Chapter 93, Section 93.9o

Pennsylvania's Draft 2004 Integrated Water Quality Monitoring and Assessment Report (Part 5) as impaired by nutrients from agricultural activities. No point sources of pollution, including municipal separate storm sewer systems (MS4s), exist within the watershed. The stream and impairment listings addressed by this TMDL are listed in Table 1.

TABLE 1. 1996, 1998, 2002 AND 2004 SECTION 303(D) LISTINGS FOR UNT 09655 TO BOW CREEK (SWP 07-D)

Waterbody	Stream Code/ Segment ID	Year Listed	Miles	Cause	Source
UNT to Bow Creek	9655	1996	0.7	Nutrients	Agriculture
UNT to Bow Creek (09655)	Priority Organics erroneously listed as the cause of impairment on the 1998 List				
Bow Creek	6438	2002	0.9	Nutrients	Agriculture
Bow Creek (UNT 09655)	6438	2004*	0.9	Nutrients	Agriculture

* Pennsylvania's 2004 Integrated Report has not yet been approved by EPA.

Section 303(d) of the Clean Water Act (CWA) and its implementing regulations require a TMDL to be developed for those waterbodies identified as impaired by the state where technology-based and other controls will not provide for attainment of water quality standards. This TMDL was developed to address the impairments caused by excess nutrients in waters of the UNT 09655 to Bow Creek.

According to Federal regulations at 40 CFR §130.2(g), load allocations (LAs) are best estimates of the nonpoint or background loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Table 2 summarizes the elements of the TMDL for phosphorus developed by PADEP. Despite the fact that EPA believes that annual loads are an appropriate measure for this TMDL, for the sake of consistency, we are breaking the annual TMDL loads down into daily loads.

TABLE 2. SUMMARY OF TMDL FOR UNT 09655 TO BOW CREEK

Parameter	WLA[1]	LA	MOS[2]	TMDL		Existing Load	% Reduction
	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/day	lbs/yr	
Phosphorus	0.0	73.14	8.13	81.27	0.22	106.02	23.3%

[1] PADEP indicates that there are no point sources in UNT 09655 to Bow Creek
[2] The TMDL explicitly assigns a MOS value of 10%

The TMDL is a written plan and analysis established to ensure that a waterbody will attain and maintain water quality standards. The TMDL is a scientifically-based strategy which considers current and foreseeable conditions, the best available data, and accounts for uncertainty with the inclusion of a margin of safety (MOS) value. Conditions, available data, and the understanding of the natural processes can change more than anticipated by the MOS. If

this occurs, the option is always available to refine the TMDL for resubmittal to EPA for approval.

III. Discussion of Regulatory Conditions

EPA finds that Pennsylvania has provided sufficient information to meet all of the eight basic requirements for establishing a phosphorus TMDL for the UNT to Bow Creek. EPA therefore approves the TMDL and information contained in the appendices for phosphorus in the UNT 09655 to Bow Creek. EPA's rationale for approval is set forth according to the regulatory requirements listed below.

1. The TMDL is designed to implement the applicable water quality standards.

Water Quality Standards consist of three components: designated and existing uses; narrative and/or numerical water quality criteria necessary to support those uses; and an antidegradation statement. The designated use of the entire UNT to Bow Creek Watershed is Warm Water Fishery. Pennsylvania does not currently have specific numeric water quality criteria for nutrients (nitrogen or phosphorus). Therefore, Pennsylvania utilized its narrative water quality criteria, which states "water may not contain substances attributable to point or nonpoint source waste discharges in concentrations or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant, or aquatic life"[2], to establish an endpoint for phosphorus such that the designated uses of the UNT 09655 to Bow Creek Watershed are attained and maintained.

In order to numerically express this endpoint consistent with the general water quality criteria, PADEP uses a Reference Watershed Approach in combination with the AVGWLF[3] watershed loading model. The reference watershed is representative of the conditions required for the impaired watershed to meet its designated uses. This representative condition is analyzed to determine an appropriate level of nutrient loading to the waterbody. The Reference Watershed Approach consists of comparing the biologically-impaired watershed with a reference watershed that is meeting its designated uses for aquatic life to determine an appropriate level of nutrient loading to the waterbody. This approach is based on comparing the impaired watershed to one with similar designated uses, geology, landuses, physiographic province, land area, soils, and meteorological patterns. The AVGWLF model provides a powerful and accurate means of estimating the dissolved and total nutrient loadings to a stream from the watershed with added GIS capabilities. The model provides monthly streamflow, soil erosion, and sediment yield values and includes both surface runoff and groundwater sources, as well as nutrient loads from point sources and onsite wastewater disposal (septic) systems[4]. Calibration of this model is not required. However, it has been applied and validated to an 85,000 hectare watershed in upstate New York. The rationale of this method is that achieving nutrient loadings in the impaired watershed similar to those loadings of the reference watershed will ensure that the impaired

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[2] Pennsylvania Code, Title 25., Environmental Protection, Chapter 93. Water Quality Standards, Section 93.6(a).

[3] Arcview Generalized Watershed Loading Function model, the Environmental Resources Research Institute of Pennsylvania State University's Arcview based version of the GWLF model developed by Cornell.

[4] Haith, D.A., R. Mandel and R.S. Wu, Generalized Watershed Loading Functions, Version 2.0, Cornell University, Dec. 15, 1992.

watershed will attain and maintain its designated uses and general water quality criteria.

The UNT 09658 Watershed is used as the reference watershed for comparison with the UNT 09655 to Bow Creek Watershed to develop the phosphorus TMDL. UNT 09658 is also a tributary to Bow Creek, located east of the UNT 09655 subbasin. UNT 09658 is identified in the 2002 Section 305(b) Report database as attaining its designated uses. Table 3 below compares these watersheds. EPA finds the use of the UNT 09658 Watershed as a reference watershed to be reasonable for this TMDL.

TABLE 3. COMPARISON BETWEEN UNT TO BOW CREEK AND REFERENCE WATERSHEDS

ATTRIBUTE	WATERSHED	
	UNT 09655 to Bow Creek (SWP 07-D)	**UNT 09658 Reference (SWP 07-D)**
Physiographic Province	Ridge & Valley - Great Valley Section (100%)	Ridge & Valley - Great Valley Section (100%)
Drainage Area (square miles)	0.37	0.36
Landuse Distribution	Agriculture - 78% Forested - 11% Development - 10%	Agriculture - 59% Development - 22% Forest - 17%
Geology	Interbedded Sedimentary (100%)	Interbedded Sedimentary (100%)
Soil Associations	Berks-Weikert-Bedington (PA033)	Berks-Weikert-Bedington (PA033)
Dominant Hydro Soil Group	C (52%) D (35%) B (13%)	C (52%) D (35%) B (13%)
K Factor	0.24	0.24
16-Year Average Rainfall (in)	41.3	41.3
16-Year Average Runoff (in)	4.3	4.4

Using the continuous simulation AVGWLF model, PADEP modeled the nutrient loads originating from nonpoint sources in the reference watershed. As previously mentioned, AVGWLF has the ability to estimate dissolved and total monthly nutrient loads to streams from watersheds including surface runoff, groundwater sources, point sources, septic systems, monthly streamflow, soil erosion, and sediment yield values. In order to make these estimates, AVGWLF requires daily precipitation and temperature data, runoff sources, and transport and chemical parameters. The AVGWLF model is a combined distributed/lumped parameter watershed model. In terms of surface loading, this means that the model allows the user to distribute multiple landuse/cover scenarios in the watershed. However, the loads originating from the watershed are lumped, and spatial routing of nutrient loads is not available. In terms of subsurface loading, the load contributions from subsurface areas are not distinct and are considered lumped using a water balance approach. The AVGWLF model relies on the Soil Conservation Service Curve Number (SCS-CN) to estimate surface runoff and the Universal Soil

Loss Equation (USLE) to estimate erosion and sediment yield. Monthly estimates of nutrient loadings, applicable to each watershed, are generated by using watershed-specific local daily weather inputs and USLE factors[5]. The following average existing load values for phosphorus, illustrated in Table 4, were determined for the UNT 09658 reference watershed and the UNT 09655 to Bow Creek Watershed using watershed-specific data.

TABLE 4. EXISTING PHOSPHORUS LOADING VALUES FOR THE REFERENCE WATERSHED AND THE UNT 09655 TO BOW CREEK WATERSHED

Watershed	Area (Acres)	Phosphorus Load (lbs/yr)	Unit Area Phosphorus Loading Rate (lbs/acre/yr)
UNT 09655 to Bow Creek	232.19	106.02	0.46
UNT 09658 Reference	214.90	75.06	0.35

Although nutrients (phosphorus and nitrogen) is listed as the cause of impairment and is subsequently modeled, only a TMDL for phosphorus is being established to help restore the designated uses of the UNT to Bow Creek Watershed. This is due to PADEP's finding that phosphorus is the limiting nutrient in all waters of the UNT to Bow Creek Watershed. A common N:P ratio is 10:1, and an increase in this ratio indicates a limitation of phosphorus[6]. The ratio for this watershed was determined to be 24:1, indicating that it is phosphorus-limited. Phosphorus is often the major nutrient in shortest supply and is frequently a prime determinant of the total biomass[7]. It is also most effectively controlled using existing engineering technology and landuse management. EPA finds this to be a reasonable determination.

The final step in the process is to determine the appropriate pollutant loading for each watershed. For the UNT 09655 to Bow Creek Watershed, the values generated for phosphorus loading were based on those found in the UNT 09658 reference watershed. In the process of determining the total phosphorus loadings in the reference watershed, a unit area loading coefficient for the parameter of concern was calculated. Those area loading coefficients were applied to the UNT 09655 to Bow Creek Watershed to determine an allowable (TMDL) phosphorus loading. EPA finds this application reasonable to implement the applicable water quality standards.

Table 5 illustrates the phosphorus TMDL calculations. The target TMDL value for phosphorus is determined by multiplying the unit area loading value of the reference watershed by the total area in acreage of the impaired watershed.

TABLE 5. PHOSPHORUS TMDL CALCULATIONS

Watershed	Unit area loading rate in Reference Watershed (tons/acre/yr)	Total watershed area of Impaired Watershed (acres)	Phosphorus TMDL (lbs/yr)

[5] Local daily weather inputs include temperature and precipitation. The USLE factors are KLSCP; K=changes in soil loss erosion, LS=length slope factor, C=vegetation cover factor, P=conservation practices factor.

[6] Horne, A.J. and C.R. Goldman. 1994. Limonology (2nd Edition). McGraw-Hill Inc., New York, New York.

[7] U.S. EPA. 1980. Modeling Phosphorus Loading and Lake Response under Uncertainty: A Manual and Compilation of Export Coefficients. EPA 440/5-80-011.

UNT 09655 to Bow Creek	0.35	232.19	81.27

EPA find that the TMDL submitted by PADEP has been appropriately designed to determine the acceptable level of nutrient loading to UNT 09655 to Bow Creek, while ensuring that the applicable water quality standards are attained and maintained.

2. The TMDL includes a total allowable load as well as individual WLAs and LAs.

Tables 2 and 5 indicate the total allowable loads for phosphorus as determined using the Reference Watershed Approach and the AVGWLF model.

A. Wasteload Allocations (WLAs)

Pennsylvania indicates that no point sources of phosphorus, including MS4s, exist within the watershed. Therefore, no the TMDL does not assign any WLAs.

B. Load Allocations (LAs)

The TMDLs include LAs for nonpoint sources. According to Federal regulations, 40 CFR §130.2(g), LAs are best estimates of the loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. The AVGWLF process enables the LA to be distributed to sources based on landuse type.

The process of allocating phosphorus loads to distinct landuses in the UNT 09655 to Bow Creek Watershed begins by subtracting 10% from the TMDL value for the MOS. For example, the allowable load for phosphorus in the UNT 09655 to Bow Creek Watershed of 81.27 lbs/yr is reduced by 8.13 lbs/yr to 73.14 lbs/yr. See below for further discussion on the application of a MOS in TMDLs.

As discussed earlier, LAs for phosphorus were determined by multiplying the unit area loading rate for phosphorus of the UNT 09658 reference watershed by the total area in the UNT 09655 to Bow Creek Watershed. The determination of how LAs are distributed is at the discretion of PADEP. To determine the distribution of the phosphorus LAs between contributing land based sources, PADEP uses a method called the Equal Marginal Percent Reduction (EMPR)[8]. This method equitably assigns greater reduction requirements to the largest contributing source. The EMPR method assigns equal percent reductions to all baseline loads after adjusting any landuse loads which individually exceed the total load allocation. This process is established on a site-specific basis and considers several factors regarding ability to affect the pollutant loading processes. According to PADEP's analysis, cropland runoff is the major source of phosphorus loading to UNT 09655 to Bow Creek. Table 6 shows the load allocations of phosphorus in the UNT 09655 to Bow Creek Watershed. Existing phosphorus loads to UNT to Bow Creek were determined by PADEP utilizing a simple landuse area/loading coefficient methods where the loadings were computed based on landuse type and watershed loading values taken from the AVGWLF model.

[8] Pennsylvania Department of Environmental Protection. June 1986. Implementation Guidance for the Water Quality Analysis Model 6.3. Document 391-2000-007.

TABLE 6. SUMMARY OF LAS FOR PHOSPHORUS IN THE UNT 09655 TO BOW CREEK WATERSHED

	Phosphorus		
Landuse	**Existing Load (lbs/yr)**	**Allocated Load (lbs/yr)**	**Percent Reduction**
Hay/Pasture	11.00	8.99	18
Cropland	71.50	40.65	43
Mixed Forest	0.10	0.10	0
Deciduous Forest	-	-	-
Low Development	-	-	-
Streambank	0.12	0.10	17
Groundwater	21.40	21.40	0
Septic System	1.90	1.90	0

EPA finds that PADEP appropriately applied the EMPR method for phosphorus in the UNT 09655 to Bow Creek Watershed TMDL. According to Federal regulations at 40 CFR §130.2(g), LAs are best estimates of the loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. While it is not necessary to specifically approve an allocation method, EPA believes that the EMPR method used by PADEP is acceptable because it supports three main objectives: (1) to assure compliance with the applicable water quality standard; (2) to minimize the overall cost of compliance, and; (3) to provide maximum equity among competing discharges.

3. The TMDL considers the impacts of background pollutant contributions.

Pennsylvania has included natural background as a component of the LAs, as required by 40 CFR §130.2(g). There are two separate considerations of background pollutants within the context of this TMDL. First, there is the inherent assumption of the Reference Watershed Approach that, because of the similarities between the reference and impaired watersheds, the background pollutant contributions will be similar. Therefore, the background pollutant contributions will be considered when determining the loads for the impaired watershed which are consistent with the loads from the reference watershed. Secondly, the AVGWLF model implicitly considers background pollutant contributions through the groundwater component of the model process.

4. The TMDL considers critical environmental conditions.

EPA regulations at 40 CFR §130.7(c)(1) require TMDLs to take into account critical conditions for streamflow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of UNT 09655 to Bow Creek is protected during times when it is most vulnerable.

Critical conditions are important because they describe the factors that combine to cause a violation of water quality standards and will help in identifying the actions that may have to be undertaken to meet water quality standards.[9] In specifying critical conditions in the waterbody, an attempt is made to use a reasonable "worst case" scenario condition. Critical conditions are the combination of environmental factors (*e.g.*, flow, temperature) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence. For example, stream analysis often uses a low flow (7Q10) design condition as critical because the ability of the waterbody to assimilate pollutants without exhibiting adverse impacts is at a minimum.

Within the context of the Reference Watershed Approach, the assumption is that the reference watershed is achieving its designated use even during critical environmental conditions. Thus, achieving phosphorus loadings in the impaired watershed consistent with that of the reference watershed will effectively consider critical conditions. To account for different flow conditions, the AVGWLF model uses daily average temperature, daily time step and total precipitation values for each year simulated. PADEP modeled each watershed for a period of 23 years to develop the existing loading values for each watershed. The length of the model time period will also effectively consider critical environmental conditions. EPA finds that Pennsylvania adequately considered critical conditions in the TMDL analysis of the UNT 09655 to Bow Creek Watershed.

5. The TMDL considers seasonal environmental variations.

Seasonal variations involve changes in streamflow as a result of hydrologic and climatological patterns. In the continental United States, seasonally-high flow normally occurs during the colder period of winter and in early spring from snowmelt and spring rain, while seasonally-low flow typically occurs during the warmer summer and early fall drought periods[10]. The AVGWLF watershed modeling analysis was run over a 23-year period and appropriately considers seasonal environmental variations. As discussed in Section 4 above, the 23-year simulation period of the model appropriately considers seasonal variations in precipitation and temperature conditions. The model considers seasonal changes requiring specifications of the growing season, hours of daylight for each month, the months in which manure is applied to the land and by using daily time steps for weather data and water balance calculations. EPA finds that both the AVGWLF model and the assumptions of the Reference Watershed Approach effectively consider seasonal environmental variations.

6. The TMDL includes a MOS.

This requirement is intended to add a level of safety to the modeling process to account for any uncertainty. A MOS may be implicit, built into the modeling process, or explicit, taken as a percentage of the WLA, LA, or TMDL.

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[9] EPA Memorandum regarding EPA Actions to Support High Quality TMDLS from Robert H. Wayland III, Director, Office of Wetlands, Oceans, and Watersheds to the Regional Water Management Division Directors, August 9, 1999.

[10] U.S. EPA. 1997. Technical Guidance Manual for Developing Total Maximum Daily Loads, Book 2, Part 1, Section 2.3.3. EPA 823-B-97-002.

PADEP reserves 10% of the TMDL value for phosphorus as the MOS to account for uncertainty in the data and computational methodology used in the analysis. Table 2 indicates the actual value of the MOS for each TMDL. EPA finds this explicit MOS acceptable.

7. There is reasonable assurance that the TMDL can be met.

EPA requires that there is reasonable assurance that TMDL can be implemented. Regarding the UNT 09655 to Bow Creek TMDL for phosphorus, there exists several programs that can be utilized to help implement the TMDL. With regard to load allocations for nonpoint sources, numerous state programs, such as CWA Section 319 and Pennsylvania's Growing Greener programs, are available.

The UNT 09655 to Bow Creek TMDL identifies the necessary overall load reductions for phosphorus and distributes those reduction goals to the appropriate nonpoint sources. PADEP believes that the reduction goals established by this TMDL will be achieved through changes in current land use practices, including the incorporation of more agricultural BMPs. BMPs that would be helpful in lowering the amount of nutrients reaching UNT 09655 to Bow Creek include streambank fencing, riparian buffer strips, strip cropping, contour plowing, conservation crop rotation, and heavy use area protection. Determining the most appropriate BMPs, where they should be installed, and actually putting them into practice, will require the development and implementation of a comprehensive watershed restoration plan.

EPA agrees with PADEP that the reduction goals specified in this TMDL help to set the stage for local citizens to design and implement watershed restoration plans, correct current use impairments. PADEP has already established a single-point contact in its Southcentral Regional Office to serve as a Watershed Manager. This individual is charged with supporting local efforts for developing and implementing future watershed restoration plans the UNT 09655 to Bow Creek.

8. The TMDL has been subject to public participation.

Pennsylvania published a notice of availability for the UNT 09655 to Bow Creek Watershed TMDL for public review and comment in the *Pennsylvania Bulletin* June 5, 2004. A public meeting was held on June 24, 2004 at the East Hanover Township Municipal Building in Grantville, Pennsylvania. The occurrence of this meeting was made available to the public by publishing a notice in the *Harrisburg Patriot News* on June 7, 2004.

A 30-day comment period from June 5, 2004 to July 6, 2004 was provided for the submittal of comments. The Department received written comments from EPA only. EPA finds that PADEP has sufficiently addressed our comments on the UNT 09655 to Bow Creek TMDL and has adequately conducted the public participation process.

Although not specifically stated in the TMDL Report, PADEP routinely posts the approved TMDL report their web site: www.dep.state.pa.us./watermanagement_apps/tmdl/