UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029
7/1/2008

Ms. Cathy Curran Myers
Deputy Secretary for Water Management
Pennsylvania Department of Environmental Protection
Rachel Carson State Office Building
P.O. Box 2063
Harrisburg, PA 17105

Dear Ms. Myers:

On June 30, 2008, the U.S. Environmental Protection Agency (EPA), Region III, established Total Maximum Daily Loads (TMDLs) for the following waters and pollutants: total phosphorus and sediment for the Indian Creek Watershed, total phosphorus and sediment for Southampton Creek Watershed, total phosphorus and sediment for Paxton Creek Watershed, total phosphorus for Goose Creek Watershed and total phosphorus for Sawmill Run Watershed. These TMDLs were established in accordance with Section 303(d)(1)© and (2) of the Clean Water Act to address impairments of water quality as identified on Pennsylvania's Clean Water Act Section 303(d) List of impaired waters. These TMDLs were completed to partially fulfill the 1997 TMDL Consent Decree requirements and at the request of the Pennsylvania Department of Environmental Protection.

In accordance with Federal regulations at 40 CFR Section 130.7, a TMDL must comply with the following requirements: (1) be designed to attain and maintain the applicable water quality standards; (2) include a total allowable loading and as appropriate, WLAs for point sources and load allocations for nonpoint sources (including the impacts of background pollutant contributions); (3) take critical stream conditions into account (the conditions when water quality is most likely to be violated); (4) consider seasonal variations; (5) include a margin of safety (which accounts for uncertainties in the relationship between pollutant loads and instream water quality); and (6) be subject to public participation. EPA also considered whether there is reasonable assurance that the TMDLs can be met. The TMDLs for the above referenced waters and pollutants satisfied each of these requirements. A copy of each of the TMDL reports and EPA's Response to Comments has been included with this letter. These reports can also be found on the EPA, Region III, TMDL website, under 'What's New' – http://www.epa.gov/reg3wapd/tmdl/index.htm.

As you know, all new or revised National Pollutant Discharge Elimination System permits must be consistent with the TMDL wasteload allocation pursuant to 40 CFR Section 122.44 (d)(1)(vii)(B). Please submit all such permits to EPA for review as per EPA's letter dated October 1, 1998.

If you have any questions or comments concerning this letter, please do not hesitate to contact Mr. Thomas Henry at (215) 814-5752.

Sincerely,

Signed

Jon M. Capacasa, Director
Water Protection Division

Enclosures

cc: Steve Balta – PA SWRO (w/o enclosures)
Ken Bowman – PA SWRO
Bill Brown – PADEP
Rachel Diamond – PA SCRO
Joseph Feola – SERO
Jenifer Fields – SERO
Rita Graham – PA SWRO
John Hines – PADEP
Lee McDonnell – PA SCRO
Brian Trulear – EPA

2008

Nutrient and Sediment TMDLs for the Indian Creek Watershed, Pennsylvania: Established by the U.S. Environmental Protection Agency

Jon Capacasa, Director,
Water Protection Division
6/30/2008

FINAL

Siltation and Nutrients TMDL Development for the Indian Creek Watershed, Pennsylvania

June 2008

Prepared for:
United States Environmental Protection Agency, Region 3
Contract 68-C-02-108, Task Order #113

Prepared by:

Tetra Tech, Inc.
10306 Eaton Place, Suite 340
Fairfax, VA 22030

EXECUTIVE SUMMARY

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (USEPA) Water Quality Planning and Management Regulations (Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for impaired waterbodies. A TMDL establishes the amount of a pollutant that a waterbody can assimilate without exceeding its water quality standard for that pollutant. TMDLs provide the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991).

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. The TMDL components are illustrated using the following equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

Indian Creek drains an area of approximately 7 square miles in Montgomery County, Pennsylvania. Its watershed includes portions of eight municipalities and has three National Pollution Discharge Elimination System (NPDES) permitted discharges. Various degrees of residential development (low intensity residential, medium intensity residential and high intensity residential) are scattered thoughout the watershed and the middle portion of the watershed is predominantly pasture.

This TMDL is developed to address segments in the Indian Creek watershed listed on the state's 303(d) list as not meeting aquatic life uses and impaired by siltation (sediment) and nutrients. The TMDLs were developed using the GWLF watershed model linked to the EFDC hydrodynamic model. The sediment TMDL was developed to meet and loading targets established using a reference watershed, and the nutrient TMDL was developed to meet the seasonal average concentration targets for total phosphorus (TP) shown in table ES-1. Both TMDLs were developed to protect designated aquatic life uses.

Table ES-1. Nutrient Endpoints for Indian Creek TMDL

Parameter	Period	Target Concentration
TP	April 1 – October 31	0.040 mg/L

In addition to the seasonal average nutrient target, modeling analysis also demonstrates that the TMDL complies with established water quality criteria for dissolved oxygen at all points in the stream as well as with identified levels of acceptable periphyton densities.

Table ES-2. Summary of Sediment and Nutrient TMDLs for Indian Creek

Indian Creek Watershed	Sediment TMDL (lb/yr)	TP TMDL (lb/yr)
Existing	12,693,686	11,389
Allowable Load	641,733	1,598
MOS (10%)	32,087	80
Future Residential Growth (1%)	38,504	96
Σ WLA	571,013	1,422
Σ LA	0	0
TMDL	**641,604**	**1,598**

Allowable daily loads were also identified for all sources of sediment and nutrients. A statistical approach was used to determine the maximum allowable daily load consistent with the long term loading allocation.

Table ES-3. Allowable Daily Loads of Sediment and Nutrient TMDLs for Indian Creek

NPDES ID	Facility/Township	Sediment Maximum Daily (lb/day)	TP Maximum Daily (lb/day)
PA0036978	Telford Borough Authority	523	0.846
PA0054950	Pilgrim's Pride	35	0.181
PA0024422	Lower Salford Authority (Harleysville STP)	533	0.694
MS4	Lower Salford	497	1.862
MS4	Souderton	45	0.303
MS4	Telford	104	0.726
MS4	Franconia	1818	5.214

Because the entire Indian Creek watershed is covered by areas within 4 Municipal Separate Storm Sewer Systems (MS4s), all allocated loads are assigned to the Waste Load Allocation (WLA) category. The four MS4 jurisdictions are Lower Salford, Telford, Souderton, and Franconia. WLAs were assigned to each of the three permitted point source facilities as well. Tables ES4-6 show WLAs for permittees in the watershed.

Table ES-4. Sediment WLAs

NPDES ID	Facility/Township	Existing Load (lb/yr)	TMDL (lb/yr)	Maximum Daily (lb/day)	% Reduction
PA0036978	Telford Borough Authority	100,455	100,455	523	0%
PA0054950	Pilgrim's Pride	5,540	5,540	35	0%
PA0024422	Lower Salford Authority (Harleysville STP)	63,926	63,926	533	0%
MS4	Lower Salford	2,619,340	80,950	497	97%
MS4	Souderton	84,171	7,272	45	91%
MS4	Telford	58,772	16,864	104	71%
MS4	Franconia	9,757,660	296,005	1,818	97%

Table ES-5. TP WLAs

NPDES ID	Facility/Township	Existing Load (lb/yr)	TMDL (lb/yr)	Maximum Daily (lb/day)	% Reduction
PA0036978	Telford Borough Authority	5695.66	156.10	0.846	97%
PA0054950	Pilgrim's Pride	791.53	20.60	0.181	97%
PA0024422	Lower Salford Authority (Harleysville STP)	1066.16	101.30	0.694	90%
MS4	Lower Salford	803.32	303.29	1.862	62%
MS4	Souderton	49.4	49.40	0.303	0%
MS4	Telford	118.18	118.18	0.726	0%
MS4	Franconia	2863.44	849.18	5.214	70%

CONTENTS

1. Introduction and Background 1
1.1. Watershed Description 1
1.2. Impaired Waterbodies 3
1.3. Water Quality Standards 5
1.4. TMDL Targets 6
1.4.1. Sediment TMDL Target 6
Reference Watershed Approach 6
Selected Reference Watershed and TMDL Targets 6
1.4.2. Nutrient TMDL Targets 8
2. Data Inventory and Analysis 10
2.1. Stream Flow and Climate Data 10
2.2. PADEP Pre-TMDL Monitoring Data 11
3. Source Assessment 23
3.1. Nonpoint Sources 23
3.1.1. Agriculture 23
3.1.2. Biosolids 23
3.1.3. Urban Runoff 24
3.1.4. Septic Systems 25
3.2. Point Sources 25
3.2.1. MS4s 25
3.2.2. NPDES Permitted Facilities 26
Telford 26
Pilgrims Pride 28
Lower Salford 30
Ambient Sampling Above and Below Point Sources 32
3.3. Indian Valley Golf Course Water Withdrawals 33
3.4. Summary of Critical Water Quality Factors 33
4. TMDL Technical Approach 35
4.1. Sediment 35
4.1.1. Watershed modeling - Sediment 35
Land Use and Land Cover Data 35
Soils Data 36
Weather Data 36
4.1.2. Watershed Model Results – Sediment 36
4.2. Nutrients 37
4.2.1. Watershed Modeling - Nutrients 38
4.2.2. Model Setup 39
Land Use and Land Cover Data 41
Soils Data 42
Weather Data 43
Nonpoint Source Representation 44
4.2.3. Model Testing 48
4.2.4. Watershed Model Results – Nutrients 53
4.2.5. Receiving Water Model 55
4.2.6. EFDC Model Setup 56
Segmentation 57
Meteorological Data 58
Point Source Representation 58
Nonpoint Source Representation 59

Linkage of GWLF to EFDC 59
4.2.7. EFDC Model Calibration 60
5. TMDL Allocation Analysis 64
5.1. Sediment TMDLs 65
Sediment WLAs 65
5.2. Nutrient TMDLs 68
Nutrient WLAs 68
5.3. Daily Load Expressions 70
5.4. Margin of Safety 71
5.5. Future Residential Growth 72
5.6. Critical Conditions and Seasonal Variations 72
6. Reasonable Assurance 73
7. Public Participation 74
References 76
Appendix A: Ambient Sampling Results Above and Below Municipal STPs 78
Appendix B: EFDC Calibration Plots 86
Appendix C: Results of EFDC Sensitivity Analysis 91
Appendix D: EFDC Results for Baseline Scenario 93
Appendix E: EFDC Results for Load Reduction Scenario 96
Appendix F: Suggested Adaptive Implementation Strategy for NPDES Point Sources Dischargers 98

TABLES

Table 1-1. Summary of 2004 303(d) Listings in the Indian Creek Watershed 3
Table 1-2. Impaired and reference watershed comparison 7
Table 1-3. Sediment Endpoints Established for Indian Creek Sediment TMDL 7
Table 1-4. Total Phosphorus Endpoint Development Approaches 8
Table 1-5. N:P Ratio statistics for streams in Northern Piedmont 9
Table 1-6. Nutrient Endpoint Established for Indian Creek Nutrient TMDL 10
Table 1-7. Applicable DO criteria 10
Table 2-1. Concentration of Various Constituents in Indian Creek Tributaries 22
Table 2-2. Comparison of Chemical Data (mg/l) at Rt 63, Salford Tributary, and Indian Creek Mouth .. 22
Table 3-1. Nutrient Permit Limits for NPDES Facilities in the Indian Creek Watershed 26
Table 4-1. Land Use in the Indian Creek Watershed (Sediment model) 36
Table 4-2. Modeled Sediment Loads and Landuse Loading Rates in the Indian Creek Watershed 37
Table 4-3. NLCD Landuse Coverage Category Crosswalked with Modeled Landuse Categories 41
Table 4-4. Land Use in the Indian Creek River Watershed 41
Table 4-5. Land Use in the East Branch Perkiomen Creek Watershed 42
Table 4-6. Meteorological Stations 44
Table 4-7. Assigned C and P Factor Values for the Indian Creek Watershed 45
Table 4-8. Nitrogen and Phosphorus Concentrations in Runoff 45
Table 4-9. Septic Inspection Results by Modeled Subbasin 47
Table 4-10. Septic Representation in GWLF 48
Table 4-11. Average Annual Watershed and Point Source Nutrient Loads for the Modeled Period 53
Table 4-12. Average Monthly Watershed Loads for the Modeled Period 53
Table 4-13. Modeled Landuse Loading Rates for Nutrients 53
Table 4-14. Width and Average Depth at the Cross-Sections 58
Table 4-15. Point source data used in Indian Creek EFDC model 58
Table 4-16. Ratio Used to Convert GWLF Constituents to EFDC Constituents 60
Table 4-17. Comparison of Measured and Modeled Depth on the Main Indian Creek 60
Table 4-18. Key Water Quality Parameters for Indian Creek EFDC Model 61
Table 5-1. Summary of Sediment TMDL Loads for Indian Creek Watershed 65
Table 5-2. Sediment WLAs for Continuous Point Sources in the Indian Creek Watershed 66
Table 5-3. Existing, Reference and TMDL Landuse Loading Rates for Sediment 67
Table 5-4. MS4 Sediment WLAs (lb/yr) 67
Table 5-5. Nutrient TMDL loads for Indian Creek Watershed 68
Table 5-6. Summary of Continuous Discharger's TP Loading under the Indian Creek TMDL 69
Table 5-7. Existing, TMDL, and Maximum Daily Total Phosphorus WLAs for Permittees 69
Table 5-8. MS4 Related WLAs for Total Phosphorus 70
Table 5-9. Variables used in calculating the Daily Maximum Loads 71

FIGURES

Figure 1-1. Indian Creek watershed with municipalities, gauging station, and discharge points. 2
Figure 1-2. 303(d) impaired reaches in the Indian Creek watershed. 5
Figure 2-1. Historical precipitation (PA 3437) and flow (USGS 01472810) from 1995 to 2004 11
Figure 2-2. Diurnal monitoring locations. 13
Figure 2-3. Diurnal DO (mg/l) patterns at Indian Creek monitoring locations 14
Figure 2-4. Diurnal DO (%) patterns at Indian Creek monitoring locations 14
Figure 2-5. Longitudinal DO patterns in different time intervals at monitoring locations. 16
Figure 2-6. Longitudinal BOD patterns at Indian Creek sampling locations 17
Figure 2-7. Longitudinal total suspended solids patterns at Indian Creek sampling locations. 17

Figure 2-8. Longitudinal ammonia patterns at Indian Creek sampling locations. 18
Figure 2-9. Longitudinal dissolved phosphorus patterns at Indian Creek sampling locations..... 18
Figure 2-10. Longitudinal dissolved nitrogen patterns at Indian Creek sampling locations..... 19
Figure 2-11. Longitudinal total nitrogen patterns at Indian Creek sampling locations..... 19
Figure 2-12. Longitudinal total ortho phosphorus patterns at Indian Creek sampling locations. 20
Figure 2-13. Longitudinal dissolved ortho phosphorus patterns at Indian Creek sampling locations. 20
Figure 2-14. Longitudinal total phosphorus patterns at Indian Creek sampling locations..... 21
Figure 2-15. Longitudinal nitrate + nitrite - N patterns at Indian Creek sampling locations. 21
Figure 3-1. Land Application Sites (eMapPA). 24
Figure 3-2. Telford DMR data. 27
Figure 3-3. Pilgrims Pride DMR data. 29
Figure 3-4. Lower Salford DMR data. 31
Figure 3-5. Total Phosphorus concentration above and below Telford Discharge 33
Figure 4-1. Indian Creek subwatershed delineations. 40
Figure 4-2. Soil distribution in the Indian Creek watershed. 43
Figure 4-3. Septic Inspection Study Area and Results..... 46
Figure 4-4. East Perkiomen Creek watershed. 50
Figure 4-5. Observed and Predicted Monthly Streamflow (centimeters) – East Branch Perkiomen Crk at USGS 01493500 (1997 - 2004) 51
Figure 4-6. Observed and Predicted (centimeters) - East Branch Perkiomen Crk at USGS 01493500 (1997 - 2004) entire period 52
Figure 4-7. Comparing Annual PS and NPS Nutrient Loading in Indian Creek 54
Figure 4-8. EFDC model structure..... 55
Figure 4-9. EFDC hydrodynamics module structure. 56
Figure 4-10. EFDC water quality module Structure. 56
Figure 4-11. Indian Creek EFDC Modeling Domain..... 57
Figure 4-12. Temperature calibration results. 61

1. INTRODUCTION AND BACKGROUND

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (USEPA) Water Quality Planning and Management Regulations (Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not supporting their designated uses even if pollutant sources have implemented technology-based controls. A TMDL establishes the maximum allowable load (mass per unit of time) of a pollutant a waterbody is able to assimilate and still support its designated use(s). The maximum allowable load is determined based on the relationship between pollutant sources and in-stream water quality. A TMDL provides the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991). The development of TMDLs requires an assessment of streams' assimilative capacity, critical conditions, and other considerations.

Several segments in the Indian Creek watershed have been listed on Pennsylvania's 303(d) list of impaired waters for not meeting aquatic life uses and for impairments due to siltation and nutrients. This report documents TMDLs developed to address the nutrient and siltation impairments in Indian Creek and its tributaries.

1.1. Watershed Description

Indian Creek, a third-order stream with a drainage area of approximately 7 square miles, flows approximately 6.1 miles, through areas of Montgomery County, Pennsylvania (Figure 1-1**)**. Its watershed includes portions of eight municipalities and has three National Pollution Discharge Elimination System (NPDES) permitted discharges. About 19 tributaries (tributary 01182 through tributary 01200) drain to Indian Creek, some of which are intermittent. Various degrees of residential development (low intensity residential, medium intensity residential and high intensity residential) are scattered thoughout the watershed. The middle portion of the watershed is predominantly pasture.

The mainstem of Indian Creek flows southwesterly and discharges to the East Branch Perkiomen Creek. The nearest U.S. Geological Survey (USGS) stream gauging station (01472810) is located on East Perkiomen Creek near Schwenksville.

National Land Cover Data (NLCD) are available through the Multi-Resolution Land Characteristics Consortium (MRLC) as a joint effort between USEPA and USGS. NLCD data from 2001 were obtained for the Indian Creek watershed and is presented in Figure 1-2.

Based on the 2001 NLCD, pasture is the dominant land use, comprising approximately of 36 percent, followed by low and high intensity development (20 and 21 percent respectively). Agriculture comprises of approximately 17 percent of the watershed, while forested areas comprise of only approximately 5 percent of the watershed area. Spatially these areas are scattered throughout the watershed. A golf course is located in the northern half of the study area.

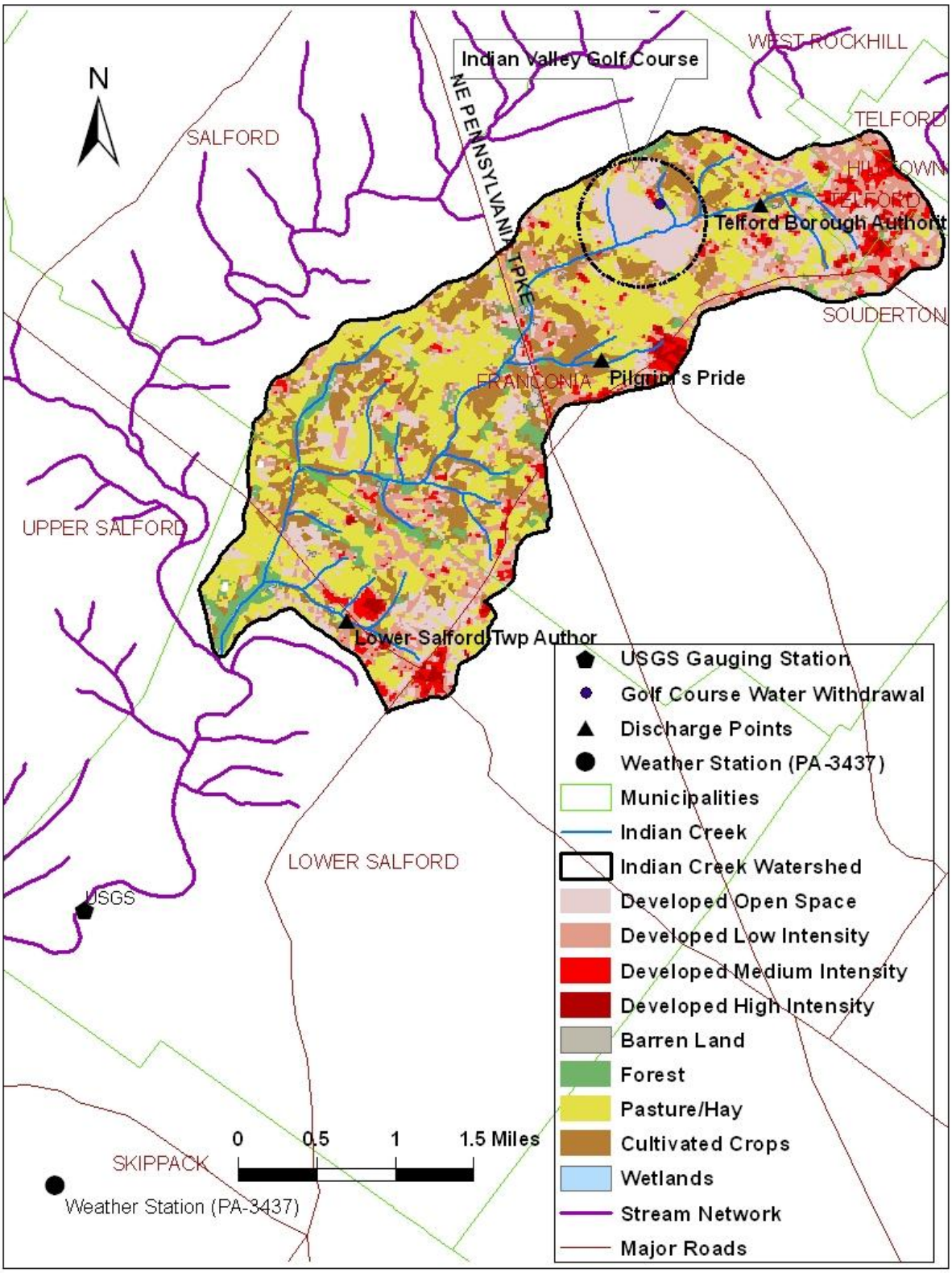


Figure 1-1. Indian Creek watershed with municipalities, gauging station, and discharge points.

1.2. Impaired Waterbodies

Indian Creek was placed on Pennsylvania's 1996 303 (d) list of impaired waterbodies for not meeting the designated aquatic life use due to various pollutants, including salinity, siltation, and nutrients. Subsequent listing cycles (2004 and 2006) have included additional impairments, as shown in the summary of the 2006 listings in Table 1-1. Attributed causes include municipal point sources, agriculture, and urban and residential stormwater runoff (Figure 1-2). Based on PADEP field assessments, the stream was also overwhelmed by sewage effluents in two locations. Available data show severe swings in dissolved oxygen (DO), oxygen saturation levels and pH. Data also indicate phosphorous and nitrogen concentrations in this system are elevated, likely contributing to the presence of thick algal mats that frequently blanket the stream in various locations throughout the watershed.

Results of one specific field investigation conducted on the Unnamed Tributary to Indian Creek, Stream Code 01182, on August 14, 2003 are included here for illustration of PADEP's impairment assessment. During this investigation, PADEP conducted chemical and biological sampling at two stations upstream and downstream of the Lower Salford Township Authority Harleysville STP (PA0024422) outfall. Based on the results of this investigation, the invertebrate community at station one was found to be "fair to poor" and the invertebrate community at Station two was found to be "poor". Recommendations of the field staff conducting the investigation included the recommendation "that the unnamed tributary to Indian Creek be listed as impaired from the Lower Salford Township Authority, Harlyesville STP outfall to the mouth for municipal point source nutrients." It was upon this recommendation and specific findings in the field as well as others similar to it throughout the Indian Creek watershed, that the stream was included on PADEP's 303(d) list as impaired. As another example, a second field form on which PADEP recorded results of the stream assessment of Indian Creek at Indian Creek Road found: "Indian Creek is impaired based on the taxa collected. This station lacked pollution sensitive taxa and was dominated by facultative taxa. The cause of impairment is likely from storm water runoff from Harleysville and Telford and from sewage effluent as the stream is effluent dominated."

This TMDL report establishes sediment and nutrient allocations to restore designated aquatic life uses in all of the impaired segments of Indian Creek and its tributaries.

Table 1-1. Summary of 2004 303(d) Listings in the Indian Creek Watershed

Source	Cause	Assessment Unit	Miles	Date Listed
Indian Creek				
Agriculture	Siltation	New ID:2851 Old ID:20010919-1119-GLW	2.16	2004
Small Residential Runoff	Siltation	New ID:3372 Old ID:20020415-1038-KAW	1.4	2004
Urban Runoff/Storm Sewers				2004
Agriculture				2004
Municipal Point Source	Nutrients			2004
Source Unknown	Cause Unknown	New ID:7958 Old ID:7007	1.05	1996
Municipal Point Source	Salinity/TDS/Chlorides			1996
Golf Courses	Cause Unknown	New ID:10180 Old ID:990405-1500-ACW	1.77	2002

Source	Cause	Assessment Unit	Miles	Date Listed
Road Runoff	Siltation			2002
Small Residential Runoff	Cause Unknown			2002
Indian Creek (Unt 00979)				
Golf Courses	Cause Unknown	New ID:10180 Old ID:990405-1500-ACW	1	2002
Road Runoff	Siltation			2002
Small Residential Runoff	Cause Unknown			2002
Indian Creek (Unt 01182)				
Municipal Point Source	Nutrients	New ID:2948 Old ID:20011010-1320-GLW	0.3	2004
Indian Creek (Unt 01185)				
Municipal Point Source	Nutrients	New ID:2948 Old ID:20011010-1320-GLW	0.3	2004
Indian Creek (Unt 01191)				
Small Residential Runoff	Siltation	New ID:3373 Old ID:20020415-1200-KAW	0.76	2004
Indian Creek (Unt 01192)				
Small Residential Runoff	Siltation	New ID:3373 Old ID:20020415-1200-KAW	0.25	2004
Indian Creek (Unt 01194)				
Agriculture	Siltation	New ID:3372 Old ID:20020415-1038-KAW	0.54	2004
Urban Runoff/Storm Sewers				2004
Municipal Point Source	Nutrients			2004
Small Residential Runoff	Siltation			2004
Indian Creek (Unt 01200)				
Agriculture	Siltation	New ID:3372 Old ID:20020415-1038-KAW	0.59	2004
Municipal Point Source	Nutrients			2004
Small Residential Runoff	Siltation			2004
Urban Runoff/Storm Sewers				2004
Municipal Point Source	Salinity/TDS/Chlorides	New ID:7958 Old ID:7007	0.61	1996
Source Unknown	Cause Unknown			1996

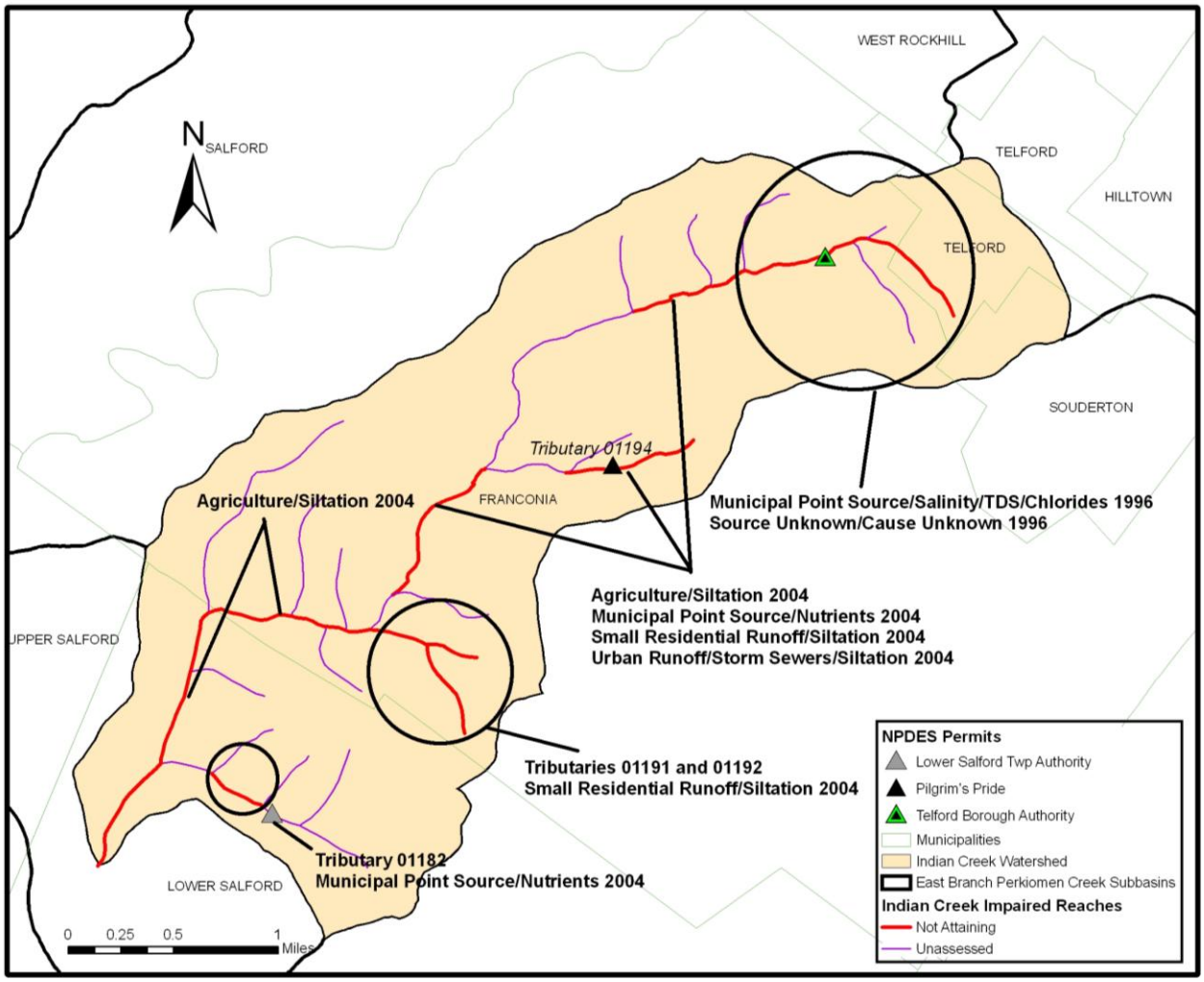


Figure 1-2. 303(d) impaired reaches in the Indian Creek watershed.

1.3. Water Quality Standards

Applicable water quality standards for streams across Pennsylvania are included in Pennsylvania's Water Quality Standards at 25 PA Code, Chapter 93. The designated use for streams in the Indian Creek Watershed is to provide habitat and appropriate ecological services as a trout stocking fishery (TSF). Numeric criteria applicable to Indian Creek and its tributaries and the related impairments include the following DO criteria:

- February 1–July 31: Maintain a minimum daily average of 6.0 mg/l with a daily minimum of 5.0 mg/l
- August 1–January 31: Maintain a minimum daily average of 5.0 mg/l with a daily minimum of 4.0 mg/l

Pennsylvania does not currently have specific numeric water quality criteria for nutrients and sediments. However, narrative water quality criteria exist (25 PA Code Chapter 93.6 (a and b)) which state: ―Water may not contain substances attributable to point or nonpoint source discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant

or aquatic life;" and "In addition to other substances listed within or addressed by this chapter, specific substances to be controlled include, but are not limited to, floating materials, oil, grease, scum and substances which produce color, tastes, orders, turbidity or settle to form deposits." Excessive nutrient concentrations in streams and rivers contribute to algal blooms and other conditions associated with eutrophication.

1.4. TMDL Targets

To meet the designated aquatic life uses of Indian Creek and its tributaries, numeric endpoints for sediment and for nutrient related parameters were identified. A reference approach was used for identifying the sediment target. Nutrient targets were developed based on a separate study that applied a weight of evidence approach, combining multiple analytical techniques to identify appropriate nutrient endpoints for the TMDL as discussed in Section 1.4.2. The nutrient endpoint for this TMDL consists of the average seasonal total phosphorus (TP) concentration associated with unimpaired aquatic life uses. Additional detail regarding derivation of the TMDL endpoints is provided in the following paragraphs.

1.4.1. Sediment TMDL Target

Because Pennsylvania water quality standard regulations do not currently include numeric criteria for sediment, EPA used the "reference watershed" approach to develop the allowable loading rates to protect designated uses in Indian Creek.

Reference Watershed Approach

The reference watershed approach is used to estimate the necessary load reduction of sediment that would be needed to restore a healthy aquatic community and allow the streams in the watershed to achieve their designated uses. The reference watershed approach is based on determining the current loading rates for the pollutants of interest from a selected unimpaired watershed that has similar physical characteristics (i.e., land use, soils, size, geology) to those of the impaired watershed.

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 cover and land use characteristics. Other features, such as base geologic formation, soils, percent slope, land use, and ecoregion, should be matched to the extent possible. The objective of this process is to reduce the loading rate of sediment (or other pollutant) in the impaired stream segment to a level equivalent to or slightly lower than the loading rate in the unimpaired reference stream segment. Achieving the sediment loadings set forth in the TMDLs will ensure that the designated aquatic life of the impaired stream is achieved.

Selected Reference Watershed and TMDL Targets

The TMDL targets established for the Indian Creek sediment TMDL were determined using Ironworks Creek as the reference watershed. Ironworks Creek is a subwatershed of the Wissahickon Creek watershed and was also used to establish the reference conditions for the Wissahickon Creek sediment TMDL. The TMDL process uses loading rates in the non-impaired watersheds as targets for loading reductions in the impaired watersheds. The reference watershed was chosen based on the fact that it was an urban watershed that was not impaired by siltation and had similar physical characteristics to the Indian Creek watershed (i.e., watershed size, land use/cover, soils, geology, ecoregion). Table 1-2 presents the characteristics of both the Indian Creek and Ironworks Creek watersheds.

The sediment delivery ratios for the Indian Creek watershed and its reference watershed were 0.19 and 0.18, respectively. Table 1-3 shows the sediment endpoints used to develop the sediment TMDL for Indian Creek.

Table 1-2. Impaired and reference watershed comparison

Characteristic	Indian Creek	Ironworks Creek
Watershed Type	*Impaired Watershed*	*Reference Watershed*
Watershed Size (acres)	4,480	11,114
Geologic Province	Piedmont	Piedmont
Dominant Rock Types	Shale	Sandstone/Metamorphic-Igneous
Dominant Soils	C	C & B
Ecoregions	Triassic Lowlands Piedmont Uplands	Triassic Lowlands Piedmont Uplands
Percent Slope of Watershed	0.71%	0.63%
Point Sources	3	0
Percent Urban	40.35%	44%
Percent Forested	4.94%	31%
Percent Land Use:		
Low Intensity Development	19.16%	39.8%
High Intensity Development	22.52%	4.2%
Hay/Pasture	36.13%	11.7%
Cropland	16.76%	10.9%
Conifer Forest	0.04%	1.8%
Mixed Forest	0.0%	10.3%
Deciduous Forest	4.9%	19.6%
Bare Rock/Sand/Clay	0.27%	0.0%
Wetlands	0.23%	0.0%
Transitional		0.1%

Table 1-3. Sediment Endpoints Established for Indian Creek Sediment TMDL

Land Use	Unit Area Loading (lb/ac/yr)
Low-Intensity Residential	124.12
High-Intensity Residential/Urban	105.12
Hay/Pasture	51.60
Row Crops	464.28
Coniferous Forest	3.13
Mixed Forest	3.99
Deciduous Forest	5.43
Quarry	0.00
Coal Mines	0.00

1.4.2. Nutrient TMDL Targets

There are presently no numeric water quality criteria for nutrients defined by PADEP water quality standards for streams. As a result, adequately protective numeric endpoints for the TMDL were derived through a separate nutrient endpoint identification study supported by EPA to develop scientifically valid TMDL targets. The endpoint identification methodology relied on a multiple lines of evidence approach using frequency distribution based analysis, stressor-responses analyses, and literature based values. The resulting candidate values were then considered and a weight-of-evidence selection process applied to select the final endpoints. The endpoint development approach used was similar to that applied for nutrient criteria development to identify nutrient targets that would protect aquatic life uses. Data for the effort were collected from sites in Pennsylvania, Maryland and New Jersey, in the same ecoregion (Northern Piedmont) as Indian Creek.

For the frequency distribution based approach, water quality data was drawn from a variety of databases including the EPA STORET and Ecological Monitoring and Assessment Program (EMAP) databases, United States Geological Survey (USGS) National Water Inventory System (NWIS) and National Water Quality Assessment (NAWQA) program, and the Maryland Biological Stream Survey (MBSS) database. Two populations of sites were developed: sites for which nutrient samples were available (all sites), and sites for which watershed land cover was available and for which reference criteria could be applied (reference sites). Based on these populations, a 25th percentile nutrient concentration of TN and TP were calculated from all sites, and a 75th percentile of for TN and TP concentrations were calculated from reference sites. Results ranged from 1.3-1.5 mg/L for TN and 16-17 ug/L for TP.

Another approach used was the modeled reference expectation approach, under which reference conditions were predicted from current conditions. Using data from the MBSS, USGS NAWQA and EPA EMAP programs, and based on natural molar N:P ratios, a range between 2-37 ug/L of total phosphorus was identified.

Stressor-response approaches, which explore the relationships between response variables and nutrient concentrations, were used as another line of evidence to derive appropriate nutrient endpoints. Data (i.e., nutrients, periphyton, macroinvertebrate composition data, algal biomass, etc.) from EPA EMAP, USGS NAWQA, USGS National Water Information System (NWIS), EPA STORET, EPA national nutrient center (NNC) database, MBSS, and PADEP periphyton biomass data were used. Application of various data analysis techniques resulted in TP thresholds as identified in Table 1-4.

A literature review of several studies was also conducted in support of this effort. Various studies, EPA recommended nutrient thresholds, state nutrient criteria studies, etc. showed TP endpoints ranging between 13-100 ug/L TP.

Table 1-4. Total Phosphorus Endpoint Development Approaches

Approach		Total Phosphorus Endpoint (ug/L)
Category	**Name**	
Reference Approach	Reference Site 75th Percentile	16 - 17
	All Sites 25th Percentile	17
	Modeled Reference Expectation	2-37
Stressor-Response	Conditional Probability - EPT	38
	Conditional Probability - Clinger Taxa	39

	Conditional Probability - % Urban Intolerant	64
	Conditional Probability - Diatoms TSI	36
Mechanistic Models	Indian Creek	40
Other Literature	USEPA Recommended Regional Criteria	36
	Summarization of Several Studies	13-100

Using a weight-of-evidence approach, the above analyses were weighted based on their applicability and the strength of the analysis. The stressor-response analyses were weighted more heavily than the reference-approach analyses due to the linkage between nutrient concentrations to specific aquatic life (both invertebrate and algal) endpoints. Using invertebrate taxa metrics, conditional probability analyses evaluated those TP concentrations which increased the risk of exceeding degradation thresholds developed for these macroinvertebrate metrics in comparable piedmont streams in Maryland. For the diatom Tropic State Index (TSI), the same analysis was used to identify TP concentration associated with a shift from meso- to eutrophic conditions. The scientific literature was variably weighted, since it included data from regions proximate to Pennsylvania. Based on greater weight to stressor-response models, a TP endpoint of 40 ug/L was selected. This value is comparable to the majority of stressor-response analyses, on the high end of the reference approaches, and intermediate to the scientific literature values, but comparable to regionally relevant literature values.

Potential nitrogen endpoints for the TMDL were evaluated; however, the principal effort of the endpoint determination work was the development of total phosphorus endpoints. This was principally due to the fact that TP was assessed as the cause of impairment. Analyses support the conclusion that these streams are P limited, based on instream N:P molar ratios evaluated against Redfield. The distributional statistics of N:P ratios taken from more than 552 stream sites across the northern piedmont region in Pennsylvania and Maryland are shown in Table 1-5.

Table 1-5. N:P Ratio statistics for streams in Northern Piedmont

Statistics for N:P Ratios in Northern Piedmont Sites in Pennsylvania and Maryland (N=552)	
	N:P Ratio
Minimum	5
5th Percentile	17
10th Percentile	25
25th Percentile	57
Median	158
Average	259

The critical Redfield ratio is 16:1, values below indicating N limitation and those above, P limitation. Ratios have to be considered in relation to supply and become less meaningful as nutrient supplies exceed uptake capacity of streams. Even so, clearly more than 95 percent of the streams are P limited.

Because these systems are not N limited, relationships between TN and response measures are more questionable. The fact that N is not limiting also means that TN contributes less to use impairment in this region. Endpoints are best derived when clear connections to use impairment can be made. Seeing that there are less clear connections with TN and stream impairment in this region, enpoints for TN were not specified for the TMDL.

The selected TP endpoint would be applied as an average concentration during the growing season from April to October, which in streams is typically the time during which the greatest risk of deleterious algal growth exists. A seasonal sample period is more appropriate than an annual or daily timeframe for this reason.

A more detailed description of the analyses and conclusions described above can be found in a summary report entitled, *Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application* (Paul and Zheng, 2007).

Based on results and recommendations of the nutrient endpoint identification study, the TP endpoint for the Indian Creek TMDL is listed in Table 1-6.

Table 1-6. Nutrient Endpoint Established for Indian Creek Nutrient TMDL

Parameter	Average Concentration	Applicable Period
TP	40 ug/L	April 1 – October 31

In addition, water quality must also meet applicable dissolved oxygen criteria in stream.

Table 1-7. Applicable DO criteria

Daily Average	Daily Minimum	Period
6.0 mg/L	5.0 mg/L	February 1–July 31
5.0 mg/L	4.0 mg/L	August 1–January 31

2. DATA INVENTORY AND ANALYSIS

To evaluate conditions throughout the watershed, chemical and physical data collected at various locations along the mainstem and tributaries were analyzed. USGS flow gauging station data and weather station data were also evaluated to support this analysis. To evaluate point source contributions in greater detail, discharge monitoring reports (DMR) were obtained for active point source dischargers in the watershed. Chemical and biological ambient monitoring data collected by PADEP upstream and downstream of these point sources were also evaluated; the results of these efforts are summarized in Appendix A.

2.1. Stream Flow and Climate Data

Flow likely affects water quality in streams, by regulating concentrations and in stream processes. Most of the time, stream flow is driven by precipitation patterns and ground water contributions. Precipitation plays a critical role in nonpoint source pollution, where it washes away the unassimilated nutrients from the terrestrial environment to streams during wet weather conditions. However, during dry weather periods, the system behaves differently. As a result, assessment of stream flow and precipitation pattern is a critical link in TMDL development and water quality analysis.

To assess hydrologic conditions of the Indian Creek Watershed, flow data were obtained from the USGS gauging station 01472810, one of the nearest gauging stations to the Indian Creek watershed. It is located on East Branch Perkiomen Creek near Schwenksville, Pennsylvania, and drains approximately 58.7 square miles. Rainfall data were obtained from the National Climate Data Center (NCDC) Station PA-3437, the nearest weather station to the Indian Creek watershed outlet. Figure 2-1 shows the monthly average values of precipitation and flow for a ten year period from 1995 to 2004. It can be seen that the lowest flows are during the summer period (July-August) and high flows are experienced during winter and early spring.

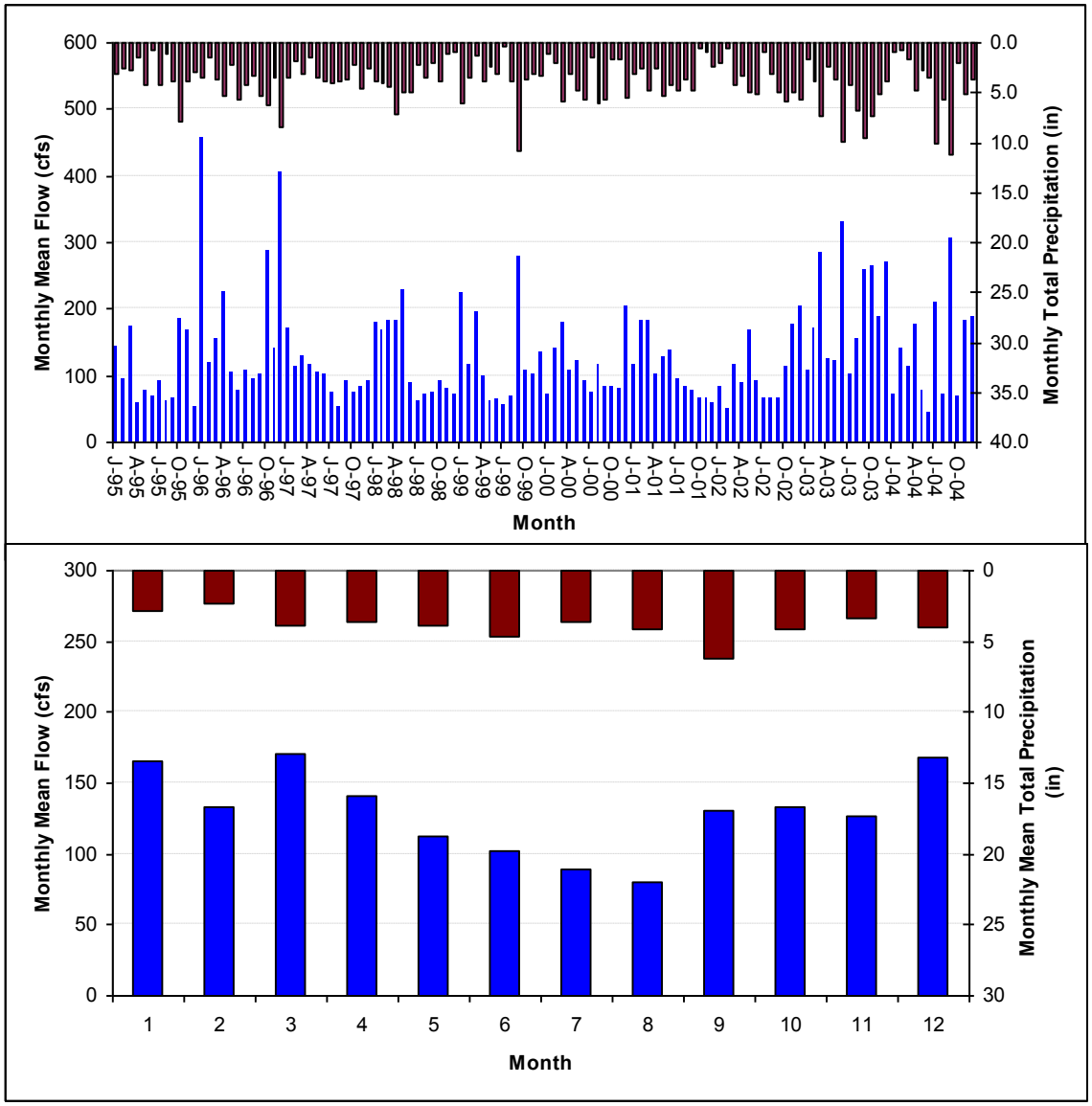


Figure 2-1. Historical precipitation (PA 3437) and flow (USGS 01472810) from 1995 to 2004.

2.2. PADEP Pre-TMDL Monitoring Data

A review of available data in the Indian Creek watershed (DMR data and the ambient monitoring above and below the Telford and Salford NPDES facilities) resulted in the determination that additional monitoring was needed to support TMDL development. EPA provided a monitoring strategy to PADEP for additional data collection. On May 9, 10, and 11, 2006 additional data were collected by PADEP for the Indian Creek Watershed at various locations (Figure 2-2). Various physical parameters such as dissolved oxygen (DO) (mg/l), Temperature (C), pH, Conductivity (mS/cm), Salinity (ppt), and TDS (g/l) were collected by YSI sondes at 3 minute intervals during a 48-hour period. This section discusses the DO and nutrient data collected in Indian Creek.

Plotting DO (mg/l) against time (hours) shows a clear diurnal pattern (Figure 2-3) for all of the sites. The Pilgrims Pride site was the only sampling site where DO was always above daily average DO criteria. For all sites in the watershed, minimum DO concentrations tend to occur between the hours of 11:00 PM and 7:00 AM. DO concentrations rise from approximately 6:00/7:00 AM until about noon, after which they begin to fall. These fluctuations indicate that biological activity is likely a factor because minimum DO levels at two stations, Bergey and Godshall, were significantly lower than the rest of the stations on the second day of monitoring. These two stations bracket the golf course upstream and downstream, respectively.

Similarly, DO saturation was plotted against time (Figure 2-4). A clear diurnal cycle was noted for all of the sites. DO saturation was above 100% during most of the day time, suggesting high biological activity (i.e., aquatic plant/algae growth). During the day, algae use CO_2, releasing O_2 to the stream, and use O_2 at night, releasing CO_2 to the stream. Anecdotal reports by PADEP sampling staff indicated that significant algal biomass was present throughout the watershed at the time of sampling. DO saturation was less than 100% during night time hours. Minimum DO saturation levels at two stations, Bergey and Godshall, were significantly lower than the rest of the stations on the second day of monitoring.

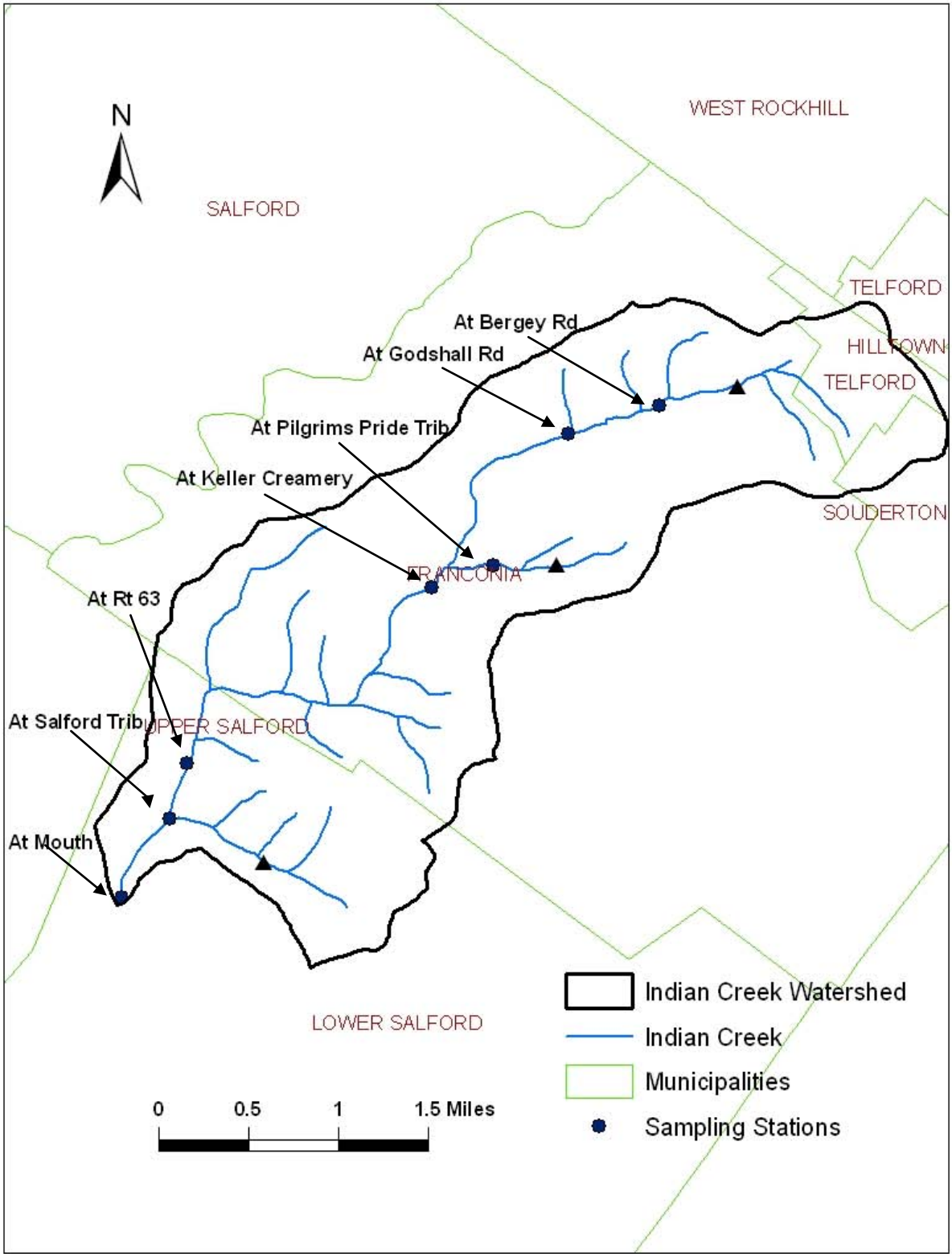


Figure 2-2. Diurnal monitoring locations.

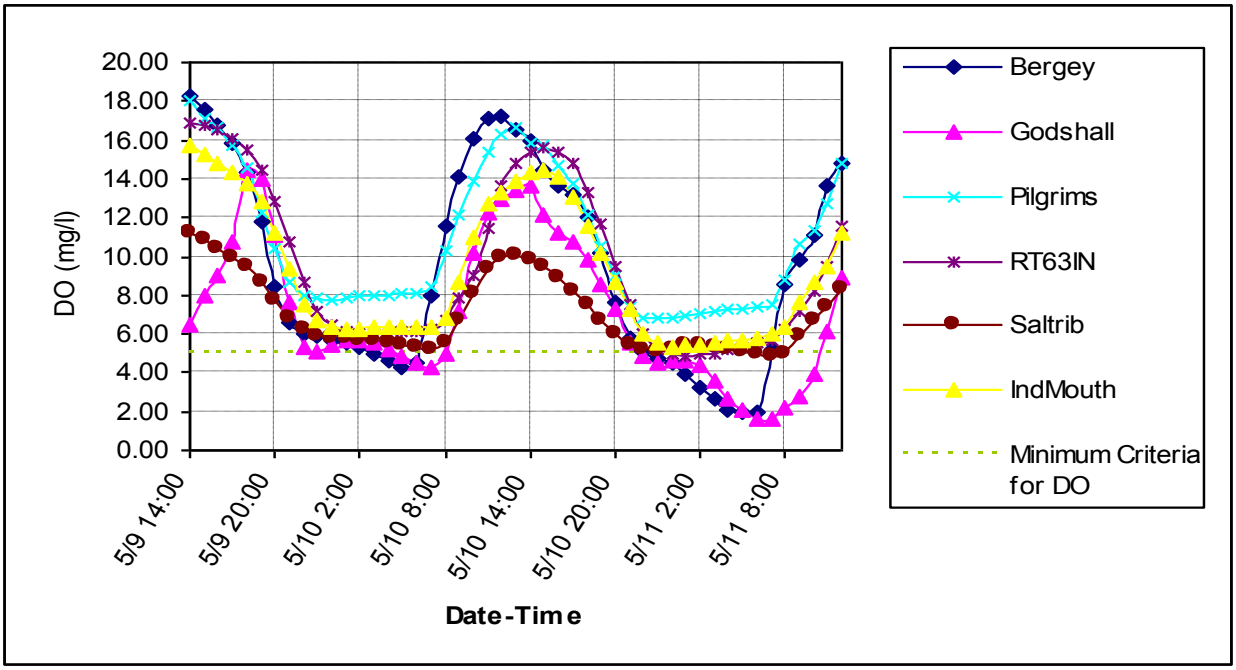


Figure 2-3. Diurnal DO (mg/l) patterns at Indian Creek monitoring locations.

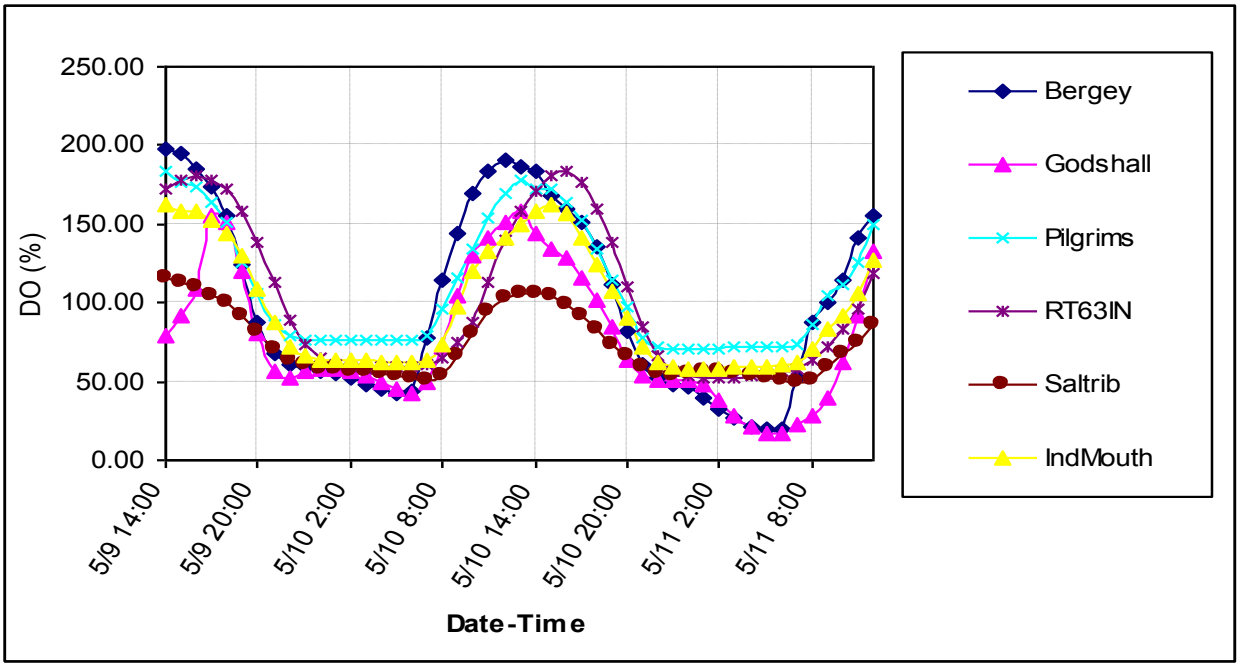


Figure 2-4. Diurnal DO (%) patterns at Indian Creek monitoring locations.

Longitudinal analysis of the water quality data was conducted to assess the variation in these parameters from the headwaters to the mouth. For this analysis, each 3 minute interval of data was averaged over three hours (for better graphical representation) to represent one data point. As shown in Figure 2-5, there is an apparent decrease in DO (mg/l) concentration at the Godshall sampling site. Concentrations then rebounded or remained similar moving downstream of the Godshall site until the next sampling site at the mouth of Indian Creek. The drop in DO concentration at this location indicates that the golf course activities are likely impacting water quality. Either water use by the golf course or other conditions related to golf course operations could be contributing to the DO drop. At the time of sampling, PADEP staff witnessed grass clippings having been disposed of directly in the stream (personal communication with PADEP staff). Longitudinally, most DO concentrations remained above the minimum DO criteria of 5 mg/l.

Chemical data were collected along with physical data. Samples were collected for chemical analysis on May 11, 2006 at various sites in Indian Creek. Longitudinal analysis was conducted for various water quality constituents such as BOD, total suspended solids, dissolved phosphorous, dissolved nitrogen, total nitrogen, alkalinity, total ortho phosphorous, dissolved ortho phosphorous, total phosphorous, nitrate + nitrite, and ammonia.

Figure 2-6 presents the longitudinal analysis of BOD data collected on May 11, 2006, showing the highest level of BOD at the Bergey Road site (possibly related to discharge associated with the Telford facility). BOD then decreases downstream. Total suspended solids remained similar from the headwaters until the Keller Creamery site, and then exhibited a slight increase at the Rt. 63 site (Figure 2-7). The ammonia-N concentration increased at Godshall but was relatively consistent for the rest of the creek (Figure 2-8)**.** Longitudinal analysis for the sampling period shows similar patterns for dissolved phosphorous, dissolved nitrogen, total nitrogen, total ortho phosphorous, dissolved ortho phosphorous, total phosphorous, and nitrate + nitrite (Figures 2-9 to 2-15). After seeing high values at the Bergey Road site, levels tend to decrease along the mainstem to the sampling station at Rt. 63. Then, an increase is seen in nutrient levels between the Rt. 63 station and the sampling station at the mouth of Indian Creek. This increase may be attributable to inputs from the tributary on which the Lower Salford facility is located (trib 01182).

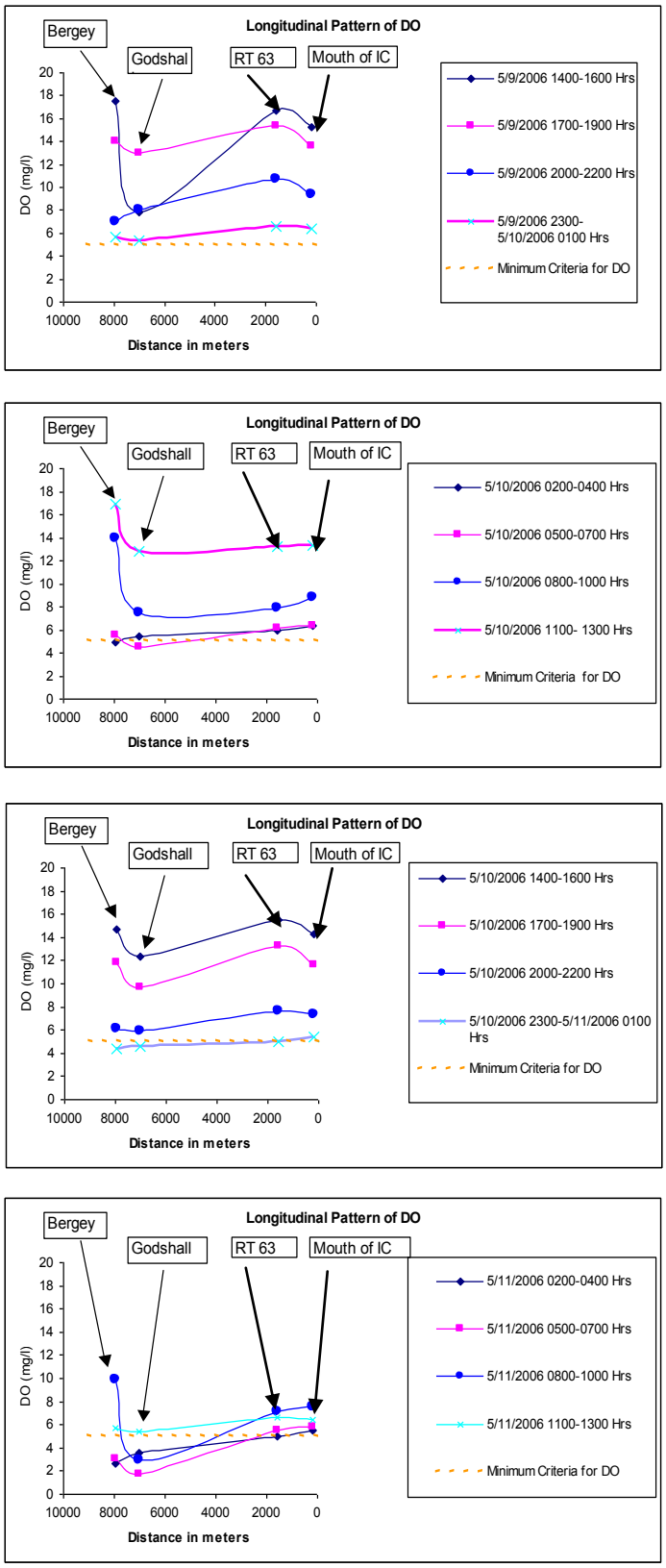


Figure 2-5. Longitudinal DO patterns in different time intervals at monitoring locations.

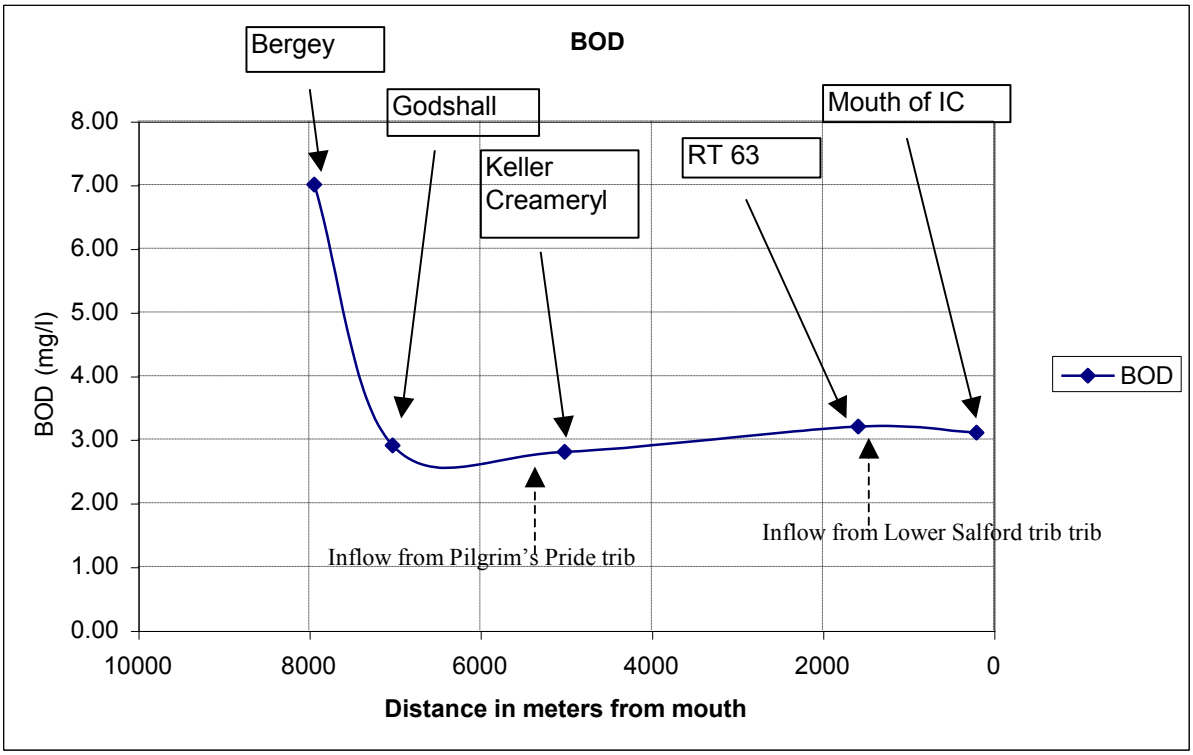


Figure 2-6. Longitudinal BOD patterns at Indian Creek sampling locations.

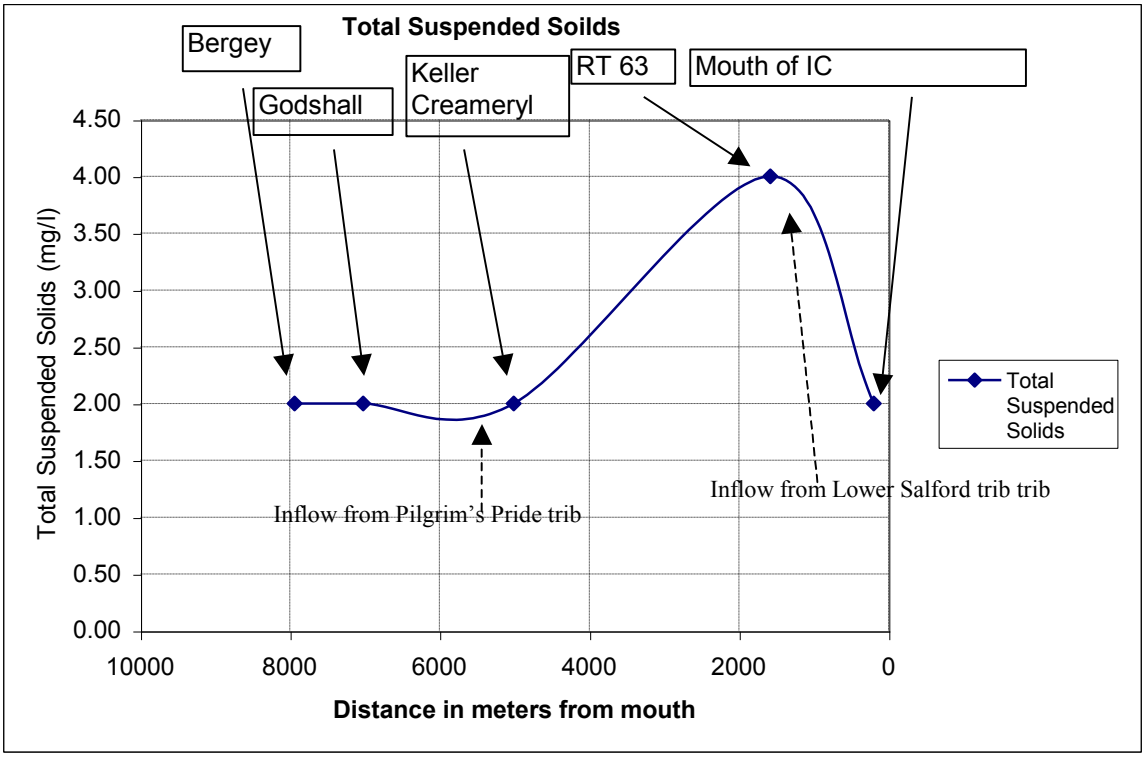


Figure 2-7. Longitudinal total suspended solids patterns at Indian Creek sampling locations.

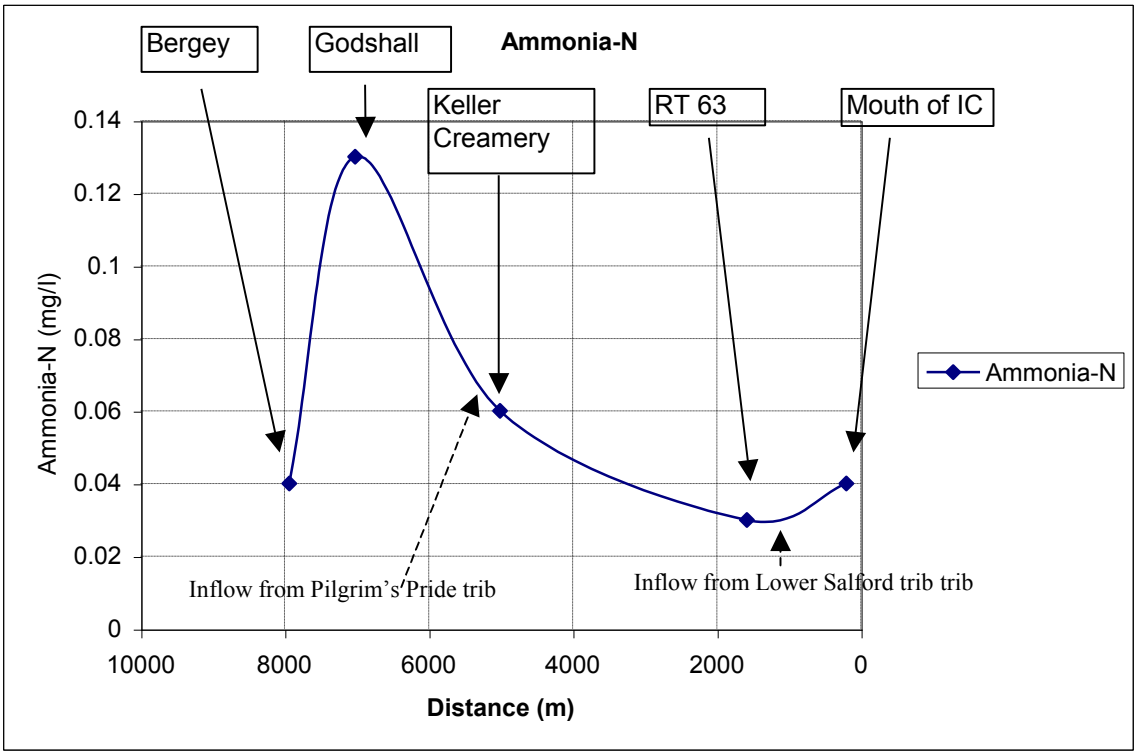


Figure 2-8. Longitudinal ammonia patterns at Indian Creek sampling locations.

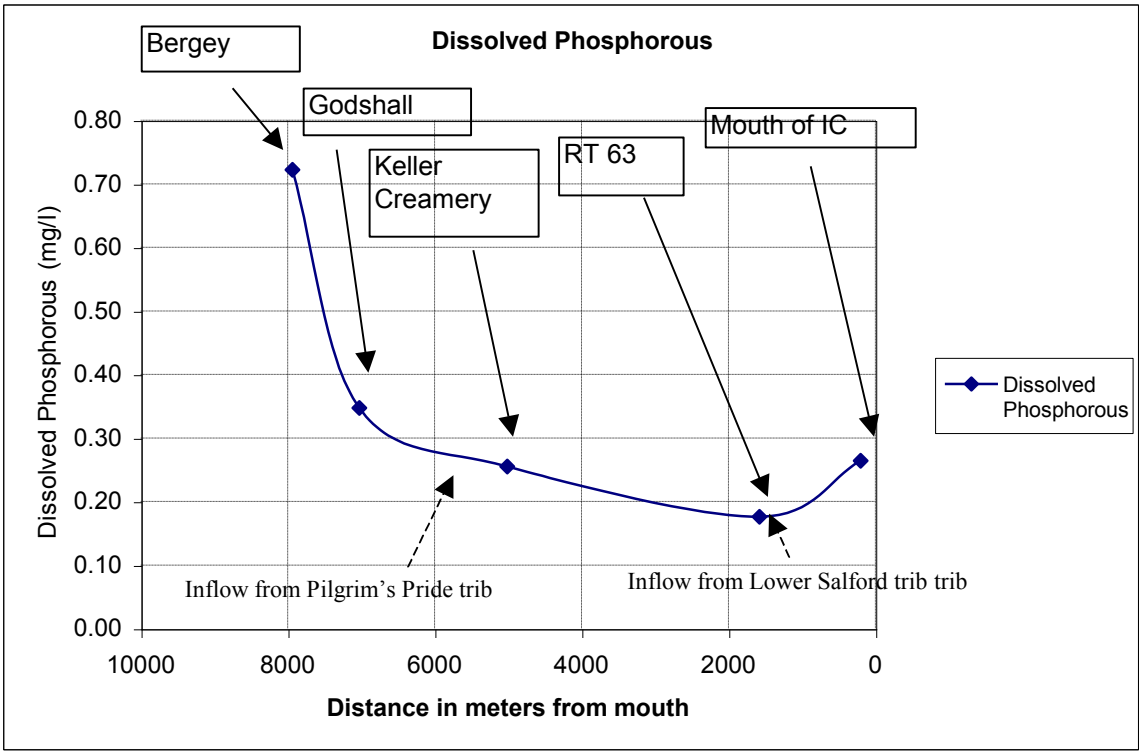


Figure 2-9. Longitudinal dissolved phosphorus patterns at Indian Creek sampling locations.

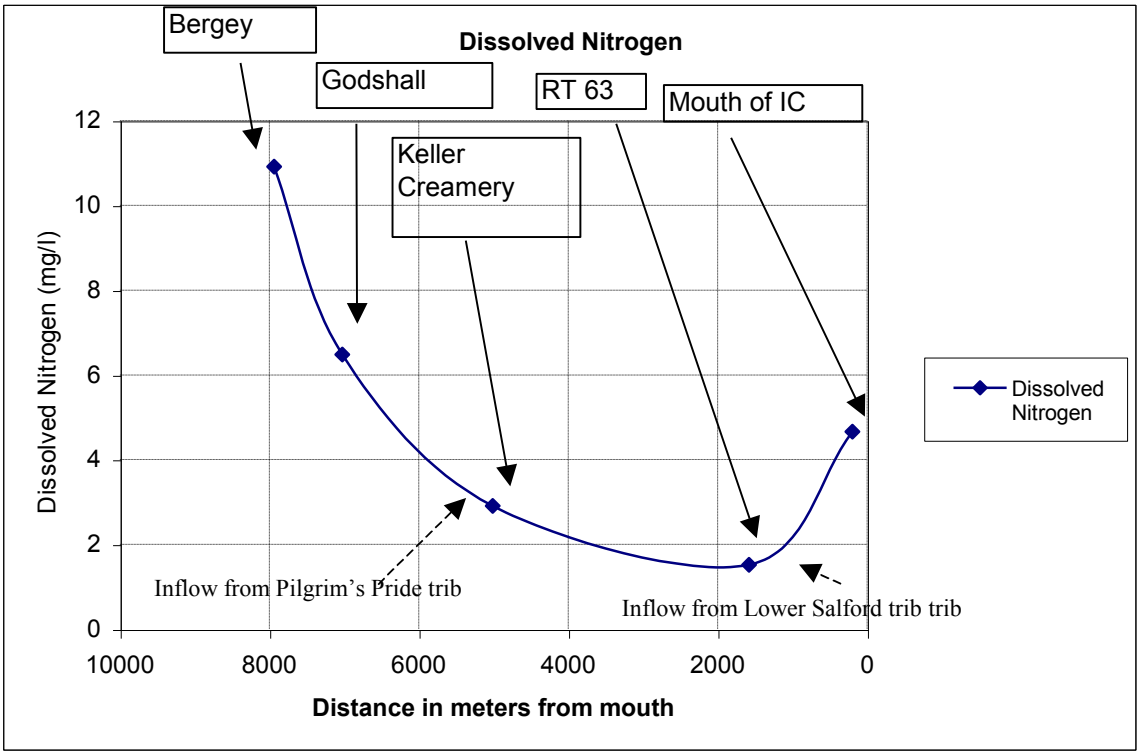


Figure 2-10. Longitudinal dissolved nitrogen patterns at Indian Creek sampling locations.

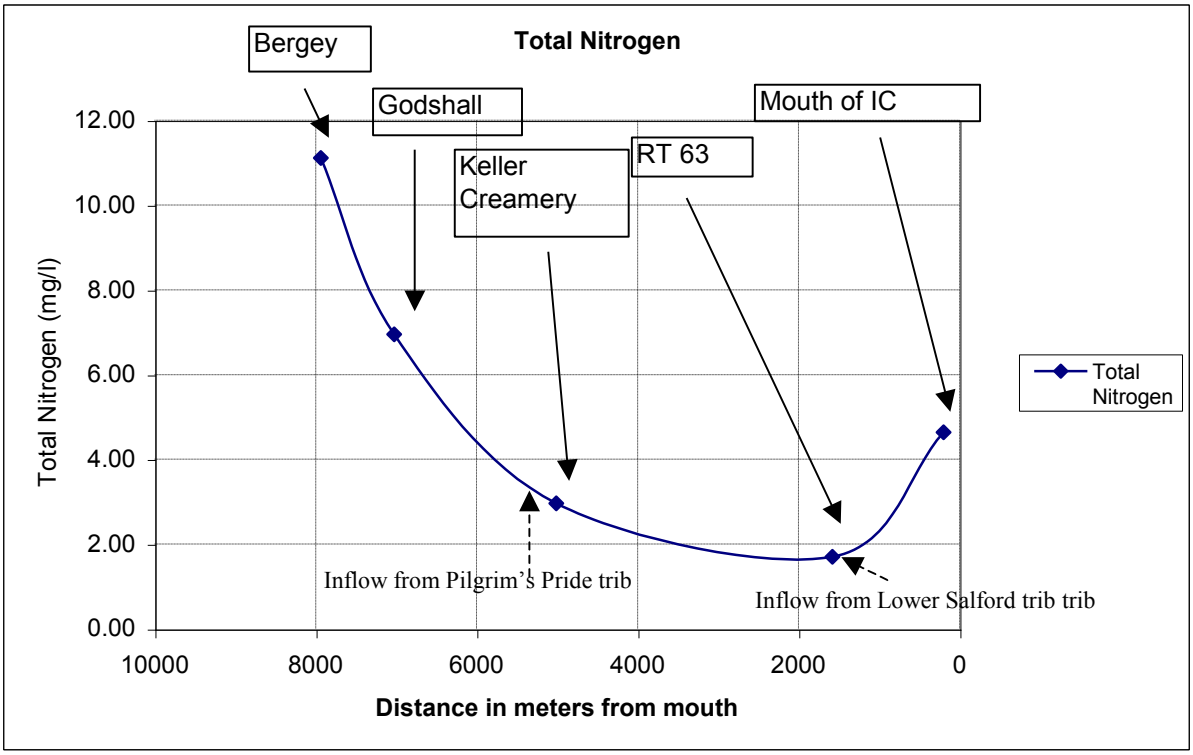


Figure 2-11. Longitudinal total nitrogen patterns at Indian Creek sampling locations.

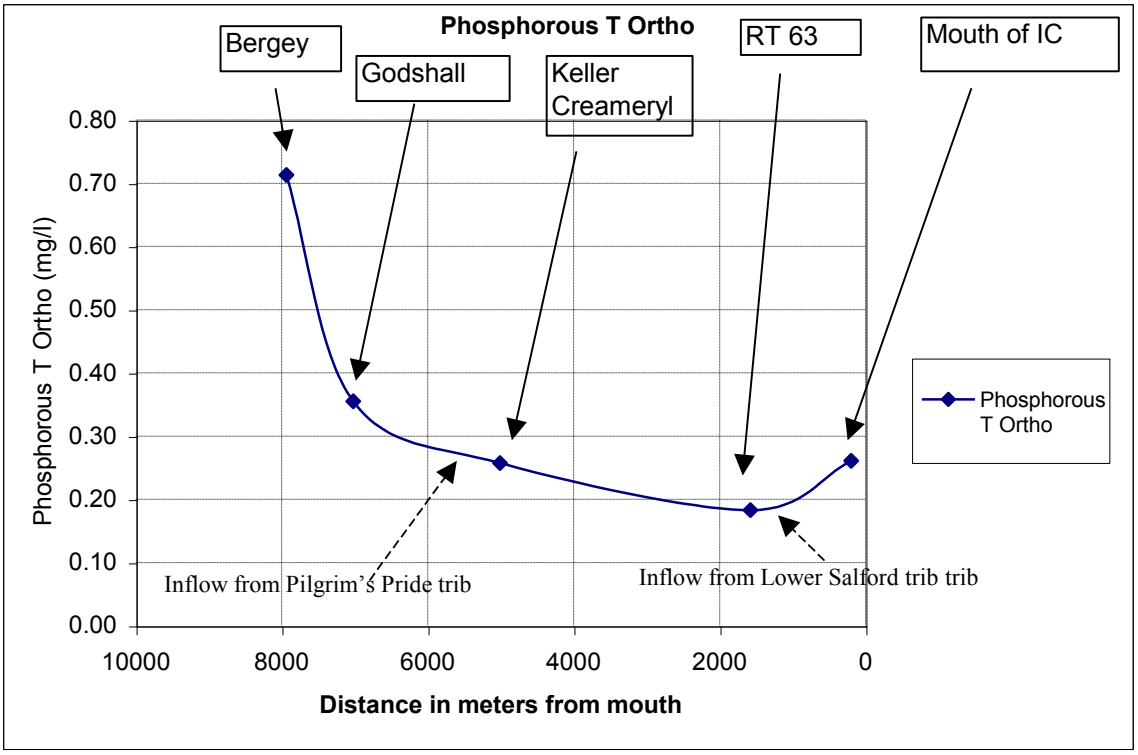


Figure 2-12. Longitudinal total ortho phosphorus patterns at Indian Creek sampling locations.

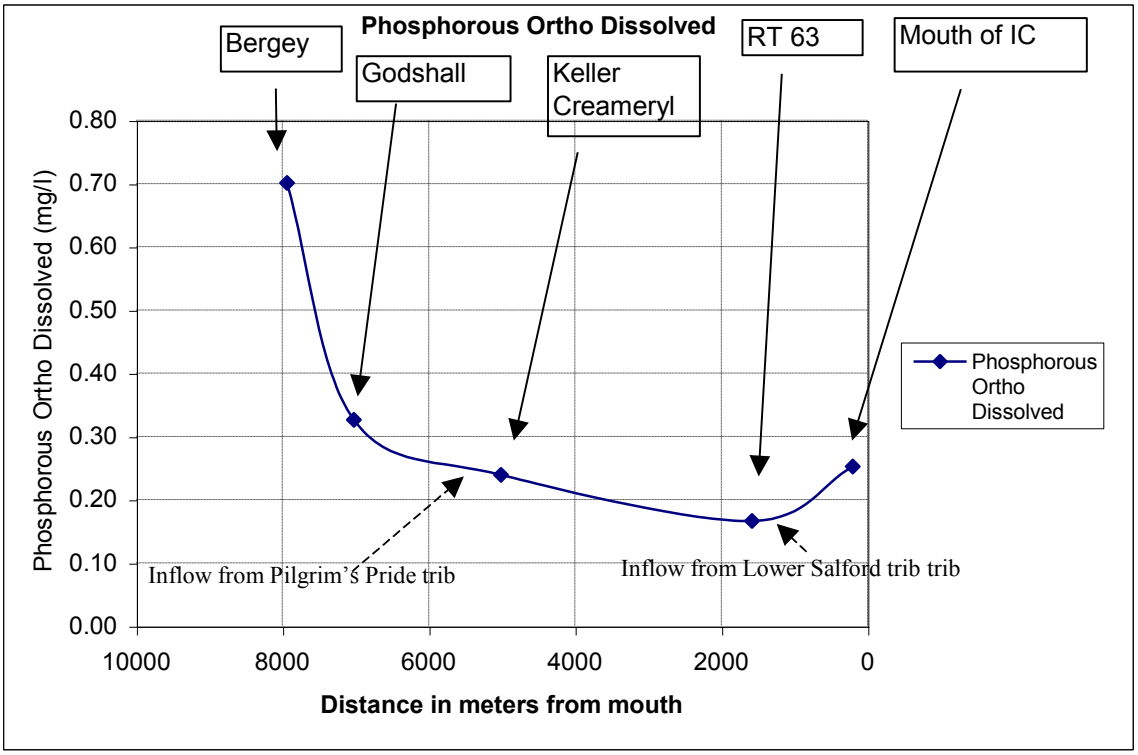


Figure 2-13. Longitudinal dissolved ortho phosphorus patterns at Indian Creek sampling locations.

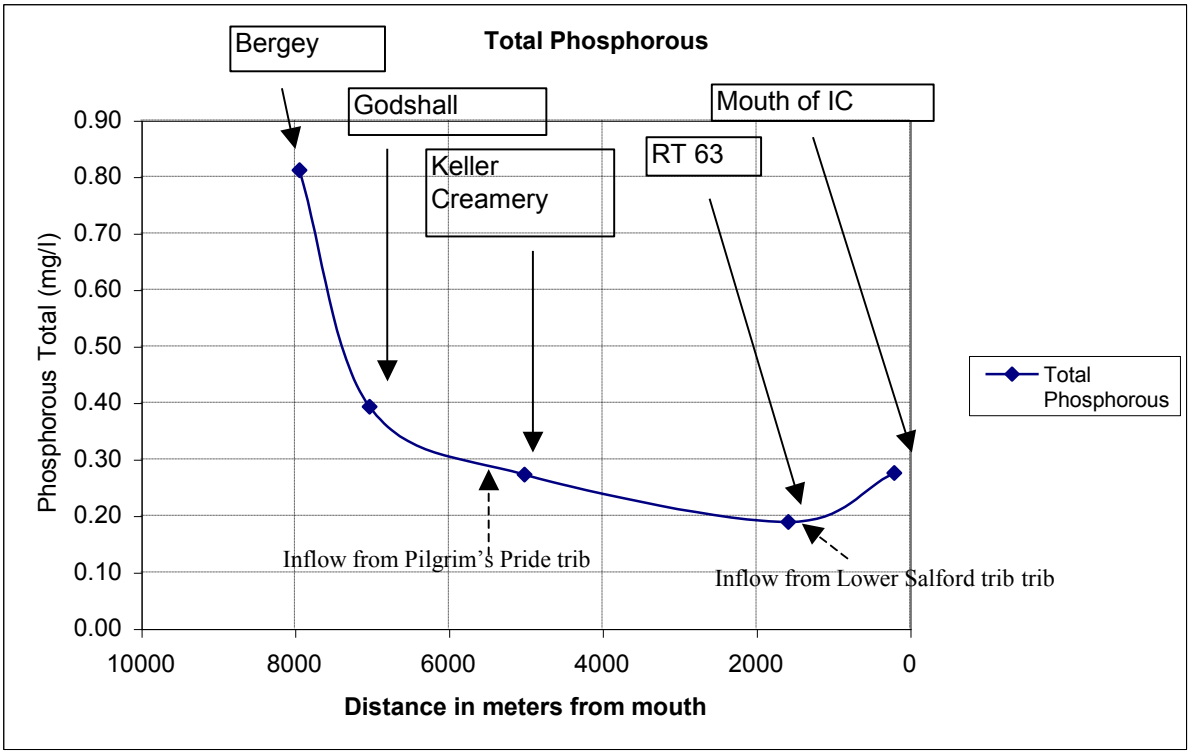


Figure 2-14. Longitudinal total phosphorus patterns at Indian Creek sampling locations.

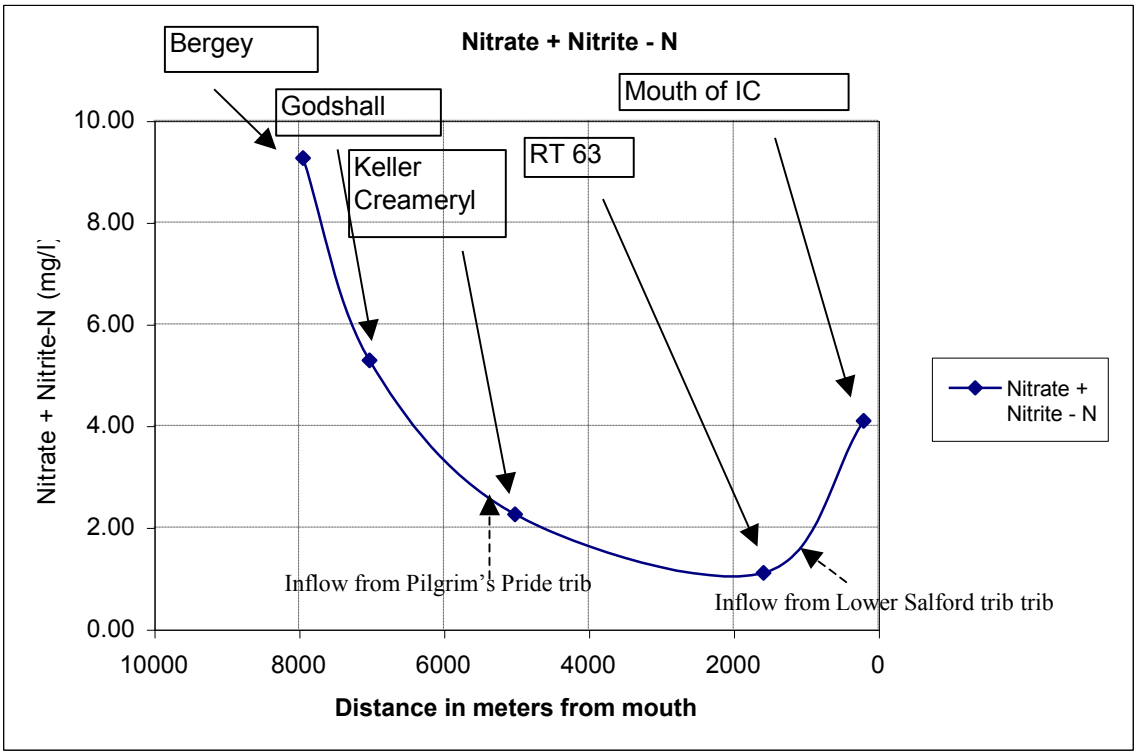


Figure 2-15. Longitudinal nitrate + nitrite - N patterns at Indian Creek sampling locations.

Table 2-1 shows concentrations of various constituents at the Pilgrims Pride and the Lower Salford tributaries, which both receive discharges from point sources. The table shows higher total suspended solids and alkalinity at Pilgrims Pride relative to the Lower Salford site; however, dissolved nitrogen, total nitrogen, and nitrate + nitrite – N are higher at the Lower Salford site.

Table 2-1. Concentration of Various Constituents in Indian Creek Tributaries

Concentration (mg/l)	Pilgrims Pride	Lower Salford Tributary
BOD	2.400	2.500
Total Suspended Solids	6.000	2.000
Dissolved Phosphorous	0.155	0.669
Dissolved Nitrogen	5.840	19.890
Total Nitrogen	5.810	19.980
Alkalinity	140.000	52.600
Phosphorous T Ortho	0.163	0.667
Phosphorous Ortho Dissolved	0.146	0.652
Phosphorous Total	0.173	0.720
Nitrate + Nitrite - N	5.200	18.600
Ammonia-N	0.020	0.070

Table 2-2 shows concentrations of various constituents at Rt. 63, Lower Salford, and at the mouth of Indian Creek. Concentrations of each of the listed constituents in the table increased from Rt. 63 to the mouth of Indian Creek which may be attributed to input from the Lower Salford tributary. Concentrations measured at Lower Salford trib were greater than concentrations at both Rt. 63 and at the mouth of Indian Creek. Additionally, concentrations at the mouth of Indian Creek were greater than concentrations at Rt. 63.

Table 2-2. Comparison of Chemical Data (mg/l) at Rt 63, Salford Tributary, and Indian Creek Mouth

Parameter	Rt 63	Salford tributary	IC mouth
Dissolved Phosphorous	0.176	0.669	0.264
Ammonia-N	0.030	0.070	0.040
Dissolved Nitrogen	1.520	19.890	4.660
Total Nitrogen	1.700	19.980	4.640
Phosphorous T Ortho	0.183	0.667	0.261
Phosphorous Ortho Dissolved	0.166	0.652	0.252
Phosphorous Total	0.188	0.720	0.275
Nitrate + Nitrite - N	1.100	18.600	4.090

3. SOURCE ASSESSMENT

This section presents the information on point and nonpoint sources of nutrients and sediment in the Indian Creek watershed.

3.1. Nonpoint Sources

In addition to point sources, nonpoint sources are expected to contribute to water quality impairments in the Indian Creek watershed. Nonpoint sources represent contributions from diffuse, non-permitted sources. Typically, nonpoint sources are precipitation driven and occur as overland flow, which carries pollutants into streams. Nonpoint sources also include non-precipitation driven events such as contributions from groundwater, septic systems, or direct deposition of pollutants from wildlife and livestock.

3.1.1. Agriculture

Agricultural lands can be a significant source nutrient loading to streams. Runoff from pastures and crop lands, livestock operations, improper land application of animal wastes and fertilizers, and erosion are all agricultural sources of nutrients. Agricultural Best Management Practices (BMPs) such as buffer strips, and the proper land application of manures and fertilizers reduce nutrient loading to waterbodies.

Based on the 2001 NLCD land use coverage available for the Indian Creek watershed, approximately 53% of the watershed can be classified as either row crop area or pasture. Manure and biosolids are applied to agricultural lands in the watershed.

3.1.2. Biosolids

The application of bio-solids to lands in the watershed represents another potentially significant source of phosphorous and other nutrients to Indian Creek. Such activities are permitted by PADEP through the Waste Management Municipal Waste Program; a facility associated with the program is known as a Municipal Waste Operation (MWO). Pennsylvania's eMap PA website (http://www.emappa.dep.state.pa.us/emappa/viewer.htm) was accessed for an initial assessment of locations in the Indian Creek watershed associated with MWOs. Sub-facility types related to MWOs that are included in eMapPA are:

- Composting
- Land Application
- Abandoned Landfills
- Active Landfills
- Processing Facility
- Resource Recovery
- Transfer Station

Based on the eMapPA database, the Indian Creek watershed contains eight sites associated with MWOs, only 3 of which are "Active" (Figure 3-1). All are categorized as land application activities, which may include facilities that use agricultural utilization or land reclamation of waste. This category generally applies to sewage sludge, which is land-applied for its nutrient value or as a soil conditioner. However, based on a questionnaire provided to the Montgomery County Conservation District, there is limited knowledge regarding application rates and practices.

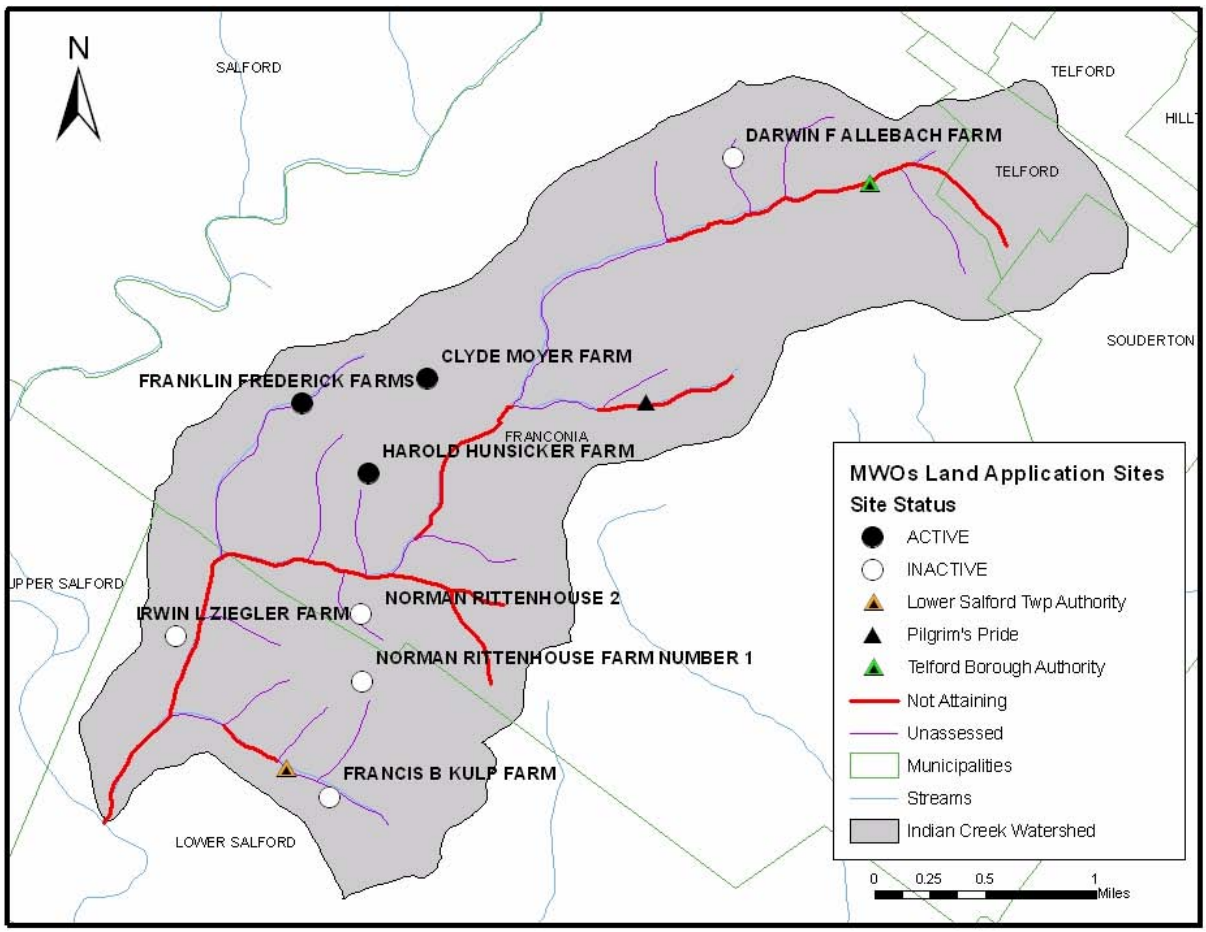


Figure 3-1. Land Application Sites (eMapPA).

These sites are associated with the Moyer Packing Company, a meat processing facility located to the east of the watershed. Activities most likely associated with these sites include application of food processing residual waste, which is required to be accomplished in accordance with the *Food Processing Residuals Manual*. The Manual contains certain performance requirements, such as use of the waste in the course of normal farming operations, nuisance prevention, metal loading rates, isolation distances, general site criteria, and the need to have a farm conservation plan (PADEP 2005).

3.1.3. Urban Runoff

Urban areas constitute a potentially significant source of nutrients carried to receiving waters through stormwater runoff. Due to the tendency of phosphorus to sorb to sediment particles, erosion may play a significant role as a phosphorus source to receiving waters. Excessive rates of fertilizer application to lawns, ballparks, and golf courses, etc., are another common source or nutrients to waterbodies from urban and developed areas. Much of the loading from urban areas is due simply to the increase in impervious surfaces relative to other land uses and the resulting increase in runoff. Higher percentages of impervious areas decrease the time required to reach peak stormwater discharge rates, increase flow velocities and exacerbate overland and in-stream erosion, further adding to potential sediment sorbed nutrient loads. In areas where onsite wastewater treatment is provided by septic systems, failures and malfunctioning systems may also pose a potential nutrient source. All of these are factors in the Indian Creek watershed.

3.1.4. Septic Systems

On-site septic systems have the potential to deliver nutrients to surface waters due to system failure and malfunction. Septic systems treat human waste using a collection system that discharges liquid waste into the soil through a series of distribution lines that comprise the drain field. In properly functioning (normal) systems, phosphates are adsorbed and retained by the soil as the effluent percolates through the soil to the shallow saturated zone. Therefore, normal systems do not contribute phosphorus loads to surface waters. A septic system failure occurs when there is a discharge of waste to the soil surface where it is available for washoff. As a result, failing septic systems can contribute high phosphorus and nitrogen loads to surface waters. Short-circuited systems (those located close to streams) and direct discharges also contribute significant nutrient loads.

Results from a sewer management study conducted by Franconia Township for its portion of the Indian Creek watershed, which covers approximately the middle 2/3 of the basin, indicate that failing and inadequate septic systems are a significant issue in portions of the Indian Creek basin (CMX 2008). Of the 409 lots with inspected septic systems, study results indicated that slightly over 20% were confirmed to be failing, with an additional 11% suspected of malfunctioning (i.e., show signs such as abnormally green grass overlying drain fields or piped discharges). While approximately 68% did not exhibit signs of failure at the time of inspection, given current permitting standards as well as soils and conditions in the watershed, approximately 47 % are considered to have a strong potential for future failure. In sum, only 21% of the systems inspected as part of the study are thought to be properly sited and performing adequately.

3.2. Point Sources

Point sources, according to 40 CFR § 122.3, are defined as any discernable, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. The National Pollutant Discharge Elimination System (NPDES) program, under Clean Water Act sections 318, 402, and 405, requires permits for the discharge of pollutants from point sources.

3.2.1. MS4s

In 1990, USEPA developed rules establishing Phase I of the NPDES storm water program, designed to prevent harmful pollutants from being washed by storm water runoff into Municipal Separate Storm Sewer Systems (MS4s) (or from being dumped directly into the MS4) and then discharged from the MS4 into local waterbodies. Phase I of the program required operators of "medium" and "large" MS4s (those generally serving populations of 100,000 or greater) to implement a storm water management program as a means to control polluted discharges from MS4s. Approved storm water management programs for medium and large MS4s are required to address a variety of water quality related issues including roadway runoff management, municipal owned operations, and hazardous waste treatment. There are no large or medium MS4s in the Indian Creek watershed.

Phase II of the rule extends coverage of the NPDES storm water program to certain "small" MS4s. Small MS4s are defined as any MS4 that is not a medium or large MS4 covered by Phase I of the NPDES Storm Water Program. Only a select subset of small MS4s, referred to as "regulated small MS4s," require an NPDES storm water permit. Regulated small MS4s are defined as all small MS4s located in "urbanized areas" as defined by the Bureau of the Census and those small MS4s located outside of an urbanized area that are designated by NPDES permitting authorities. There are four such regulated MS4s in the Indian

Creek watershed: Telford, Souderton, Franconia, and Lower Salford. As a condition of the MS4 permit, permittees are required to submit annual reports on permit activities in June of each year. The entire Indian Creek watershed falls within regulated MS4 areas.

3.2.2. NPDES Permitted Facilities

The permitted point sources in the Indian Creek watershed include two municipal sewage treatment plants (STP) in Telford and Lower Salford and a meat processing facility, Pilgrims Pride. PADEP provided permit limits and discharge monitoring report (DMR) data for the three NPDES permitted facilities in the Indian Creek watershed for the period of January 2001 to September 2005 for Telford (PA 0036978) and Pilgrims Pride (PA0054950) and January 2001 to February 2005 for Lower Salford (PA0024422). The three facilities and their nutrient and sediment limits are shown in Table 2-3. Spatially, the Telford STP is located most upstream in the Indian Creek watershed, the Pilgrims Pride discharge in the middle (on Trib-01194), and the Lower Salford STP is located most downstream on Trib-01182 (see Figure 1-1). While there are seasonal limits for NH_3-N for all three facilities PO_4-P and TP limits exist only for the period of April to October. Telford has a TP limit while Pilgrims Pride and the Lower Salford facilities have been given limits for PO_4-P (Table 3-1). Year round TSS limits also exist for all three facilities, with Pilgrims Pride having the most stringent TSS limit of 10 mg/L compared to 30 mg/L for the other two facilities.

Table 3-1. Nutrient Permit Limits for NPDES Facilities in the Indian Creek Watershed

Facility Limits				
Parameter	**Period**	**Telford (PA0036978)**	**Pilgrims Pride (PA0054950)**	**Lower Salford (PA0024422)**
Flow (MGD)	January-December	1.1	Report	0.7
Pas PO4 (mg/l)	April – October	No limit	2.0	0.5
TP (mg/l)	April – October	1.7	No limit	No limit
NH_3-N (mg/l)	May – October	1.5	3.0	1.5
NH_3-N (mg/l)	November – April	3.0	9.0	3.0
TSS (mg/L)	January-December	30	10	30

Telford

For the period April 2001-October 2001, the Telford facility had a discharge limit for TP of 1.7 mg/L; no TP limit exists for the rest of the year. Based on DMR data, in May 2002, July 2004, and June 2005, TP concentrations violated permit limits by 0.1 mg/l, 0.4 mg/l, and 0.6 mg/l, respectively. NH_3-N concentrations were well within permit limits. The TSS limit was not exceeded. Figure 3-2 shows the DMR data and permit limits for the Telford facility.

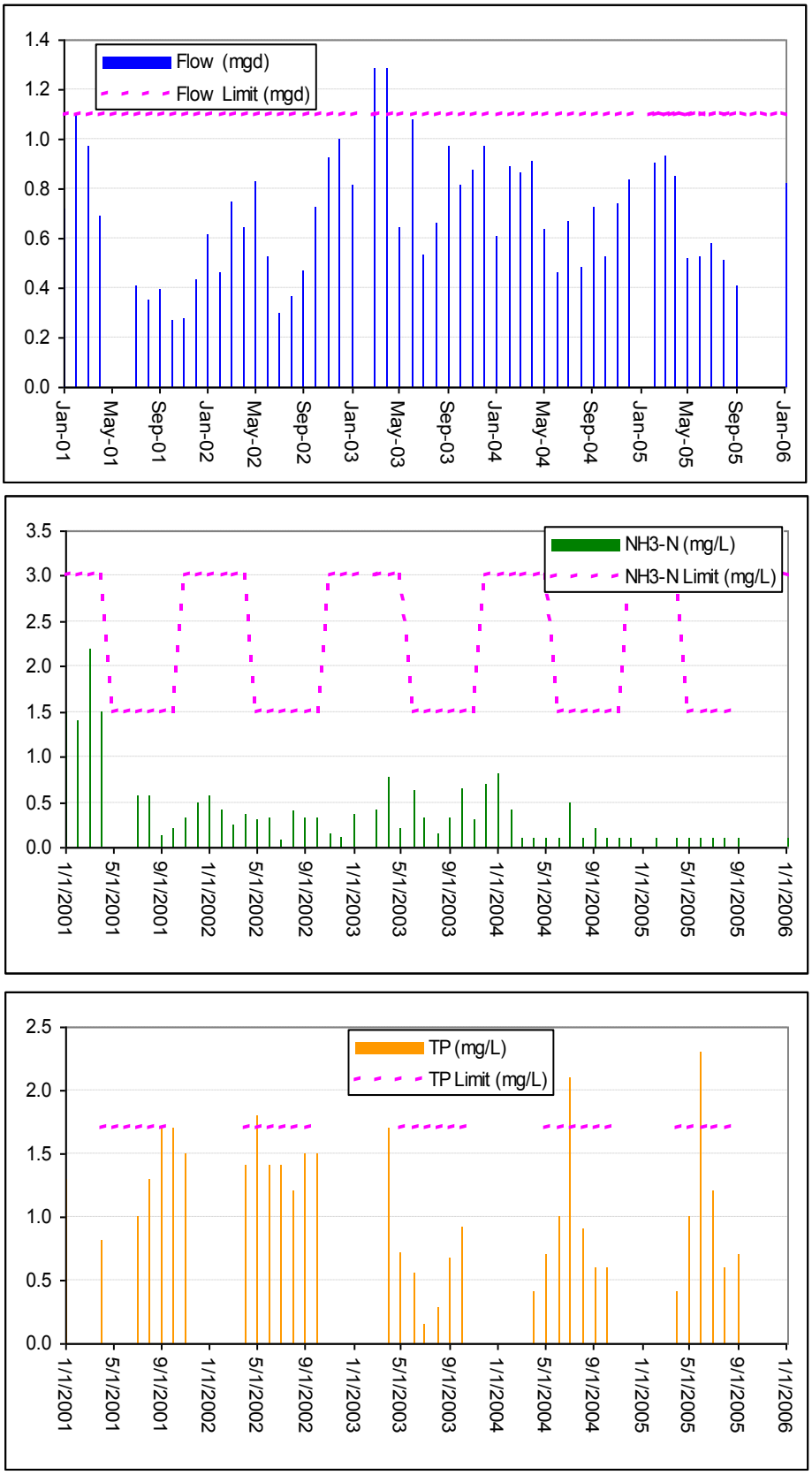


Figure 3-2. Telford DMR data.

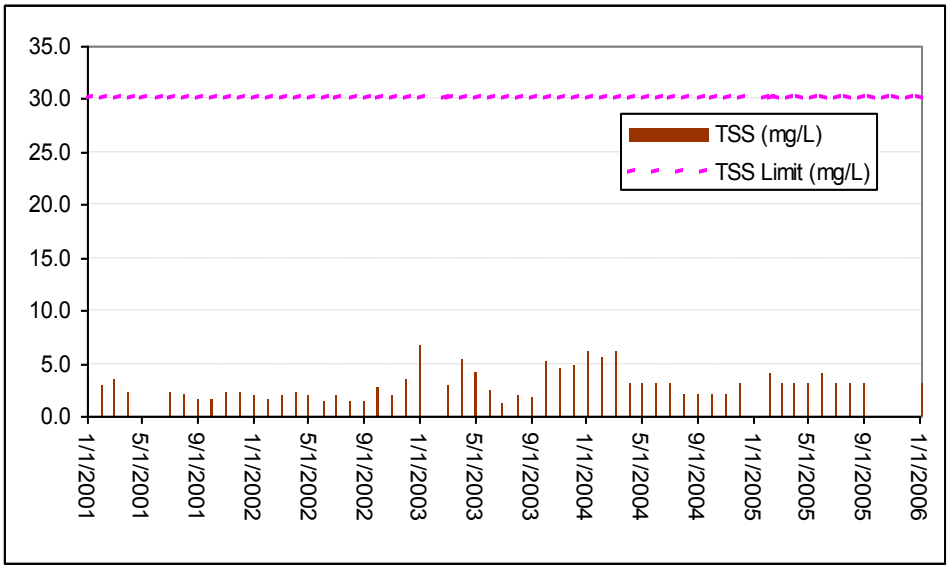


Figure 3-2. Telford DMR data (continued).

Pilgrims Pride

In April 2001, May 2001, October 2001, and October 2004 discharges from the Pilgrims Pride facility violated PO_4-P limits by 0.14 mg/l, 0.14 mg/l, 1.39 mg/l, and 0.05 mg/l, respectively. NH_3-N discharges violated the permit limit in September 2002 by 2.7 mg/l. The TSS limits were exceeded at least once every year and several times in 2001 and 2003. Figure 3-3 shows the DMR data and permit limits for the Pilgrims Pride facility.

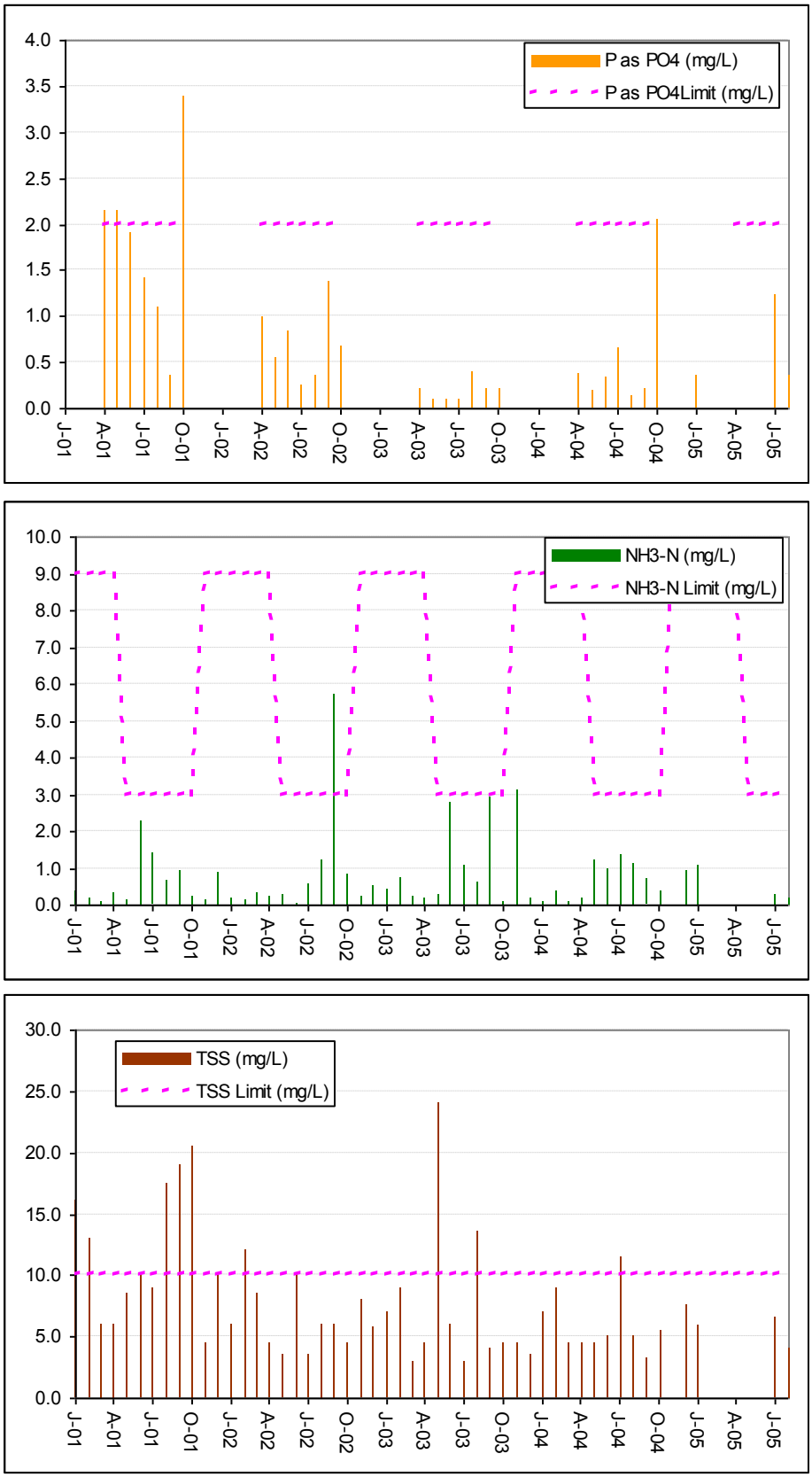


Figure 3-3. Pilgrims Pride DMR data.

Lower Salford

In November 2001, April 2003, June 2003, July 2003, and April 2004, concentrations violated the PO_4-P limits by 1.0 mg/l, 0.06 mg/l, 0.41 mg/l, 0.53 mg/l, and 1.25 mg/l, respectively. No limits exist for TP. NH_3-N concentrations exceeded the specified limits in January 2002, February 2002, March 2002, April 2002, May 2002, and June 2002 by 9.7 mg/l, 2.3 mg/l, 9.6 mg/l, 10.3 mg/l, 6.5 mg/l and 2.4 mg/l, respectively. The TSS limit was not exceeded. Figure 3-4 shows the DMR data and permit limits for the Lower Saford facility.

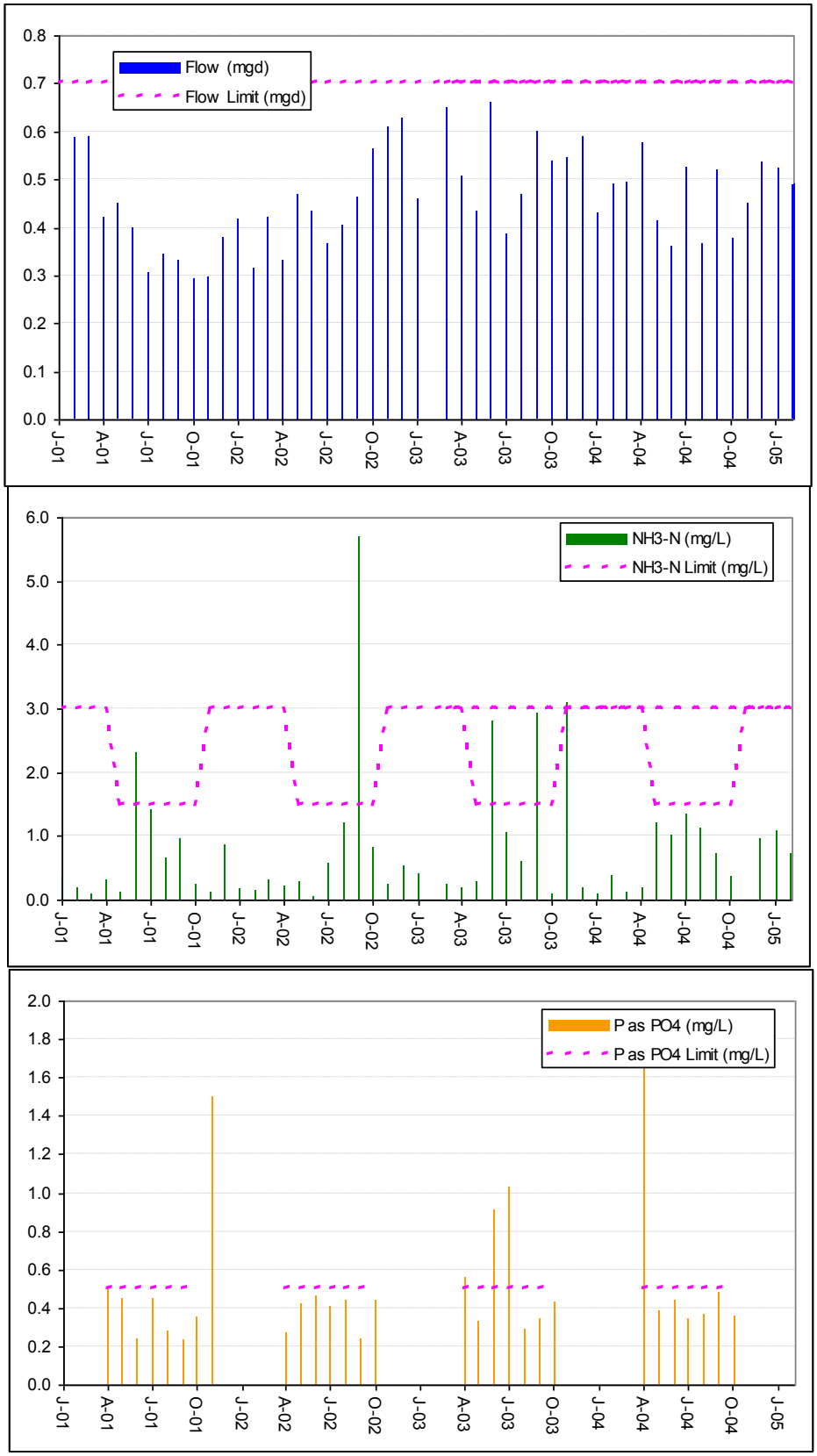


Figure 3-4. Lower Salford DMR data.

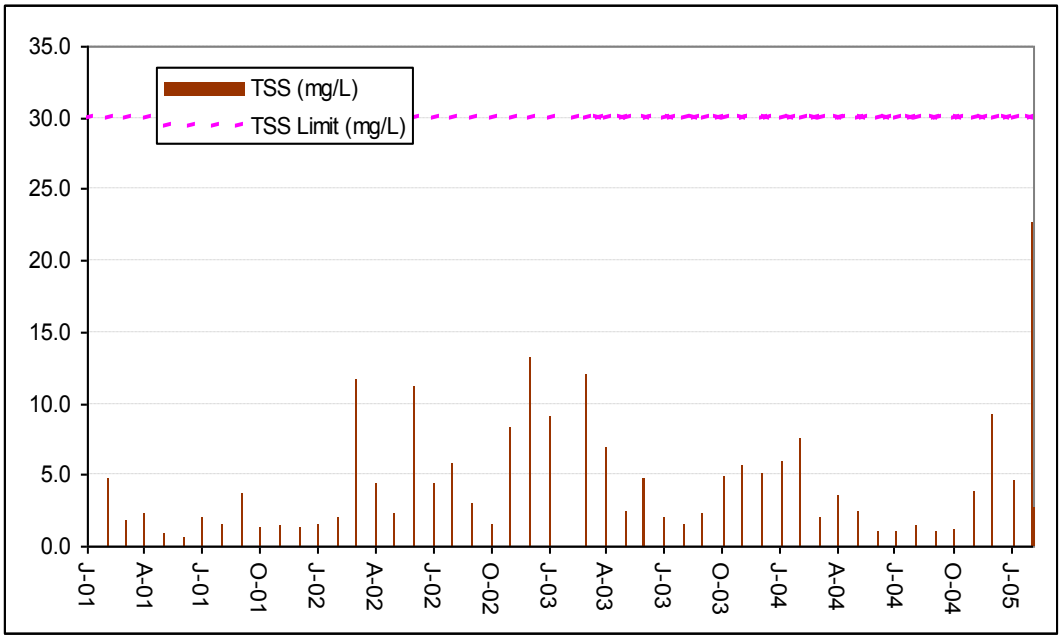


Figure 3-4. Lower Salform DMR data. (continued)

Ambient Sampling Above and Below Point Sources

Following an unassessed waters screening in the summer of 2001, PADEP determined that Indian Creek was impaired from its source to the mouth by possible nutrient impairment. From this assessment, biological habitat scores for locations throughout the Indian Creek watershed are available. They were reviewed to support this effort; however the data are more suitable for qualitative descriptions of stream conditions than for analysis of in-stream water quality as no chemical data were collected during the biological surveys. Based on findings of the unassessed waters screening, investigations were conducted to evaluate the possibility of Telford Borough Authority and Lower Salford Township Authority Harleysville STP outfalls as the source of stream impairment. The Telford STP is listed as the source of nutrient impairment to Indian Creek on the 2002 303(d) list. Chemical sampling was conducted in Indian Creek at the Telford Borough Authority STP on October 24, 2001, April 14, 2003, and on May 14, 2003; and at the Lower Salford STP on October 24, 2001, and April 14, 2003, by PADEP. In addition, biological sampling was conducted at the two sites on all the listed dates, except May 14, 2003.

At each location, samples were collected upstream of the discharge (denoted as site 1), at the discharge (effluent), and downstream of the discharge (denoted as site 2). See Appendix A for detailed discussion of sampling results at each site. In general, the ambient sampling reveals a significant influence of the point sources on the receiving streams during periods of dry weather. It also shows elevated background nutrient levels following periods of rainfall which can be attributed to nonpoint source runoff from the watershed. For example at the Telford site, sampling was conducted on October 24, 2001, under dry conditions and on April 14, 2003, and May 14, 2003, under post-rainfall conditions. Analyses of total phosphorous (TP) near the Telford discharge (Figure 3-5) suggest that the ambient concentration (represented by site 1) remained approximately the same on the sampling dates of Oct. 24, 2001, Apr. 14, 2003, and May 14, 2003. TP concentration increased downstream of the effluent in Oct. 24, 2001, decreased in Apr. 14, 2003, and remained approximately the same in May 14, 2003. Summation of the ambient TP concentration (site 1) and effluent TP concentration (effluent) approximately equaled the

concentration of TP at Site 2 on Oct. 24, 2001. The summation of ambient concentration and effluent was less than the TP concentration, however, at site 2 on Apr. 14, 2003 and on May 14, 2003. Since a greater portion of the concentration at Site 2 was contributed by effluent on the October sampling date, the effluent appears largely responsible for downstream (site 2) increased concentrations that day. Rainfall data for the period indicated periods of precipitation preceded the April and May sampling dates. This indicates that nonpoint source contributions, in addition to effluent, were affecting in-stream conditions on those days.

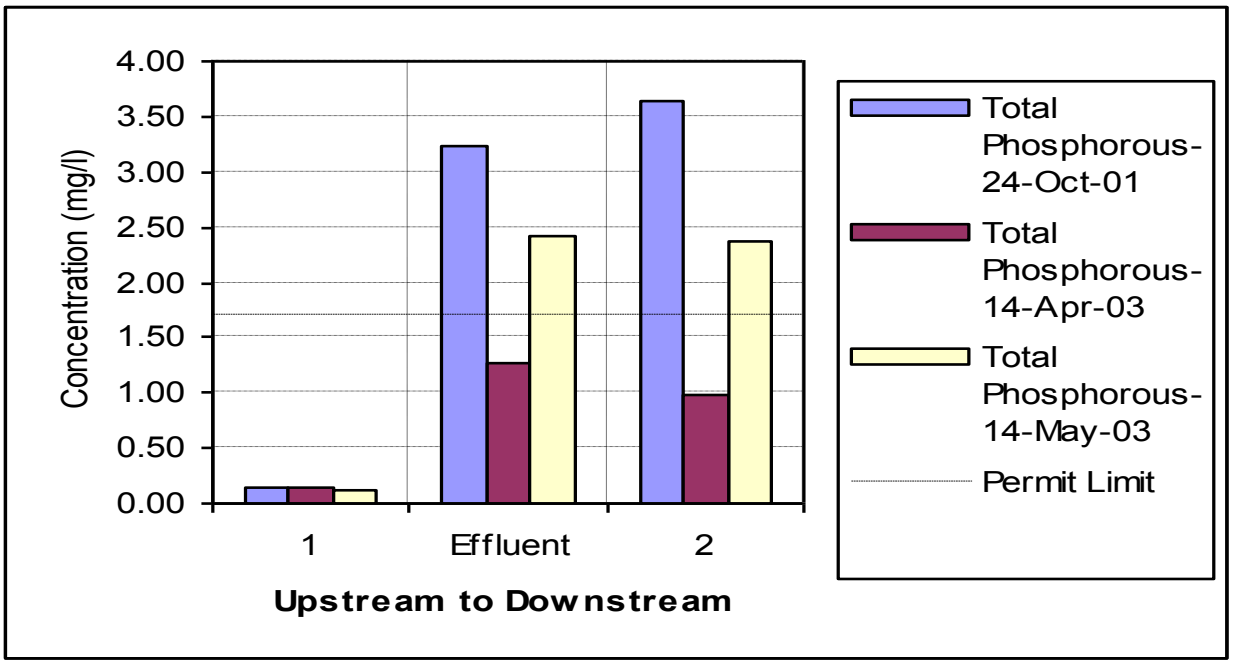


Figure 3-5. Total Phosphorus concentration above and below Telford Discharge

3.3. Indian Valley Golf Course Water Withdrawals

The Indian Valley Golf Course, located in the northern portion of the watershed. The golf course's withdrawal point is from an impoundment that is adjacent to Indian Creek. The facility is known as a "pre-compact" facility as it was in operation prior to the creation of the Delaware River Basin Commission. Thus, no restrictions on water withdrawals by the facility from Indian Creek are in effect. However, it is unclear if the water is drawn directly from the Indian Creek or if any of the water is returned back to the Indian River. Historical data for water withdrawals were provided by the Delaware River Basin Commission (DRBC). Based on review of the data provided, water withdrawals generally increase from May until July and then decrease in subsequent months, with the month of July typically experiencing the highest levels of withdrawals.

3.4. Summary of Critical Water Quality Factors

Based on a review of available data, the Indian Creek watershed appears subject to significant nutrient loading from both point and nonpoint sources. Visual observations and diurnal monitoring of physical water quality conditions in the watershed reveal evidence of significant levels of biological activity in the form of primary productivity, algae blooms, and large swings in daily dissolved oxygen and pH levels. Chemical monitoring data show elevated levels of nutrients. At times of low flow, considerable inputs of nutrients are attributable to point source facilities in the watershed; particularly the Telford Borough

Authority and Lower Salford Authority-operated municipal sewage treatment plants. Discharge from these facilities cause receiving waters to exhibit elevated levels of nutrients over ambient concentrations during periods of dry weather. It is expected that during times of extremely low flows and warm conditions, these inputs to the watershed may contribute significantly to algal blooms and other conditions associated with eutrophication.

Nonpoint source nutrient loading from watershed land uses is also evident during periods of wet weather, as shown by the results of the ambient sampling above and below the two municipal treatment plants. Following periods of rainfall, ambient levels of nutrients upstream of point sources appear elevated relative to dry weather periods.

Land use activities in the Indian Creek watershed play an important role in water quality. Manure is collected and applied to agricultural lands in the watershed. Food processing residual wastes are also potentially applied to sites in the watershed. The watershed is suburbanizing, has multiple stormwater outfalls, and experiences typical runoff conditions associated with urban stormwater runoff and discharge. In addition, the golf course located in the headwaters region withdraws significant amounts of flow during the summer months; however it is unclear if water is withdrawn directly from the Indian Creek. These withdrawals likely compound critical low-flow periods where nutrient laden point source discharges may already be overwhelming receiving streams.

An approach to develop TMDLs for the water quality impairments in the Indian Creek watershed should be able to account for the varied nature of factors influencing problem conditions in the stream. These include point source discharges, urban runoff, water withdrawals, and application of fertilizers and manures. Such an approach should account for the various sources of nutrients to the watershed and their influences on the watershed during both low-flow and high-flow conditions. The following section describes the technical approach used to develop the Indian Creek watershed TMDL. The approach accounts for the critical processes influencing Indian Creek and is also consistent with other TMDLs developed for nearby waters.

4. TMDL TECHNICAL APPROACH

Two separate approaches were used to develop these TMDLs for Indian Creek. For sediment, a reference watershed approach using a simplified Generalized Watershed Loading Function (GWLF) simulation was applied. For nutrients (TP and TN), a separate GWLF watershed model was used to generate watershed nutrient loadings and these were linked to a receiving water model to evaluate allowable nutrient inputs from the watershed to meet the seasonal average nutrient targets.

4.1. Sediment

Section 4.2.1 provides details on the GWLF application and its underlying theory, as well as information on how the model was configured to develop the nutrient TMDLs. There are several differences in how GWLF was configured for the sediment and nutrient TMDLs; the sediment modeling is described here.

4.1.1. Watershed modeling - Sediment

For the sediment TMDL, a GWLF model was configured as a single subbasin as opposed to the multiple subbasins used to feed the EFDC model for the nutrient TMDL. This was done since a single reference watershed was used in developing the TMDL. A single modeled watershed for Indian Creek ensures that the sediment delivery ratio for the Indian Creek subbasin was similar to the reference subwatershed. Section 1.4 discusses the rational for the selected reference watershed and TMDL target.

Watershed data needed to run the GWLF model was similar to what was required for the nutrient TMDL and included GIS spatial coverages, streamflow data, local weather data, and literature values. The Indian Creek watershed was delineated into one subbasin to represent sediment loadings. The watershed was delineated based on USGS Digital Elevation Model (DEM) data, USGS 7.5 minute digital topographic maps (24K RG - Digital Rastar Graphics), and Pennsylvania's eMap stream coverage.

The following sections describe the data and information used for model setup, including watershed conditions (e.g., land use, soils), weather inputs, simulation of streamflow and nonpoint source representation.

Land Use and Land Cover Data

NLCD 2001 land use information from the MRLC was used for the Indian Creek watershed as was done in the nutrient TMDL. The land use distribution is shown below in Table 4-1.

Table 4-1. Land Use in the Indian Creek Watershed (Sediment model)

Land Use	Total Area (mi^2)	Percent of Total (%)
Low Intensity Residential	**1.31**	19.16
High Intensity Residential	**1.08**	15.79
High Intensity Commercial/Industrial/ Transportation	**0.37**	5.39
Paved_Roads	**0.09**	1.34
Bare Rock/Sand/Clay	**0.02**	0.27
Deciduous Forest	**0.34**	4.90
Evergreen Forest	**0.00**	0.04
Pasture	**2.48**	36.13
Agriculture	**1.15**	16.76
Wetlands	**0.01**	0.21
Total Area (mi^2)	**6.86**	100

Soils Data

Soils data were obtained from the Natural Resources Conservation Services (NRCS) State Soil Geographic (STATSGO) database for the respective watersheds. Figure 4-2 shows the soil distribution in the Indian Creek watershed.

Weather Data

Local rainfall and temperature data were used to simulate flow conditions in modeled watersheds. Daily precipitation and temperature data were obtained from local National Climatic Data Center (NCDC) weather stations. The Graterford station had good data coverage (96%) for both precipitation and temperature, and was used to construct the weather file used in modeling. Data gaps in the Graterford station were filled using the another nearby Sellersville station and a composite weather file was developed. The Graterford station is located approximately 6.5 miles south of the Indian Creek watershed, while the Sellersville station is located 4.2 miles north east of the Indian Creek watershed. Table 4-6 shows the Graterford and Sellersville weather stations used in the sediment watershed model.

The Indian Creek GWLF model for sediment was developed using the composite weather file created using the Greaterford and Sellersville NCDC meteorological station for a time period 1997 through 2004. The modeling period was selected based on the availability of weather and flow data that were collected during the same time period. Although weather data were available prior to 1997 there were many data gaps. It was assumed that this 8-year time period would capture any seasonal variations in the watershed with a range of precipitation and stream flow conditions being represented.

4.1.2. Watershed Model Results – Sediment

Model results for the eight year simulation period show that the landuses responsible for the highest amount of sediment loading are agricultural and developed impervious and pervious areas. While those with the highest loading rates are agricultural, developed, and bare rock/sand/clay; Table 4-2 provides a summary.

Table 4-2. Modeled Sediment Loads and Landuse Loading Rates in the Indian Creek Watershed

SOURCE	Loading Rate lb/ac/yr	Existing Load (lb/yr)
Agriculture	8,594.55	6,329,713.42
Pasture	3,727.07	5,914,860.35
High Intensity Residential-Imp	424.42	206,580.90
Low Intensity Residential-Imp	424.42	107,525.64
High Intensity Commercial/Industrial/Transportation-Imp	424.42	85,573.93
Low Intensity Residential	33.19	19,620.80
Paved_Roads	192.45	11,294.19
Bare Rock/Sand/Clay	745.43	8,948.32
High Intensity Residential	37.20	7,761.50
High Intensity Commercial/Industrial/Transportation	37.20	1,323.30
Deciduous Forest	2.23	478.98
Evergreen Forest	2.77	4.30
Wetlands	-	-
Total		12,693,685.64

Average annual sediment loading is approximately 12,693,686 lb/year. Of this, approximately 169,921 lb/year, or about 1.3% of the total existing load are from the three continuously discharging point sources.

4.2. Nutrients

To evaluate the relationship between the time variable sources, their loading characteristics, and the resulting water quality conditions in the stream, a combination of a watershed model and in-stream water quality model was used for the Indian Creek nutrient and siltation TMDLs. Assessments of the nonpoint source loading into the waterbody were developed using the GWLF (Haith and Shoemaker, 1987) computer program. GWLF modeling was accomplished using the BasinSim 1.0 watershed simulation program, a Windows-based modeling system that facilitates the development of model input data and provides additional functionality for simulating daily flows and flow and pollutant routing (Dai et al. 2000).

The hydrodynamics and water quality processes in Indian Creek were simulated using the Environmental Fluid Dynamics Code (EFDC) (Hamrick 1996,; Hamrick and Wu 1996). The EFDC model is a general purpose modeling package for simulating one, two or three-dimensional flow, transport and biogeochemical processes in surface water systems and can be used to simulate the physical, chemical, and biological interactions related to DO and nutrients dynamics in the Indian Creek. The hydrodynamic simulation module of EFDC can simulate the flow velocity, water depth, and temperature necessary for driving the mass transport and DO re-aeration computation in a water quality model (Zou et al. 2006). The water quality simulation module of EFDC is a flexible modeling framework allowing representation of the kinetic structure in a water system at different levels of complexity. At a minimum, the EFDC model can provide a representation of the water quality dynamics in the Indian Creek similar to that in the Wissahickon Creek modeling effort where a linked EFDC-WASP model was developed. Because EFDC's water quality modules are internally coupled with the hydrodynamic module, it offers a more integrated and consistent numerical representation of the prototype than an externally linked EFDC-WASP system. In addition, the flexible kinetic structure of the EFDC water quality model allows the

modeling system to be extended to an even higher level of kinetic representation when the WASP level representation is regarded insufficient.

The EFDC model was configured as a dynamic modeling system, representing the temporal and spatially variable conditions in the stream. The model was used to simulate hydrodynamic and nutrient-algae dynamics in Indian Creek in one single numerical framework and to represent seasonal and multiple year variability in water quality. Its sediment digenesis module can be activated when necessary to account for the response of benthic nutrient flux and oxygen demand in the TMDL process to enhance the predictability of the model and the reliability of the resultant TMDL.

The combination of the linked GWLF and EFDC models established the relationship between the in-stream water quality target and the source loading from the watershed to develop technically defensible TMDL allocations.

The following sections discuss the modeling approach in more detail, including the setup, testing and application of GWLF and EFDC to support development of the Indian Creek TMDLs.

4.2.1. Watershed Modeling - Nutrients

The nutrients watershed model for the Indian Creek watershed was developed using the GWLF model and the BasinSim 1.0 interface. The GWLF model, which was originally developed by Cornell University (Haith et al., 1992), provides the ability to simulate runoff, sediment, and nutrient loadings from watersheds 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. GWLF 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 daily water balance totals that are summed to give monthly values.

GWLF is an aggregate 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 homogeneous with respect to various attributes considered by the model. In addition, 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 subsurface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for subsurface flow contributions. Daily water balances are computed for an unsaturated zone as well as for a saturated subsurface 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 the conservation practices factor (P). A sediment delivery ratio based on watershed size and 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 nitrogen and phosphorus coefficients to surface runoff and a sediment coefficient to the yield portion for each agricultural source area. Manured areas, as well as septic systems, also can 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. Subsurface losses are calculated using dissolved nitrogen and phosphorus coefficients for shallow groundwater contributions to stream nutrient loads, and the subsurface submodel considers only a single, lumped-parameter contributing area. Evapotranspiration is determined using daily weather data and a cover factor dependent on 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 the equations used by the model can be found in the original GWLF paper (Haith and Shoemaker 1987) and GWLF User's Manual (Haith et al. 1992).

4.2.2. Model Setup

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

Watershed data needed to run the GWLF model were generated using GIS spatial coverages, streamflow data, local weather data, and literature values. The Indian Creek watershed was subdivided into 12 subbasins to represent nutrient loadings (Figure 4-1). The watersheds were delineated based on USGS Digital Elevation Model (DEM) data, USGS 7.5 minute digital topographic maps (24K RG - Digital Rastar Graphics), and Pennsylvania's eMap stream coverage.

The following sections describe the data and information used for model setup, including watershed conditions (e.g., land use, soils), weather inputs, simulation of streamflow and nonpoint source representation.

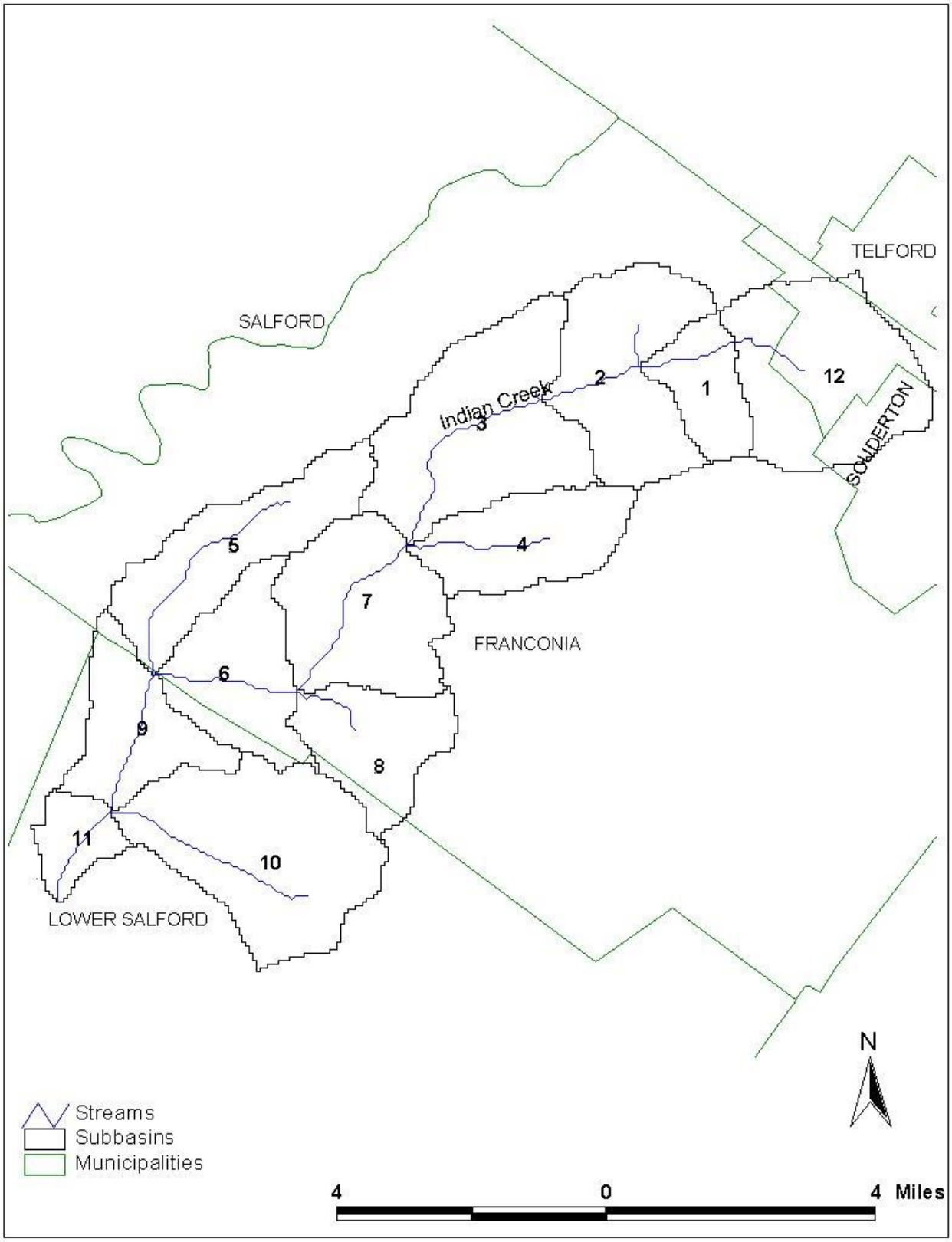


Figure 4-1. Indian Creek subwatershed delineations.

Land Use and Land Cover Data

NLCD 2001 land use information from the MRLC was available for the impaired and calibration watersheds. Table 4-3 shows the 2001 NLCD landuse categories and the matching modeled landuse category used to identify landuse specific loading rates. The NLCD land use coverage was used to calculate the area of each land use category in the watersheds. The land use distribution in the impaired and calibration watersheds is shown in Table 4-4 and Table 4-5.

Table 4-3. NLCD Landuse Coverage Category Crosswalked with Modeled Landuse Categories

2001 NLCD Category	Modeled Category
Developed, Open Space	Low Intensity Residential
Developed, Low Intensity	High Intensity Residential
Developed, Medium Intensity	High Intensity Commercial/Industrial/Transportation
Developed, High Intensity	Paved_Roads
Barren Land (Rock, Sand, Clay)	Bare Rock/Sand/Clay
Deciduous Forest	Deciduous Forest
Evergreen Forest	Evergreen Forest
Pasture/Hay	Pasture
Cultivated Crops	Agriculture
Woody Wetlands	Wetlands

Table 4-4. Land Use in the Indian Creek River Watershed

Land Use	Subbasin 1	Subbasin 2	Subbasin 3	Subbasin 4	Subbasin 5	Subbasin 6	Subbasin 7	Subbasin 8	Subbasin 9	Subbasin 10	Subbasin 11	Subbasin 12	Total Area (mi^2)	Percent of Total (%)
Low Intensity Residential	0.06	0.21	0.20	0.05	0.08	0.06	0.09	0.06	0.06	0.21	0.01	0.21	**1.31**	19.16
High Intensity Residential	0.07	0.09	0.10	0.07	0.03	0.08	0.04	0.08	0.02	0.21	0.01	0.27	**1.08**	15.79
High Intensity Commercial/Industrial/ Transportation	0.02	0.02	0.02	0.05	0.00	0.01	0.01	0.02	0.00	0.09	0.00	0.13	**0.37**	5.39
Paved_Roads	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.03	**0.09**	1.34
Bare Rock/Sand/Clay	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.02**	0.27
Deciduous Forest	0.01	0.01	0.03	0.01	0.04	0.05	0.04	0.01	0.03	0.02	0.06	0.02	**0.34**	4.90
Evergreen Forest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	0.04
Pasture	0.10	0.20	0.36	0.14	0.27	0.19	0.33	0.15	0.23	0.32	0.07	0.13	**2.48**	36.13
Agriculture	0.02	0.12	0.16	0.12	0.18	0.12	0.16	0.08	0.09	0.07	0.02	0.02	**1.15**	16.76
Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**	0.21
Total Area (mi^2)	**0.27**	**0.66**	**0.88**	**0.47**	**0.61**	**0.51**	**0.68**	**0.41**	**0.44**	**0.95**	**0.17**	**0.81**	**6.86**	100
Percent of Total (%)	3.97	9.61	12.87	6.89	8.83	7.48	9.84	6.03	6.37	13.82	2.49	11.81		

Table 4-5. Land Use in the East Branch Perkiomen Creek Watershed

Land Use	Area (mi^2)	Percent of Total
Water	0.02	0.03
Low Intensity Residential	5.98	10.39
High Intensity Residential	5.51	9.57
High Intensity Commercial/Industrial/Transportation	2.00	3.48
Paved_Roads	0.42	0.73
Bare Rock/Sand/Clay	0.53	0.92
Deciduous Forest	10.38	18.03
Evergreen Forest	0.43	0.75
Pasture	17.45	30.32
Agriculture	14.20	24.67
Wetlands	0.64	1.12
Total Area (mi^2)	**57.57**	**100**

Soils Data

Soils data were obtained from the Natural Resources Conservation Services (NRCS) State Soil Geographic (STATSGO) database for the respective watersheds. There are two MUIDs within the Indian Creek watershed and both have a hydrologic soil group of C soil type. Figure 4-2 shows the soil distribution in the Indian Creek watershed.

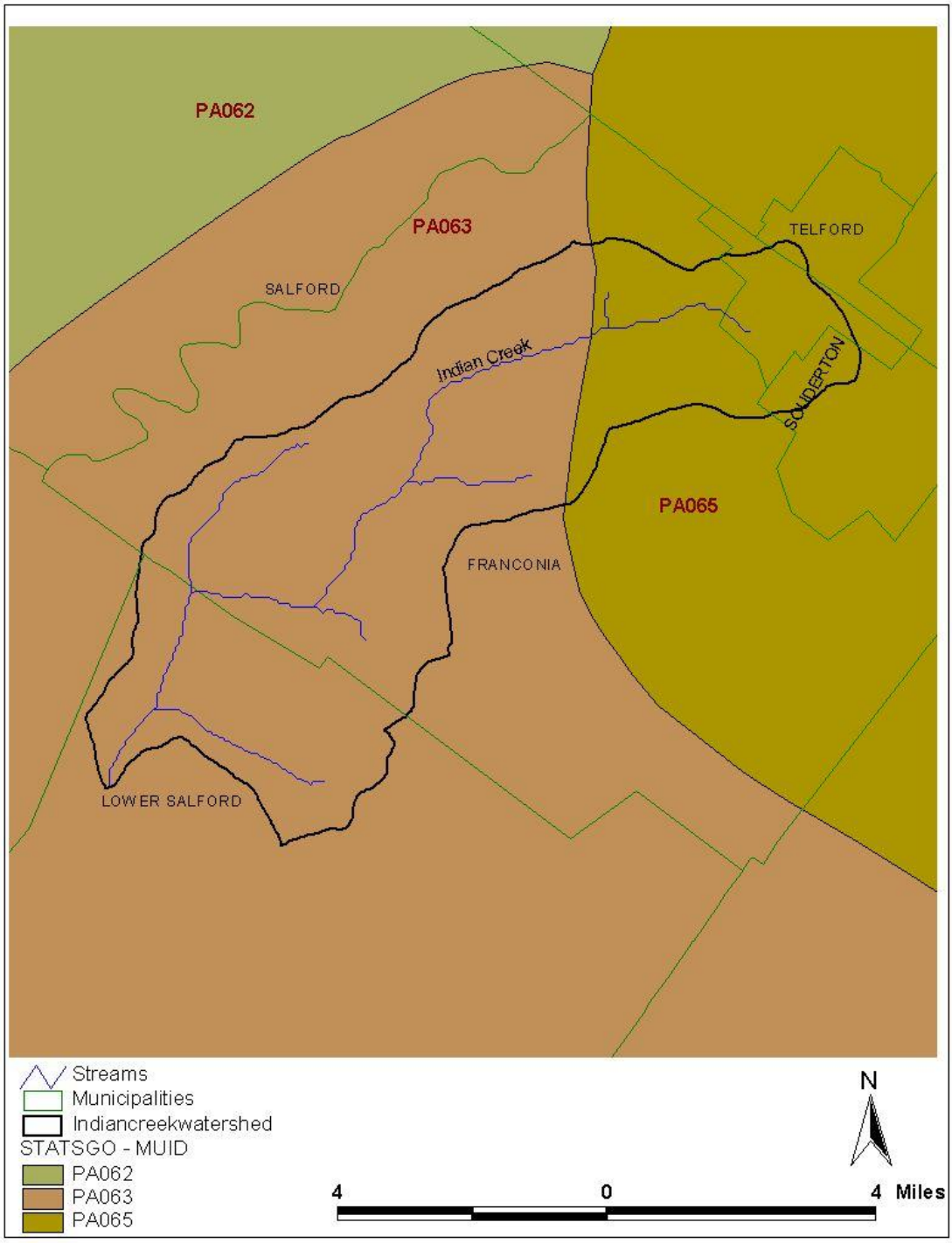


Figure 4-2. Soil distribution in the Indian Creek watershed.

Weather Data

Nonpoint source pollution is rainfall driven, therefore precipitation data are necessary to drive the watershed model. Local rainfall and temperature data were used to simulate flow conditions in modeled watersheds. Daily precipitation and temperature data were obtained from local National Climatic Data Center (NCDC) weather stations. There were two precipitation stations in close proximity to the Indian Creek watershed – Sellersville and Graterford. Since the Graterford station had good data coverage

(96%) for both precipitation and temperature, it was used to construct the weather file used in modeling. Data gaps in the Graterford station were filled using the Sellersville station and a composite weather file was developed. The Graterford station is located approximately 6.5 miles south of the Indian Creek watershed, while the Sellersville station is located 4.2 miles north east of the Indian Creek watershed. Since the NCDC summary of the day data at the two stations did not extend beyond 12/31/2004, the Willow Grove NAS surface airways station (14793) located approximately 14 miles south east of the Indian Creek was used to create another set of weather files. (Table 4-6 shows the weather stations used in the watershed model.)

Table 4-6. Meteorological Stations

Station ID	Station Name	Data Begin Date	Data End Date	Percent Coverage	Elevation (ft)
PA7938	Sellersville	5/1/1948	12/31/2004	20	340
PA3437	Graterford 1 E	1/1/1960	12/31/2004	96	240
14793	Willow Grove NAS	2/1/1945	Current	99	170

Nonpoint Source Representation

In the GWLF model, the nonpoint source load calculation is affected by terrain, such as the amount of agricultural land, land slope, soil erodibility, farming practices used in the area, and by background concentrations of nutrients (nitrogen and phosphorus) 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 in the following paragraphs.

Curve number: This parameter 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 and soils coverages. A GIS tool developed by Tetra Tech was used to determine the CNs for each land use located in each subwatershed. The tool determines the CN for each land use using a weighted average of the CNs for the soil types in each land use.

Universal Soil Loss Equation (USLE): The USLE is used in GWLF to estimate the sediment contribution from the various land uses in the watershed. The USLE is calculated as:

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

where A is soil loss (tons/acre/year). R is the rainfall and runoff factor in erosion index units. GWLF calculates the R factor, but the remaining values must be entered as input. K is the soil erodibility factor, which affects the amount of soil erosion on a given unit of land. The LS factor signifies the steepness and length of slopes and directly affects the amount of soil erosion. The C factor is related to the amount of vegetative cover in an area. C values range from 0 to 1.0, with the larger values indicating greater potential for erosion. The P factor is directly related to the conservation practices used in agricultural areas. P values range from 0 to 1.0, with larger values indicating a greater potential for erosion.

The R, K and LS values vary by subwatershed, and are estimated using a GIS tool/ArcView extension developed by Tetra Tech. The values for C and P factors used for modeling the Indian Creek watershed are presented in Table 4-7. Soil erodibility factor (K) values were derived from the STATSGO soil layer and component database. The LS values were determined for each land use type within each subwatershed using DEM data together with the subwatershed boundaries. The C value for each land use

was determined from the USLE guide book *Predicting Rainfall Erosion Losses, A Guide to Conservation Planning* (USDA 537).

Table 4-7. Assigned C and P Factor Values for the Indian Creek Watershed

Land Use	C	P
Low Intensity Residential	0.001	1
High Intensity Residential	0.001	1
High Intensity Commercial/Industrial/Transportation	0.001	1
Paved_Roads	0.01	1
Bare Rock/Sand/Clay	0.1763	0.989
Deciduous Forest	0.0001	1
Evergreen Forest	0.0001	1
Pasture	0.0433	0.88
Agriculture	0.2067	0.725
Wetlands	0.005	1

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

Unsaturated available water-holding capacity: This parameter relates to the amount of water that can be stored in the soil and affects runoff and infiltration.

Dissolved nitrogen and phosphorus in runoff: This parameter varies according to land use/cover type. Reasonable values have been established in the literature. This rate, reported in milligrams per liter, can be readjusted based on local conditions such as rates of fertilizer application and farm animal populations. Default values reported in literature (tables B-15 and B-16 in the GWLF manual) were identified and used for the various land uses in the Indian Creek watershed, as shown in Table 4-8.

Table 4-8. Nitrogen and Phosphorus Concentrations in Runoff

Land Use	Nutrient Concentration	
	N (mg/L)	P (mg/L)
Agriculture	2.9	0.26
Pasture	3	0.25
Bare Rock/Sand/Clay	0.24	0.15
Deciduous	0.19	0.006
Wetlands	0	0

Nutrient concentrations in runoff over manured areas: These concentrations are user-specified concentrations for nitrogen and phosphorus 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 concentrations 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. Limited information was available related to local manure application rates and locations. Because agricultural lands in the watershed are generally low-intensity, manure application was only simulated for cropland areas. The

default values reported in literature for cropland were used (Table B-15 from the GWLF manual for manure left on soil surface for the land use category Corn – 12.2 mg/L N and 1.90 mg/L P).

Nutrient concentrations from septic system contributions: As part of Franconia Township's Sewer Management Program, which was developed to address the township's Act 537 Plan, detailed information on septic system performance was developed in the Indian Creek watershed. Two surveys were conducted to gather information related to septic system functioning in the watershed, an initial mailed census survey of residents' on-lot systems was conducted which included questions related to general information, residents' current system, occupancy status, history of problems, lifestyle considerations and water source information. The mail-in survey was sent to 323 Township residents served by onsite systems within the watershed. The response rate for the mail in survey was 60% (195 responses). A second survey was performed during onsite inspections. As of March 2008, 282 properties had been inspected (81% of the total). Figure 4-3 shows the area of the watershed covered by the study.

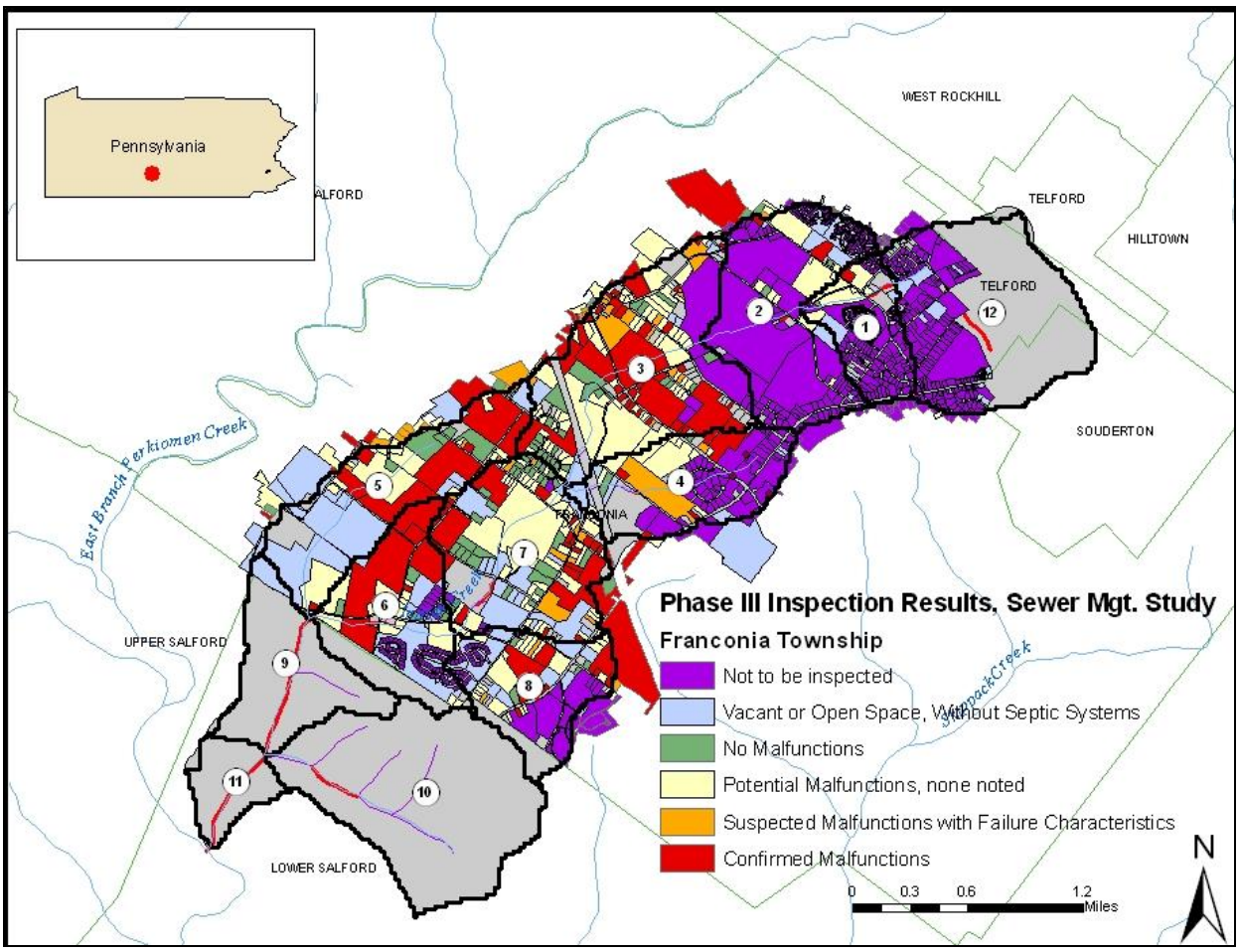


Figure 4-3. Septic Inspection Study Area and Results

Based on inspections, systems were placed into four categories:

Confirmed Malfunctions – malfunctions documented by dye testing, lab test results, and observation by a certified Sewage Enforcement Officer. Also includes piped discharges with direct evidence of sewage, reported backups, photographic documentation or other similar evidence.

Suspected Malfunctions – systems exhibiting some malfunction characteristics (e.g., abnormally green grass in vicinity of absorption area, piped discharges without direct evidence of sewage, absorption areas in known unsuitable soils, cesspools and pits.

Potential Malfunctions – systems appear to be operating satisfactorily but constructed prior to current permitting requirements, located in areas unlikely to receive permitting by current standards, systems constructed in areas mapped as unsuitable soils or located on exceptionally steep slopes greater than 25 percent.

No Malfunctions – systems appear to be operating satisfactorily.

Three additional categories were also used in the study:

Vacant or Open Space – includes properties that did not contain any onlot systems, such as vacant lots, parks, cemeteries, etc.

Do Not Inspect – includes properties that were found to be connected to an existing public sewer system or are scheduled to be connected in the near future.

Holding Tanks – include properties containing a holding tank.

Table 4-9 shows results of the study for each modeled subbasin. Note that results are not available for all portions of subbasins 9, 10, 11, and 12.

Table 4-9. Septic Inspection Results by Modeled Subbasin

SUBBASIN	Malfunctioning	Suspected Malfunction	Potential Malfunction	Normal
1	1		8	1
2	5	1	13	5
3	38	19	66	29
4	6	2	12	5
5	12	12	22	7
6	7		17	8
7	23	10	59	38
8	11	4	24	7
9				
10			1	
11	Not surveyed	Not surveyed	Not surveyed	Not surveyed
12				
Total	103	48	222	100

Data from this survey were compiled and used in parameterizing the GWLF model to represent septic system loading to Indian Creek. Table 4-10 shows how the GWLF model was configured to represent septic loading in Indian Creek. Because study results did not cover the entire portion of subbasins 9, 10, 11, and 12, certain assumptions were made with regard to the existences of onlot systems in those subbasins. Subbasin 10 and the upper portion of subbain 12 were assumed to be largely sewered, while subbasins 9 and 11 were assumed to be similar to subbasin 5 given similar landuse characteristics. This was deemed to be a conservative assumption with respect to septic loading in subbasins 9 and 11 since some of those areas are likely served by sewer connections. For purposes of model parameterization, the conservative assumption that a single system serves 4 individuals was applied. Additionally, 50% of the

suspected and potential malfunctions were assigned to the ―normal" category and 50% were assigned to the direct discharge category.

Table 4-10. Septic Representation in GWLF; # Persons Served by Septic System Categories per Subbasin

Subbasin	Normal	Direct Discharge
1	20	20
2	48	48
3	286	322
4	48	52
5	96	116
6	66	62
7	290	230
8	84	100
9	48	58
10	50	50
11	7	9
12	17	17
Total	1060	1084

Background nitrogen and phosphorus concentrations in groundwater: Subsurface concentrations of nutrients (primarily nitrogen and phosphorus) contribute to the nutrient loads in streams. Nutrient concentrations in groundwater were based on the results from a nationwide study of mean dissolved nutrients as measured in streamflow (as reported in Haith et al. 1992). For the Indian Creek watershed, the groundwater concentrations were assumed to be approximately 0.021 mg/L for phosphorus and 0.71 mg/L for nitrogen, based on values for eastern U.S. watersheds (Table B-16 in the GWLF manual).

Background nitrogen and phosphorus concentrations in soil: Because soil erosion results in the transport of nutrient-laden sediment to nearby surface waterbodies, reasonable estimates of background concentrations in soil must be provided. Because there were no local soil concentration data to support the modeling effort, literature values were used. The percent sediment weight of nitrogen and phosphorus in the top 30 cm of soil was calculated based on maps in the GWLF manual (Figures B-3 and B-4 in the GWLF manual) as 1,500 mg/kg and 660 mg/kg, respectively.

Other less important factors that can affect sediment and nutrient loads in a watershed also are included in the model. More detailed information about these parameters and those outlined above can be obtained from the GWLF User's Manual (Haith et al. 1992). Pages 15 through 41 of the manual provide specific details that describe equations and typical parameter values used in the model.

4.2.3. Model Testing

Streamflow data are generally used to test or calibrate watershed hydrologic parameters for the GWLF model. There are no active U.S. Geological Survey (USGS) gages in the Indian Creek watershed, nor is there information available regarding historical stream flow data. The closest available gage is USGS 1472810 on East Branch Perkiomen Creek near Schwenksville, Pennsylvania (Figure 4-3). The Indian Creek watershed drains to the East Branch Perkiomen Creek, which contributes drainage to the gage. Therefore the East Branch Perkiomen creek watershed was modeled for calibration purposes. The East Branch Perkiomen Creek watershed exhibits similar hydrologic properties such as soils, land use and

geology characteristics to the Indian Creek. Once calibrated, the hydrology parameters from the calibration watershed were applied to the Indian Creek watershed.

GWLF predicted overall water balances in the calibration watershed. The East Branch Perkiomen Creek watershed was modeled using the composite weather file created using the Greaterford and Sellersville NCDC meteorological station for a time period 1997 through 2004. This modeling period was selected based on the availability of weather and flow data that were collected during the same time period. Although weather data were available prior to 1997 there were many data gaps. It was assumed that this 8-year time period would capture any seasonal variations in the watershed with a range of precipitation and stream flow conditions being represented. Calibration plots for the East Branch Perkiomen Creek are presented in Figures 4-4 and 4-5. In general, the seasonal trends and peaks are captured reasonably well for the modeling period in the calibration watershed.

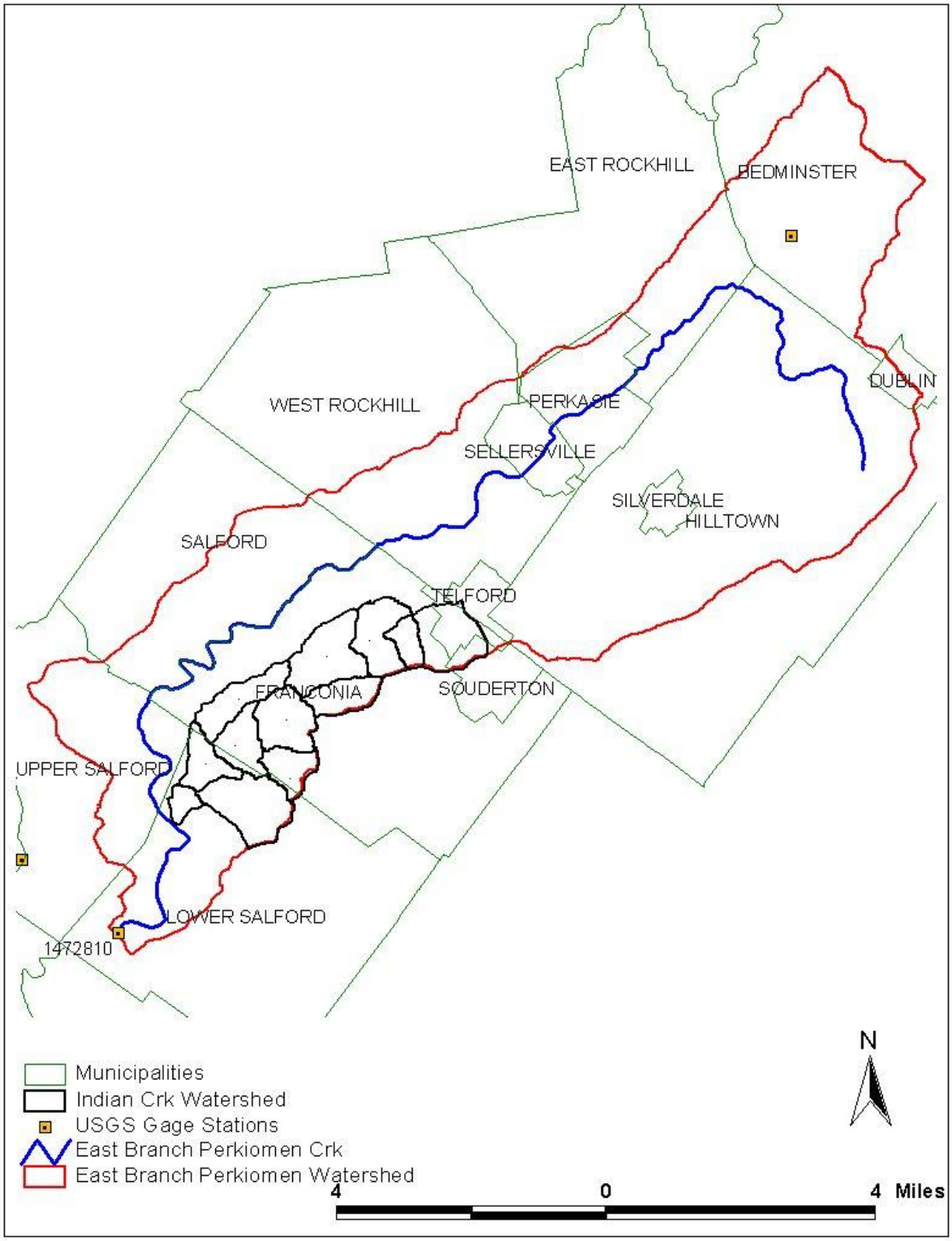


Figure 4-4. East Perkiomen Creek watershed.

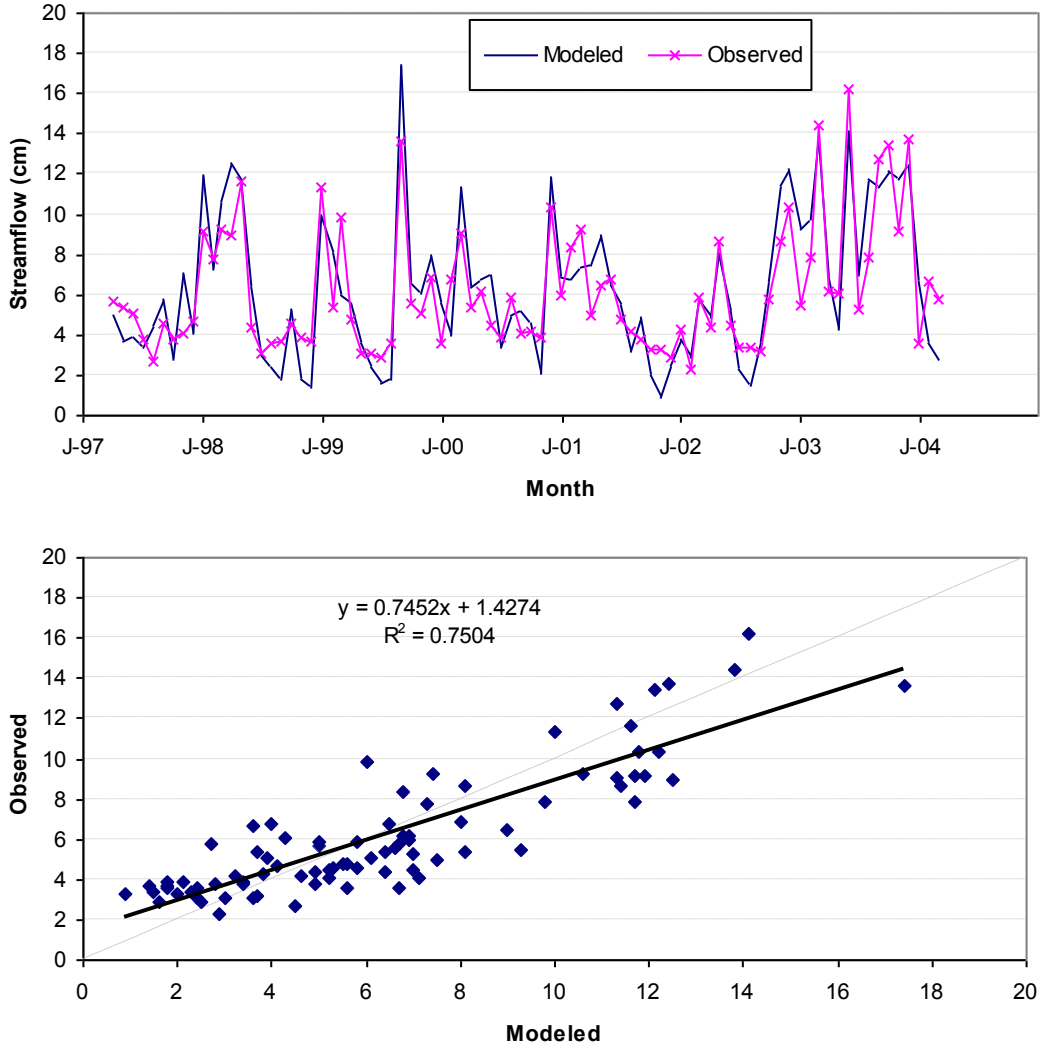


Figure 4-5. Observed and Predicted Monthly Streamflow (centimeters) – East Branch Perkiomen Crk at USGS 01493500 (1997 - 2004)

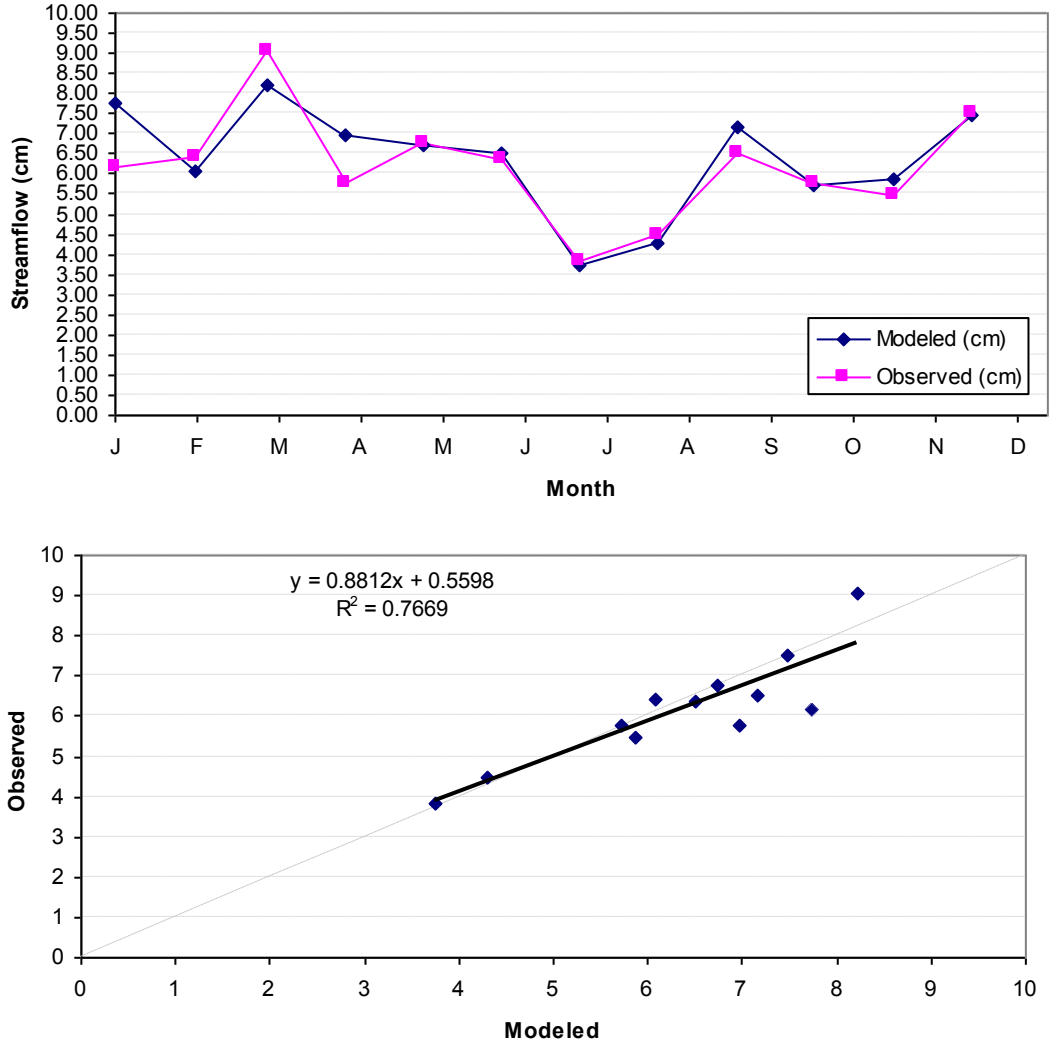


Figure 4-6. Observed and Predicted (centimeters) - East Branch Perkiomen Crk at USGS 01493500 (1997 - 2004) entire period

4.2.4. Watershed Model Results – Nutrients

For the nutrients simulation, the GWLF model was run for the period from April 2005 to December 2006 to obtain predicted loading values for TP and TN. This period was selected because it coincides with the period during which monitoring data are available for various locations in Indian Creek. Average annual and monthly predicted loads from the watershed (based on the modeled period) are shown in Table 4-11 and Table 4-12. These are loads from the watershed in total and represent the sum of subbasin loads. For comparison, Table 4-11 also shows the permitted annual loads from the three continuously discharging point sources in the watershed. Watershed loading values were used in conjunction with the EFDC receiving water model to determine the necessary TMDLs for Indian Creek.

Table 4-11. Average Annual Watershed and Point Source Nutrient Loads for the Modeled Period

	AVG. Annual Watershed Load	Total Point Source Loads
TN (lb/yr)	28,331	48,646.55
TP (lb/yr)	3,820	7,553.37

Table 4-12. Average Monthly Watershed Loads for the Modeled Period

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
TN (lb)	62	29	19	74	40	20	76	23	9	346	43	65
TP (lb)	8	1	1	5	2	1	11	1	0	69	1	9

Predicted unit area loading rates by landuse are shown in Table 4-13

Table 4-13. Modeled Landuse Loading Rates for Nutrients

Landuse	TN (lb/acre/yr)	TP (lb/acre/yr)
Agriculture	11.40	2.79
Pasture	2.63	0.51
Paved_Roads	0.15	0.03
Bare Rock/Sand/Clay	0.45	0.25
Deciduous Forest	0.07	0.00
Evergreen Forest	0.14	0.00
Wetlands	0.00	0.00
High Intensity Residential	1.36	0.23
High Intensity Commercial/Industrial/Transportation	6.18	0.72
Low Intensity Residential	3.86	0.44

Landuse categories producing the highest loading rates for TP include agriculture, impervious areas associated with low-intensity residential, and impervious areas associated with high-intensity commercial/industrial/transportation. For TN, the highest loading categories include agriculture, impervious residential and commercial areas, followed by pasture lands and pervious residential and commercial areas. Because the entire watershed is an MS4, landuse loads, while modeled as nonpoint source runoff, are subject to WLAs under the NPDES Phase II stormwater permitting program.

Because the critical condition in Indian Creek occurs during low flow periods, when point sources are the dominant source of nutrients in the watershed, overall nonpoint loads were compared to overall point source loads derived from DMR data (Table 4-8 compares predicted annual watershed loads with

permitted point source loads). For the period modeled, average point source TN loads far exceeded nonpoint source loads while average point source TP loads were slightly less than nonpoint source loads. However, the relationship varies depending on flow and season as well as on the values selected to represent point source discharges.

Model results show highest nonpoint TP loading occurred during the month of October during the simulation period; the same is true of TN loading. Figure 4-7 compares modeled nonpoint loads in Indian Creek to typical annual loading values for point sources. Point source loading values were developed from facility monitoring data from the three NPDES permitted facilities (see Table 4-15). These values represent existing discharge levels and are actually less than baseline (permitted) loading levels, because the facilities typically discharge at volumes lower than design flow volumes and at concentrations lower than permitted concentration limits.

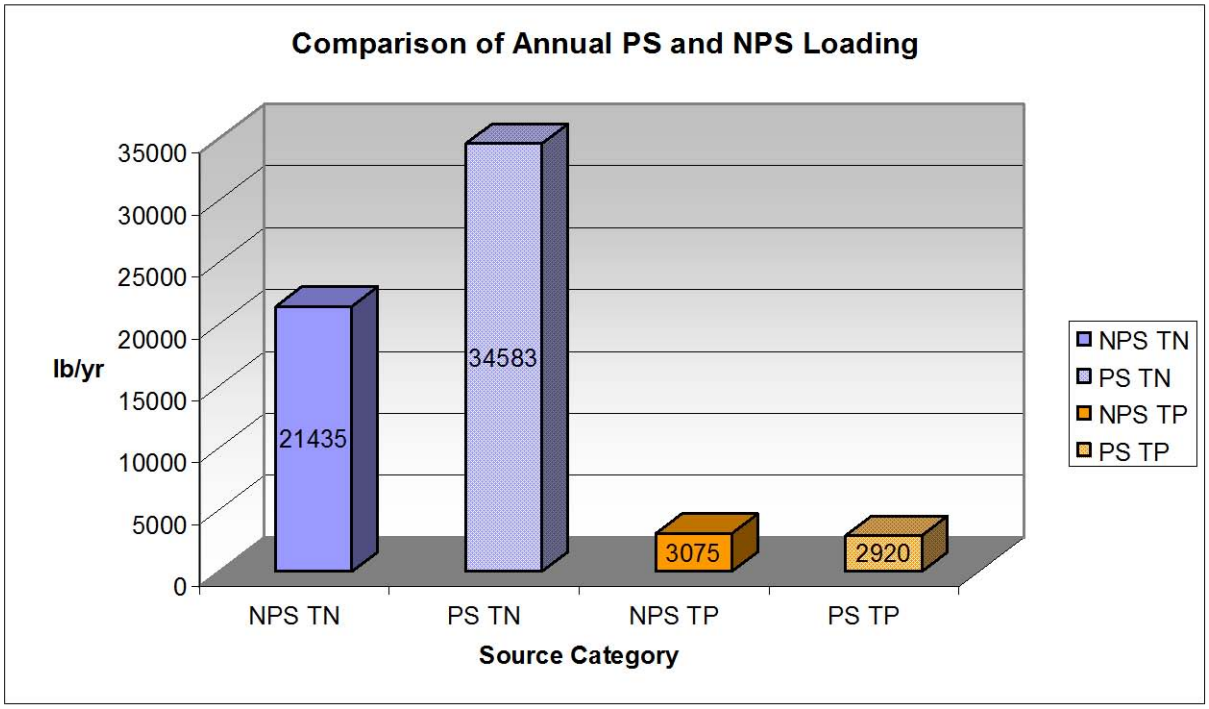


Figure 4-7. Comparing Annual PS and NPS Nutrient Loading in Indian Creek

4.2.5. Receiving Water Model

EFDC (Environmental Fluid Dynamics Code) is used for the receiving water modeling of Indian Creek. The EFDC model is a dynamic model that can simulate time-variable water quality constituents. In the Indian Creek EFDC model, both time variable point sources and nonpoint sources are represented. The nonpoint sources are estimated with the watershed model GWLF and the GWLF results are linked to EFDC.

EFDC is a general purpose modeling package for simulating three-dimensional flow, transport, and biogeochemical processes in surface water systems including rivers, lakes, estuaries, reservoirs, wetlands, and coastal regions. The EFDC model is a widely tested model and is supported by USEPA. In addition to hydrodynamic and salinity and temperature transport simulation capabilities, EFDC is capable of simulating cohesive and noncohesive sediment transport, near field and far field discharge dilution from multiple sources, eutrophication processes, the transport and fate of toxic contaminants in the water and sediment phases, and the transport and fate of various life stages of finfish and shellfish. Special enhancements to the hydrodynamic portion of the code, including vegetation resistance, drying and wetting, hydraulic structure representation, wave-current boundary layer interaction, and wave-induced currents, allow refined modeling of wetland marsh systems, controlled flow systems, and near-shore wave induced currents and sediment transport. The EFDC model has been extensively tested and documented. The model is presently being used by a number of organizations including universities, governmental agencies, and environmental consulting firms.

The structure of the EFDC model includes four major modules: (1) a hydrodynamic model, (2) a water quality model, (3) a sediment transport model, and (4) a toxics model (Figure 4-6). For Indian Creek, the hydrodynamic and water quality modules are used; the sediment and toxics modules were not used. The EFDC hydrodynamic model itself, which was used for this study, is composed of six transport modules including dynamics, dye, temperature, salinity, near field plume, and drifter (see Figure 4-7). Various products of the dynamics module (i.e., water depth, velocity, and mixing) are directly coupled to the water quality, sediment transport, and toxics models. A schematic diagram for the water quality model is included in Figure 4-8.

.

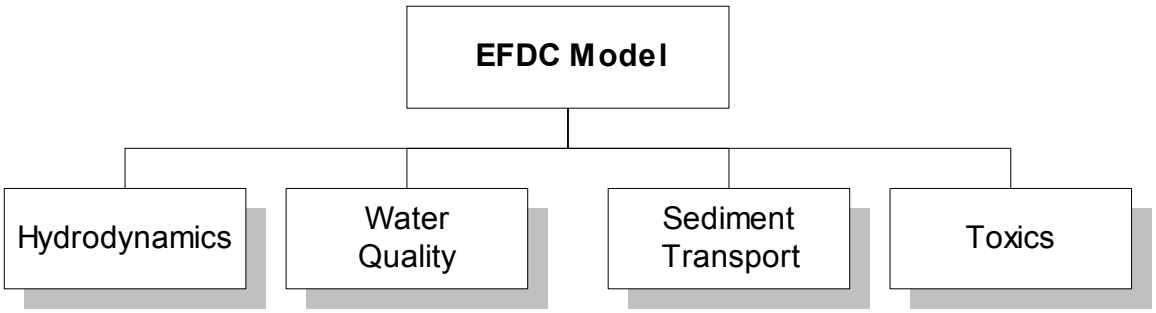


Figure 4-8. EFDC model structure.

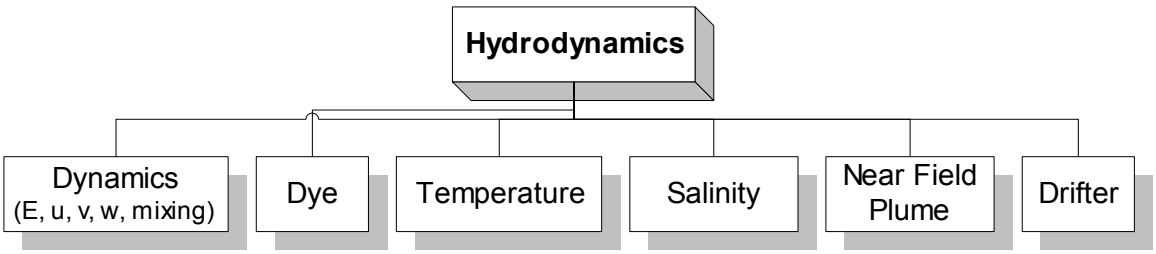


Figure 4-9. EFDC hydrodynamics module structure.

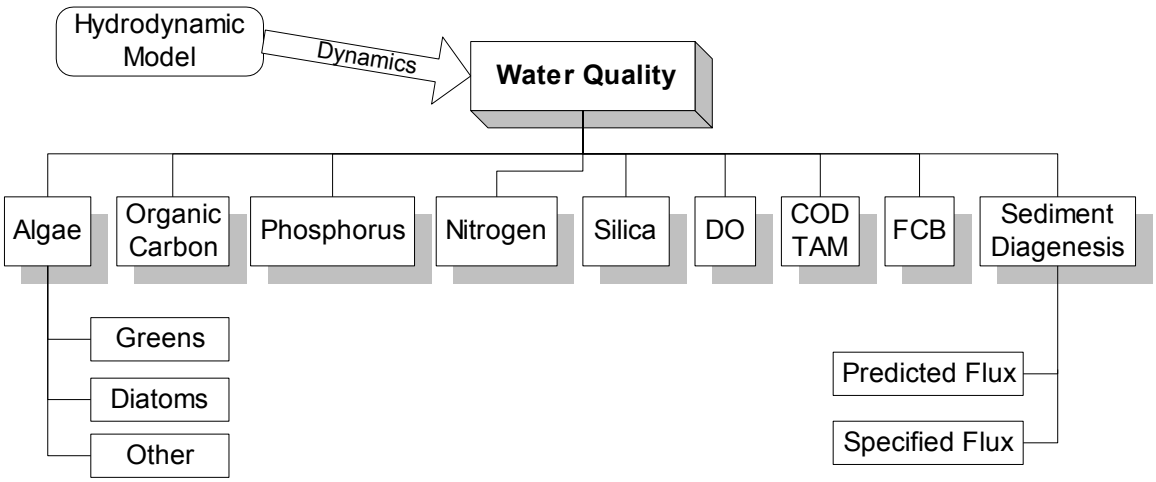


Figure 4-10. EFDC water quality module Structure.

The EFDC code includes a eutrophication submodel for water quality simulation (Park et al. 1995), which is functionally equivalent to the CE-QUAL-ICM or Chesapeake Bay Water Quality model Cerco and Cole 1993). The water column eutrophication models are coupled to a functionally equivalent implementation of the CE-QUAL-ICM biogeochemical processes model (DiToro and Fitzpatrick 1993). Figure 4-9 shows the schematic diagram. In addition to the phytoplankton, benthic algae or macroalgae can be simulated in EFDC. The eutrophication models can be executed simultaneously with the hydrodynamic component of EFDC. EFDC accepts an arbitrary number of point and nonpoint source loadings as well as atmospheric and ground water loadings.

4.2.6. EFDC Model Setup

Indian Creek monitoring data, including water depth, DO, and nutrients, were available for 05/09/2006 to 05/11/2006. In addition, DO and nutrients data were collected in August, 2006. To develop a reliable model for Indian Creek with limited data, a two-step approach was used to develop and calibrate the model. In the first step, the model was setup for a 30-day period using the field data from May 2006 as a pre-calibration run. This period was chosen to save computation time as it was anticipated that the model would reach a pseudo steady state within a simulation period of 30 days. The model reached pseudo-steady-state after 10 days simulation. In this step, the hydrodynamics were calibrated and the water quality parameters were estimated. In the second step, the water quality parameters obtained in pre-calibration were refined and finalized for TMDL development by linking it to the watershed model.

Segmentation

To set up the EFDC model, the stream was divided into discrete cells for computation. The stream network GIS coverage was cleaned to represent only the mainstem of Indian Creek and the two major tributaries that include point sources (Pilgrims Pride and Lower Salford). The mainstem of Indian Creek was divided into 49 segments. The tributary in subbasin 4 (Pilgrims Pride) was divided into eight segments and the tributary in subbasin 10 (Lower Salford) was divided into nine segments. The lengths of the segments were set to 200 meters for 63 segments among the total of 66 segments. The lengths for the three upstream segments (one on the mainstem, two on tributaries) are less than 200 meters. Since Indian Creek is a shallow stream, only one layer is used in the vertical direction. Figure 4-10 shows the EFDC modeling domain for Indian Creek.

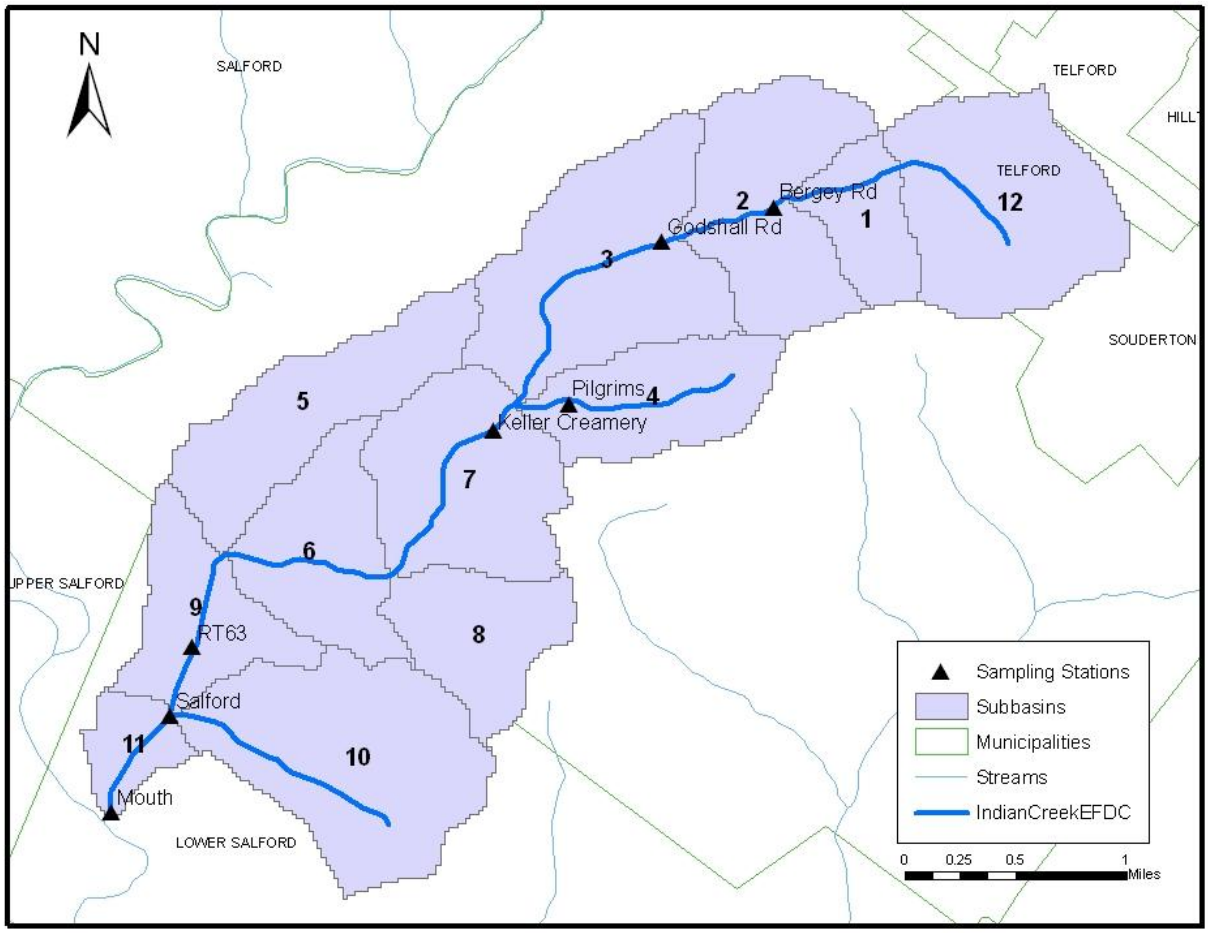


Figure 4-11. Indian Creek EFDC Modeling Domain.

Survey data from seven cross-sections were processed to obtain the width and average depth for the modeled segments (Table 4-14). The locations of cross-sections are also shown in Figure 4-11. The widths and depths of the segments on the mainstem were calculated by interpolating the surveyed data. The widths and depths of the segment on the two tributaries were specified directly with the surveyed data.

Table 4-14. Width and Average Depth at the Cross-Sections

Location	Width (ft)	Average Depth (ft)	Width (meter)	Average Depth (meter)
Bergey	8.20	0.25	2.50	0.08
Godshall	16.30	0.49	4.97	0.15
Pilgrims Pride (Tributary)	6.20	0.29	1.89	0.09
Keller Creamery	15.30	0.51	4.66	0.16
RT63	21.30	0.78	6.49	0.24
Salford (Tributary)	11.70	0.26	3.57	0.08
Indian Creek Mouth	19.20	0.68	5.85	0.21

Meteorological Data

EFDC requires time-variable weather time series to drive the model. Weather data including wind, air temperature, relative humidity, precipitation, and solar radiation are from the NCDC weather station Willow Grove NAS. Raw data were processed to EFDC format. For the pre-calibration step, the weather information from 05/09/2006 to 05/11/2006 was input to the model repeatedly for 30 days. For the second step, weather data from 04/01/2005 to 10/31/2006 are input to the EFDC model.

Point Source Representation

In the pre-calibration step, which used field data collected in May 2006, representative point source effluent flows were obtained by averaging the DMR flows for the month May for the period from 2001 to 2005. Nutrients and DO DMR data for the month of May for the same period were processed to estimate the nutrients in the effluents from the point sources. It was assumed that the total amount of ammonia and nitrate was identical among the three point sources since only one point source (Pilgrims Pride) had NO3 measurements. In addition, no data were available for the ratios of PO4 to TP in the effluents for the three point sources. In-stream PO4 and TP measurements show that over 93 percent of TP is PO4. Therefore, it was assumed that TP in the effluents was mainly PO4 and recorded TP concentrations were directly assigned to the EFDC model as PO4. Since PO4 is the major phosphorus species that algae use for growth, the assumption is conservative for TMDL development.

In the second step of calibration, if there were recorded data for both flow and nutrients within 2005, the data were used directly. For the time period without any record, averaged data from 2001 to 2004 were used. The assumptions for NO3 and PO4 are the same as in the pre-calibration step. Table 4-15 shows the values used in the model for the three point sources.

Table 4-15. Point source data used in Indian Creek EFDC model

Time	Telford STP				Pilgrims Pride				Lower Salford STP			
	Flow (mgd)	PO4 (mg/L)	NH3 (mg/L)	NO23 (mg/L)	Flow (mgd)	PO4 (mg/L)	NH3 (mg/L)	NO23 (mg/L)	Flow (mgd)	PO4 (mg/L)	NH3 (mg/L)	NO23 (mg/L)
Apr-05	0.848	0.400	0.100	5.931	0.138	0.925	0.234	5.798	0.459	0.246	0.100	5.931
May-05	0.519	1.000	0.100	5.898	0.136	0.740	0.480	5.518	0.442	0.126	0.103	5.894
Jun-05	0.527	2.300	0.100	7.605	0.158	0.793	1.540	6.165	0.462	0.164	0.100	7.605
Jul-05	0.577	1.200	0.100	26.090	0.128	1.230	0.290	25.900	0.396	0.178	0.133	26.057

Time	Telford STP				Pilgrims Pride				Lower Salford STP			
	Flow (mgd)	PO4 (mg/L)	NH3 (mg/L)	NO23 (mg/L)	Flow (mgd)	PO4 (mg/L)	NH3 (mg/L)	NO23 (mg/L)	Flow (mgd)	PO4 (mg/L)	NH3 (mg/L)	NO23 (mg/L)
Aug-05	0.511	0.600	0.100	4.700	0.136	0.360	0.200	4.600	0.396	0.110	0.100	4.700
Sep-05	0.405	0.700	0.100	9.518	0.106	0.100	0.200	9.418	0.478	0.103	0.100	9.518
Oct-05	0.583	1.180	0.323	12.158	0.129	1.580	0.380	12.100	0.443	0.126	0.100	12.380
Nov-05	0.705	1.500	0.220	12.280	0.121	1.580	1.153	11.347	0.475	0.479	0.130	12.370
Dec-05	0.810	1.500	0.353	12.007	0.116	1.580	0.635	11.725	0.534	0.479	0.270	12.090
Jan-06	0.713	1.300	0.670	4.486	0.126	0.360	0.426	4.730	0.457	0.246	0.440	4.716
Feb-06	0.840	1.300	0.585	3.831	0.125	0.360	0.364	4.053	0.475	0.246	0.363	4.054
Mar-06	0.958	1.300	0.592	6.452	0.140	0.360	0.184	6.860	0.538	0.246	0.533	6.510
Apr-06	0.848	0.400	0.100	5.931	0.138	0.925	0.234	5.798	0.459	0.246	0.100	5.931
May-06	0.519	1.000	0.100	5.898	0.136	0.740	0.480	5.518	0.442	0.126	0.103	5.894
Jun-06	0.527	0.400	0.050	3.650	0.158	0.010	0.650	3.050	0.462	0.100	0.050	3.650
Jul-06	0.577	0.400	0.050	2.450	0.128	0.090	0.510	1.990	0.396	0.090	0.050	2.450
Aug-06	0.511	0.800	0.900	12.850	0.136	0.320	0.390	13.360	0.396	0.130	0.050	13.70
Sep-06	0.405	0.500	0.050	19.900	0.106	0.045	0.200	19.750	0.478	0.120	0.050	19.90
Oct-06	0.583	0.400	0.050	22.450	0.129	0.030	0.310	22.190	0.443	0.120	0.620	21.880

Nonpoint Source Representation

In the pre-calibration simulation period, flows in Indian Creek were measured during the cross-section survey between 05/09/2006 and 05/11/2006. Watershed inflows between the cross-section locations were calculated and were distributed to corresponding EFDC model cells. Recorded water temperature time series in Indian Creek at the cross-sections were averaged and were assumed to be the water temperature in the watershed inflows. The temperature data were also repeated for the 30-day simulation period.

For the nutrients and organic carbon entering Indian Creek with watershed inflows, the GWLF model results including TP and TN for the period from 05/09/2006 to 05/11/2006 were used. The TP and TN results were processed to 12 nutrient and organic carbon species that are required by EFDC. DO in the watershed inflows are assumed to be at the saturation level.

For the second step of calibration, watershed runoff generated by GWLF for the period from 04/01/2005 and 10/31/2006 were processed to EFDC format, and flows were distributed to corresponding EFDC cells. The TP and TN generated by GWLF were processed and input to EFDC using the same approach as for the pre-calibration step. DO in the watershed inflows were assumed to be at the saturation level. The following section discusses the linkage between GWLF and EFDC.

Linkage of GWLF to EFDC

In the EFDC model, the variables for carbon and nutrients include labile particulate organic carbon (LPOC), refractory particulate organic carbon (RPOC), dissolved organic carbon (DOC), labile particulate organic phosphorus (LPOP), refractory particulate organic phosphorus (RPOP), dissolved organic phosphorus (DOP), orthophosphate (PO4), labile particulate organic (LPON), refractory particulate organic nitrogen (RPON), dissolved organic nitrogen (DON), ammonia (NH4), and nitrate

(NO3). To link the GWLF model to EFDC, GWLF-generated TP and TN were converted to the 12 EFDC water quality variables.

To derive the conversion of TP and TN to LPOC, RPOC, DOC, LPOP, RPOP, DOP, PO4, LPON, RPON, DON, NH4, and NO3, river and stream data from Montgomery County were obtained from USEPA's STORET. Ratios were calculated using the monitoring data from all the stations. The ratios are listed below in Table 4-16.

Table 4-16. Ratio Used to Convert GWLF Constituents to EFDC Constituents

EFDC Constituent	GWLF Constituents	Conversion ratio
RPOC	TN	0.92
LPOC	TN	0.92
DOC	TN	0.37
RPOP	TP	0.38
LPOP	TP	0.38
DOP	TP	0.15
PO4	TP	0.09
RPON	TN	0.16
LPON	TN	0.16
DON	TN	0.07
NH4	TN	0.01
NO3	TN	0.59

4.2.7. EFDC Model Calibration

Due to the limited data, the hydrodynamic calibration of the EFDC model was achieved by matching the measured average depth and modeled depth. In addition, modeled temperature and measured temperature were compared to insure correct thermal parameters. A comparison of depth is shown in Table 4-17. Figure 4-12 shows the results of temperature calibration.

Table 4-17. Comparison of Measured and Modeled Depth on the Main Indian Creek

Location	Measured Depth(m)	Modeled Depth (m)
IC Mouth	0.21	0.24
RT63	0.23	0.23
Keller Creamery	0.16	0.17
Godshall	0.15	0.12
Bergey	0.08	0.14

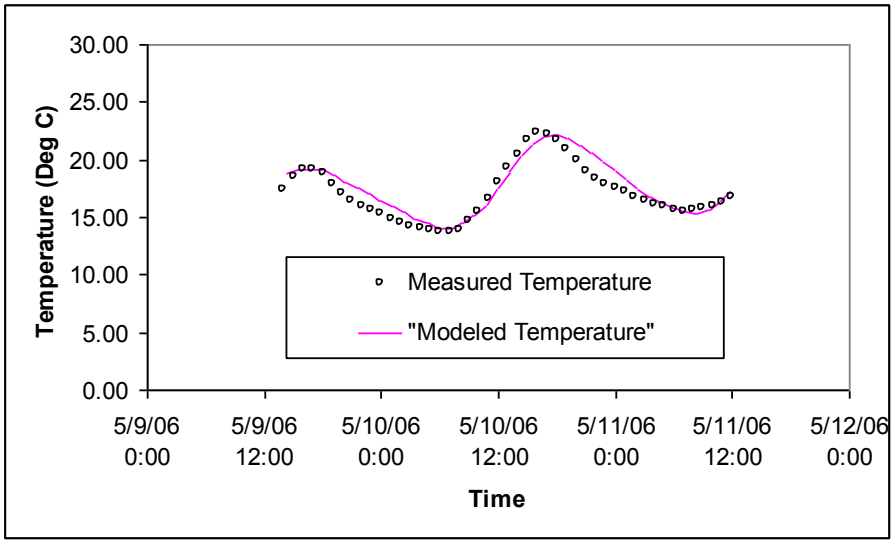


Figure 4-12. Temperature calibration results.

The next step was to calibrate the water quality parameters in Indian Creek. In the pre-calibration step, the flow and depth reach steady-state condition quickly. Although the flow and incoming nutrients are constant, weather conditions and water temperature in the watershed inflows are time variable. PO4, NH4, NO3 and DO were used as calibration targets, along with maximum, average, and minimum DO. Parameters were adjusted until model results agreed reasonably well with data during pre-calibration.

After the pre-calibration, the model was run for the long-term simulation and parameters were calibrated to observed data. Calibration plots showing longitudinal profiles of PO4, NH4, NO3, maximum DO, average DO, and minimum DO from the mouth of Indian Creek to upstream are presented in Appendix B: EFDC Calibration Plots. The comparison of modeled and monitored DO time series is also shown. The key parameters for the Indian Creek water quality model are shown in Table 4-18. The original calibration conducted in 2006 used only May 2006 data. The August 2006 data were also used in the updated calibration to obtain more reliable values of the benthic macroalgae parameters. The major change is the phosphorus half-saturation constant for macroalgae, which was changed from the original estimation of 0.005 mg/L to 0.05 mg/L after using two sets of data for the updated calibration.

Modeled NH4 is slightly lower than data, especially around 7000 meters from the Indian Creek mouth, where the golf course is located. Due to insufficient information on golf course irrigation, withdrawal water is not included in the current model. The increase of NH4 at this location may be caused by golf course irrigation. Modeled NO3 near Telford STP is strongly related to the NO3 in the effluent from Telford STP. The low modeled NO3 at this location is caused by the low NO3 concentration from Telford STP that is derived from Pilgrims Pride data. The modeled PO4 agrees well with the observed data. The longitudinal and time variable plots of DO show that the model is able to catch the DO fluctuation fairly well with slight over-predicting of minimum DO. Overall, the model is reasonably reliable to be used in TMDL development.

Table 4-18. Key Water Quality Parameters for Indian Creek EFDC Model

Parameter	Parameter Description	Value
KHNm	nitrogen half-saturation for macroalgae (mg/L)	0.125
KHPm	phosphorus half-saturation for macroalgae (mg/L)	0.05

Parameter	Parameter Description	Value
DOPTm	optimal depth (m) for macroalgae growth	0.3
TMm1	lower optimal temperature for macroalgae growth (degC)	12
TMm2	upper optimal temperature for macroalgae growth (degC)	25
KTG1m	suboptimal temperature effect coef. for macroalgae growth	0.02
KTG2m	superoptimal temperature effect coef. for macroalgae growth	0.001
TRm	reference temperature for macroalgae metabolism (degC)	20
KTBm	temperature effect coef. for macroalgae metabolism	0.1
FCRPm	carbon distribution coef. for macroalgae predation: refractory POC	0.3
FCLPm	carbon distribution coef. for macroalgae predation: labile POC	0.3
FCDPm	carbon distribution coef. for macroalgae predation: DOC	0.4
FCDm	carbon distribution coef. for macroalgae metabolism	0.2
KHRm	half-sat. constant (gO2/m3) for macroalgae DOC excretion	0.5
FPRPM	phos. distribution coef. for macroalgae predation: RPOP	0.1
FPLPM	phos. distribution coef. for macroalgae predation: LPOP	0.1
FPDPM	phos. distribution coef. for macroalgae predation: DOP	0.1
FPIPM	phos. distribution coef. for macroalgae predation: Inorganic P	0.7
FPRm	phos. distribution coef. of RPOP for macroalgae metabolism	0.1
FPLm	phos. distribution coef. of LPOP for macroalgae metabolism	0.1
APCM	factor to modify APC for macroalgae	0.5
FPDm	phosphorus distribution coef. of DOP for macroalgae metabolism	0.4
FPIm	phosphorus distribution coef. of P4T for macroalgae metabolism	0.4
CPprm1	constant used in determining algae Phos-to-Carbon ratio	42
CPprm2	constant used in determining algae Phos-to-Carbon ratio	85
CPprm3	constant used in determining algae Phos-to-Carbon ratio	200
FNRPM	nitrogen distribution coef. for marcoalgae predation: RPON	0.4
FNLPM	nitrogen distribution coef. for marcoalgae predation: LPON	0.5
FNDPM	nitrogen distribution coef. for marcoalgae predation: DON	0.1
FNRm	nitrogen distribution coef. of RPON for macroalgae metabolism	0.2
FNLm	nitrogen distribution coef. of LPON for macroalgae metabolism	0.4
FNDm	nitrogen distribution coef. of DON for macroalgae metabolism	1
FNIm	nitrogen distribution coef. of DIN for macroalgae metabolism	0
ANCm	nitrogen-to-carbon ratio for macroalgae	0.088
rNitM	maximum nitrification rate (gN/m3/day)	0.02
AOCR	stoichiometric algae oxygen-to-carbon ratio (gO2/gC)	2.67
AONT	stoichiometric algae oxygen-to-nitrate ratio (gO2/gN)	4.33
AOCRpm	macroalgae photosynthesis oxygen-to-carbon ratio	2.67
PMm	max. growth rate for macroalgae (1/day)	0.8
BMRm	basal metabolism rate for macroalgae (1/day)	0.1
PRRm	predation rate on macroalgae (1/day)	0.01

After the calibration, two scenarios were conducted to evaluate the impact of point sources and nonpoint sources on the stream. The first scenario sets nutrient contributions from point sources to zero and the second scenario sets nutrient contributions from nonpoint sources to zero. The results are shown in Appendix C. Under the nonpoint source only scenario, modeled DO results achieve the water quality standard (exhibiting less fluctuation due to algae) for the entire simulation period for all the stations. The results support the assumption that point sources are the dominant factor controlling algae levels and DO fluctuation.

To calculate the TMDL, two additional scenarios were run—baseline and the load reduction scenario. The results for each are presented in Appendix D and E respectively. The baseline condition for the Indian Creek TMDL uses the existing condition watershed runoff and nutrient loading generated with GWLF and used in model calibration. The weather conditions were also identical to those used in model calibration. Point sources were set at their permit limits (rather than existing discharges based on DMR data). Among the three point sources, discharge flow limits of Telford STP and Lower Salford STP were used in the baseline condition. Because there is no flow limit for Pilgrims Pride discharge, the recorded flows were used. For nutrients discharged from the three point sources, TP and NH4 permit limits were used for the baseline condition. The simulation period is from 04/01/2005 to 10/31/2006. The first two months were considered a stabilization period to eliminate the impacts of the model's initial conditions. Beginning with the baseline condition, successive model runs were performed to evaluate the level of instream nutrient concentrations during the target growing season period. Source loads were reduced until the average instream nutrient concentration for the period from April 1 to October 31 was met.

The model results for the baseline conditions show that both modeled average TPconcentration is higher than the TP target. In addition, modeled DO concentrations fall below the daily minimum of 5 mg/L and daily average of 6 mg/. The phosphorus concentrations from both the watershed runoff and point sources were reduced iteratively until TP met seasonal target levels and DO met the respective criteria. The simulation period is the same as in baseline conditions. The load reduction results can be found in Appendix E.

5. TMDL ALLOCATION ANALYSIS

A TMDL is the total amount of pollutant that can be assimilated by the receiving waterbody while still achieving water quality standards or goals. It is comprised of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is represented by the equation:

$$TMDL = \Sigma WLAs + \Sigma LAs + MOS$$

In TMDL development, allowable loadings from pollutant sources that cumulatively amount to no more than the TMDL must be established; this provides the basis to establish water quality based controls. TMDLs can be expressed on a mass loading basis or as a concentration in accordance with 40 CFR 130.2(l).

The load allocation (LA) is the portion in the TMDL that is assigned to nonpoint sources. Since the entire Indian Creek watershed is included in multiple MS4s regulated under the Phase II storm water program, the municipalities within Indian Creek watershed received WLAs to address the land-based stormwater loading. Therefore, the load allocation for sediment and nutrients in the Indian Creek watershed is zero. Once a municipality delineates its MS4 area, the sediment and nutrient loads associated with nonpoint sources may be parsed out of the WLA and allocated to the LA portion of the TMDL.

Federal regulations (40 CFR 130.7) require TMDLs to include individual WLAs for each point source. In addition USEPA's stormwater permitting regulations require municipalities to obtain permit coverage for all stormwater discharges from an urban municipal separate storm sewer system (MS4). A November 22, 2002 USEPA Memorandum from Robert Wayland and James Hanlon, Water Division Directors (http://www.epa.gov/boston/npdes/stormwater/) clarified existing regulatory requirements for MS4s connected with TMDLs. One key point is that NPDES-regulated MS4 discharges must be included in the wasteload allocation component of the TMDL and may not be addressed by the load allocation component of TMDL.

Based on this memorandum, MS4s within the Indian Creek watershed were treated as point sources for TMDL allocation purposes, and the loading generated within the boundary of an MS4 area was assigned a WLA.

There are three point source facilities and five MS4 communities within the Indian Creek watershed, all requiring WLAs.

5.1. Sediment TMDLs

The sediment TMDL for the Indian Creek watershed was developed using the GWLF model and identification of targets was based on a reference watershed. The GWLF model was used to establish existing loading conditions for the Indian River watershed. The unit area loading rates established for the reference watershed in the Wissahickon TMDL (i.e., Ironworks Creek) were used to identify the sediment loading target; these rates were further refined to arrive at the final allocation for the landuse loading derived (MS4) portion. Further information about selection of the sediment target can be found in Section 1.4.

Model results show that existing sediment loading is approximately 12,693,686 lb/year. The target sediment values for the watershed were determined by multiplying the land use area of the Indian Creek watershed by the target unit area loading rates established using Ironworks reference watershed in the Wissahickon Creek TMDL (see Table 1-3). Based on this calculation, the target or allowable sediment load for the Indian Creek watershed is 641,733 lb/year.

From the allowable sediment load, a 5 percent MOS and a 6 percent future residential gross growth wasteload allocation were subtracted. It was assumed that since point sources were not a significant source of sediment in the watershed (approximately 1.3 percent of the existing loading), they would not require a reduction. Therefore, the point source sediment total of 169,922 lb/yr (calculated using permit limits and corresponding flow limits) was also subtracted from the allowable load and this resulted in a target value for the remaining portion of the watershed of 401,220 lb/yr. Because the entire watershed is considered an MS4, this remaining load is the amount allocated to the MS4 WLA. Finally, earlier versions of the DRAFT TMDL inadvertently included a small portion of Upper Salford in the overall allocation. For sediment, the Upper Salford MS4 area had been allocated 129 lb/yr. Subtracting this from the total allowable MS4 load leaves the target value for the remaining watershed as 401,091 lb/yr. Not counting the MOS or the Future Growth allocations, the WLA portions of the sediment TMDL is 571,013 lb/yr, the TMDL is 641,604 lb/yr, see Table 5-1 for a summary. The following sections describe in more detail how the allocations for point source facilities and MS4 areas were identified.

Table 5-1. Summary of Sediment TMDL Loads for Indian Creek Watershed

Indian Creek Watershed	Sediment Loading (lb/yr)
Existing Load	12,693,686
Allowable Load	641,733
MOS (5%)	32,087
Future Residential Growth (6%)	38,504
Σ WLA Point Sources	169,922
Σ WLA MS4	401,091
Σ LA	0
TMDL*	**641,604**

*Less 129 lb/yr previously allocated to Upper Salford

Sediment WLAs

For the permitted facilities, the sediment WLA was calculated using permit limits and corresponding flow limits. (Because the Pilgrims Pride facility does not have a flow limit, a maximum flow value based on reported flow was used to compute the WLA for the Pilgrims Pride Facility.) Table 5-2 presents the

WLAs assigned to each of the point source facilities. The sediment WLA is an annual average based on a seven year simulation period. A corresponding daily maximum load expression was developed using a statistical approach outlined in EPA's *Draft Options for Expressing Daily Loads in TMDLs* (EPA 2007). Calculation details are provided in Section 5.3. EPA did not impose reductions to permitted facility discharge levels for sediment.

Table 5-2. Sediment WLAs for Continuous Point Sources in the Indian Creek Watershed

Point Source Facility	NPDES ID	Sediment WLA (lb/yr)	Sediment WLA (mg/L)	Daily Maximum (lb/day)
Telford	PA0036978	100,455	30	523
Pilgrims Pride	PA0054950	5,540	10	35
Lower Salford	PA0024422	63,926	30	533
	Total WLA	**169,922**	**--**	**--**

To determine the allowable sediment loading associated with each MS4, the township boundary GIS layer was overlaid with the watershed boundary and the MS4 WLA was proportionally assigned to each municipality based on area and landuses contained.

The MS4 loadings were derived based on the modeled GWLF results after the EMPR reduction analysis. First the GWLF model was used to estimate landuse specific unit area loadings for each subbasin. The municipality total areas were then overlaid with the subbasins within GIS to estimate the MS4 area falling within each subbasin. Next this unit area loading for each landuse within a particular subbasin was multiplied by the area of the municipality that it falls into to estimate the MS4 loads.

In each municipality, the reference loading rate was applied to each appropriate landuse and multiplied by the area of the landuse in the jurisdiction to determine the allowable sediment loading. The initial reference loading rates were then adjusted downward for all categories except forest and wetlands until the resulting loads for the MS4 portion of the WLA equaled the appropriate value, 401,220 lb/yr. Table 5-3 shows existing, reference, and TMDL landuse loading rates. Table 5-4 provides the total and daily maximum sediment loads allocated to each of the MS4 jurisdictions and the landuse breakdown.

At this time, EPA cannot determine what portion of the municipalities are designated/used for collection or conveying stormwater, as opposed to portions that are truly nonpoint sources. As part of the Phase II stormwater permit process, MS4s will be responsible for evaluating and mapping out areas that are draining to or discharging to storm sewers. Since these systems have not yet been delineated, the TMDL lumps nonpoint source loadings into the WLA portion of the TMDL. Once these delineations are available, the nonpoint source loadings can then be separated out of the WLAs and moved under the LA. After adjusting the WLAs and LAs based on MS4 service area delineation, Pennsylvania may initiate the TMDL revision process.

Table 5-3. Existing, Reference and TMDL Landuse Loading Rates for Sediment

SOURCE	Existing Unit Area Load (lb/ac/yr)	Reference Target Unit Area Loading (lb/ac/yr)	Final Target Unit Area Loading (lb/ac/yr)
Agriculture	8595	464	291
Pasture	3727	52	32
Paved_Roads	192	105	66
Bare Rock/Sand/Clay	745	619	388
Deciduous Forest	2	5.43	5
Evergreen Forest	3	3.99	3.99
Wetlands	0	0	0
High Intensity Residential*	37 / 424	105	66
High Intensity Commercial/Industrial/Transportation*	37 / 424	105.12	66
Low Intensity Residential*	33 / 424	124.12	78

* denotes pervious / impervious estimated loading rates

Table 5-4. MS4 Sediment WLAs (lb/yr)

Source	Lower Salford	Souderton	Telford	Franconia
Agriculture	35,033	388	1,681	176,524
Pasture	13,326	402	431	37,068
Paved_Roads	1,405	307	600	1,551
Bare Rock/Sand/Clay	345	-	-	4,312
Deciduous Forest	414	-	11	744
Evergreen Forest	6	-	-	-
Wetlands	-	-	-	-
High Intensity Residential	11,503	3,000	6,264	24,850
High Intensity Commercial/Industrial/Transport	3,849	1,273	3,644	6,805
Low Intensity Residential	15,068	1,901	4,234	44,150
Total WLA (lb/yr)	**80,950**	**7,272**	**16,864**	**296,005**
Maximum Daily (lb/day)	**497**	**45**	**104**	**1818**

5.2. Nutrient TMDLs

The nutrient TMDL for the Indian Creek watershed was developed using a separate application of the GWLF watershed model of the Indian Creek watershed linked to an in-stream EFDC model of Indian Creek. The GWLF model was used to establish existing nonpoint loading conditions for the Indian Creek watershed. The seasonal average TP target was used as the endpoint (Section 1.3). In addition, average periphyton levels and daily minimum and average DO were also evaluated to ensure that reductions made to comply with the seasonal nutrient endpoint will also adequately address necessary DO criteria and nuisance algal levels.

As with the sediment TMDL, stormwater nutrient loads are covered under the Phase II NPDES Stormwater Program and were considered waste loads. Since the entire watershed is considered an MS4, and thus receives a waste load allocation, the load allocation is zero. Again, in earlier drafts of the TMDL, 0.15 lb/yr TP had been allocated to Upper Salford under the total MS4 allocation. That small portion of load has been removed from this Final version of the report. Table 5-5 presents a summary of the TMDL components for TP. The load reduction scenario required an approximately 70 percent reduction in total phosphorus non-point sources.

Table 5-5. Nutrient TMDL loads for Indian Creek Watershed

Indian Creek Watershed	TP Loading (lb/yr)
Existing Load	11,389.11
Allowable Load	1,598.20
MOS (5%)	79.91
Future Growth (6%)	95.892
Σ WLA Point Source	278
Σ WLA MS4	1,144.25
Σ LA	-
TMDL	**1,598.05**

Nutrient WLAs

Since the entire watershed lies within MS4 areas, the entire allocated load is considered WLA. The two types of WLA include the three continuous dischargers and the landuse based load originating from areas within the jurisdictions responsible for implementing the MS4s in the watershed: Lower Salford, Souderton, Telford and Franconia. Table 5-6 presents key loading information for the continuous dischargers. Flows for the Pilgrims Pride facility were derived from monitored flows collected during the critical summer period.

Table 5-6. Summary of Continuous Discharger's TP Loading under the Indian Creek TMDL

				TMDL Conditions			
NPDES ID	**Facility Name**	**Flow (MGD)**	**Baseline Load (lb/yr)**	**WLA Annual Load (lb/yr)**	**Growing Seasonal Load (lb/season)**	**Maximum Daily Load (lb/day)**	**Concentration (mg/L)**
PA0024422	Lower Salford	0.7	1,066.16	101.30	59.40	0.69	0.0475
PA0054950	Pilgrims Pride	Report	791.53	20.60	12.30	0.18	0.052
PA0036978	Telford	1.1	5,695.68	156.10	91.50	0.85	0.04658
Total			**7,553.37**	**278.00**	**163.20**	**1.72**	

Landuse based, or MS4 associated WLAs are the second type of WLA specified in this TMDL. To determine the phosphorus loading associated with each MS4, the township boundary GIS layer was overlaid with the watershed boundaries and the land-based WLA was proportionally assigned to each municipality based on area. Existing, TMDL, and Maximum Daily TP Loads for each permittee (point source and MS4) are presented in Table 5-7. TP WLAs for each MS4 municipality are presented in Table 5-8 by landuse.

At this time, EPA cannot determine what portion of the municipalities are designated/used for collection or conveying stormwater, as opposed to portions that are truly nonpoint sources. As part of the Phase II stormwater permit process, MS4s will be responsible for evaluating and mapping out areas that are draining to or discharging to storm sewers. Since these systems have not yet been delineated, the TMDL lumps nonpoint source loadings into the WLA portion of the TMDL. Once these delineations are available, the nonpoint source loadings can then be separated out of the WLAs and moved under the LA. After adjusting the WLAs and LAs based on MS4 service area delineation, Pennsylvania may initiate the TMDL revision process.

Table 5-7. Existing, TMDL, and Maximum Daily Total Phosphorus WLAs for Permittees

NPDES ID	Facility/Township	Existing Load (lb/yr)	TMDL (lb/yr)	Maximum Daily (lb/day)	% Reduction
PA0036978	Telford Borough Authority	5695.66	156.10	0.846	97%
PA0054950	Pilgrim's Pride	791.53	20.60	0.181	97%
PA0024422	Lower Salford Authority (Harleysville STP)	1066.16	101.30	0.694	90%
MS4	Lower Salford	803.32	303.29	1.862	62%
MS4	Souderton	49.4	49.40	0.303	0%
MS4	Telford	118.18	118.18	0.726	0%
MS4	Franconia	2863.44	849.18	5.214	70%

Table 5-8. MS4 Related WLAs for Total Phosphorus

Landuse/Source	LOWER SALFORD	SOUDERTON	TELFORD	FRANCONIA
Agriculture	72.80	3.27	14.18	208.31
Pasture	63.16	5.23	5.61	176.95
Paved_Roads	0.30	0.17	0.33	0.31
Bare Rock/Sand/Clay	0.07	0.00	0.00	0.99
Deciduous Forest	0.07	0.00	0.01	0.21
Evergreen Forest	0.00	0.00	0.00	0.00
Wetlands	0.00	0.00	0.00	0.00
High Intensity Residential	16.63	8.91	18.60	35.77
High Intensity Commercial/Industrial/Transport	18.45	12.05	34.49	30.63
Low Intensity Residential	37.51	9.93	22.11	105.35
Groundwater	53.90	3.27	7.12	177.57
Point Sources	101.30		156.10	20.60
TMDL (lb/yr)				**1,422.25**
5% MOS				**79.91**
6% FUTURE GROWTH				**95.892**
Total Allowable Load (lb/yr)				**1,598.05**
Existing Load (lb/yr)				**11,389.11**

5.3. Daily Load Expressions

Table 5-7 lists the maximum daily loads associated with the long-term allocations that have been determined to meet the identified seasonal average TP target of .04 mg/L. A statistical approach based on guidance provided in the Technical Support Document for Water Quality Based Toxics Control (EPA, 1991) was used to develop these daily maximum values. EPA's Draft Guidance Document, *Options for Expressing Daily Loads in TMDLs*, (EPA, 2007) recommends this approach as an appropriate way to develop daily maximum load values for TMDLs using allocation timeframes other than daily. The draft guidance provides the following description of the rationale for using this approach to develop maximum daily load values that correspond to long term loading values such as those identified in this TMDL:

> In the case where the daily data are normally distributed about the mean, the maximum daily load expressed as the *p*th percentile of the distribution is calculated as
>
> $$MDL = \mu + Z_p\,\sigma = \mu + Z_p\,{}^{CV}\!/_{\mu},$$
>
> where MDL is the maximum daily limit, Φ is the mean of the distribution (in this case, the average load to achieve WQS), σ is the standard deviation of the daily loads, *CV* is the coefficient of variation of the daily loads (standard deviation divided by the mean), and Z_p is the *p*th percentage point of the standard normal distribution. (Z-scores are published in basic statistical reference tables and are often included as a spreadsheet function [e.g., NORMSINV(y) in MS Excel]. For the 95th percentile, Z_p = 1.645, and for the 99th percentile, Z_p = 2.326.)
>
> In the case where the daily data are lognormally distributed about the mean—as is often the case with loads that are dependent on flow magnitude—the MDL corresponding to a

long-term average (LTA) calculated in the TSD relates the permit MDL to the desired LTA as

$$MDL = LTA \cdot \exp\left(Z_p \sigma_y - 0.5\sigma_y^{\ 2}\right),$$

where
Z_p = pth percentage point of the standard normal distribution, as above
CV = coefficient of variation of the untransformed data

$$\sigma_y = \sqrt{\ln\left(CV^2 + 1\right)}$$

For the Indian Creek TMDL, daily maximums were calculated for each of the sources assuming a log-normally distributed dataset, using the 95th percentile z-statistic. For the continuous dischargers, the coefficient of variation was calculated based on monitoring data. Since no such data were available for the MS4 sources, a coefficient of variation of 0.6 was assumed. Table 5-9 summarizes key parameters used in each calculation. Note that using this method, the higher the coefficient of variation, the lower the corresponding daily maximum value.

Table 5-9. Variables used in calculating the Daily Maximum Loads

Facility/Township	Telford Borough Authority	Pilgrim's Pride	Lower Salford Authority	Lower Salford	Souderton	Telford	Franconia
NPDES ID	PA0036978	PA0054950	PA0024422	MS4	MS4	MS4	MS4
Sediment							
CV	0.452	0.619	0.953	0.6	0.6	0.6	0.6
Z_p	1.645	1.645	1.645	1.645	1.645	1.645	1.645
σy	0.431	0.569	0.803	0.554	0.554	0.554	0.554
Total Phosphorus							
CV	0.487	1.03	0.711	0.6	0.6	0.6	0.6
Z_p	1.645	1.645	1.645	1.645	1.645	1.645	1.645
σy	0.461	0.8503	0.639	0.554	0.554	0.554	0.554

5.4. Margin of Safety

The margin of safety (MOS) is the portion of the pollutant loading reserved to account for any uncertainty in the data. There are two ways to incorporate the MOS (USEPA 1991): (1) implicitly incorporate the MOS by using conservative model assumptions to develop allocations or (2) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations.

A five percent explicit MOS was used to account for uncertainty in the modeling process. This was based on previous experience for TMDL development in Pennsylvania, professional judgment and published literature.

5.5. Future Residential Growth

An allocation of six percent of the total allowable load was made to future residential growth for each of the parameters addressed in this TMDL. Both the MOS and the future growth allocations were taken from the allowable portion of landuse related loadings.

5.6. Critical Conditions and Seasonal Variations

Federal Regulations (40 CFR 130.7(c)(1)) require TMDLs to consider critical conditions for streamflow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality and designated uses of the waterbodies are protected during periods when they are most vulnerable. Critical conditions include combinations of environmental factors that result in attaining and maintaining the water quality criteria and have an acceptably low frequency of occurrence (USEPA, 2001).

TMDLs for Indian Creek adequately address critical conditions for flow through the use of a dynamic model and analysis of all flow conditions in the basin. In Indian Creek, critical conditions tend to occur during warm weather months during periods of low flow. For nutrient impaired systems such as Indian Creek, critical conditions can occur as a result of a combination of wet and dry weather conditions depending on the system. Therefore the use of a dynamic modeling application capable of representing conditions resulting from both low and high flow regimes is appropriate. The linkage to a dynamic watershed loading model ensures that nonpoint source loads from the watershed delivered at times other than the critical period were also considered in the analysis.

The TMDL was calculated based on the 7-month period from April to October as this was determined to be the period during which most severe algal growth conditions are likely to occur. At times during this period, much of the Indian Creek stream flow is dominated by point source flows.

Critical conditions for nutrient loads were also considered by determining WLAs based on maximum flows from dischargers set by design flows specified in NPDES permits for each facility. Under normal summer conditions, the combined discharge flows are approximately 40 percent of combined design flows. Use of design flows in TMDL determination provides additional assurance that when design flows are reached, the water quality in the stream will meet water quality criteria.

Model simulation of multiple complete years accounted for seasonal variations. Continuous simulation (modeling over a period of several years that captured precipitation extremes) inherently considers seasonal hydrologic and source loading variability. The constituent concentrations were simulated on a sub-daily time step, capturing seasonal variation and allowing for evaluation of critical conditions.

6. REASONABLE ASSURANCE

EPA requires that there is reasonable assurance that TMDLs can be implemented. TMDLs represent an attempt to quantify the pollutant load that may be present in a waterbody and still ensure attainment and maintenance of water quality standards. Point source allocations will be implemented through the NPDES program. MS4 allocations will be implemented by the respective municipalities and integrated into their stormwater management programs.

WLAs will be implemented through the NPDES permit process. According to 40 CFR 122.44(d)(1)(vii)(B), the effluent limitations for an NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source. Although TMDLs are not required to include an implementation component, EPA has included for consideration an adaptive management NPDES permitting approach in Appendix F.

It is worth noting that EPA has prepared a separate ―Treatability Report" which summarizes the existing treatment processes for the Indian Creek point source dischargers and discusses nutrient removal techniques that are available and some costs. Included in this report is a summarization of BMPs that are available for various land use types, including suburban/urban areas such as the Indian Creek Watershed, for nutrient removal. There is information about treatment types and expected efficiencies, limitations, costs, etc. that may be useful for MS4 communities.

7. PUBLIC PARTICIPATION

As part of the TMDL development process, a public participation process is required. Each state must provide for public participation consistent with its own continuing planning process and public participation requirements.

To date, EPA has held two information meetings during the course of the TMDL development process. On November 30, 2006 at the Lower Salford Township Building, EPA informed stakeholders of our TMDL development plans and presented an overview of the TMDL process. And, on December 17, 2007 in EPA's Region 3 office, stakeholders were presented with the selected TMDL endpoints and methodology used to derive such endpoints, as well as a conceptual adaptive management approach for TMDL implementation.

In terms of the proposed TMDL, a notice of availability for comments on the draft TMDL was published in *The Philadelphia Inquirer* on February 26, 2008 and on EPA Region 3's TMDL website and *The Souderton Independent Newspaper* on February 27, 2008. EPA is accepting public comments from February 27, 2008 through midnight on April 6, 2008. EPA will also be holding a public meeting to present details and answer questions regarding the proposed TMDLs on March 18, 2008 from 7:00pm to 9:00pm at the Lower Salford Township Building, 379 Main Street, Harleysville, Pennsylvania.

EPA welcomes input from interested parties and the general public on the proposed TMDL document. **All comments must be postmarked no later than the close of the comment period, April 6, 2008.** All comments can be sent to Ms. Lenka Berlin at the address below. Electronic submission of comments is encouraged. The TMDL report is available at the EPA Region III office or website (http://www.epa.gov/reg3wapd/tmdl/index.htm). A copy of the report can also be requested through the contact provided below. Please direct any questions about the proposed TMDL document or meeting to Ms. Mary Kuo at (215) 814-5721 or kuo.mary@epa.gov.

berlin.lenka@epa.gov
or
Ms. Lenka Berlin (3WP30)
US EPA, Region III
1650 Arch Street, Philadelphia, PA 19103
Phone: 215-814-5259

Following receipt of comments during the public comment period, EPA will finalize the TMDL and make revisions as necessary. A document providing EPA's responses to public comments will also be prepared as part of the final TMDL.

Note that EPA is seeking public comment on two scenarios: (1) whether TP and TN TMDL and allocations are necessary to achieve necessary nutrient reductions within the Indian Creek Watershed, or (2) if TP only allocations and controls are sufficient. To the extent that the commenters feel that both TP and TN TMDLs are needed, EPA is also soliciting comment on whether the proposed TN endpoints are appropriate.

Data analysis and modeling runs have established a clear linkage between phosphorus loading and periphyton densities in the watershed; however, the linkage between nitrogen and periphyton in this system is somewhat less well-established. Nevertheless, EPA is proposing TN endpoints in this TMDL because of the potential downstream effects of excess nitrogen loading to coastal and estuarine waters, such as the Delaware Bay. In a similar situation, NPDES permittees within Pennsylvania are currently receiving both TP and TN effluent limits in order to help meet water quality standards in the Chesapeake

Bay. Additionally, PADEP is working on the development of numeric nutrient criteria development and is considering criteria adoption for multiple indicators including nitrogen, as other states have. EPA expects that establishment of nitrogen allocations at this time may enable permittees to address and plan for treatment upgrades and capital expenditures for compliance with both TP and TN limits together rather than requiring facilities to address phosphorus now and nitrogen at a later date.

REFERENCES

Ambrose, R.B., T.A. Wool, and J.L. Martin. 1993. The water quality analysis and simulation program, WASP5: Part A, model documentation version 5.1. U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA, 210 pp.

Arnold, J. G., and P. M. Allen. 1999. Automated methods for estimating baseflow and groundwater recharge from streamflow records. JAWRA 33:6 1010-1018.

Bingner, R. L, Theurer, F. D. 2000. Physics of suspended sediment transport in AnnAGNPS. Proceedings of the 2002 Second Federal Interagency Hydrologic Modeling Conference, Las Vegas, NV, July 28 – August 1, 2002. No page numbers, published as CD-ROM. 12 pp. 2002.

Carrick, H. and C. Godwin. 2006. *TMDL Endpoint Estimates for an Urban-suburban Stream Based Upon In-Stream Periphyton Biomass (Wissahickon Creek Watershed, Pennsylvania)*. School of Forest Resources, The Pennsylvania State University, 11 p.

Cerco, C.F., and T. Cole. 19 93. T hree-dimensional eutrophication model of Chesapeake Bay. *J. Environ. Engnr.*119:1006-1025.

CMX. 2008. DRAFT Sewage Management Program Phase III, 2007 Annual Report. Prepared for Franconia Township.

Dai, T., R.L. Wetzel, T. R. Christensen, and E.A. Lewis. 2000. BasinSim1.0: A windows-based watershed modeling package. Virginia Institute of Marine Science. College of William and Mary. Gloucester Point, VA.

DiToro, D.M ., and J.F. Fitzpatrick. 1993. Chesapeake Bay sediment flux model. Contract Report EL-93-2. Prepared by HydroQual, Inc. for USEPA Chesapeake Bay Program, U.S. Army Engineer District, Baltimore, MD, and U.S. Army Engineer Waterways Exp. Station.

Dodds, W.K. 2005. *Eutrophication and Trophic State in Rivers and Streams.* Limnol. Oceanogr. In press.

Dodds, W.K., V.H. Smith, and K. Lohman. 2006. ―Erratum: Nitrogen and phosphorus relationships to benthic biomass in temperate streams". NRC Research Press Web site, (http://pubs.nrc-cnrc.gc.ca/rp2_home_e.html). April 21, 2006.

Haith, D.A., and L.L. Shoemaker. 1987. Generalized watershed loading functions for streamflow nutrients. Water Resources Bulletin 23(3):471-478.

Hamrick, J.M. 1996. User's Manual for the Environmental Fluid Dynamics Code – EFDC. The College of William and Mary, Virginia Institute of Marine Sciences.

Hamrick, J. M. and T.S. Wu, 1996. Computational Design and Optimization of EFDC/HEM3D Surface Water Hydrodynamic and Eutrophication Models. Computational Methods for the Next Generation Environmental Models. U.S. Environmental Protection Agency, National Environmental Supercomputer Centre.

Matlock, M. D., M. E. Matlock, D. E. Storm, M. D. Smolen, and W. J. Henley. 1998. Limiting nutrient determination in lotic ecosystem using a quantitative nutrient enrichment periphytometer. JAWRA 34:5 1141-1147.

PADEP 2005. Personal Communication, James Wentzel, Pennsylvania DEP.

PADEP 2005a. Equal Marginal Percent Reduction (EMPR) (An Allocation Strategy) and Watershed EMPR for Point Source Discharges, January 20, 2005

Paul, M., and Lei Zheng 2007. Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application.

Shanaha, P. and M. Alam. 2001. The Water Quality Simulation Program, WASP5, Version 5.2-MDEP Manual:Part A. Hydraulics and Water Resource Engineers, INC., Waltham, MA.

USEPA (U.S. Environmental Protection Agency). 1991. *Technical Support Document for Water Quality based Toxics Control*. EPA/505/2-90-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 1999. Protocol for Developing Sediment TMDLs (First Edition), EPA 841-B-99-004. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

Welch, E.B., J.M. Jacoby, R.R. Horner, and M.R. Seeley. 1988. *Nuisance Biomass Levels of Periphytic Algae in Streams.* Hydrobiologia 157: 161-168.

Zou, R., Carter, S., Shoemaker, L., Parker, A., and Henry, T., 2006. An Integrated Hydrodynamic and Water Quality Modeling System to Support Nutrient TMDL Development for Wissahickon Creek. Journal of Environmental Engineering, ASCE, 132(4), 555-566

APPENDIX A: AMBIENT SAMPLING RESULTS ABOVE AND BELOW MUNICIPAL STPS

Following an unassessed waters screening in the summer of 2001, PADEP determined that Indian Creek was impaired from its source to the mouth by possible nutrient impairment. From this assessment, biological habitat scores for locations throughout the Indian Creek watershed are available. They were reviewed to support this effort, however the data are more suitable for qualitative descriptions of stream conditions than for analysis of in-stream water quality as no chemical data were collected during the biological surveys. Based on findings of the unassessed waters screening, investigations were conducted to evaluate the possibility of Telford Borough Authority and Lower Salford Township Authority Harleysville STP outfalls as the source of stream impairment. The Telford STP is listed as the source of nutrient impairment to Indian Creek on the 2002 303(d) list. Chemical sampling was conducted in Indian Creek at the Telford Borough Authority STP on Oct. 24, 2001, Apr. 14, 2003, and on May 14, 2003; and at the Lower Salford Township Authority Harleysville STP on Oct. 24, 2001 and Apr. 14, 2003 by PADEP. Additionally, biological sampling was conducted in the above mentioned two sites on all the above dates, except May 14, 2003.

At each location, samples were collected upstream of the discharge (site 1), at the discharge (effluent), and downstream of the discharge (site 2).

Telford Ambient Sampling

Analyses of total phosphorous (TP) near the Telford discharge (Figure A-1) suggest that the ambient concentration (represented by site 1) remained approximately the same on the sampling dates of Oct. 24, 2001, Apr. 14, 2003, and May 14, 2003. TP concentration increased downstream of the effluent in Oct. 24, 2001, decreased in Apr. 14, 2003, and remained approximately the same in May 14, 2003. Summation of the ambient TP concentration (site 1) and effluent TP concentration (effluent) approximately equaled the concentration of TP at Site 2 on Oct. 24, 2001. The summation of ambient concentration and effluent was less than the TP concentration, however, at site 2 on Apr. 14, 2003 and on May 14, 2003. Since a greater portion of the concentration at Site 2 was contributed by effluent on the October sampling date, the effluent appears largely responsible for downstream (site 2) increased concentrations that day. Rainfall data for the period indicated periods of precipitation preceded the April and May sampling dates. This indicates that nonpoint source contributions, in addition to effluent, were affecting in-stream conditions on those days.

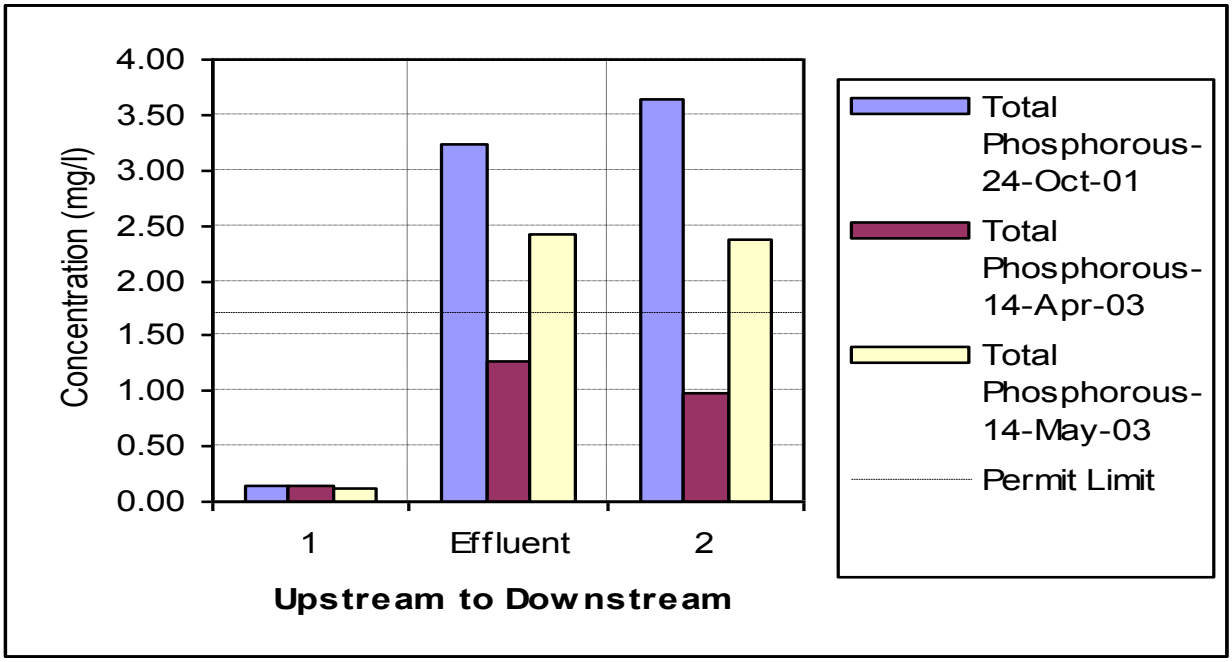


Figure A-1. Total Phosphorus concentration at the sampling sites

Analyses of total nitrogen (TN) near the Telford discharge (Figure A-2) suggest that concentrations increased from site 1 to the effluent location and remained approximately the same at site 2 for Oct. 24, 2001, Apr. 14, 2003, and May 14, 2003. The increase in concentration on Oct. 24, 2001 at site 2 from ambient (site 1) concentration was mostly due to the effluent discharge. Elevated TN concentration at site 2 on May 14, 2003 relative to the ambient concentration (site 1) could be attributed to the effluent, since the ambient concentration was much lower than effluent.

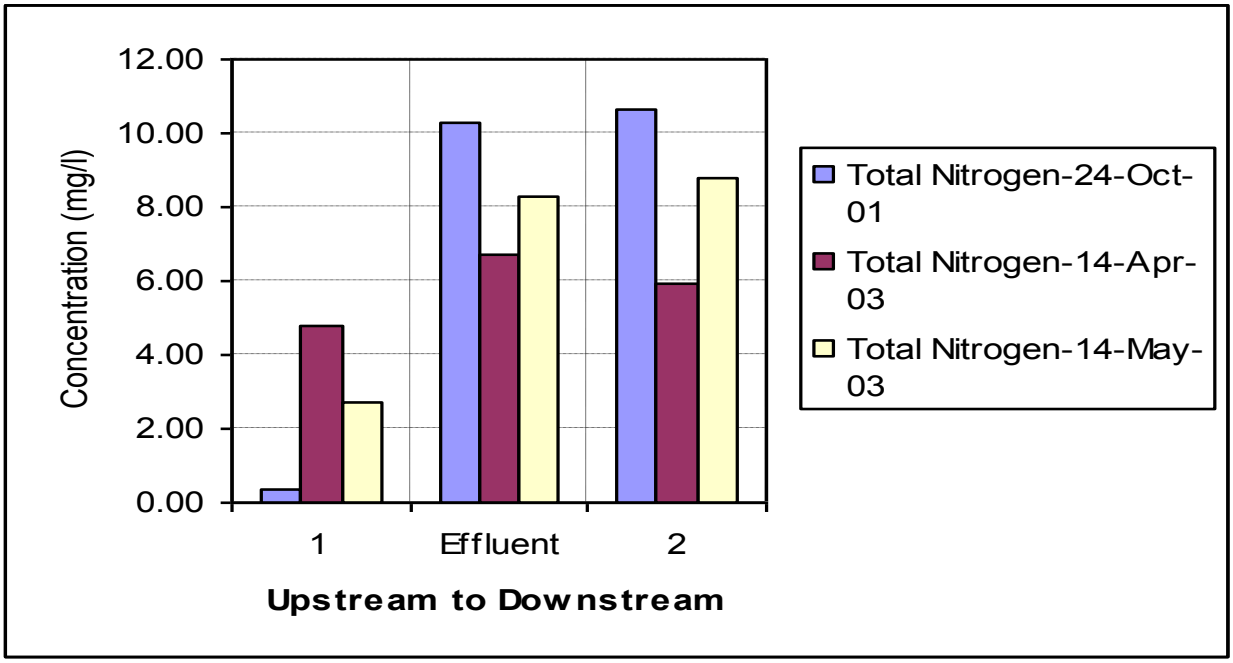


Figure A-2. Total nitrogen concentration at the sampling sites.

Analysis of NH_3-N concentration near the Telford discharge (Figure A-3) shows that the concentrations remained similar on different sampling days (Oct. 24, 2001 and May 14, 2003) and up and downstream of the effluent (site 1 and site 2). However, elevated concentrations were observed on Apr. 14, 2003 relative to the other two dates. The increase is likely attributable to the rainfall that occurred within the 3 days prior to sampling. Concentrations on Apr. 14, 2003 increased from site 1 to the effluent site, and remained high at downstream site 2 although they were lower than those directly at the outfall (possibly due to dilution from higher stream flows). Precipitation also occurred 3 days prior to the May sampling; however, the magnitude of the rainfall was less than the magnitude of rainfall that occurred 3 days prior to the April sampling. Therefore, the effluent was most likely responsible for the spike in concentration from site 1 to the effluent, but the elevated ambient concentrations may have been related to nonpoint source runoff related to the recent rainfall.

NO_3-N concentration near the Telford discharge (Figure A-4) shows that concentrations increased from site 1 to the effluent site and remained almost the same for site 2 on all the sampling dates (Oct. 24, 2001, Apr. 14, 2003, and May 14, 2003). Increased concentrations of NO_3-N at site 2 from ambient concentration (site 1) are also likely attributable to the effluent discharge. However, the effluent does not appear to be as dominant a factor as the in-stream nitrate concentrations under periods influenced by wet weather.

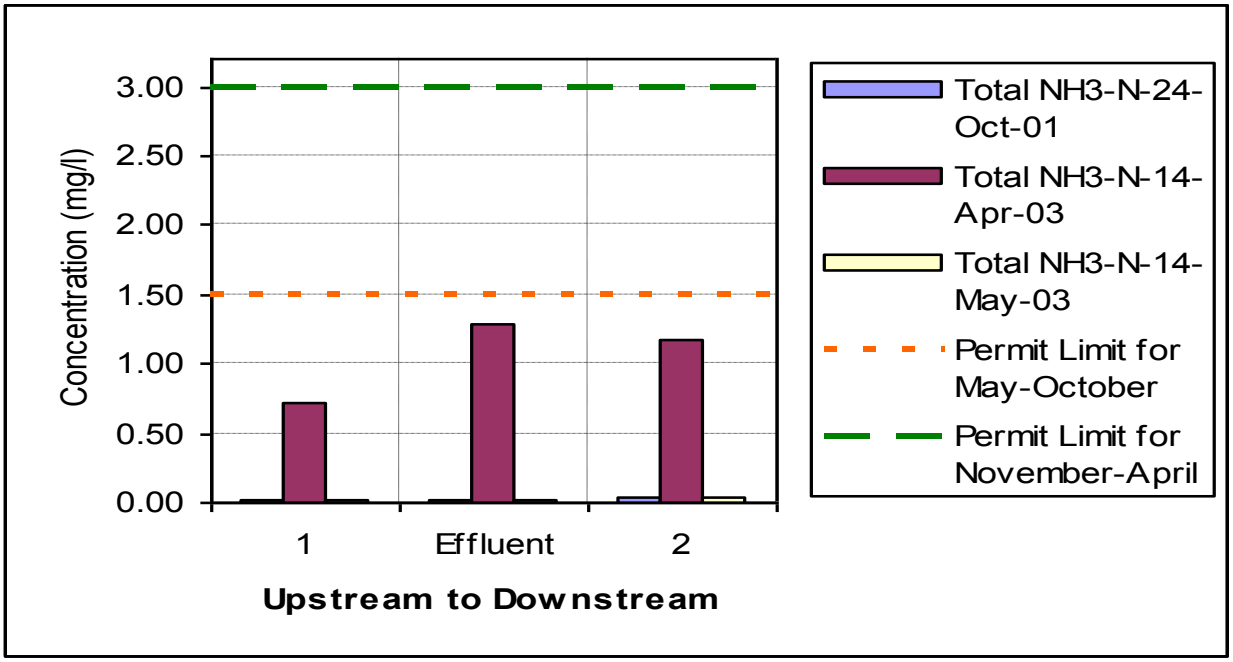


Figure A-3. NH_3-N concentration at the sampling sites.

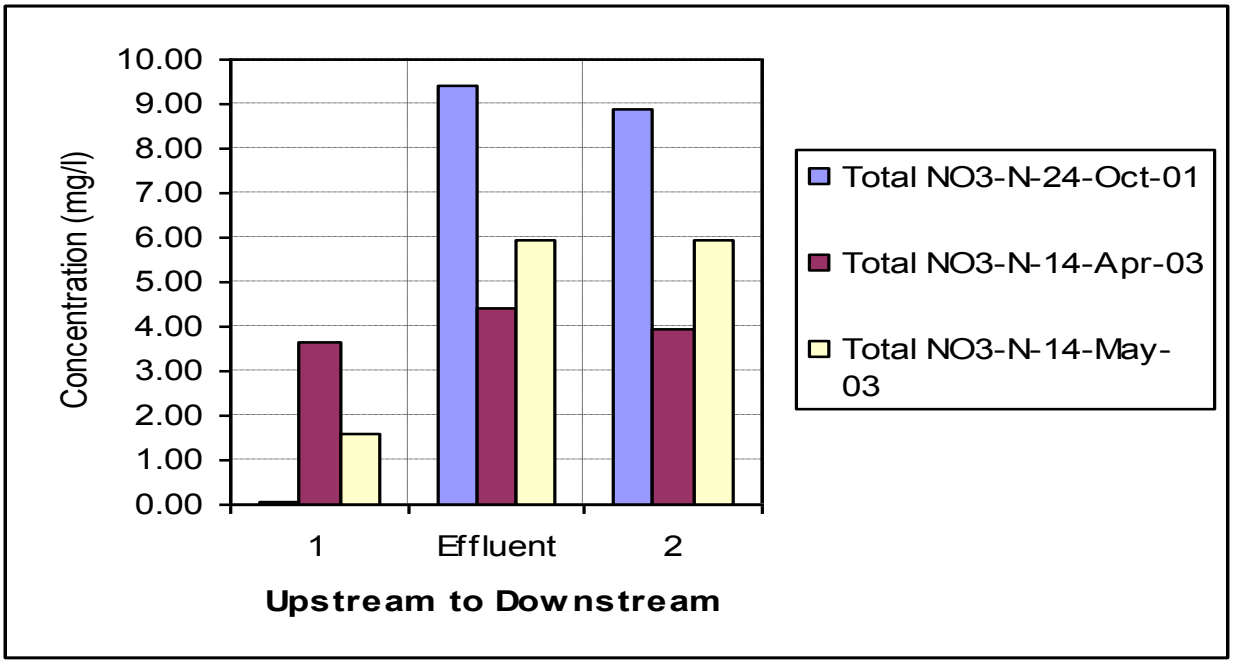


Figure A-4. NO_3-N concentration at the sampling sites.

The increase in TN concentration on Apr. 14, 2003 is due largely to the increase proportionally, of NH_3-N concentrations on the sampling dates (Figures A-2 and A-3). Whereas, the TN increase on Oct. 24, 2001, and May 14, 2003 was due to an increase in the proportion of NO_3-N on the sampling dates (Figures A-2 and A-4). Control of nutrient concentrations at the effluent discharge would significantly control

downstream water quality; however, during wet weather periods, additional loading of nutrients will occur due to nonpoint source runoff.

Lower Salford Ambient Sampling

Analysis of total phosphorous (TP) near the LowerSalford discharge (Figure A-5) showed that the in-stream concentration substantially decreased downstream of the effluent discharge on the Oct. 24, 2001 sampling, suggesting the possibility of healthy in-stream nutrient processing. However, concentrations were not decreased downstream of the effluent (site 2) on Apr. 14, 2003 suggesting influence of the effluent discharge on that day to downstream concentrations. Ambient concentration (site 1) remained similar for both the sampling dates.

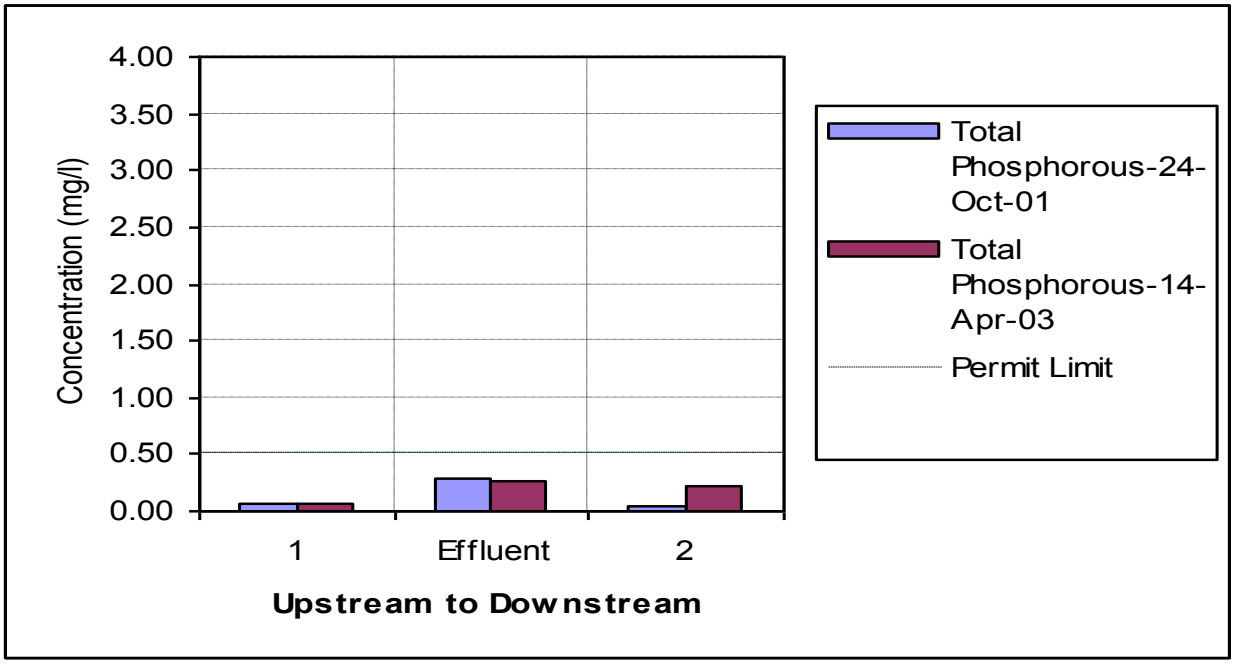


Figure A-5. TP concentration at the sampling sites.

Figure A-6 shows that total nitrogen (TN) in Oct. 24, 2001 increased downstream. Concentrations at the effluent and at site 2 remained similar, and greater than the ambient concentration, suggesting the influence of the effluent discharge on downstream water quality. Similar to trends shown at the Telford discharge, TN concentrations on Apr. 14, 2003 (following wet weather) increased at the effluent and further decreased at site 2 suggesting elevated ambient concentrations due to nonpoint source runoff and possible dilution at site 2 due to potentially higher stream flow.

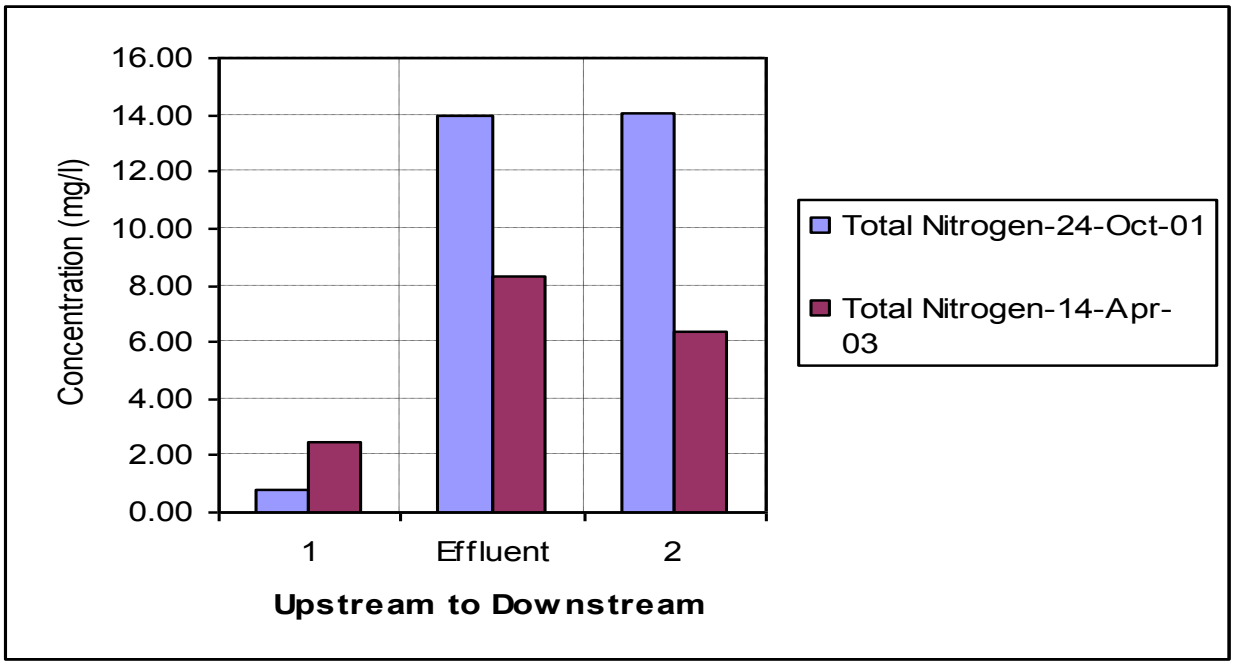


Figure A-6. TN concentration at the sampling sites.

Figure A-7 shows NH_3-N concentration at LowerSalford during the sampling. Lower concentrations were observed across all the three sites (site 1, effluent, site 2), on all the sampling dates.

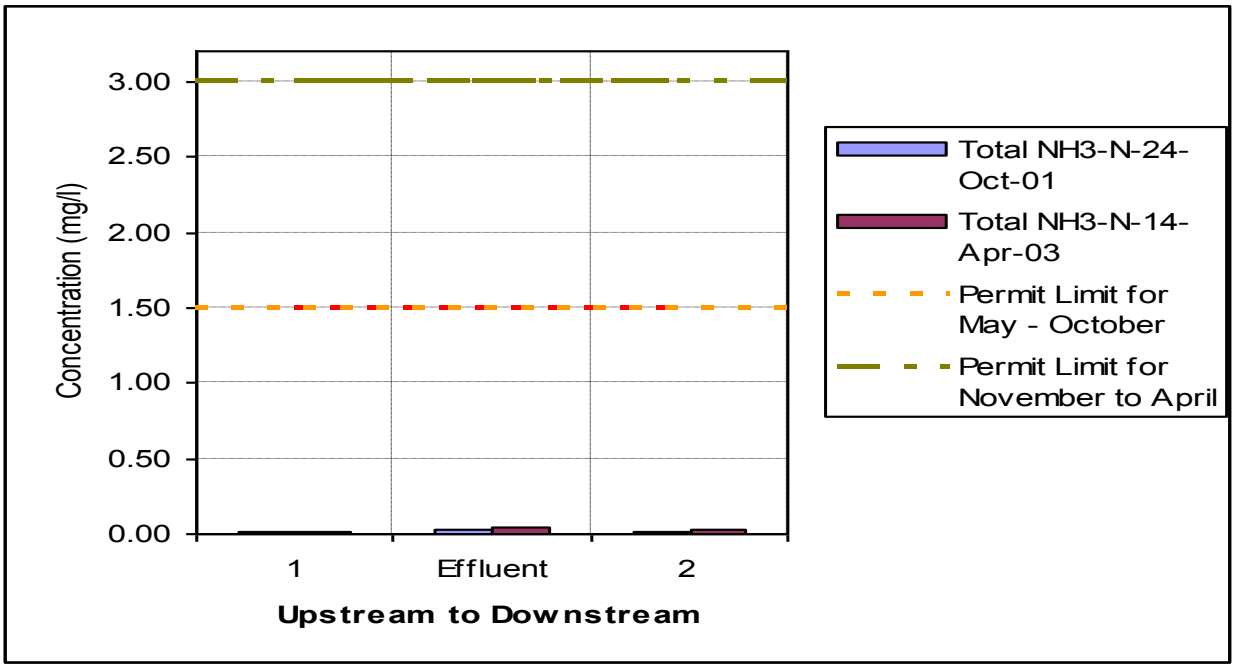


Figure A-7. NH_3-N concentration at the sampling sites.

Figure A-8 shows NO_3-N concentration at LowerSalford. In Oct. 24, 2001, NO_3-N concentrations appear to be attributable to the input from the discharge. On the April sample date, again, ambient concentrations appear elevated and dilution occurred at site 2, likely because of higher stream flows following the wet weather.

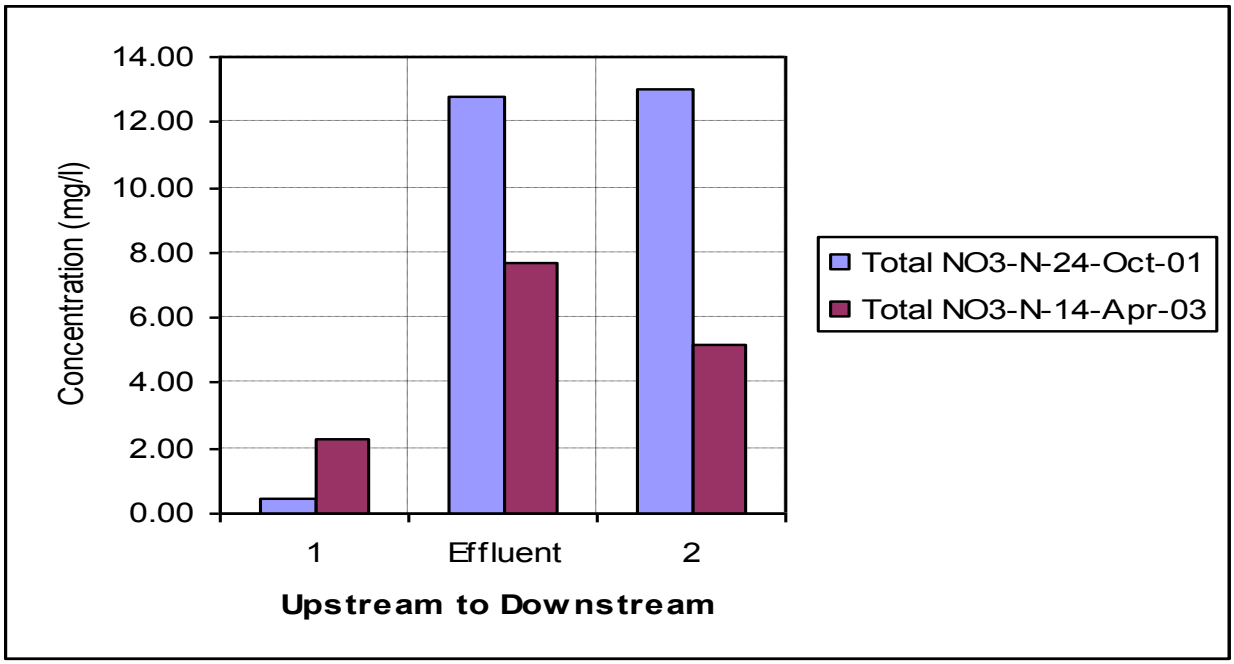


Figure A-8. NO_3-N concentration at the sampling sites.

On all the sampling dates, across all sites, the major portion of TN concentration was due to increased levels of NO_3-N concentration (Figures A-6 and A-8).

APPENDIX B: EFDC CALIBRATION PLOTS

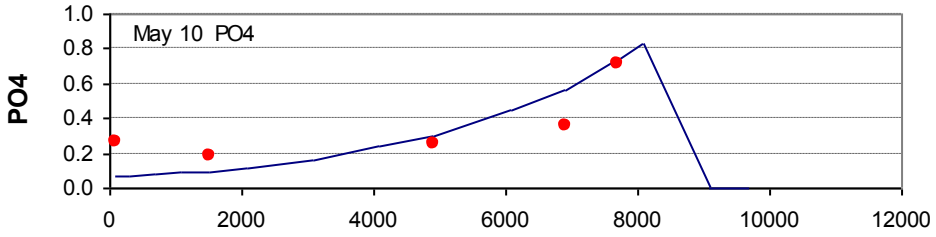


Figure B-1. Longitudinal profile of PO4 in Indian Creek.

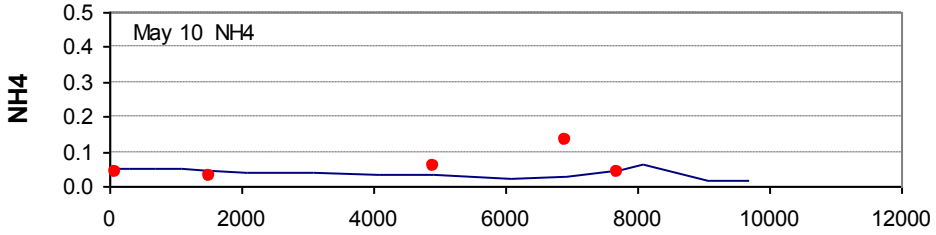


Figure B-2. Longitudinal profile of NH4 in Indian Creek.

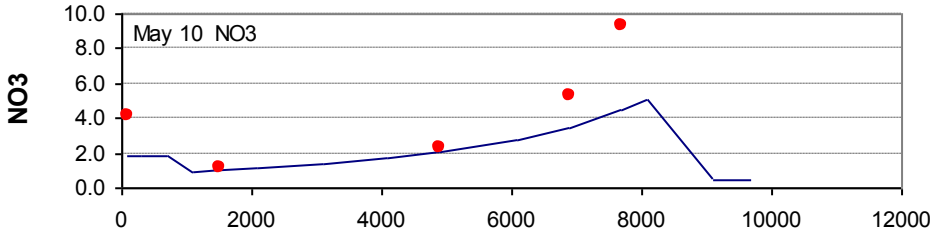


Figure B-3. Longitudinal profile of NO3 in Indian Creek.

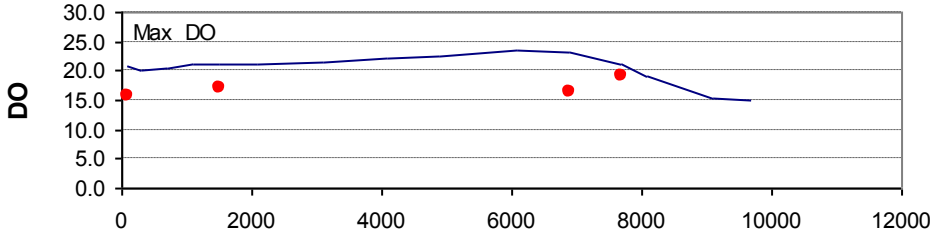


Figure B-4. Longitudinal profile of maximum DO in Indian Creek.

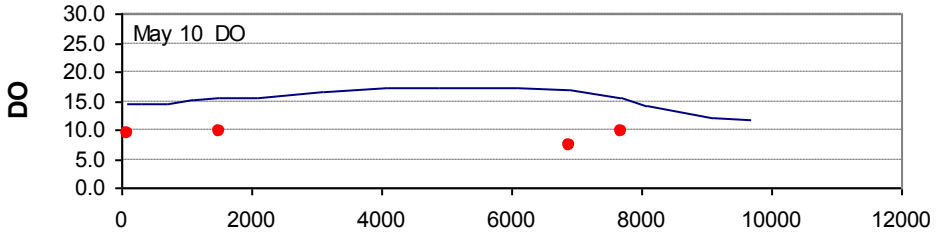


Figure B-5. Longitudinal profile of average DO in Indian Creek.

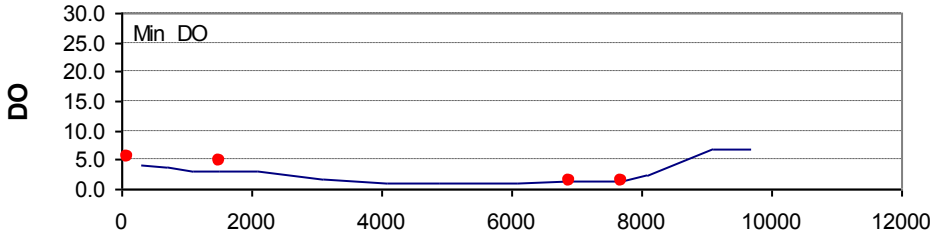


Figure B-6. Longitudinal profile of minimum DO in Indian Creek.

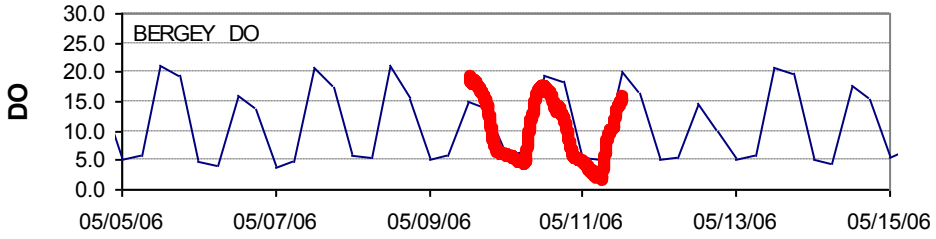


Figure B-7. Comparison of modeled and monitored DO at Bergey Rd. in Indian Creek.

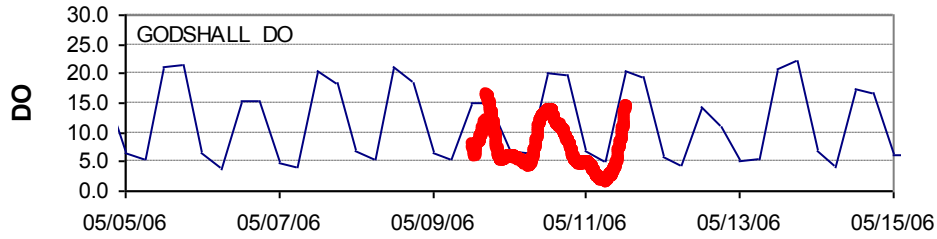


Figure B-8. Comparison of modeled and monitored DO at Godshall Rd. in Indian Creek.

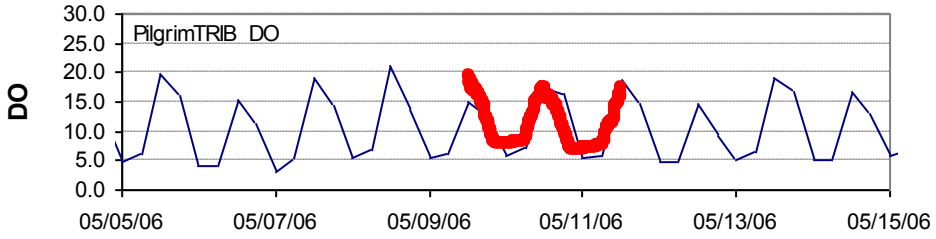


Figure B-9. Comparison of modeled and monitored DO at Pilgrim Pride (Tributary) in Indian Creek.

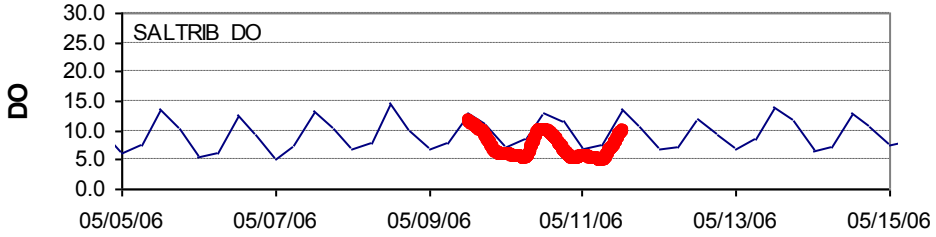


Figure B-10. Comparison of modeled and monitored DO at Lower Salford (Tributary) in Indian Creek.

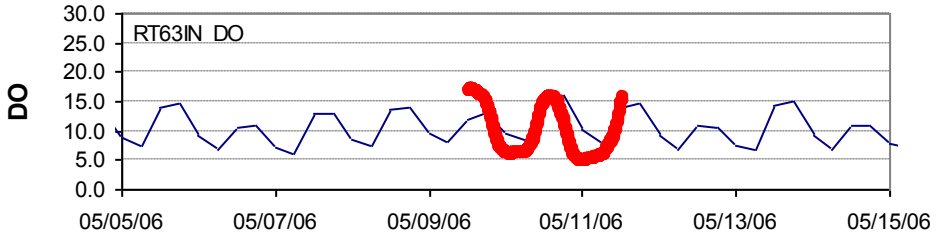


Figure B-11. Comparison of modeled and monitored DO at RT63 in Indian Creek.

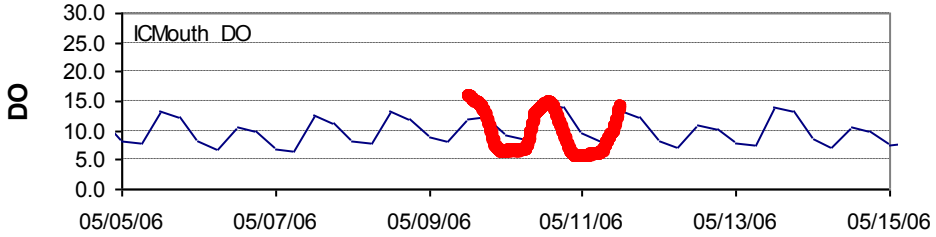


Figure B-12. Comparison of modeled and monitored DO at the mouth of Indian Creek.

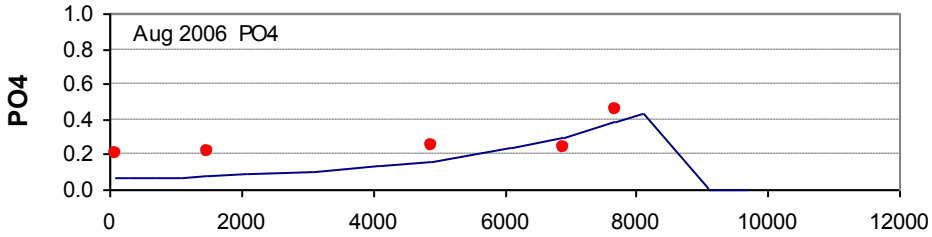


Figure B-13. Longitudinal profile of PO4 in Indian Creek in August 2006

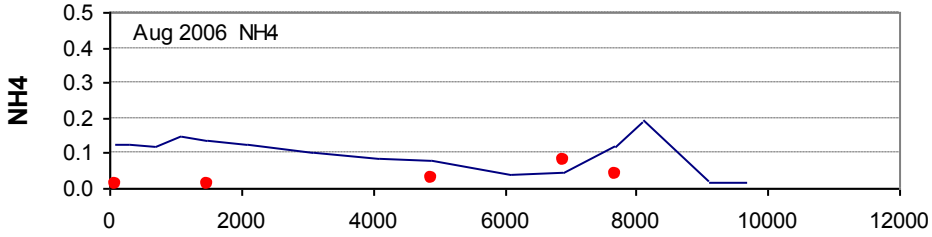


Figure B-14. Longitudinal profile of NH4 in Indian Creek in August 2006

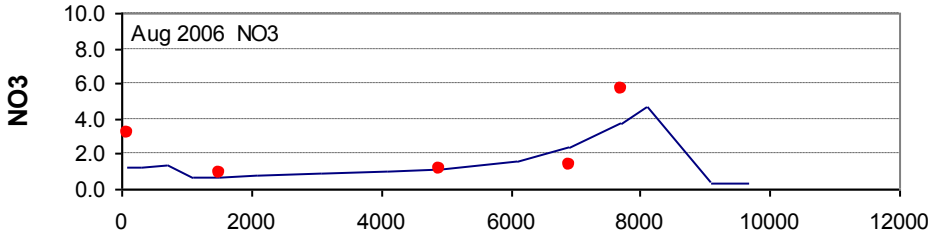


Figure B-15. Longitudinal profile of NO3 in Indian Creek in August 2006

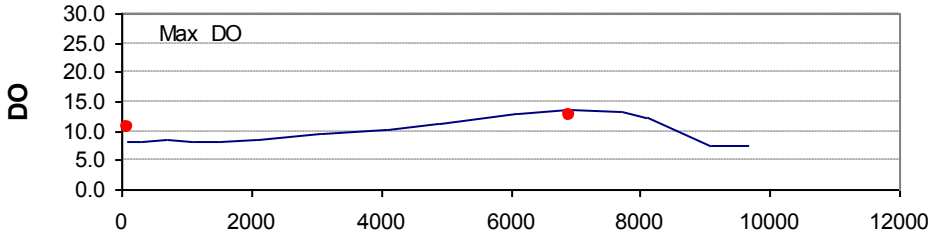


Figure B-16. Longitudinal profile of maximum DO in Indian Creek in August 2006

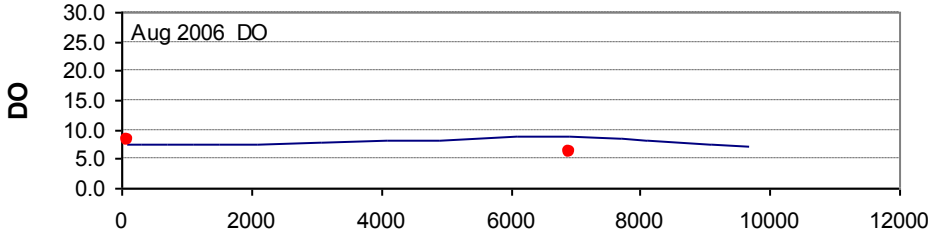


Figure B-17. Longitudinal profile of average DO in Indian Creek in August 2006

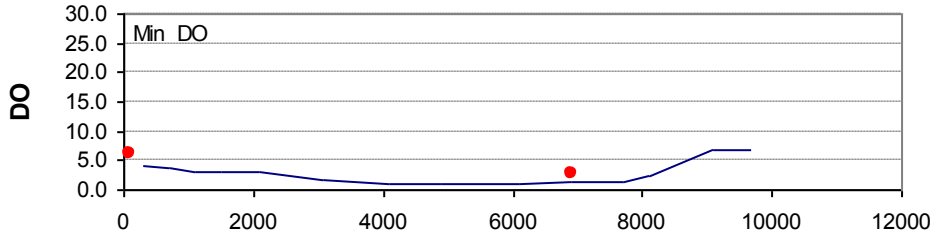


Figure B-18. Longitudinal profile of minimum DO in Indian Creek in August 2006

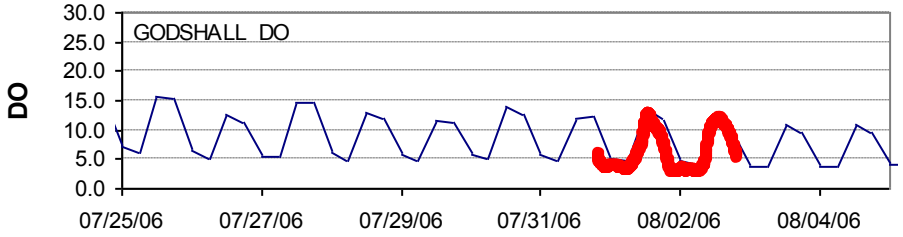


Figure B-19. Comparison of modeled and monitored DO at Godshall Rd. in Indian Creek in August 2006.

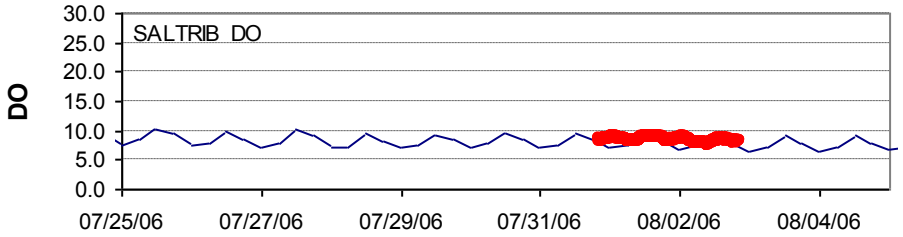
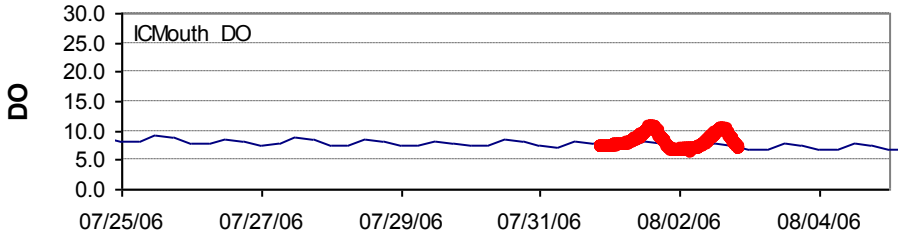


Figure B-20. Comparison of modeled and monitored DO at Lower Salford (Tributary) in Indian Creek in August 2006.



Comparing Model results against the second set of data in 2006

Figure B-21. Comparison of modeled and monitored DO at the mouth of Indian Creek in August 2006.

APPENDIX C: RESULTS OF EFDC SENSITIVITY ANALYSIS

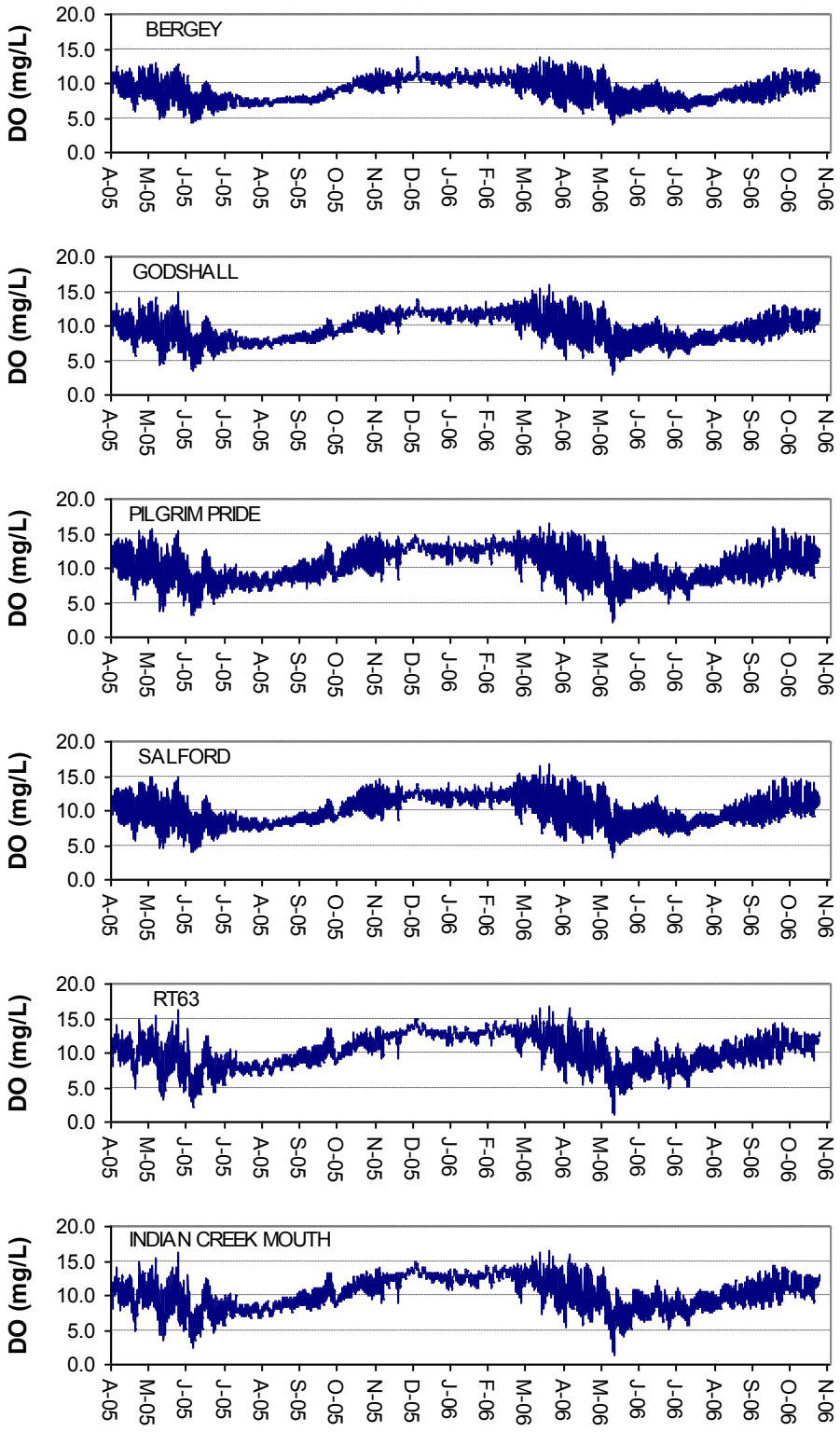


Figure C-1. Modeled DO with only point sources.

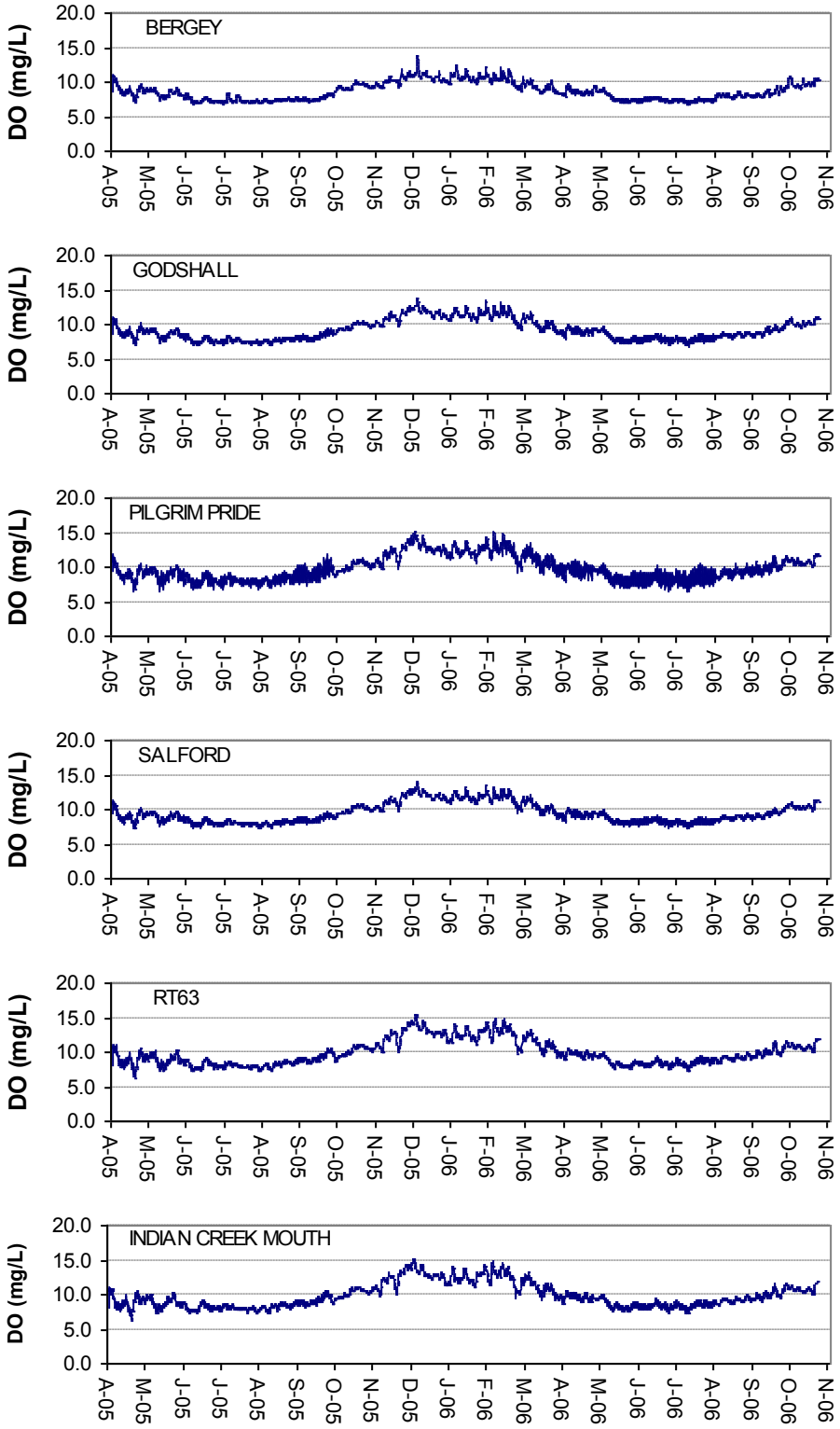


Figure C-2. Modeled DO with only nonpoint sources.

APPENDIX D: EFDC RESULTS FOR BASELINE SCENARIO

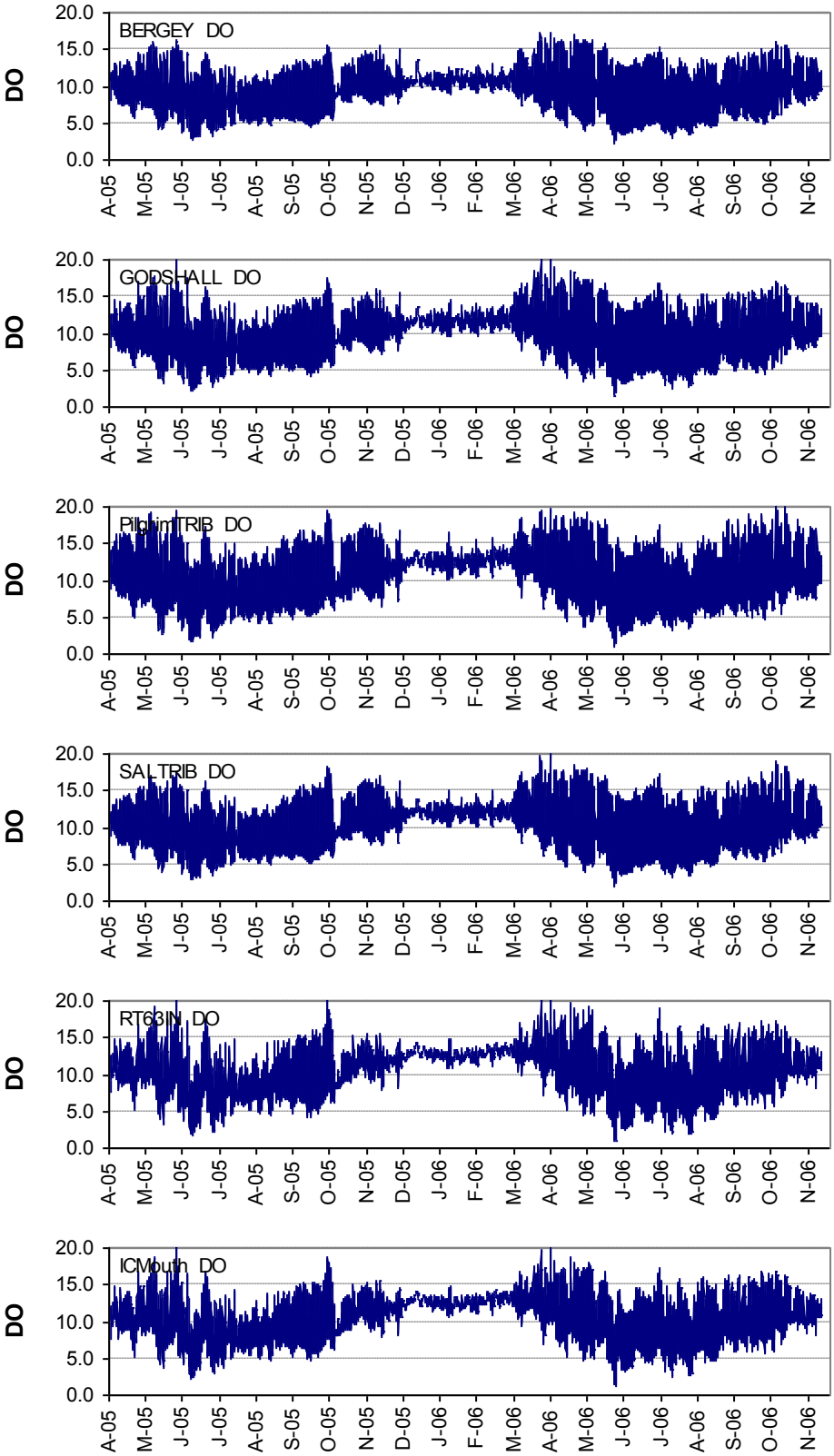
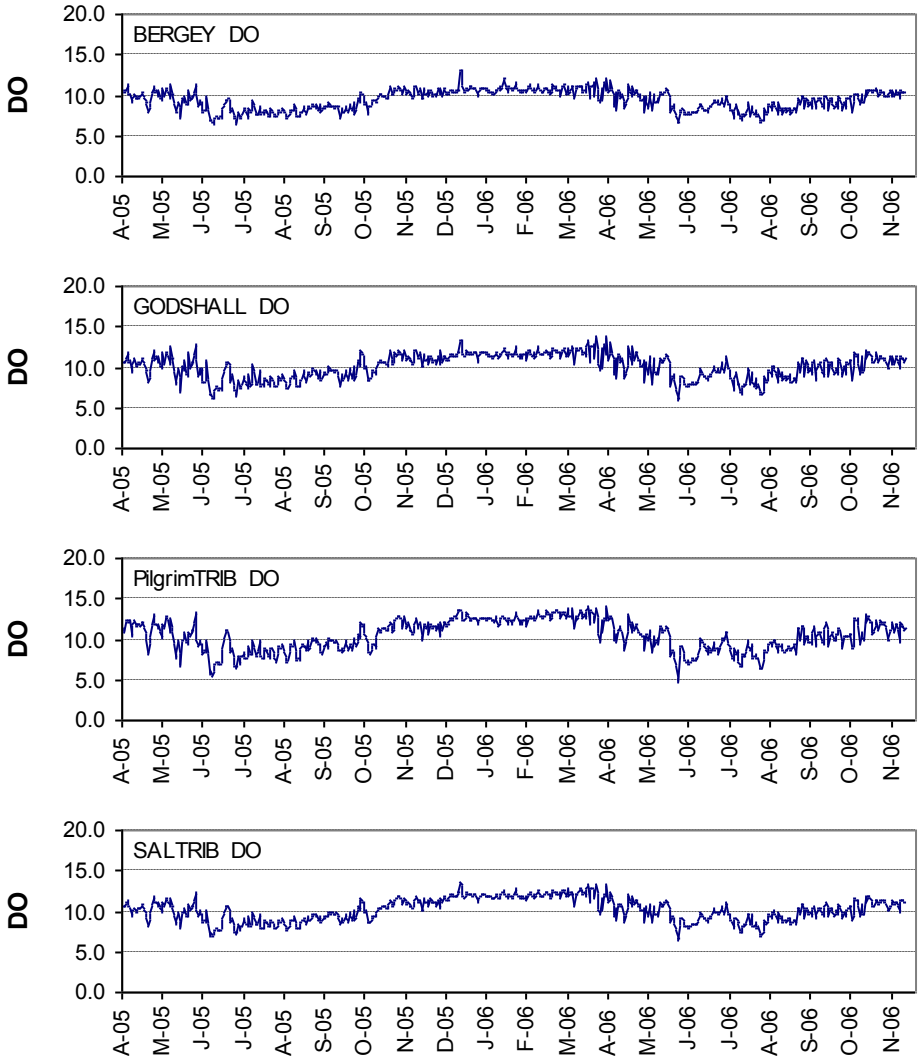


Figure D-1. Modeled DO under baseline condition.



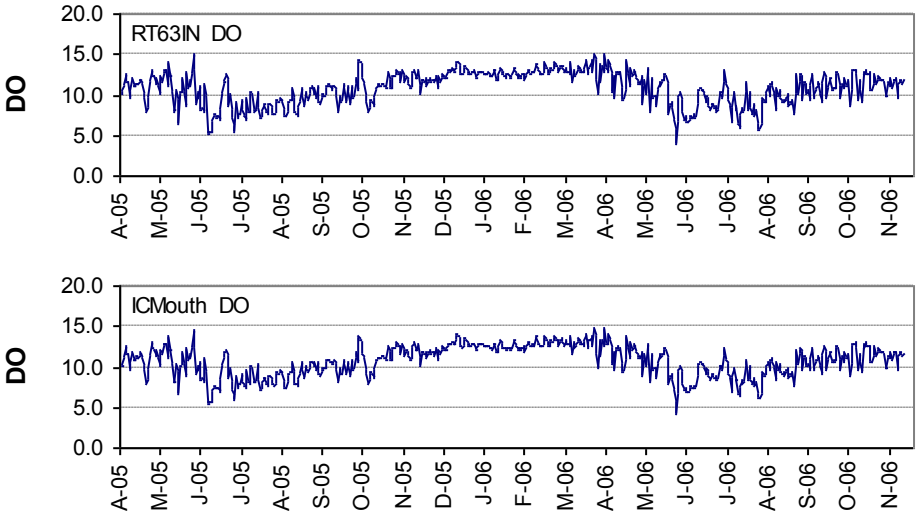


Figure D-2. Modeled DO average under baseline condition.

APPENDIX E: EFDC RESULTS FOR LOAD REDUCTION SCENARIO

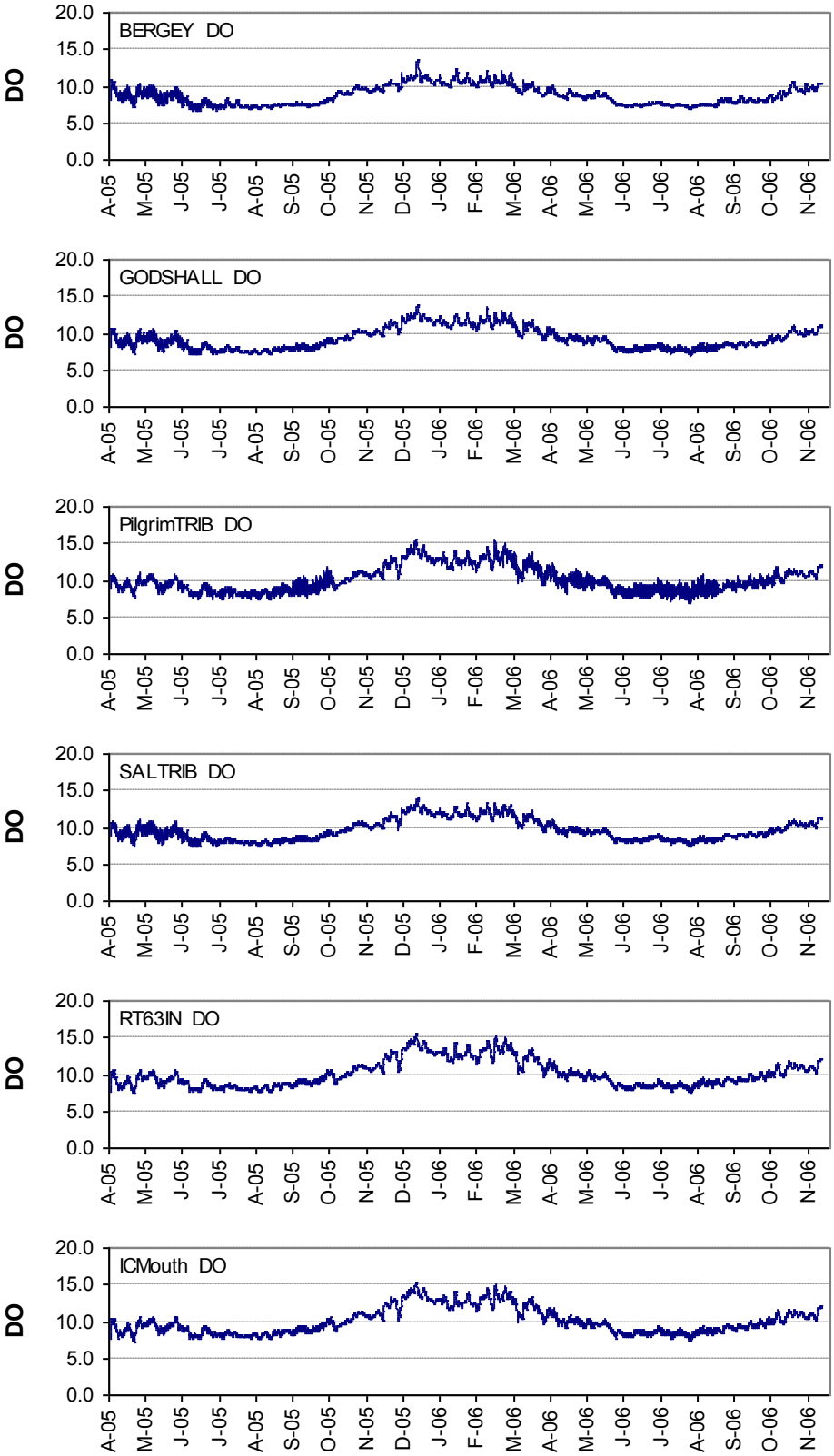


Figure E-1. Modeled DO under load reduction scenario (hourly)

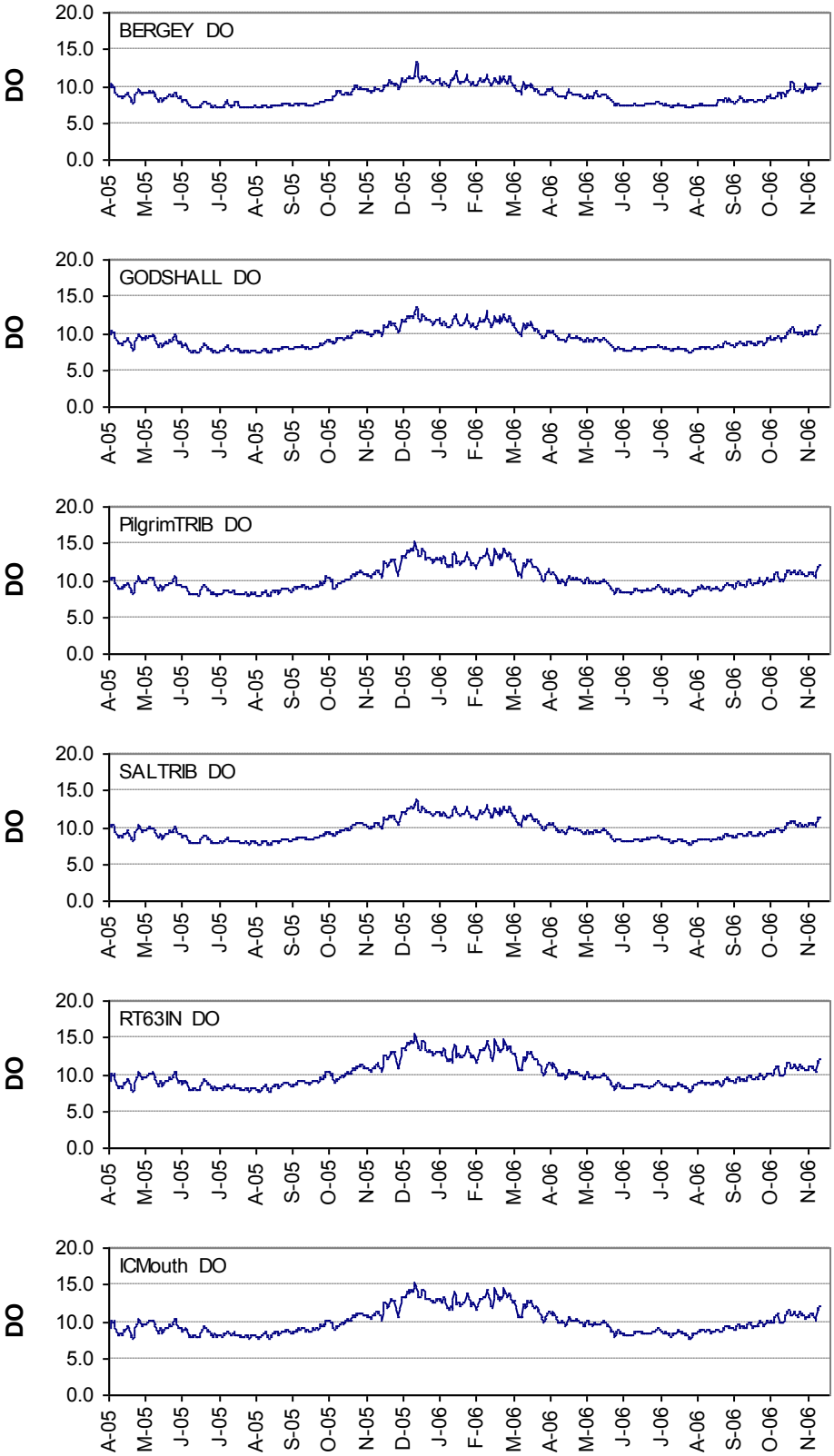


Figure E-2. Modeled daily average DO under load reduction scenario

APPENDIX F: SUGGESTED ADAPTIVE IMPLEMENTATION STRATEGY FOR NPDES POINT SOURCES DISCHARGERS

- EPA regulations do not require an implementation plan to be established as part of or with the establishment of the TMDLs. However, EPA provides this implementation strategy to assist the National Pollutant Discharge Elimination System (NPDES) permit issuing authority in the development and issuance of NPDES permits for point sources with waste load allocations (WLAs) under this TMDL. The Pennsylvania Department of Environmental Protection (PADEP) is the NPDES permitting authority in Pennsylvania, and will make the final determination, subject to EPA review, on issuance of the NPDES permits consistent with the assumptions and requirements of the approved TMDL WLAs. This strategy provides guidance for PADEP to use in issuing, reissuing, or modifying NPDES permits. This strategy should be considered where it may be appropriate to allow interim effluent limits and a compliance schedule to achieve the final effluent limits. This strategy may be appropriate to ensure that point source dischargers achieve and maintain their prescribed nutrient loading levels to restore and protect the receiving waters, while providing opportunities for reducing costs and improving efficiencies by allowing the use of phased permit requirements based on interim technology-based analysis. This process recognizes that PADEP has indicated that it may proceed with its development of nutrient water quality standards/criteria by 2010. Any NPDES permit issued by PADEP that contains such interim limits and/or compliance schedules must explain the reasons and findings in the draft permit submittal for public comment and EPA review. Any such permit with interim limits must include a compliance schedule with a fixed date to implement the effluent limit consistent with the final WLA. Best Management Practices should be considered as a means to address nutrient reductions and can be reflected in the compliance schedules to meet the final TMDL WLAs. Final compliance dates must be based on EPA regulations at 40 CFR 122.47.

During the TMDL development process, several categories of point source dischargers assigned TMDL WLAs were identified as needing NPDES permit requirements to implement the Total Phosphorus WLAs of this TMDL. EPA's Treatability Study provides additional information on 31 facilities in PA and options for removal of nitrogen and phosphorus.

- Category 1 - Dischargers where treatability considerations (i.e. ability to provide chemical addition w or w/o filtration) could yield performance in the range of 0.5 – 1.0 mg/l Total P. This may include facilities with design flows greater than or equal to 10,000 gpd.
- Category 2 – Dischargers where limitations on cost or technology have not been fully explored during TMDL development. Interim technology-based limits could be in the range of 1.0 – 2 mg/l Total P. This may include dischargers with design flows greater than or equal to 2,000 gpd and less than 10,000 gpd.
- Category 3 – Insignificant dischargers who are likely to have a minimal contribution to the WLA (i.e. whose sum is equal to less than one percent of the total and are part of a WLA assigned to insignificant sources). This may include dischargers with design flows less than 2,000 gpd.
- Category 4 – Dischargers who existing limits were more stringent than those above would maintain existing limits.

These categories should be utilized when establishing the interim technology-based requirements in NPDES permits. In the event that a facility seeks to expand or increase its design capacity, they should be capped at their existing load, consistent with the current design flow within that relevant category.

The timeline for implementing WLA requirements into NPDES permits could follow a three phased approach.

- **Phase I - THRU June 2008 (TMDL Development and Establishment)** - consists of studies and analyses performed during the TMDL development process. These actions include:
    - Characterization of existing facilities
    - Determination of nutrient endpoints in southeastern PA
    - Treatability study of southeastern PA facilities
    - Review of National Nutrient Study
    - Review effectiveness of BMPs for MS4s
    - EPA Office of Water study on retrofits for municipal WWTPs

- **Phase II - June 2008 thru June 2013 (Progressive Improvement)** - Optimization phase which would implement interim nutrient control limitations along with a compliance schedule to achieve the final effluent limit in NPDES permits based on evaluation of reductions that can be achieved in the near term using existing technologies while the long-term facilities planning process moves forward. This time period also allows PADEP to consider any necessary changes in the TMDLs based on adoption of nutrient criteria. PADEP may consider applying the discharge categories mentioned above. Based on the analysis from Phase I and applying existing regulations, permits should require interim TP limits as follows:
    - **Category 1** - 0.5 - 1.0 mg/l monthly average during the growing season.
        - Basis - Nutrient Treatability study
    - **Category 2** – 1.0 - 2.0 mg/l monthly average during the growing season.
        - Basis - PA's existing Phosphorus regulations
    - **Category 3** - Existing effluent quality
    - **Category 4** – Existing limits more stringent than above.

  EPA's Treatability Study identified an interim nitrogen value of 8 mg/l as a monthly average during the growing season as achievable through BNR processes. Along with any interim effluent limits, compliance schedules to achieve final permit limitations consistent with the WLAs in the TMDL must be incorporated into the permits in order to address TMDL and water quality requirements. All permits issued during Phase II must contain effluent limits consistent with the established TMDL.

  Actions required during this phase include:
    - Issue, reissue, or modify NPDES permits with requirements as specified above
    - Collection of effluent data for TP and TN
    - Optimization of treatment at individual facilities
    - Implementation of BMPs
    - Completion of wastewater facilities planning

- Consideration of trading where appropriate

- **Phase III – Begins June 2013 (Final TMDL Implementation)**
  Actions required during this phase include:
  - Continue to issue, reissue, or modify NPDES permits to reflect final water quality based effluent limits and final compliance schedules
  - Facility design and construction
  - Compliance with final WQBELs consistent with the TMDLs.

  If Pennsylvania adopts numeric nutrient criteria by 2013, it may be necessary to revise the TMDLs and associated WLAs. If so, the revised criteria would serve as the basis for the revised TMDLs and WLAs. NPDES permits would thereafter be modified accordingly, including necessary revisions to compliance schedules, if allowed, requiring dischargers to meet WLAs or revised WLAs based on criteria. If nutrient criteria do not cause the TMDLs to be modified, the permits would not be modified and the existing TMDL allocations would be governing. Final compliance dates must be based on EPA regulations at 40 CFR 122.47.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 ARCH STREET
PHILADELPHIA, PA 19107

Response Document for Nutrient and Sediment TMDLs in Pennsylvania for

Southampton Creek, Indian Creek, Chester Creek, Paxton Creek and Sawmill Run

June 30, 2008

Jon Capacasa, Director
Water Protection Division
U.S. EPA, Region III

This document contains the EPA responses to all comments received during the Public Comment period for the waters identified above. EPA considers this document to be a part of the EPA established TMDLs.

INTRODUCTION

The Environmental Protection Agency proposed nutrient total maximum daily loads (TMDLs) for five watersheds in Pennsylvania: Southampton Creek in Bucks County, Indian Creek in Montgomery County, Chester Creek in Chester County, Paxton Creek in Harrisburg and Sawmill Run in Allegheny County and Pittsburgh. Sediment TMDLs were also proposed for Southampton Creek, Indian Creek, Paxton Creek and Sawmill Run. The public comment period ran from February 27 to April 18, 2008 for Southampton Creek, Indian Creek and Chester Creek and from March 4 to April 18, 2008 for Paxton Creek and Sawmill Run. EPA also held a public meeting in each watershed, with the exception of the Paxton Creek watershed where two meetings were held. The public meetings were held on March 5, 2008 in the Chester Creek watershed, March 13, 2008 in the Southampton Creek watershed, March 18, 2008 in the Indian Creek watershed, March 20, 2008 in the Sawmill Run watershed and March 19, 2008 and April 17, 2008 in the Paxton Creek watershed.

EPA received a number of comments for each TMDL. A list of those commenting on the proposed TMDLs is shown in Table 1 below. Because there were many similar comments for the five waters, EPA has decided to combine the Response Document for the five waters into one document. In addition, for those comments that apply to multiple waters, we have included a General Response section.

The EPA responses are clarifications of the proposed TMDLs and are considered to be part of the final EPA established TMDLs holding the same implications of any requirements and authority contained in the TMDL reports themselves.

In addition to the public meetings described above, EPA participated in several other meetings with stakeholders. EPA hosted a meeting with representatives from the Pennsylvania Municipal Authorities Association and the 'Periphyton Group' on April 8, 2008. Also in attendance were representatives of many of the municipalities with wastewater treatment facilities and/or MS4 responsibilities in the watersheds. The representatives included municipal staff and/or the municipalities' legal counsel. Staff from the EPA Headquarters TMDL and Standards programs met with representatives of the 'Periphyton Group' on April 22, 2008 to discuss the group's concerns with the TMDLs. In addition to the meetings, EPA also hosted several conference calls on the TMDLs. The first call was with the 'Periphyton Group' on June 12, 2008. Municipalities from the Indian Creek, Paxton Creek, Chester Creek and Neshaminy Creek were represented. The second conference call was with the Pennsylvania Municipal Authorities Association on June 18, 2008. EPA is also scheduling a conference call with municipal authorities and their legal counsel within the Indian Creek and Southampton Creek watersheds. Comments received during those meetings and conference calls were considered in the completion of these TMDLs. To assist the municipal authorities in the implementation of these TMDLs, the PADEP Southeastern Regional Office has offered to meet individually with each municipality.

In addition to comments received during the open comment period and the requested clarification letters for several of those comment letters, EPA received three additional comment letters dated June 25, 2008. EPA received those comment letters by e-mail on June 26, 2008. There was one comment letter each for the Indian Creek TMDLs, the Paxton Creek TMDLs and

the Chester Creek TMDL. EPA established these TMDLs on June 30, 2008 as required by the 1997 Consent Decree. Because the comment letters were received only a few days before the TMDLs were to be established under the requirements of the Consent Decree, EPA did not have sufficient time to properly consider the comments contained in the letters. Therefore, the comments received are not part of the Administrative Record for the establishment of these TMDLs.

Table of Contents

Part A:

I. **List of Commenters (Table 1)**

II. **Definitions and Acronyms**

III. **General Responses**

a. **General Response #1: Response to "Critical Evaluation of Total Phosphorus Endpoint Determination using Conditional Probability and Change Point Analysis", Hall & Associates, and additional information concerning the approach and applicability of the EPA endpoint methods**

b. **General Response #2: Response to legal issues**

c. **General Response #3: Total Nitrogen TMDL**

d. **General Response #4: EPA's approach to allocating to municipal separate storm sewer systems (MS4), Combines Sewer Systems (CSOs) and other Stormwater Sources**

e. **G**eneral **Response #5: Adaptive Management Recommendation and Phased TMDLs**

f. **General Response #6: Pennsylvania Department of Environmental Protection's identification of impairments for the five waters**

g. **General Response #7: Adjusted Endpoints for the Sawmill Run and Paxton Creek Nutrient TMDLs Based on Representative Ecoregions**

h. **General Response #8: MS4 and Other NPDES-regulated Storm Water implementation**

i. **General Response #9: Scope of Chester Creek TMDL**

j. **General Response #10: EPA's watershed report for Chester Creek**

k. **General Response #11: EPA's Consideration of Algal Biomass in Establishing the TMDLs**

l. **General Response #12: Spatial Extent of the Paxton Creek Nutrient TMDL**

m. **General Response #13: Paxton Creek Water Quality and Biological Data – Susquehanna River Basin Commission, 2006 and 2007**

n. **General Response #14: Consideration of Nonpoint Source Contributions of Nutrients**

Table of Contents

Part B:

I. Responses to Specific Comment Letters

Part C:

I. Response Document References

II. Supporting Information

III. Literature Review Report

Indian Creek Watershed Nutrient and Sediment TMDLs, Southampton Creek Watershed Nutrient and Sediment TMDLs, Chester Creek Watershed Nutrient TMDL, Paxton Creek Watershed Nutrient and Sediment TMDLs and Sawmill Run Watershed Nutrient TMDL

Response to Comments - Part A

SECTION A-I

Table 1: Summary of Commenters on the TMDLs for Southampton Creek, Indian Creek, Chester Creek, Paxton Creek and Sawmill Run

Letter Number	Name	Organization	Comments on Behalf of	TMDL	Date of Comment Letter
1	Kevin Garber	Babst, Calland, Clemens, Zomnir	ALCOSAN	Sawmill Run	April 24, 2008
2	William Brown	Environmental Engineering & Management	Ambler	Chester Creek	April 16, 2008
3	William Brown	Environmental Engineering & Management	Ambler	Indian Creek	April 16, 2008
4	William Brown	Environmental Engineering & Management	Ambler	Paxton Creek	April 16, 2008
5	William Brown	Environmental Engineering & Management	Ambler	Sawmill Run	April 16, 2008
6	William Brown	Environmental Engineering & Management	Ambler	Southampton Creek	April 16, 2008
7	Glenn Jonnet		Baldwin Township	Sawmill Run	April 15, 2008
8	Lawrence Barrett			Chester Creek	April 6, 2008
9	Jean Statler	Municipality of Bethel Park	Municipality of Bethel Park	Sawmill Run	April 18, 2008
10	George Zboyovsky	Borough of Brentwood	Borough of Brentwood	Sawmill Run	April 17, 2008
11	Richard Minsterman	Gateway	Brentwood Borough	Sawmill Run	April 2, 2008
12	Sue Marra Byham	Cheyney University	Cheyney University	Chester Creek	April 3, 2008
13	Thomas Hartswick	Borough of Castle Shannon	Borough of Castle Shannon	Sawmill Run	April 14, 2008
14	Evan Andrews	Pennoni Associates	Chadds Ford Township	Chester Creek	April 17, 2008
15	Anne Murphy	Chester-Ridley-Crum Watersheds Association	Chester-Ridley-Crum Watersheds Association	Chester Creek	April 1, 2008

Letter Number	Name	Organization	Comments on Behalf of	TMDL	Date of Comment Letter
16	James Close	City of Harrisburg	City of Harrisburg	Paxton Creek	March 28, 2008
17	James Close	City of Harrisburg	City of Harrisburg	Paxton Creek	April 3, 2008
18	Thomas Chew	Concord Township Sewer Authority	Concord Township Sewer Authority	Chester Creek	April 16, 2008
19	Douglas Sample	Borough of Crafton	Borough of Crafton	Sawmill Run	April 11, 2008
20	John Davis		John Davis	Chester Creek	April 3, 2008
21	John Davis		John Davis	Chester Creek	April 6, 2008
22	Daniel Mator	Borough of Dormont	Borough of Dormont	Sawmill Run	April 17, 2008
23	Louis Smith	East Goshen Municipal Authority	East Goshen Municipal Authority	Chester Creek	April 3, 2008
24	George Whitmayer	Franconia Sewer Authority	Franconia Sewer Authority	Indian Creek	April 18, 2008
25	Kevin Baver	Township of Franconia	Township of Franconia	Indian Creek	April 18, 2008
26	Richard Minsterman	Gateway	Brentwood, Crafton, Dormont, Ingram, Mt. Lebanon, Mt. Oliver, Whitehall	Sawmill Run	April 11, 2008
27	John Hall	Hall & Associates	Periphyton Coalition	Chester Creek	April 18, 2008
28	John Hall	Hall & Associates	Telford Borough, Pilgrams Pride	Indian Creek	April 18, 2008
29	Bill Hall	Hall & Associates	Harrisburg Authority	Paxton Creek	April 18, 2008

Letter Number	Name	Organization	Comments on Behalf of	TMDL	Date of Comment Letter
30	John Hall	Hall & Associates	Unnamed municipalities	Chester Creek, Paxton Creek, Wissahickon Creek, Neshaminy Creek, Indian Creek	April 11, 2008
31	Steven Hann	Hamburg, Rubin, Mullin, Maxwell & Lupin	Lower Salford Township Authority	Indian Creek	April 18, 2008
32	Steven Hann	Hamburg, Rubin, Mullin, Maxwell & Lupin	Lower Salford Township Authority	Indian Creek	April 18, 2008
33	James Close	City of Harrisburg	City of Harrisburg	Paxton Creek	April 18, 2008
34	Michele Torres	The Harrisburg Authority	The Harrisburg Authority	Paxton Creek	April 18, 2008
35	George Wolfe	Lower Paxton Township	Lower Paxton Township	Paxton Creek	April 18, 2008
36	Delton Plank	Lower Salford Township	Lower Salford Township	Indian Creek	April 16, 2008
37	Richard Minsterman	Gateway	Mt. Oliver Borough	Sawmill Run	April 2, 2008
38	Joanne Malloy	Borough of Mount Oliver	Borough of Mount Oliver	Sawmill Run	April 3, 2008
39	John Hines	Pennsylvania Department of Environmental Protection	Pennsylvania Department of Environmental Protection	Chester Creek, Indian Creek, Southampton Creek	April 18, 2008
40	Drannon Buskirk	The Paxton creek Watershed and Education Association	The Paxton Creek Watershed and Education Association	Paxton Creek	April 11, 2008
41	Michael Lichte	Pittsburgh Water & Sewer Authority	Pittsburgh Water & Sewer Authority	Sawmill Run	April 16, 2008
42	Pete Slack	Pennsylvania Municipal Authorities Association	Pennsylvania Municipal Authorities Association	Indian Creek, Southampton Creek, Chester Creek, Paxton Creek, Sawmill Run	April 16, 2008

Letter Number	Name	Organization	Comments on Behalf of	TMDL	Date of Comment Letter
43	Steven Miano	Hangley, Aronchick, Segal & Pudlin	Borough of Souderton	Indian Creek	April 18, 2008
44	Gary Myers	Susquehanna Township	Susquehanna Township	Paxton Creek	April 18, 2008
45	Paul Cornell	Swatara Township	Swatara Township	Paxton Creek	April 18, 2008
46	Mark Fournier	Telford Borough	Telford Borough	Indian Creek	April 21, 2008
47	John Interrante	Environmental Engineering & Management	Upper Gwynedd Township	Indian Creek, Southampton Creek, Chester Creek	April 18, 2008
48	Timothy Hagey	Warminster Township Sewer Authority	Warminster Township Sewer Authority	Chester Creek	April 18, 2008
49	Kevin Oakes	West Chester Borough	West Chester Borough	Chester Creek	April 16, 2008
50	Robert Layman	Westtown Township	Westtown Township	Chester Creek	April 17, 2008
51	James Leventry	Borough of Whitehall	Borough of Whitehall	Sawmill Run	April 3, 2008
52	Richard Minsterman	Gateway	Borough of Whitehall	Sawmill Run	April 2, 2008
53	Richard “Sam” Nucci	Ingram	Ingram	Sawmill Run	April 28, 2008
54	Richard Minsterman	Gateway	Ingram	Sawmill Run	April 2, 2008
55	James Ellison	City of Harrisburg Authority	City of Harrisburg Authority	Paxton Creek	May 21, 2008

SECTION A-II

Definitions and abbreviations:

BMP - Best Management Practice. Methods, measures or practices selected by an agency to meet its nonpoint source control needs. BMPs include but are not limited to structural and nonstructural controls and operation and maintenance procedures. BMPs can be applied before, during and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters

Critical conditions – environmental conditions under which the pollutant(s) of concern have the greatest environmental impacts.

CSO – Combined Sewer Overflow

CWA – Clean Water Act, as amended, 33 U.S.C 1251 *et seq*

EPA – United States Environmental Protection Agency

Impaired water. Any segment where it is known that water quality does not meet applicable water quality standards, and/or is not expected to meet applicable water quality standards, even after the application of the technology-based effluent limitations required by sections 301(b) and 306 of the Act.

Impaired waters list – A list of waters that has been identified by the state as impaired or threathened by one or more pollutants. The list is required by the Clean Water Act Section 303(d) and is to be submitted to EPA every even numbered year (Federal Regulations at 40 CFR 130.7)

LA - Load allocation. The portion of a receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources. Load allocations 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. Wherever possible, natural and nonpoint source loads should be distinguished.

Load or loading. An amount of matter or thermal energy that is introduced into a receiving water; to introduce matter or thermal energy into a receiving water. Loading may be either man-caused (pollutant loading) or natural (natural background loading).

Loading capacity. The greatest amount of loading that a water can receive without violating water quality standards

LTCP - Long term control plan for the control of stormwater overflows

MOS - Margin of safety

MS4 – Municipal Separate Storm Sewer System

NPDES – National Pollutant Discharge Elimination System.

PADEP – Pennsylvania Department of Environmental Protection

SRBC – Susquehanna River Basin Commission

SSO – Sanitary Sewer Overflow

TMDL - Total maximum daily load. The sum of the individual WLAs for point sources and LAs for nonpoint sources and natural background plus a margin of safety. If a receiving water has only one point source discharger, the TMDL is the sum of that point source WLA plus the LAs for any nonpoint sources of pollution and natural background sources, tributaries, or adjacent segments. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure. If Best Management Practices (BMPs) or other nonpoint source pollution controls make more stringent load allocations practicable, then wasteload allocations can be made less stringent. Thus, the TMDL process provides for nonpoint source control tradeoffs.

TN – Total Nitrogen

TP – Total Phosphorus

(WLA) Wasteload allocation. The portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation.

WQS - Water quality standards. Provisions of State or Federal law which consist of a designated use or uses for the waters of the United States and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the Act. For TMDL purposes defined as consisting of numeric criteria, narrative criteria, designated uses and anti-degradation.

Refer to "Terms of Environment – Glossary, Abbreviations and Acronyms (revised December 1997)", Communications, Education and Community Affairs, US EPA, EPA– 175-B-97-001

SECTION A-III

General Response #1: Response to "Critical Evaluation of Total Phosphorus Endpoint Determination using Conditional Probability and Change Point Analysis", Hall & Associates, and additional information concerning the approach and applicability of the EPA endpoint methods

The method and approach used by EPA to interpret the Pennsylvania narrative criteria as it relates to nutrient impairments to developing the end point for the nutrient TMDLs was questioned. Several comment letters received by EPA included a Critical Evaluation of the process as an attachment to the comment letter. Several others advanced the opinion that, without supporting data or evaluation, the end points were not properly developed and should not apply to these waters and TMDLs. EPA cannot respond directly to those comments that simply stated an opinion without justification. However, we can respond to what we believe to the critical evaluation of the approach. We believe that this evaluation was flawed and indicated the reviewer's lack of understanding of the science behind the approach. This general response serves as the response to this incorrect evaluation as well as serves to address the other very general comments received on the process – comments that claimed the approach to be inappropriate without supporting data and/or evaluation. We also are responding to those who fail to understand the concept of eco-region analysis and how the evaluation and results of such an evaluation can apply to those waters within an eco-region without specific water quality data. The eco-region approach to end point determination is not much different, actually it is more specific, than the statewide approach used by the state for other pollutants, i.e. assigning a DO standard statewide for all streams of a particular use designation without actual DO data for each and every stream.

Comment Letter #28 included an attachment "Critical Evaluation of Total Phosphorus Endpoint Determination using Conditional Probability and Change Point Analysis". EPA believes that this evaluation missed the concepts used in the development of the TMDL endpoint. The memorandum included at the end of this General Response was prepared by EPA's contractor in response to the evaluation.

In addition, EPA Headquarters (EPA HQs) has reviewed the approach used to determine the TMDL endpoint for TP. EPA HQs has indicated that the approach is appropriate and consistent with EPA guidance. The supporting memorandum is included below.

TETRA TECH

Date: **4/28/2008**

To: **Tom Henry, USEPA Region 3**

From: **Michael Paul, PhD and Lei Zheng, PhD**

Subject: **General response to common concerns with the endpoint approach developed for TP TMDLS in Pennsylvania**

We have prepared this memo in response to criticisms made of the technical approach used by Dr. Zheng and myself for developing total phosphorus (TP) endpoints for a series of total phosphorus (TP) total maximum daily loads (TMDLs) in the Piedmont ecoregion of southeastern Pennsylvania. Those criticisms were communicated in various comments submitted in response to the TMDLs for various streams in Pennsylvania.

In our opinion, there are three critical errors in many of the comments: first, they mischaracterize the effort that was undertaken; second, they mischaracterize the technical process that was used to derive the nutrient endpoints; and third, it appears the specific analytical method we used was misunderstood. The following specific responses apply.

1. <u>The effort undertaken was mischaracterized.</u>

Comments allude several times to criteria development and causal analysis, but that was not the purpose of this analytical effort. Dr. Zheng and I were engaged by colleagues within Tetra Tech (Tt), under contract with United States Environmental Protection Agency (EPA) Region 3, to develop a TP endpoint for TMDLs to protect aquatic life uses in several streams within the piedmont ecoregion of southeastern Pennsylvania. We were not engaged to diagnose the cause of aquatic life use impairment as that phase had already been conducted. Likewise, we were not asked to develop a criterion. Rather, we were requested to develop a TP endpoint that would be protective of aquatic life uses using a process that was transparent, reproducible, and scientifically defensible. Again, this effort was not undertaken to "show" that TP is the cause of impairment

Again, the causal analysis phase was a different component of this TMDL and was not the focus of this effort. Tt was not asked to determine the cause of impairment; we were given a cause and asked to determine a protective value. As a result, in our opinion the discussion in the evaluation relative to causal analysis or standards or criteria development mischaracterizes the analytical effort with which we were involved and is misleading and irrelevant.

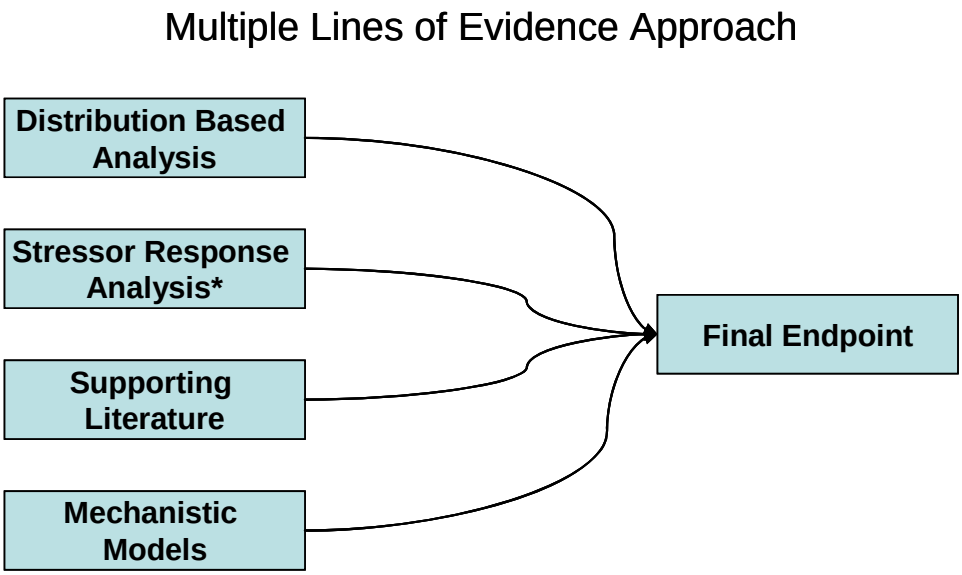
2. <u>The technical approach used was mischaracterized.</u>

Some comments mischaracterize the technical approach used to derive the TMDL TP endpoint. The method we used to derive the endpoint was not conditional probability – change point analysis.

Rather, we used what is referred to as a weight-of-evidence approach (Figure 1), of which conditional probability and change point analysis were part of one line of evidence, namely stressor-response analyses. In addition, Tt looked at distribution-based approaches, other stressor-response based methods, relevant supporting literature, and mechanistic nutrient models. Even though this was not a criteria based approach, it is perhaps pertinent to mention that Chapter 7 of the USEPA 2000 Nutrient Criteria Guidance Manual for Rivers and Streams (EPA-822-b-00-002) reviews methods for establishing nutrient criteria (USEPA 2000). Those methods include distribution based approaches, stressor-response analyses, use of published nutrient thresholds or recommended limits, and mechanistic models. Moreover, on page 94 of that document, in the first paragraph, the nutrient guidance reads:

> "A **weight of evidence** approach that combines one or more of the three approaches described…**will produce criteria of greater scientific validity**."

It is our reading of this that the weight-of-evidence approach we used which includes the use of stressor-response analyses is considered the preferred approach for developing scientifically defensible nutrient endpoints.



***Includes change point analysis of conditional probabilities as one approach.**

Figure 1

Some comments imply that we used only change point analysis to derive the endpoint. That is incorrect. Conditional probability is only one element of one line of evidence. The final endpoint was actually derived using a weight of evidence approach including several independent lines of evidence (Figure 1). The majority of evidence for developing this endpoint was not addressed by the comments. It is our opinion that comments of this nature mischaracterize the actual method used and, in so doing, ignore the strength of the approach and are misleading.

3. <u>The analytical technique is misunderstood.</u>

After reading some comments, it is our opinion that the authors misunderstand how conditional probability and change point analysis work and, therefore, the conclusions drawn by those comments are incorrect. One author undertook a re-analysis of the data we used and provided to EPA. They calculated phosphorus thresholds for a range of macroinvertebrate biological conditions in addition to the conditions we used in our original work. They conclude from their analysis showing a relatively consistent TP threshold for various Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) (EPT) Richness "conditions" that "the number of EPT taxa is insensitive to the TP concentration" (p.7). The author of these comments even ended his strongly worded introduction with the statement that "… a more detailed assessment shows that the endpoints are not affected by nutrient levels – the same change point occurs regardless of the biological target. Such a result confirms that nutrients are not controlling the ecological condition of concern." Looking at the raw data available in the original report it is non-sensical to conclude that the number of EPT taxa is insensitive to TP when, clearly, above 40 ug/L there is a precipitous decline in EPT taxa (Figure 2).

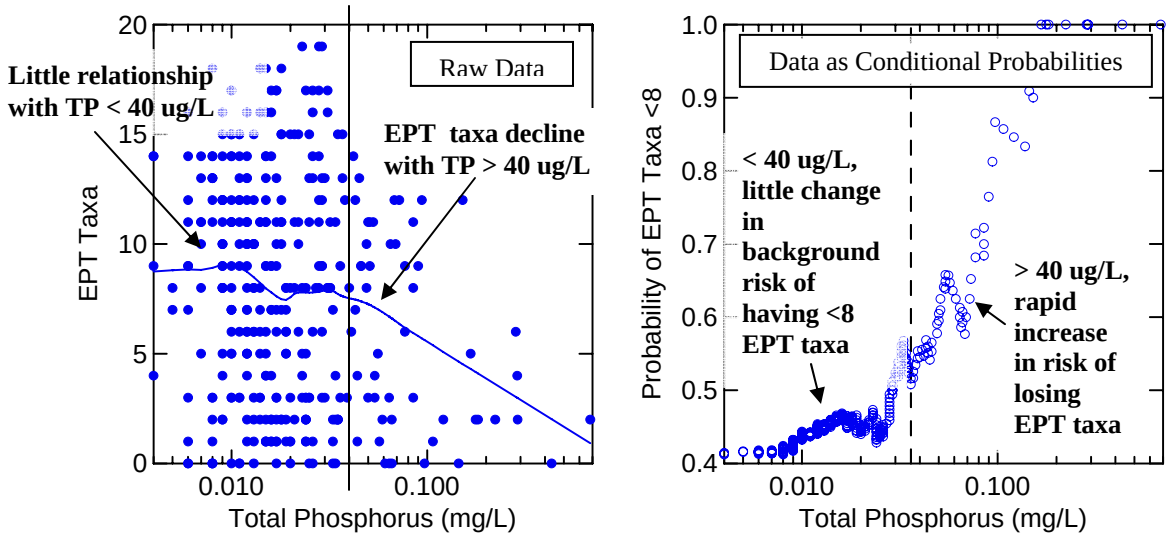


Figure 2

We used change point analysis (CPA) to identify that TP concentration where the greatest increase in the risk of decline in a number of biological metrics occurred. CPA is an analytical method used to identify thresholds in the relationship between a dependent response variable and some independent variable (Qian et al. 2003, King and Richardson 2003). This can be identified using either raw data (Figure 2 above on left) or data converted into conditional probabilities (Figure 2 above on right). Conditional probabilities express data in a risk format (Paul and MacDonald 2005). For example, identifying the probability of having some adverse condition occur (e.g., having less than 8 EPT taxa) as a stressor concentration (TP) increases. We converted out data into conditional probabilities and then we used change points analysis to identify the threshold in the TP-conditional probability relationship. The threshold is the inflection point or the point where the probability of observing the adverse biological condition is increasing the most. In the example above, this occurs at 38 ug/L (0.038 mg/L) TP.

We used macroinvertebrate and water chemistry data from piedmont streams in Maryland collected as part of the Maryland Biological Stream Survey (MBSS) by the Maryland Department of Natural Resources. There was insufficient data from the Pennsylvania piedmont to conduct a comparable analysis. The MBSS has developed a series of macroinvertebrate metrics that they use to evaluate biological condition. These metrics are scored to be combined into a multimetric. The conditions we chose (e.g., < 8 EPT taxa) were the midpoint of the scoring range of the metrics we used. We selected these conditions because it represented that point where scores shift from good to poor. But, as the comments of this author have shown, we could have selected higher or lower conditions and come to the same threshold. However, the author apparently misunderstands why.

The author recalculated conditional probabilities using a range of different conditions (e.g., from <2 to < 14 EPT Taxa) and re-ran the change-point analyses. What he discovered is that across this range, the TP threshold remains constant (Figure 3).

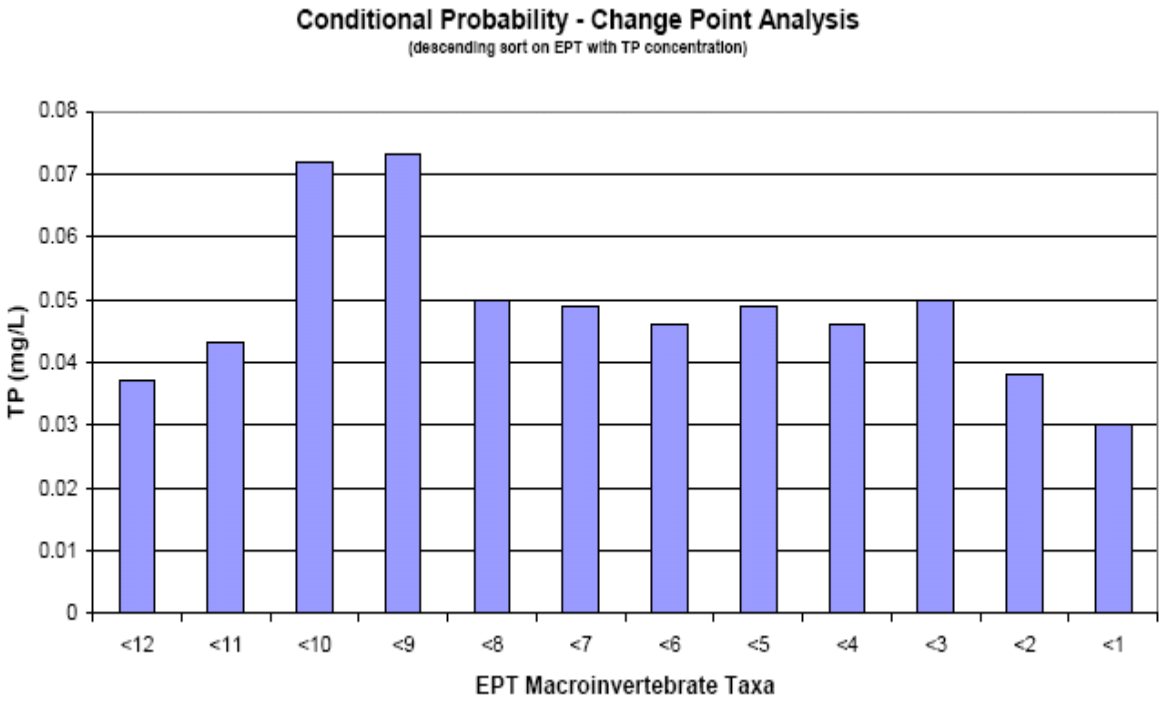


Figure 3 – Figure 6 from the evaluation

He concludes that "the number of EPT taxa is insensitive to the TP concentration". But Figure 3 is not a plot of TP versus biological condition. It simply demonstrates that no matter what biological condition one chooses, the risk of losing EPT taxa increases dramatically between 30 and 50 ug/L, which is actually consistent with what the raw data show in Figure 2 above. What the evaluation fails to recognize is that relative to any biological condition (e.g., EPT<2), the probability of encountering that condition starts to increase rapidly above 40 ug/L. Rather than showing that "the number of EPT taxa is insensitive to the TP concentration", what the author has shown in Figure 3 is that across the range of conditions, there is a dramatic decline in the number of EPT taxa above 40 ug/L. Whether one uses a conditional probability of having fewer than 14 taxa or fewer than 3 taxa, above 40 ug/L, the likelihood of losing EPT taxa in Piedmont streams increases after showing little response to TP below 40 ug/L. This simply reinforces what is evident by looking at the raw data in Figure 2 above on the left. Again, whether one is looking at EPT taxa loss risk relative to 14

EPT taxa or 2 EPT taxa, the risk increases above 40 ug/L because the decline in EPT taxa is so steep. What the author of the evaluation has in fact demonstrated, in dramatic fashion, is that the increasing likelihood of losing EPT taxa is powerful and is so complete that the decline in response to TP impacts most piedmont streams with more than 1 EPT taxon and that it is not a multi-threshold response – the likelihood of decline increases above 40 ug/L. This reinforces, rather than conflicts with, the conclusion that biological condition declines dramatically above 40 ug/L.

If there were, indeed, no relationship between biological condition and TP, as the author of these comments claims, then the plot of conditional probability versus TP would be flat. There would be no increase in the likelihood of observing a degraded biological condition (e.g., loss of EPT taxa) as TP increases. But this is not the case – in fact, just the opposite occurs. Again, in Figure 4, the comments made have actually provided strong evidence that no matter what adverse condition one selects, the risk of observing it always increases with increasing TP. The relationship is never flat for any of the conditions they examined.

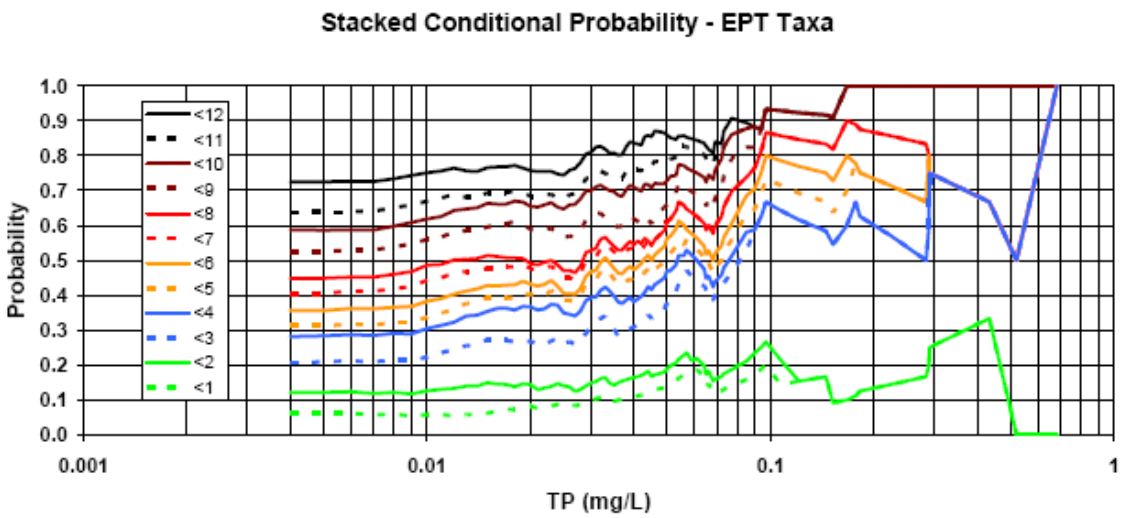


Figure 4 - Figure 7 from evaluation

We have focused on the evaluation for EPT taxa, but it applies equally well to any of the response measures we examined that were reviewed in the evaluation – percent clingers or TSI. It is our opinion that the author of these comments simply misunderstood the technical analysis performed and rather than weakening the evidence for the threshold selected, their analysis actually reinforces the threshold selected.

References

King, R. S., and C. J. Richardson. 2003. *Integrating bioassessment and ecological risk assessment: An approach to developing numerical water-quality criteria*. Environmental Management 31:795-809.

Paul, J.F. and M. E. McDonald. 2005. *Development of empirical, geographically specific water quality criteria: a conditional probability analysis approach*. Journal of the American Water Resources Association 41: 1211–1223

Qian, S.S., King, R.S., Richardson, C.J., 2003. *Two Statistical Methods for the Detection of Environmental Thresholds*. Ecological Modeling 166: 87–97.

United States Environmental Protection Agency (USEPA). 2000a. "*Nutrient Criteria Technical Guidance Manual: Rivers and Streams*". United States Environmental Protection Agency, Office of Water, Washington, DC. EPA-822-B-00-002

06/11/08

MEMORANDUM

From: William Swietlik, Chief
Ecological and Health Processes Branch
EPA/OW/HECD/OST

To: Robert Koroncai, Associate Director
Water Protection Division
EPA/Region 3

Subject: Development of Nutrient Endpoints for TMDLs in Pennsylvania

The Headquarters nutrient team and I have completed our review of the document entitled: *Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania*, prepared for Region 3 by Tetra Tech, Inc., dated November 20, 2007. It is our conclusion that the approach used in the document to derive the nutrient TMDL endpoints for use in implementing Pennsylvania's narrative standard is a scientifically defensible approach and is consistent with EPA guidance for deriving nutrient criteria.

The approach used in the document is an example of the multiple-lines-of-evidence (or weight-of-evidence) approach. The report examined different lines of evidence to derive nutrient numbers in three categories, and involved 17 different lines of evidence, constituting a very thorough analysis. The multiple-lines-of evidence approach is recommended by EPA in the following guidance.

- U.S. EPA. 2000b. *Nutrient Criteria Technical Guidance Manual: Rivers and Streams*. Office of Water, Office of Science and Technology, Washington, DC. EPA-822-B-00-002. In summary, this guidance states that a weight of evidence approaches that combines one or more of the three approaches; 1) Reference reaches, 2) Predictive relationships and, 3) Published threshold values; while considering downstream effects, will produce criteria of greater scientific validity.

- U.S. EPA. 2006. *Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria.* Office of Water and Office of Research and Development, Washington, DC. EPA-822-R-06-001. This document recommends an integration and synthesis of multiple methods. This recommendation is based on a conclusion of the USEPA Science Advisory Board that "no single method would suffice complete criteria development in every situation and that multiple methods applied simultaneously (synthesized) may be more appropriate for criteria development."

In October, 2007 EPA HQ provide training to the Region II and III States on the weight-of-evidence methodology and how it can be applied to developing numeric nutrient values. It is

good to see the Region benefited from our training and that you are now employing this approach.

General Response #2: Response to Legal Issues

Comment A. Several commenters asserted that EPA created new water quality standards for Pennsylvania, exceeding the Clean Water Act authority and/or illegally interpreting Pennsylvania's narrative water quality standard in developing the TMDL endpoint. Any new water quality standard must undergo formal notice and comment rulemaking.

> **Response: Pennsylvania has adopted water quality standards ("WQS") applicable to the waters addressed in these TMDLs which EPA approved pursuant to Section 303(c) of the CWA. Pennsylvania has both numeric and narrative criteria set forth in 25 PA Code Chapter 93 (with related provisions set forth in Chapters 16 and 96). Water quality standards include both the existing and designated beneficial water uses (e.g., aquatic life), as well as narrative and numeric criteria sufficient to protect those uses. 40 CFR Section 131.2 Pennsylvania does not currently have numeric criteria applicable to nitrogen and phosphorus, although Pennsylvania has adopted water quality standards implementation regulations applicable to nutrient discharges at 25 PA Code Chapter 96.5. For waters impaired by the discharge of phosphorus, those regulations require point sources discharges "be limited to an average monthly concentration of 2 mg/l" unless more stringent controls on point source discharges are determined to be necessary as a result of TMDL development for the receiving water. 25 PA Code Chapter 96.5(c). In other words, under that regulation, the NPDES permit must include at a minimum effluent limit for the discharge of phosphorus of 2 mg/l average monthly concentration, unless through the TMDL development a more stringent water quality based effluent limit is determined. While this regulation does not by itself establish a numeric water quality criterion (since it does not establish an ambient water quality criteria sufficient to protect water uses and moreover is not applicable to nonpoint sources) the regulation does provide minimum requirements applicable to point source discharges of phosphorus.**
>
> **Pennsylvania does have general narrative water quality criteria that includes the following: "Water may not contain substances attributable to point or nonpoint source 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." 25 PA Code Chapter 93.6(a).**
>
> **As required by federal regulations at 40 CFR Section 130.7(c)(1), "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numeric water quality standards….". To determine the appropriate water quality endpoint by which the TMDL could ensure adequate protection of beneficial water uses, and since Pennsylvania did not have numeric water quality criteria, EPA started with that general criteria set forth above. EPA interpreted the Pennsylvania narrative criteria to determine a sufficiently protective water quality endpoint using the method described in the TMDLs and elsewhere in this response to comments. Please refer to General Response #1 and elsewhere for more information on the approach used to determine the TP endpoint. As part of the public comment process, PADEP reviewed and expressed explicit support for EPA's interpretation**

of the Commonwealths' general water quality criteria and phosphorus endpoint. As discussed elsewhere in the TMDLs and supporting documentation, the endpoint was selected at a level to restore and maintain aquatic life as described in the report "*Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania*' and the supplemental reports for the Allegheny Plateau and the Ridge and Valley ecoregions. Application of these endpoints also was protective of aesthetic and recreational uses by limiting algal biomass growth.

EPA provided extensive notice of the interpretation of Pennsylvania narrative criteria including the technical approach as part of the public comment process for these TMDLs. The comment period for each TMDL is provided in the Introduction to the Response Document. Because EPA interpreted Pennsylvania's existing narrative water quality criteria, EPA did not establish a water quality standard or criteria pursuant to Section 303(c) of the CWA. Commenters misunderstand and/or mischaracterize the development of the numeric endpoint as the promulgation of a water quality standard. In order for EPA to propose such a water quality standard applicable to Pennsylvania waters, and in the absence of a submission of a new or revised WQS from the state, Section 303(c)(4)(B) of the CWA provides that the Administrator must first make a determination "that a revised or new standard is necessary to meet the requirements" of the CWA. Because Pennsylvania's narrative criteria were sufficient to meet the requirements of the CWA, EPA has not made (and does not expect to make) such a finding in this case. Because EPA was interpreting an existing narrative water quality criterion, EPA was not required to undertake the rulemaking (and associated public process) for the promulgation of water quality standards for Pennsylvania. EPA supports Pennsylvania's ongoing efforts to develop and adopt statewide numeric nutrient criteria. When Pennsylvania adopts numeric phosphorus criteria and submits them to EPA, EPA will make a decision whether that submission is consistent with the requirements of the CWA. If the numeric criterion is significantly different than the phosphorus endpoint developed by EPA, it may be necessary to revisit and revise the TMDL.

Comment B: Several commenters argued that EPA regulations at Clean Water Act Section 122.44(d)(vi) require EPA to follow PADEP policy/guidance on interpretation of the narrative water quality standard regarding nutrients. The commenters insist that EPA has a history of developing TMDLs based on other more appropriate interpretations for nutrients and has been inconsistent with regards to comments to the Court on the endpoint.

Response: The EPA regulations cited by the commenters contain requirements for establishing water quality-based effluent limitations in NPDES permits. They do not establish requirements for establishing TMDLs. As described above, EPA interpreted Pennsylvania's narrative criteria using a "weight-of-evidence" approach that is consistent with EPA numeric criteria development guidance. The commenters are referred to General Response #1 for the support memorandum from EPA Headquarters on the approach used by EPA. EPA's review of applicable Pennsylvania statutes, regulations, and "procedures" did not find anything that would prohibit EPA from using a "weight-of-evidence" approach that relies, in part, on macroinvertebrate health to establish a TMDL nutrient endpoint protective of

aquatic life. PADEP routinely uses instream biology, including macroinvertebrate health, to assess waters for CWA Section 303(d) impaired waters listing purposes. 25 PA Code Chapter 96.5(c) prescribes point source limitations on phosphorus discharges as necessary to protect designated uses, including aquatic life. Pennsylvania's 2007 Assessment Methodology recognizes that biological impairment may be correlated with the presence of excessive nutrient levels in the absence of DO criteria violations. Moreover, Pennsylvania's 2007 ICE Survey guidance directs staff to collect benthic macroinvertebrate data to assess attainment of aquatic life uses. Furthermore, as described in PADEP's comments on the proposed TMDLs, PADEP supports the proposed nutrient endpoint process for phosphorus (See Comment Letter #39). EPA developed these TMDLs consistent with regulations requiring that TMDLs are established to attain and maintain applicable water quality standards and uses, 40 CFR 130.7(c)(1). The commenters are also referred to General Response #11 for a discussion on the difference in approaches used for past and present TMDLs.

Comment C: Several commenters argued that EPA exceeded the CWA authority in establishing TMDLs without first disapproving a state established TMDL. They argue that the CWA and the TMDL Consent Decree in Pennsylvania gives Pennsylvania primary authority to establish TMDLs.

Response: The 1997 Consent Decree referenced by the commenters represents a settlement of a case alleging that, since Pennsylvania had not established a sufficient number of TMDLs up to that point, there was a mandatory duty for EPA to establish TMDLs for Pennsylvania. While EPA did not admit to such a duty or liability in settling the case, EPA agreed to "backstop" the establishment of TMDLs for waters Pennsylvania identified on the 1996 CWA section 303(d) list of impaired waters. Consistent with Section 303(d) of the CWA, the Consent Decree recognizes the state's primary responsibility to develop TMDLs. However, the Consent Decree also requires EPA to establish on a certain schedule where the state fails to do so. EPA was not given any grace period under the Consent Decree – that is, a specific number of TMDLs were to be completed by specific dates and if the state failed to complete these TMDLs by the date specified, then EPA was to establish those TMDLs by that same date.

While Pennsylvania is not a party to the Consent Decree, PADEP has entered into a Memorandum of Understanding (MOU) with EPA on Section 303(d) program issues, including the development of TMDLs. Pursuant to that 1997 MOU, EPA and PADEP have agreed on workplans and established schedules for TMDLs on a routine basis. In order to comply with the commitments of both the Consent Decree and the MOU, and in order to help Pennsylvania run an efficient and effective TMDL program, PADEP and EPA have decided which entity would establish TMDLs for which waters on the basis of resources, experience and other factors. For the waters that are the subject of these comments, Pennsylvania requested EPA to establish these TMDLs. Implicit in that request is the recognition that Pennsylvania will not be establishing those TMDLs by the Consent Decree deadline. Since waiting until the state 'failed' to complete the required TMDLs by the

deadline would not give EPA adequate time to establish TMDLs, upon the request from the state that EPA establish certain TMDLs, EPA moved forward to ensure the Consent Decree requirements wee met. The TMDLs now being established by EPA are the final non-mining TMDLs to be completed under the Consent Decree. They must be established by June 30, 2008. Over the life of the Consent Decree, the state has requested EPA to establish many TMDLs in order to meet the Consent Decree deadlines. EPA has established 452 TMDLs since 1997 at the request of the state. (Altogether EPA and PADEP have established over 5300 TMDLs.) These requests were, in most cases, based on the state's lack of resources, technical as well as financial and personnel. At times there were simply too many TMDLs required to be completed under the Consent Decree for the state to get them all done in time. At other times TMDLs were so significantly complex that the state requested EPA to establish them, thereby allowing EPA to bring its own, as well as contractor, expertise into the development process. Such is the case for these TMDLs. Because the state was already working on hundreds of mining-related TMDLs as well as a significant number of non-mining TMDLs and due to the complexity of the TMDLs being established herein, the state requested EPA to assist in meeting the Consent Decree deadlines by establishing the TMDLs for the five (5) watersheds. EPA agreed. EPA has a number of documents that support this, including a summary of an August 24, 2005 meeting between EPA and PADEP, a June 6, 2005 memorandum "Remaining 1996 waters needing TMDLs" from Thomas Henry, Region III TMDL Program Manager to Lee McDonnell, PADEP TMDL manager, a memorandum "summary of meeting – July 28, 2004" from Thomas Henry, Region III TMDL Program Manager to Lee McDonnell, PADEP program manager dated July 9, 2004 and a memorandum "PA TMDLs and the contracts" from Thomas Henry, Region III TMDL Program Manager to Lee McDonnell, PADEP TMDL program manager dated July 18, 2005.

Comment D: A few commenters claimed that EPA exceeded the CWA Section 303(d) authority to establish TMDLs for non-listed waters/pollutants in the absence of formal Section 303(d) listing of waters/pollutants. The commenters argue that the CWA requires notice and comment to change Section 303(d) listed waters/pollutants when establishing TMDLs. The commenters go on to say that the TMDLs developed are for water/pollutant combinations not exactly as found on the CWA Section 303(d) lists.

Response: EPA regulations state that TMDLs shall be established for the water quality limited segments identified on a state's section 303(d) list (40 CFR 130.7(c)(1)) and for all pollutants preventing or expected to prevent attainment of water quality standards as identified on the section 303(d) list. 40 CFR 130.7(c)(1)(ii). In many cases the source(s) of impairment to downstream waters are pollutants in the upstream waters themselves, as well as sources of pollutants to those upstream waters. In those cases, in establishing a TMDL for the listed water and pollutants, it may be necessary to establish a TMDL that explicitly addresses the upstream impairments and sources of pollutants. If EPA determines during the development of a TMDL for a 303(d) listed portion of the stream that an unlisted, upstream portion of the waterbody is impaired and is contributing to the downstream impairment, Section 303(d) does not limit EPA's authority to establish

a TMDL which addresses the cause(s) of impairment of both the listed and non-listed portions of the waterbody. Where EPA's TMDL analysis of a basin or watershed causes EPA to determine that other basin or watershed segments are similarly impaired, EPA has authority under the CWA and the Pennsylvania Consent Decree to address those linked impairments in a holistic manner at one time with a watershed TMDL rather than piece-by-piece over time. Where the public is placed on notice in the proposed TMDL that EPA has determined that various additional segments of the basin are impaired by certain pollutants and that EPA is proposing to address those impairments in a comprehensive manner using pollutant allocations that derive from a basin-wide analysis and where the public has an opportunity to comment on the impaired status of these waters before EPA establishes the TMDLs, EPA does not have a separate obligation under the CWA to take public comment on a listing amendment.

For the TMDLs covered by these comments, the scope of the TMDL (including both the specific pollutants and segments identified as impaired) was part of the publicly noticed action upon which EPA requested and received comment. By seeking such notice and comment on the specific geographic scope of the TMDLs as well as the pollutants that cause the impairments in that waterbody, EPA satisfied any obligation it might have under the CWA to take public comment on a listing amendment.

In fact, based on such comments EPA has made significant changes to the scope of the Chester Creek TMDL reducing its geographic reach to Goose Creek. [cross reference to Comment #9. For all other segments and pollutants that were not previously identified on Pennsylvania's 303(d) lists, EPA has adequately identified the scope of the impairment and pollutants covering those impairments in the publicly proposed draft TMDLs.

Commenters also claim the Chester Creek and Indian Creek basins were never listed as impaired for nutrients and therefore EPA has no authority to establish a TMDL that addresses nutrients. Even if Pennsylvania's 1996 list did not specifically identify nutrients as the pollutants causing the impairment, Pennsylvania did include a Chester Creek basin segment on the 1996 section 303(d) list. Under federal regulations and the Consent Decree it is appropriate that EPA establish that listed segment's TMDL(s) "for all pollutants preventing…the attainment of water quality standards" regardless of whether the specific pollutant was previously identified. Since EPA determined during the course of its TMDL analysis that nutrients were in fact the pollutants causing the impairment of the listed segment, EPA was authorized to establish a TMDL for nutrients. If EPA's TMDL analysis of the basin causes EPA to determine that other basin segments were similarly impaired, the statute, regulations and Consent Decree authorizes EPA to address those linked impairments in a holistic manner through a watershed TMDL rather than piece-by-piece over time.

Commenters also state that while a portion of Paxton Creek was listed for nutrients, the cause of the impairment was "agricultural" and therefore EPA has no

authority to make allocations to address the CSO source nutrient impairment to municipalities without formally amending the list. The same logic that applies supports EPA's determination that it is authorized to establish a nutrient TMDL for Paxton Creek regardless of whether the section 303(d) list identified the particular "source" of the impairing nutrients – CSO or agricultural runoff. Because the 303(d) lists must identify impairments based on "existing and readily available" data and information, there may be limited information available at the time of listing to identify the particular source of a pollutant. In fact, the TMDL development process often serves as the vehicle by which additional information is collected and analyzed giving the basis for refined determinations about the impairment's scope and the pollutant source. Such was the case in these TMDLs.

Comment E: Several commenters argue that the Pennsylvania Consent Decree limits EPA's authority to establish only those TMDLs for segments and/or for pollutants on the 1996 303(d) list.

Response: This is simply not true. The Pennsylvania Consent Decree says that if Pennsylvania does not do so first, EPA must establish TMDLs for "all water quality-limited segments identified on Pennsylvania's 1996 Section 303(d) list." (CD Para. 15). The Consent Decree does not in any way limit EPA's authority to establish TMDLs for other impaired segments in Pennsylvania, where appropriate. Nor does the Consent Decree put limits on EPA's obligation or authority, depending on what specific pollutant (if any) is identified on the list. As described above in Comment D, in some cases it is necessary to address pollutants and their sources in non-listed segments in order to establish a TMDL for a listed segment that is set at a level necessary to implement the applicable water quality standards.

Nor does it matter that none of the waters for which TMDLs have been established was specifically identified as nutrient impaired "for invertebrates." As long as the waters were listed in 1996, the Consent Decree obligation applies. The State or EPA is authorized to confirm the waters' true impaired status, and calibrate the TMDL accordingly, as they we go about developing the TMDL. Nor does Paragraph 5 of the Decree require EPA to consider a TMDL-driven refinement of the impaired status of these waters as a "disapproval" of the 1996 listing, requiring additional notice/comment before EPA establishes a new list with the correct impairment designations.

In any case, because Pennsylvania has specifically requested that EPA establish TMDLs for the waters addressed by the June 30, 2008 EPA actions that are sufficient to attain and maintain water quality standards for the waters covered by these TMDLs, EPA has the authority to establish these TMDLs.

Comment F: Several commenters were concerned that EPA violated the CWA by not considering economics in establishing TMDLs/endpoints/allocations.

Response: The CWA Section 303(d) requires TMDLs to be established for impaired or threatened waters at a level necessary to implement the applicable water quality

standards with seasonal variations and a margin of safety. Federal regulations at 40 CFR Section 130.7(c) track the statute and require TMDLs to be developed at levels necessary to attain and maintain the applicable narrative and numerical water quality standard with seasonal variations and a margin of safety and that take into account critical conditions. TMDLs are to include wasteload allocations for each point source and load allocations for nonpoint sources. Neither the CWA nor EPA's implementing regulations require the state or EPA to consider the costs to implement the TMDL when establishing the TMDL at a level necessary to implement the applicable water quality standards.

General Response #3: Total Nitrogen TMDL

Many, if not all, of the commenters believe that including a TMDL for Total Nitrogen is not appropriate. Most of the comments were opinion only and did not include any beneficial evaluation or additional data to justify that position. EPA's literature review showed several major investigators have recommended that both total phosphorus and total nitrogen be controlled. Dodds and Welch (2000) found that correlation does not support the idea of TP as the sole limiting nutrient in rivers and streams. A regression model using both TN and TP explained the highest proportion of variances in biomass. They concluded that both TN and TP can control primary production in at least some streams and rivers. They proposed that if pulses of TP occur, such as storm runoff, they can be taken up in excess of requirements and stored inside algal cells. If controlling of TP pulses is not possible then control of TN may be necessary. Dodds and Welch (2000) suggested that given the bioassay and correlation data and that periphyton can consume phosphorus in excess of immediate needs, setting nutrient criteria for both TN and TP makes sense. In addition to the seasonal average and maximum regression equations developed, Dodds, et al. (2006) presented a threshold value for TN and TP. Dodds notes that the literature data set included breakpoints that "may provide important guidance" in the control of benthic chlorophyll. "The breakpoints provide evidence for a saturation effect of nutrients on periphyton biomass accrual…They suggest that there is little probability of low benthic algal chlorophyll above the breakpoint value for TN and TP. If TN or TP is below the breakpoint, there is more likely to be low chlorophyll…" Dodds, et al. (2006) provided an analysis of breakpoints from regression for TN and TP.

EPA's own nutrient criteria development guidance recommends that both total phosphorus and total nitrogen are appropriate for criteria development for streams in order to be effective. However, if a state shows that causal variable (nitrogen or phosphorus) is the limiting nutrient, the state should develop criteria for at least the limiting nutrient. If the non-limiting nutrient is likely contributing to a downstream impairment, source reduction strategies should be implemented in advance of developing quantified limits where specific downstream criteria are not yet adopted.

EPA believes that total nitrogen is an important pollutant to be considered in any nutrient control plan. However, for the protection of aquatic life use, which is the major consideration in this TMDL, the application of the process used by EPA for the interpretation of the State's narrative standard concluded that total phosphorus was the limiting pollutant for these waters and that nitrogen control may be necessary for downstream waters. Based on our findings in the endpoint determination, EPA has concluded that more information and study is needed before we can conclusively recommend an in-stream value for total nitrogen. Downstream impacts should also be fully evaluated. It is our understanding that PADEP is of the same view and will continue to collect and evaluate appropriate data as they consider whether a numeric criterion should be developed and implemented for total nitrogen. EPA encourages the state to continue to evaluate the need for nitrogen criteria for aquatic life protection. However, EPA is NOT including a TMDL for total nitrogen for these five (5) waters at this time.

General Response #4: EPA's approach to allocating to municipal separate storm sewer systems (MS4), Combines Sewer Systems (CSOs) and other Stormwater Sources

Municipal Separate Storm Sewer Systems (MS4) are defined by EPA as point sources needing an NPDES permit. EPA clarification memorandum dated November 22, 2002, has clarified existing EPA regulatory requirements for, and provides guidance on, establishing wasteload allocations (WLAs) for storm water discharges in TMDLs approved or established by EPA. The memorandum made it clear that:

- NPDES-regulated storm water discharges must be addressed by the WLA component of the TMDL, and

- NPDES-regulated storm water discharges may not be addressed by the load allocation (LA) of the TMDL

MS4 permits exist in each of the five watersheds for which EPA has developed TMDLs. NPDES permits have been issued to Townships for these storm sources. As EPA understands it, the specific service area that each MS4 covers has not been definitively defined, and one of the first steps that a township needs to take is to define that MS4 service area. Until that is accomplished the entire township was assumed to be the service area in the TMDL. EPA understands that some of that township area may be areas that will not be expected to be covered by the MS4 requirements - forests or agricultural lands as examples. Because the townships and have not yet established the service area, EPA has assigned the required WLAs to an entire township area. The Townships must take the next step of area definition in order to more accurately define the WLAs and Las.

Following the townships service area identification, the established TMDL allows the state to adjust the assigned allocations based on the land area to be serviced and the remaining area. Sufficient information is provided in the TMDL to allow for this reassignment based on land use and allowable loading factors. Using this information the WLA can be adjusted to account for the land area in the MS4, with the remaining allocated load reassigned to the LA. The total allocated load – adjusted MS4 WLA + LA – must equal the original MS4 WLA for the township. This adjustment to the permitted WLA would be reflected in the MS4 NPDES permit. This adjustment to the TMDL can be accomplished by the state submitting a formal TMDL modification request to EPA. Public participation of the adjustments can be either through the NPDES process or by a separate TMDL modification notice.

EPA recognizes that sufficient data may not be available to allocate loads to each individual combined or separate sewer overflow. The above noted clarification memorandum states that "It may be reasonable to express allocations for NPDES-regulated storm water discharges from municipal sources as a single categorical wasteload allocation when data and information are insufficient to assign each source or outfall individual WLAs." EPA recognizes that the available data and information usually are not detailed enough to determine WLAs for NPDES-regulated storm water discharges on a outfall-specific basis. In this situation, EPA recommends expressing the WLAs in the TMDL as either a single number for all NPDES-regulated storm

water discharges, or when information allows, as different WLAs fir different identifiable categories (municipal storm water as distinguished from storm water from construction sites).

Using these recommendations, EPA established TMDLs for categories. Each MS4 received a WLA, CSOs were combined and received one WLA and SSOs, where they were identified, were allocated a zero loading since these types of discharges are considered illegal. In some cases a Long Term Control Plan (LTCP) was either developed or in the process of being developed. Although data and information was requested from these LTCPs none were received. Therefore a general approach was used. See below on implementation expectations for storm water.

General **Response #5: Adaptive Management Recommendation and Phased TMDLs**

Some commenters suggested that we define these TMDLs as phased TMDLs since the PADEP is in the process of developing nutrient criteria. All TMDLs, including phased TMDLs must meet all of the regulatory requirements, including meeting existing and applicable water quality standards, include WLAs, include LAs, and a margin of safety as well as include seasonal considerations and critical conditions. However, phased TMDLs should also include a monitoring plan and a scheduled timeframe for revision to the TMDL. There is some confusion over the difference between Phased TMDLs and implementation options. Phased TMDLs are a matter of TMDL development while staged implementation and adaptive management are post-development implementation concepts.

The term phased TMDLs is limited to TMDLs that for scheduling reasons need to be established despite significant data uncertainty and where the state expects that the loading capacity and allocation scheme will be revised in the near future as additional information is collected. Such uncertainty may arise because the TMDL used a surrogate to interpret a narrative standard, as an example. Phased TMDLs may also be used when a revision to an applicable water quality is underway and will necessitate development of a second phase, revised TMDL to comply with the new standard.

These TMDLs are considered phased. It is recognized that PADEP will be developing numeric water quality criteria for nutrients in the future. These TMDLs note that adjustments can be made to the allocations based on any new criteria developed by the state, if appropriate. EPA is clear in its 1991 guidance and subsequent clarifying memorandum, that all TMDLs must meet the basic regulatory requirements of a TMDL, whether it is a phased TMDL or not. Therefore phased TMDLs, as all other TMDLs, must be designed to implement the existing water quality standards, include total allowable loads, wasteload allocations, load allocations where appropriate, a margin of safety, consider seasonal considerations and critical conditions.

Adaptive management is an iterative implementation process that makes progress toward achieving water quality goals while using any new data and information to reduce uncertainty and adjust implementation activities. If adaptive implementation activities reveal that a TMDL loading capacity needs to be changed, the revision would require approval. In most cases adaptive management is not anticipated to lead to re-opening of a TMDL. Instead, it is a tool used to improve implementation strategies.

The suggested implementation option described in the Appendix to the TMDLs is an adaptive management approach. It also contains some phased considerations. Since the state is in the process of developing proposed numeric nutrient criteria, the suggested approach allows for a TMDL modification, if necessary, based on the findings and numeric standards adopted by the state. It also allows for an iterative approach to implementation – treating to a level that should be readily achieved without additional costly treatment modifications and then final control levels after a reasonable period of time or when the state standards are in place. A final end date was suggested since it is unknown at this time when the state's numeric standards will actually be adopted into the state standards and implemented.

Some commenters also suggested that the TMDL allow for trading. A TMDL can be the basis for determining trading options. If sources would like to implement some sort of trading activity, then the TMDL provides the goals for that trading. EPA is evaluating the need to modify an existing TMDL, with EPA approval, when trading results in WLA and/or LA adjustments. Results of trading activities must be consistent with the TMDL assumptions and be shown to maintain applicable water quality standards.

General Response #6: Pennsylvania Department of Environmental Protection's identification of impairments for the five waters

The Clean Water Act (CWA) Section 303(d) requires the identification of all waters for which the effluent limitations required by Section 1311(b)(1)(A) and section 1311(b)(1)(B) of the CWA are not stringent enough to implement any water quality standard applicable to those waters. It further requires the development of total maximum daily load for each of the waters identified, considering seasonal variation and margin of safety.

The implementing regulations at 40 CFR Section 130.7 requires the identification of waters that are not now meeting or are not expected to meet (threathened waters) applicable water quality standards. Note that gives EPA the authority to develop TMDLs for waters and pollutants that are not now impaired but data shows a downward trend in water quality. This regulation defines the applicable water quality standard as those water quality standards established under section 303 of the CWA, including numeric criteria, **narrative criteria** (emphasis added), waterbody **uses** (emphasis added) and antidegradation requirements.

- By regulation the states shall evaluate all existing and readily available water quality data and information to develop the list and at a minimum include such evaluation for the following categories of waters:
- Waters identified in the most recent section 305(b) water quality report as partially meeting, not meeting or threathened,
- Waters for which dilution calculations or predictive modeling indicates nonattainment of water quality standards
- Waters identified as impaired or threathened in the Section 319 report

For these waters TMDLs are to be established at levels necessary to attain and maintain the applicable water quality standards. Seasonal variation, a margin of safety for any lack of knowledge concerning relationships between effluent and water quality and critical conditions should be taken into account when establishing the TMDLs. TMDLs are appropriate for any pollutant and can be established using the pollutant-by-pollutant or bio-monitoring approach.

In most cases, PADEP has used a biomonitoring approach to identify impaired waters. EPA 1994 listing guidance provides for this type of data to be used in the listing decision process. The guidance includes beneficial use impairment and evidence of a narrative criterion violation using biological assessments that demonstrate loss of biological integrity as acceptable data and information for listing decisions. Use of biological data carries through to the most recent EPA listing guidance. We note that the guidance, consistent with the regulations as noted above, includes technical analysis, such as predictive modeling or Rapid Bioassessment Protocol results that show that criteria will be violated or beneficial uses will not be maintained as acceptable data and information for listing decisions. EPA's predictive modeling for the five waters support PADEP's position that these waters are impaired and will not attain or maintain applicable water quality standards under design conditions.

The guidance recognizes that biological assessments can provide compelling evidence of water quality impairment because they directly measure the aquatic community's response to pollutants or stressors. Biological assessments address the cumulative impacts of all stressors, especially habitat degradation, loss of biological diversity and nonpoint source pollution.

EPA's National Clarifying Guidance for 1998 emphasizes the need to list waters based on existing and applicable water quality standards. A decision not to list a water because a water quality standard is in the process of being revised is inconsistent with the regulations and the CWA. States should include on the section 303(d) lists, waters that do not meet an applicable water quality standard at the time of listing, even if the standard is in the process of being revised.

Further the 1998 guidance addresses the situation where the specific pollutant has not been identified – cause unknown. The guidance requires in these circumstances that the state indicate on the list, **if possible** (emphasis added), the class of pollutants causing the impairment. A March 26, 2002 clarifying memorandum further supports the need to list a water using biological information even if the specific pollutant is unknown. When existing and readily available data and information (biological, chemical, or physical) are sufficient to determine that a pollutant has caused, is suspected of causing, or is projected to cause the impairment, the water should be include on the impaired waters list.

Therefore listing of waters based on biological data and information is an acceptable approach. In addition, identifying an unknown cause is also acceptable. The TMDL development process can be an acceptable method for determining the specific pollutant under these circumstances. If EPA modifies a state list, by either adding waters or pollutants or removing waters or pollutants, then EPA must provide public notice to those changes. The public comment period for the TMDL can be an acceptable approach to the required public notice of listing changes. EPA used this approach for several waters where the cause was unknown but, through the TMDL data collection and review process, the cause was identified as nutrients.

Based on the above and the biological data collected by PADEP, the waters under consideration in this Response Document have been properly listed as impaired. EPA predictive modeling confirms the impairment.

As discussed in General Response #2 above, EPA is under court order to complete TMDLs for waters identified as impaired on Pennsylvania's 1996 section 303(d) list. It is clear in that order that, if the state fails to complete the required TMDLs, then EPA must do so. Following several modifications to the original order, the final end date for completing TMDLs for the 1996 waters impaired by sources other than mining is June 30, 2008. For a number of reasons, PADEP has failed to meet the TMDL development schedule for several waters and has requested that EPA assist in establishing those TMDLs. The five waters that are the subject of this Response Document fall under that category. EPA has stressed the need to approach TMDL development on a watershed basis. A watershed approach was used for Sawmill Run (nutrients and sediment), Indian Creek (nutrients and sediment), Chester Creek (nutrients) and Southampton Creek (sediment only). In some cases this meant that TMDLs have been established by EPA for some waters that were not included on the 1996 list of waters but were included on later lists. As discussed in General Response #2 above, this is acceptable. Note that following comment from

several organizations and PADEP, EPA has limited the TMDL development for nutrients to Goose Creek and not the entire Chester Creek watershed.

Some commenters wanted EPA to ignore various sources of the impairment simply because the source was not indentified until after the 1996 list of impaired waters. Although the cause was identified in 1996 (nutrients for example) the source was not (agriculture identified in 1996 and CSOs added in 1998). This suggestion is inconsistent with federal law and regulations. During the TMDL development process ALL sources of the impairment must be identified and allocated appropriate loads. Simply ignoring a significant source because it was not on a particular list is unacceptable. Such an approach would either not allow the TMDL to be developed to attain and maintain applicable water quality standards or the 1996 listed sources would be severely restricted to account for the other, uncontrolled sources.

Data used by PADEP for listing decisions, such as stream survey reports, can be obtained from PADEP. The data used by EPA to confirm or identify specific pollutants has been included in the TMDL reports. This data includes, but is not limited to, that data EPA requested PADEP to collect in 2005 and 2006, USGS data and SRBC data.

The following Tables show the segments listed by PADEP, the source of impairment when known and the year of first listing.

Impaired Waters Listing Information for Paxton Creek, Indian Creek, Chester Creek, Sawmill Run and Southampton Creek from Pennsylvania's draft 2008 List of Impaired Waters

Paxton Creek			
Aquatic Life (7884) - 4.84 miles	Agriculture	Nutrients	1996
	Combined Sewer Overflow	Organic Enrichment/Low DO	1996
	Urban Runoff/Storm Sewers	Nutrients	2004
		Suspended Solids	1998
Aquatic Life (8288) - 1.57 miles	Urban Runoff/Storm Sewers	Cause Unknown	1998
		Siltation	1998
Paxton Creek (Unt 10140)			
Aquatic Life (13463) - 1.42 miles	Urban Runoff/Storm Sewers	Siltation	2008
Paxton Creek (Unt 10141)			
Aquatic Life (8316) - 1.44 miles	Agriculture	Siltation	1998
	Urban Runoff/Storm Sewers	Cause Unknown	1998
Paxton Creek (Unt 10142)			
Aquatic Life (13463) - 0.72 miles	Urban Runoff/Storm Sewers	Siltation	2008
Paxton Creek (Unt 10147)			
Aquatic Life (8315) - 0.89 miles	Construction	Siltation	1998
	Urban Runoff/Storm Sewers	Cause Unknown	1998
Paxton Creek (Unt 10151)			
Aquatic Life (8285) - 1.15 miles	Construction	Siltation	1998
	Urban Runoff/Storm Sewers		1998
Paxton Creek (Unt 10152)			
Aquatic Life (8285) - 0.56 miles	Construction	Siltation	1998
	Urban Runoff/Storm Sewers		1998
Paxton Creek (Unt 10153)			
Aquatic Life (8285) - 1.14 miles	Construction	Siltation	1998
	Urban Runoff/Storm Sewers		1998
Paxton Creek (Unt 10155)			
Aquatic Life (8288) - 3.92 miles	Urban Runoff/Storm Sewers	Cause Unknown	1998
		Siltation	1998
Paxton Creek (Unt 10159)			
Aquatic Life (8288) - 1.25 miles	Urban Runoff/Storm Sewers	Cause Unknown	1998
		Siltation	1998
Paxton Creek (Unt 10161)			
Aquatic Life (8288) - 0.64 miles	Urban Runoff/Storm Sewers	Cause Unknown	1998
		Siltation	1998

Indian Creek

Aquatic Life (2851) - 2.16 miles	Agriculture	Siltation	2004
Aquatic Life (3372) - 2.64 miles	Agriculture	Siltation	2004
`	Municipal Point Source	Nutrients	2004
	Small Residential Runoff	Siltation	2004
	Urban Runoff/Storm Sewers		2004
Aquatic Life (3373) - 0.78 miles	Small Residential Runoff	Siltation	2004
Aquatic Life (7958) - 1.05 miles	Municipal Point Source	Salinity/TDS/Chlorides	1996
	Source Unknown	Cause Unknown	1996
Aquatic Life (10180) - 1.77 miles	Golf Courses	Cause Unknown	2002
	Road Runoff	Siltation	2002
	Small Residential Runoff	Cause Unknown	2002
Indian Creek (Unt 00979)			
Aquatic Life (10180) - 1 miles	Golf Courses	Cause Unknown	2002
	Road Runoff	Siltation	2002
	Small Residential Runoff	Cause Unknown	2002
Indian Creek (Unt 01182)			
Aquatic Life (2948) - 0.3 miles	Municipal Point Source	Nutrients	2004
Aquatic Life (3373) - 1.33 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01183)			
Aquatic Life (3373) - 0.35 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01184)			
Aquatic Life (3373) - 0.33 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01185)			
Aquatic Life (2948) - 0.3 miles	Municipal Point Source	Nutrients	2004
Aquatic Life (3373) - 0.84 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01186)			
Aquatic Life (3373) - 0.39 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01187)			
Aquatic Life (3373) - 1.26 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01188)			
Aquatic Life (3373) - 0.62 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01189)			
Aquatic Life (3373) - 0.41 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01190)			
Aquatic Life (3373) - 0.4 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01191)			
Aquatic Life (3373) - 0.76 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01192)			
Aquatic Life (3373) - 0.25 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01193)			
Aquatic Life (3373) - 0.49 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01194)			
Aquatic Life (3372) - 0.54 miles	Agriculture	Siltation	2004
	Municipal Point Source	Nutrients	2004
	Small Residential Runoff	Siltation	2004
	Urban Runoff/Storm Sewers		2004
Aquatic Life (3373) - 0.38 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01195)			
Aquatic Life (3373) - 0.38 miles	Small Residential Runoff	Siltation	2004

Indian Creek (Unt 01196)			
Aquatic Life (3372) - 0.45 miles	Agriculture	Siltation	2004
	Municipal Point Source	Nutrients	2004
	Small Residential Runoff	Siltation	2004
	Urban Runoff/Storm Sewers		2004
Indian Creek (Unt 01197)			
Aquatic Life (3373) - 0.55 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01198)			
Aquatic Life (3373) - 0.43 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01199)			
Aquatic Life (3373) - 0.65 miles	Small Residential Runoff	Siltation	2004
Indian Creek (Unt 01200)			
Aquatic Life (3372) - 1.76 miles	Agriculture	Siltation	2004
	Municipal Point Source	Nutrients	2004
	Small Residential Runoff	Siltation	2004
	Urban Runoff/Storm Sewers		2004
Aquatic Life (3373) - 0.58 miles	Small Residential Runoff	Siltation	2004
Aquatic Life (7958) - 0.61 miles	Municipal Point Source	Salinity/TDS/Chlorides	1996
	Source Unknown Cause	Unknown	1996

Chester Creek			
Aquatic Life (7) - 1.64 miles	Industrial Point Source	Priority Organics	1996
Aquatic Life (9) - 1.1 miles	Municipal Point Source	Suspended Solids	1996
Aquatic Life (9743) - 6.59 miles	Hydromodification	Siltation	2002
Aquatic Life (9900) - 5.94 miles	Municipal Point Source	Cause Unknown	2002
Recreational (12452) - 0.24 miles	Source Unknown	Pathogens	2006
Recreational (12454) - 0.67 miles	Source Unknown	Pathogens	2006
Recreational (12458) - 0.39 miles	Source Unknown	Pathogens	2006
Recreational (12461) - 0.66 miles	Source Unknown	Pathogens	2006
Recreational (12465) - 0.38 miles	Source Unknown	Pathogens	2006
Recreational (12466) - 0.57 miles	Source Unknown	Pathogens	2006
Recreational (12469) - 0.11 miles	Source Unknown	Pathogens	2006
Recreational (12473) - 0.89 miles	Source Unknown	Pathogens	2006
Recreational (12474) - 0.26 miles	Source Unknown	Pathogens	2006
Fish Consumption (13079) - 0.4 miles	Source Unknown	PCB	2006
Chester Creek (Unt 00601)			
Aquatic Life (9743) - 0.07 miles	Hydromodification	Siltation	2002
Chester Creek (Unt 00616)			
Aquatic Life (9900) - 0.59 miles	Municipal Point Source	Cause Unknown	2002
Recreational (12473) - 0.59 miles	Source Unknown	Pathogens	2006
Chester Creek (Unt 00617)			
Aquatic Life (9900) - 0.6 miles	Municipal Point Source	Cause Unknown	2002
Recreational (12460) - 0.6 miles	Source Unknown	Pathogens	2006
Chester Creek (Unt 00618)			
Aquatic Life (9900) - 0.68 miles	Municipal Point Source	Cause Unknown	2002
Recreational (12456) - 0.13 miles	Source Unknown	Pathogens	2006
Recreational (12472) - 0.55 miles	Source Unknown	Pathogens	2006
Chester Creek (Unt 00619)			
Aquatic Life (9900) - 0.98 miles	Municipal Point Source	Cause Unknown	2002
Recreational (12453) - 0.74 miles	Source Unknown	Pathogens	2006
Recreational (12471) - 0.21 miles	Source Unknown	Pathogens	2006

Sawmill Run			
Aquatic Life (8735) - 0.58 miles	Combined Sewer Overflow	DO/BOD temp	1996
		Nutrients	1996
Aquatic Life (8737) - 0.78 miles	Abandoned Mine Drainage	Metals	1996
	Combined Sewer Overflow	DO/BOD temp	1996
		Nutrients	1996
Aquatic Life (8738) - 2.81 miles	Combined Sewer Overflow	DO/BOD temp	1996
		Nutrients	1996
Aquatic Life (8741) - 1.45 miles	Combined Sewer Overflow	DO/BOD temp	1996
		Nutrients	1996
Aquatic Life (8744) - 0.59 miles	Abandoned Mine Drainage	Metals	1996
	Combined Sewer Overflow	Organic Enrichment/Low DO	1996
Aquatic Life (8755) - 3.1 miles	Combined Sewer Overflow	Organic Enrichment/Low DO	1996
Sawmill Run (Unt 37166)			
Aquatic Life (8743) - 2.43 miles	Combined Sewer Overflow	Organic Enrichment/Low D.O.	2002
	Urban Runoff/Storm Sewers	Siltation	2002
Sawmill Run (Unt 37167)			
Aquatic Life (8743) - 0.58 miles	Combined Sewer Overflow	Organic Enrichment/Low D.O.	2002
	Urban Runoff/Storm Sewers	Siltation	2002
Sawmill Run (Unt 37168)			
Aquatic Life (8740) - 0.87 miles	Combined Sewer Overflow	Organic Enrichment/Low D.O.	2002
Sawmill Run (Unt 37169)			
Aquatic Life (8745) - 0.66 miles	Combined Sewer Overflow	Organic Enrichment/Low D.O.	2002
Sawmill Run (Unt 37170)			
Aquatic Life (11481) - 1.68 miles	Combined Sewer Overflow	Organic Enrichment/Low D.O.	2002
Sawmill Run (Unt 37171)			
Aquatic Life (11481) - 0.53 miles	Combined Sewer Overflow	Organic Enrichment/Low D.O.	2002
Sawmill Run (Unt 37172)			
Aquatic Life (8739) - 0.71 miles	Combined Sewer Overflow	Organic Enrichment/Low D.O.	2002
Sawmill Run (Unt 37173)			
Aquatic Life (8739) - 0.59 miles	Combined Sewer Overflow	Organic Enrichment/Low D.O.	2002
Sawmill Run (Unt 37174)			
Aquatic Life (8756) - 0.91 miles	Combined Sewer Overflow	Organic Enrichment/Low D.O.	2002
Sawmill Run (Unt 63871)			
Aquatic Life (8743) - 1.59 miles	Combined Sewer Overflow	Organic Enrichment/Low D.O.	2002
	Urban Runoff/Storm Sewers	Siltation	2002

Southampton Creek			
Aquatic Life (10727) - 0.02 miles	Urban Runoff/Storm Sewers	Cause Unknown	2004
		Siltation	2004
Aquatic Life (13059) - 0.66 miles	Municipal Point Source	Organic Enrichment/Low D.O.	2006
Southampton Creek (Unt 02453)			
Aquatic Life (13060) - 0.72 miles	Municipal Point Source	Nutrients	1996
		Organic Enrichment/Low D.O.	1996
		Pathogens	1996

Note that the 2006 and the draft 2008 PADEP list of impaired waters for Southampton has the incorrect first listing date for nutrients. The correct first listing date is 1996. A 2008 e-mail from PADEP describes this error.

General Response #7: Adjusted Endpoints for the Sawmill Run and Paxton Creek Nutrient TMDLs Based on the Representative Ecoregions

Several commenters were concerned that the endpoints established by EPA for Sawmill Run and Paxton Creek were based on an ecoregion that was not appropriate to the two waters. EPA heard those concerns and completed an analysis similar to the approach described in the report "*Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application*", for the ecoregions in which Pittsburgh and Harrisburg reside. The results of the additional analysis are shown in the following report, which is included as an Appendix to the above referenced report.

In summary, Sawmill Run is in the Allegheny Plateau ecoregion. Values for Sawmill Run were based on data extracted from the USGS, USEPA STORET, and USEPA EMAP programs. The analysis relied on EMAP data alone since little other data was available. As a result, we relied on the distribution based and other literature based approaches. These values ranged between 19 and 60ug/L total phosphorus, with the central tendency of all lines of evidence around 35ug/L. As a result the endpoint settled on for Sawmill Run, after hearing the concerns from those who commented, is 35ug/L.

Paxton Creek falls within the Ridge and Valley ecoregion. Values for Paxton Creek were based on data extracted from the USGS, USEPA STORET, USEAP EMAP and the Maryland DNR MBSS programs. There was an abundance of data for this region for every line of evidence. As a result we were able to perform stereo-response analysis in addition to other analysis. The distribution-based approaches led to values between 10 and 15ug/L and the modeled reference expectation approach produced a significant TP model which a value of 7ug/L TP. We looked at stressor-response analysis using several invertebrate indices using change-point analysis on conditional probabilities using both EMAP and MBSS metrics. These analysis yielded values between 14 and 23ug/L. Again the scientific literature for this region included values ranging from 10 to 60ug/L, with a central tendency towards the 20 to 30ug/L range. The stressor-response analysis and reference based approaches were weighted most strongly. Given this, balancing the values from other studies and taking the commenters concern that we use the data from the appropriate ecoregion, the TP endpoint for Paxton Creek has been set 25ug/L for the final TMDL.

The report supporting these endpoints is included below.

Development of Nutrient Endpoints for Allegheny Plateau and Ridge and Valley Ecoregions of Pennsylvania: TMDL Application

Prepared for

United States Environmental Protection Agency

Region 3

Philadelphia, PA

By

Michael J. Paul and Lei Zheng

Tetra Tech, Inc.

400 Red Brook Boulevard, Suite 200

Owings Mills, MD 21117

June 24, 2008

Table of Contents

Page

Introduction.....1

Frequency Distribution Based Approach.....4

Modeled Reference Expectation Approach.....8

N:P Ratios Suggest P Limitation Dominates the Northern Piedmont Ecoregion.....9

Stressor-Response Approach.....9

Data.....11

Data Analysis: Overview.....11

Data Analysis: Metric Calculation.....14

Results: Benthic Macroinvertebrate Metrics – Nutrient Relationships.....14

Literature Based Analysis: Current Existing Endpoints or Threshold Values.....19

Recommended Endpoints.....21

Total Phosphorus (TP).....21

Literature Cited.....28

List of Figures

Figure Page

1 Simplified diagram illustrating the causal pathway between nutrients and aquatic life use impacts 1

2 Map of the sample sites used in the development of nutrient endpoints using the distribution based approach in this study, labeled by agency affiliation 5

3 Plot of TN and TP samples in the All Sites (All) and two Reference Site (Ref) populations used to estimate candidate endpoints with the distribution based approach 7

4 Response of the three MBSS invertebrate metrics to increases in phosphorus concentration 17

5 Response of three EMAP invertebrate metrics to increases in phosphorus concentration. 18

6 Response of the last EMAP invertebrate metric to an increase in phosphorus concentration 19

List of Tables

Table Page

1 Values of TN and TP candidate endpoints derived using the distribution based approach 6

2 Threshold values for the MBSS and EMAP benthic macroinvertebrate IBI metrics in the Ridge and Valley ecoregion (Southerland et al. 2005, Klemm et al. 2003). 15

3 Summary of candidate endpoints for each of the analytical approaches discussed for the Allegheny Plateau 22

4 Summary of candidate endpoints for each of the analytical approaches discussed for the Ridge and Valley 24

Introduction

The United States Environmental Protection Agency (USEPA) in Region 3 is overseeing the development of nutrient TMDLs to protect aquatic life use for several streams Pennsylvania. Tetra Tech, Inc, (Tt) was approached to establish appropriate and scientifically defensible nutrient endpoints that are protective of aquatic life. Tetra Tech developed endpoints for the Piedmont region as part of this work and published those in a report entitled, "Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application" dated November 30, 2007. That document described the process that was applied in detail, the results of those analyses, and the final recommended TP and TN endpoints. This addendum applies matching methodology to the development of endpoints for streams of the Ridge and Valley and Allegheny Plateau ecoregions of Pennsylvania.

Nutrients affect aquatic systems in diverse ways, and the effects on most non-primary producer aquatic life uses are indirect (Figure 1).

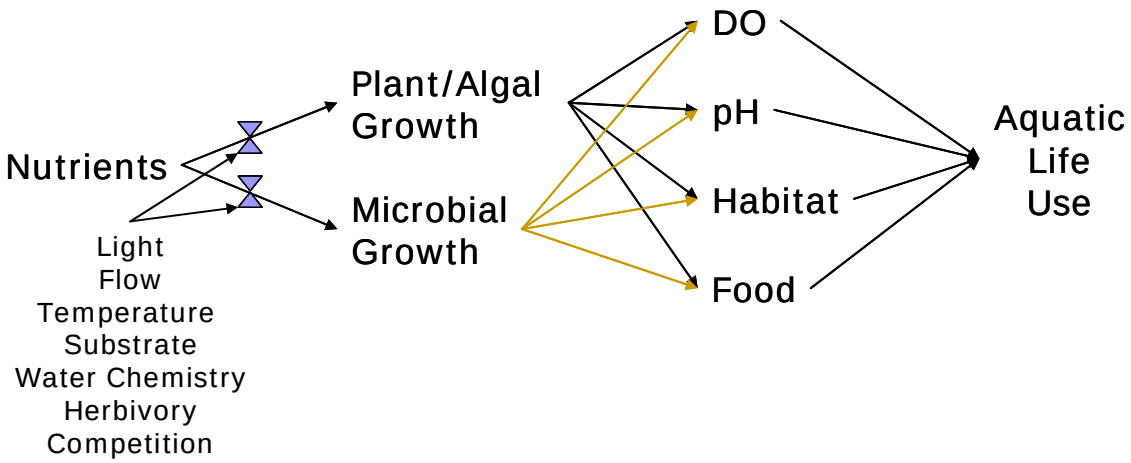


Figure 5 – Simplified diagram illustrating the causal pathway between nutrients and aquatic life use impacts. Nutrients enrich both plant/algal as well as microbial assemblages, which lead to changes in the physical/chemical habitat and food quality of streams. These effects directly impact the insect and fish assemblages. The effects of nutrients are influenced by a number of other factors as well, such as light, flow, and temperature.

Nutrients cause enrichment of primary producer and decomposer biomass and productivity, the increase of which leads to changes in the physical and chemical stream environment (e.g., reduced oxygen, loss of reproductive habitat, alteration on the availability of palatable algal taxa, etc.). It is these effects which directly result in changes to the biological stream community (e.g., loss of disturbance sensitive taxa), and ultimately impair the use of a stream for aquatic life.

Traditionally, water quality endpoints to protect aquatic life use were developed using toxicological approaches. Such approaches have been applied for a range of pollutants to develop water quality endpoints. However, as explained above, nutrient enrichment does not have a direct toxicological effect on non-primary producer aquatic life. It is worth mentioning that nutrients do, however, affect algal and plant aquatic life directly, altering the diversity and composition of those assemblages radically. For insects, fish and other aquatic life, however, the mode of action of nutrients is indirect and through a causal pathway that involves alteration of physical, chemical, and biological attributes of their habitat. As a result, traditional toxicological approaches are not appropriate.

The USEPA has published guidance on nutrient endpoint development for the protection of designated uses for a range of waterbody types including rivers and streams (USEPA 2000a), but also for lakes and reservoirs (USEPA 2000b), estuaries (USEPA 2001), and wetlands (USEPA 2007). The principal method described in those documents is the use of a frequency distribution-based approach (often called the reference approach), where a percentile of a distribution of values is used to identify a nutrient endpoint. The sample distributions were typically either from least disturbed reference sites (sensu Stoddard et al. 2006) or the entire population of sample sites. These documents, however, clearly encourage the use of alternative scientifically defensible approaches and, especially, the application of several approaches in a multiple-lines-of-evidence framework, to establish defensible and protective endpoints. The documents state that, “a weight of evidence

approach that combines (multiple) approaches…will produce endpoints of greater scientific validity." The approaches recommended include the frequency distribution approach, stressor-response analyses, and literature based values.

In determining nutrient endpoints for developing TMDLs to protect aquatic life uses of Ridge and Valley and Allegheny Plateau streams in Pennsylvania, we relied on a multiple lines of evidence approach framework considering all of the following approaches: frequency distribution based analysis, stressor-responses analyses, and literature based values. The following sections describe these approaches in detail including the methods used for each and the results. The resulting candidate values were then considered and a weight-of-evidence applied to develop final endpoint recommendations.

Due to the limitation of watershed sizes and the difficulty in obtaining stressor response gradients (especially for reference sites) in the target watersheds, we used an ecoregional nutrient endpoint development approach similar to that applied for nutrient criteria development to identify nutrient targets that would protect aquatic life uses in these watersheds. The USEPA, in their recommendations for nutrient endpoint development, specified that "Ecoregional nutrient criteria will be developed to account for the natural variation existing within various parts of the country." (USEPA 2000a)

They go on to explain the importance of ecoregions:

"Ecoregions serve as a framework for evaluating and managing natural resources. The ecoregional classification system developed by Omernik (1987) is based on multiple geographic characteristics (e.g., soils, climate, vegetation, geology, land use) that are believed to cause or reflect the differences in the mosaic of ecosystems."

The two targeted watersheds for this report, Sawmill Run and Paxon Creek, are located within the Allegheny Plateau and Ridge and Valley ecoregions, respectively. We collected data from the same ecoregions in Pennsylvania, Maryland, West Virginia, and Virginia. We made the assumption

that nutrient dynamics in the two watersheds should be similar to nutrient dynamics in sites selected from across these two ecoregions, given similarities in geology, soils, and climate.

Frequency Distribution Based Approach

For this approach, we identified water quality samples collected by a variety of agencies from streams in the Allegheny Plateau and Ridge and Valley ecoregions stored in a variety of databases including the USEPA Storage and Retrieval (STORET) and Environmental Monitoring and Assessment Program (EMAP) databases, United States Geological Survey (USGS) National Water Inventory System (NWIS) and National Water Quality Assessment (NAWQA) program, and the Maryland Biological Stream Survey (MBSS) database (Figure 2). Two populations of sites were developed. The first was all sites for which nutrient samples were available (All Sites). The second was all sites for which watershed land cover was available and for which reference criteria could be applied (Reference Sites).

The All Sites population included samples from all of the agencies described above. For sites with multiple samples, samples were averaged to estimate an average site nutrient concentration. This reduced the influence of any one site on the percentiles. After all the sites were prepared, we calculated the 25th percentile nutrient concentration of total phosphorus (TP) and total nitrogen (TN).

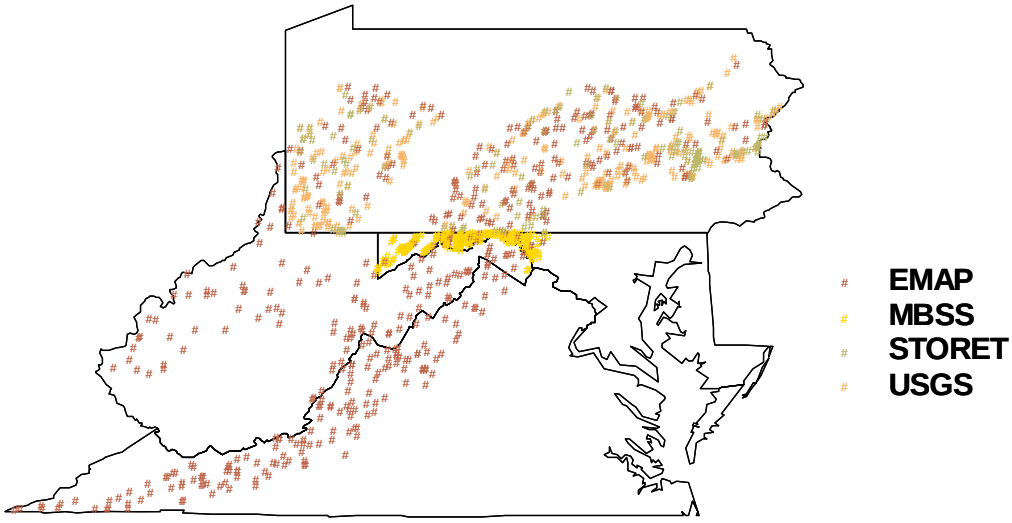


Figure 6 – Map of the sample sites used in the development of nutrient endpoints using the distribution based approach in this study, labeled by agency affiliation.

For sites where land cover information was available (USEPA EMAP, USGS NAWQA, and MBSS), we developed land cover screening criteria to identify least disturbed watersheds (sensu Stoddard et al. 2006). Least disturbed sites represent those watersheds with minimal human disturbance and, therefore, provide the best empirical estimate of chemical integrity. We developed two different reference criteria: >80% Forest, <5% urban (N=7) and >70% Forest, <5% urban (N=24). We then calculated the 75th percentile of total phosphorus and total nitrogen concentrations associated with these populations.

The distribution based analyses resulted in lower endpoints for nutrients from the All Sites population than from the two Reference Site populations in both ecoregions (Figure 3, Table 1). For the Allegheny Plateau ecoregion, total phosphorus endpoints were between 19 and 36 μg/L and total nitrogen endpoints between 260 and 665 μg/L (Table 1). For the Ridge and Valley ecoregion, distribution based total phosphorus endpoints were between 10 and 15 μg/L and total nitrogen endpoints between 280 and 620 μg/L (Table 1).

Table 1 – Values of TN and TP candidate endpoints derived using the distribution based approach.

Parameter	Reference Sites >80% Forest <5% Urban	Reference Sites >70% Forest <5% Urban	All Sites
	75th Percentile	75th Percentile	25th Percentile
Allegheny Plateau			
TN (μg/L)	425	664	260
TP (μg/L)	36	33	19
N	25	39	125 (TN) 185 (TP)
Ridge and Valley			
TN (μg/L)	480	618	281
TP (μg/L)	13	15	10
N	122	147	885 (TN) 1073 (TP)

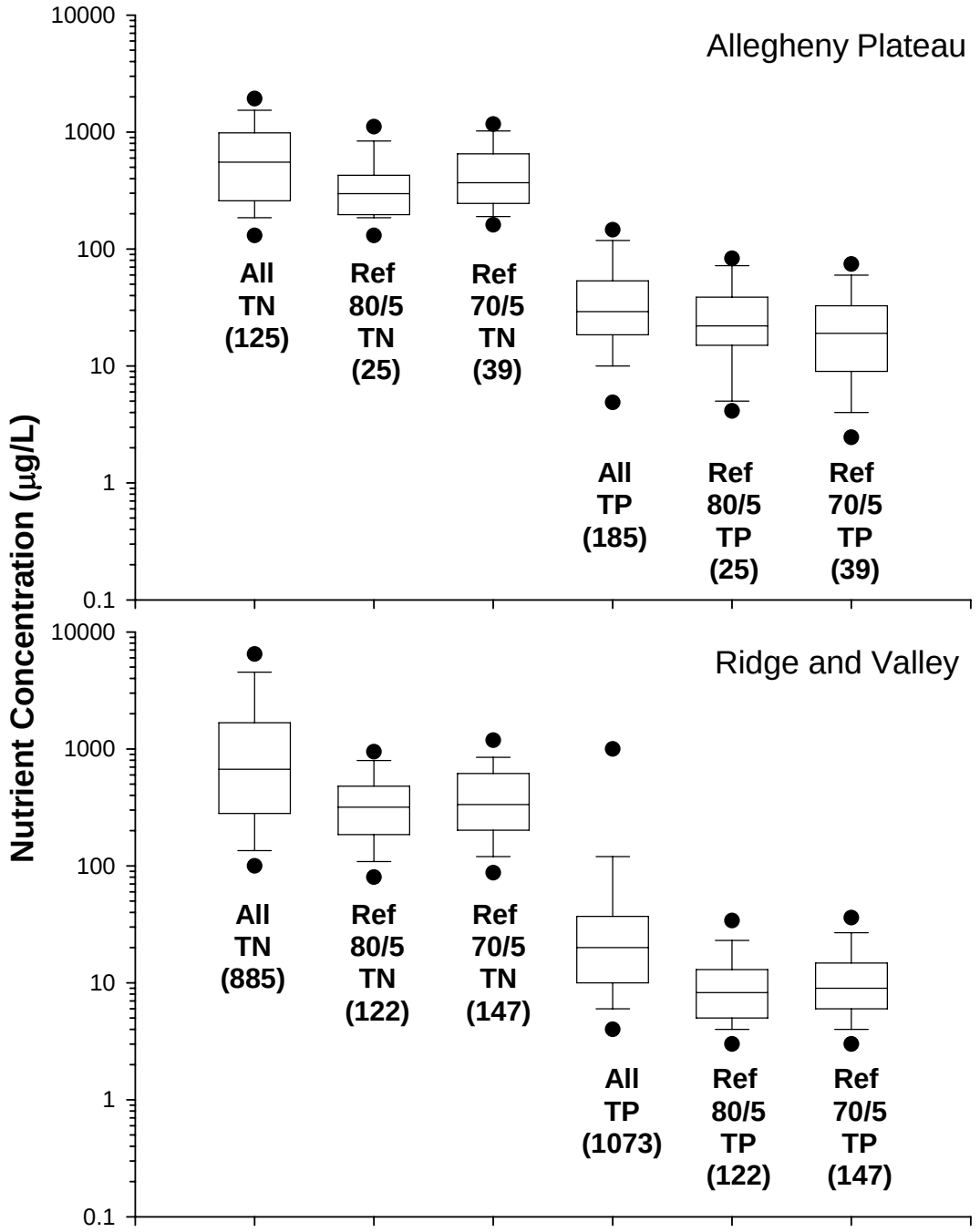


Figure 7 – Plot of TN and TP samples in the All Sites (All) and two Reference Site (Ref) populations used to estimate candidate endpoints with the distribution based approach. Sample sizes are shown below each label. Lines indicate the median values (50th percentiles), boxes are the quartiles (25th and 75th percentiles), whiskers are 10th and 90th percentiles, and symbols are the 5th and 95th percentiles.

Modeled Reference Expectation Approach

Another approach that falls under the rubric of "reference approaches" is the modeled reference expectation approach (Dodds and Oakes 2004). In this approach, multiple regression models of total nutrients versus human land cover (agriculture and urbanization) are built and then solved for the condition of no human land cover (i.e., the intercept). This approach has been used to estimate nutrient concentrations in the absence of human disturbance in the Midwest (Dodds and Oakes 2004).

We developed modeled reference expectation models for the Allegheny Plateau region using data from the USEPA EMAP program, since it was the only one which had both land cover and nutrient data. The final equation for total nitrogen was:

$$\mathrm{Log}_{10}(\mathrm{TN}) = 2.48 + 0.40(\mathrm{arcsine}\sqrt{\%\ \mathrm{Agriculture}}) + 0.94(\mathrm{arcsine}\sqrt{\%\ \mathrm{Urban}})\ ;$$

(R^2 = 0.24, F=9.98, p<0.001).

Solving for the undisturbed condition leads to a modeled reference total nitrogen concentration for the Allegheny Plateau of 302 μg/L. No significant model for total phosphorus could be created with the land cover data for the Allegheny Plateau, so we estimated the TP value for this approach using N:P ratios (see below).

Similarly, we developed modeled reference expectation models for TN and TP in the Ridge and Valley ecoregion using data from the USEPA EMAP and Maryland DNR MBSS programs, since they were the only ones which had both land cover and nutrient data. The final equation for TP was:

$$\mathrm{Log}_{10}(\mathrm{TP}) = 0.86 + 0.62(\mathrm{arcsine}\sqrt{\%\ \mathrm{Agriculture}})\ ;$$

(R^2 = 0.27, F=169.0, p<0.001)

and for TN was:

$$\mathrm{Log}_{10}(\mathrm{TN}) = 2.32 + 1.01(\mathrm{arcsine}\sqrt{\%\ \mathrm{Agriculture}}) + 0.13(\mathrm{arcsine}\sqrt{\%\ \mathrm{Urban}});$$

(R^2 = 0.51, F=234.6, p<0.001)

Solving for the undisturbed condition leads to a modeled reference Ridge and Valley TP endpoint of 7 μg/L and TN endpoint of 209 μg/L.

N:P Ratios Suggest P Limitation Dominates the Allegheny Plateau Ecoregion

We calculated N:P ratios across all sites in the Allegheny Plateau dataset. The average molar N:P ratio for All Sites was 86:1. We applied this ratio to the TN value estimated from the modeled reference expectation value for TN in the Allegheny Plateau, which yielded a TP value of 8 μg/L TP. The molar ratio of N:P based on the recommended USEPA nutrient criteria for this ecoregion (TP=10 μg/L, TN=310 μg/L) is 68:1. Applying this value, as well as the Redfield molar N:P ratio (16:1), to the value of TN estimated using the modeled reference expectation approach above led to estimated TP values of 10 and 42 μg/L, respectively. We would defend the use of natural ratios rather than Redfield given uncertainties in the applicability of Redfield to freshwater systems combined with the fact that Allegheny Plateau average N:P ratios are much higher than Redfield.

Stressor-Response Approach

Stressor-response approaches refer to a suite of analytical techniques that derive candidate endpoints by exploring the relationships between response variables and nutrient concentrations. Typical response variables in the context of nutrient endpoint development include water chemical aquatic life use indicators (dissolved oxygen, pH, etc.), algal biomass and/or algal assemblage metrics (e.g., percent nutrient sensitive diatoms), and aquatic life use indicators or biocriteria indicators (e.g., algal multimetric indices or individual metrics scores, invertebrate multimetric indices or individual metrics, etc.). The value of these indicators is their direct linkage to aquatic life use designations. They, therefore, provide a way to connect nutrient concentrations directly to

aquatic life use protection. We used a few different stressor-response analytical techniques to develop candidate nutrient endpoints using invertebrate response indicators.

We selected two important nutrient variables to examine biological responses: total nitrogen (TN) and total phosphorus (TP). TN and TP are two of the four primary variables EPA recommended for nutrient endpoint development and are likely to limit aquatic primary producers. TP and TN may reflect stream trophic status better than inorganic P and N because nutrient depletion can be partially offset by increases in particulate fractions of TP and TN resulting from drift and suspension in the water column (Dodds 2002). In addition, TN and TP are also measured more frequently in most of the national and state programs than other nutrient variables.

The primary response variable of interest for stream trophic state characterization is algal biomass, which is most commonly reported as mg/m^2 Chl a. Chl a is a photosynthetic pigment and is a sensitive indicator of algal biomass. It is considered an important biological response variable for nutrient-related problems (USEPA 2000a). Periphyton is also often analyzed for dry mass (DM) and ash free dry mass (AFDM), which includes non-algal organisms. The USEPA also recommends a measure of turbidity as the response variable. However, turbidity is often associated with total suspended solids (TSS) and other environmental factors and is less commonly used as a direct response variable. In addition to these, algal species composition often responds dramatically to excess nutrients, including the proliferation of eutrophic and nuisance algal taxa. As a result, algal metrics are frequently used as direct indicators of nutrient enrichment (van Dam et al. 1994, Pan et al. 1996). We did not have sufficient algal endpoints to explore these response variables in the Allegheny Plateau and Ridge and Valley ecoregions, as we did for the Piedmont analysis. The aquatic life response variable for which we had sufficient information to consider was macroinvertebrate metrics from multimetric indices. Macroinvertebrate indices are the most reliable

and frequently used bioindicators, and many macroinvertebrate metrics are sensitive to nutrient enrichment.

Data:

We collected data from four different national and state programs, similar to those used in the distribution based analyses:

- USEPA Environmental Monitoring and Assessment Program (EMAP)
- USGS National Water Information System (NWIS)
- USEPA STORET database
- Maryland Biological Stream Survey (MBSS) program

Two projects, the USEPA EMAP and MBSS programs, simultaneously collected nutrients and macroinvertebrate composition data, which were valuable for exploring invertebrate assemblage responses to nutrients. The MBSS collected thousands of macroinvertebrate samples from its statewide stream survey including numerous samples in the Ridge and Valley ecoregion and the EMAP Mid-Atlantic Highlands Assessment collected similar samples across both ecoregions throughout Virginia, West Virginia, Maryland, and Pennsylvania.

Data Analysis: Overview

Establishing definitive stressor-response relationships is a valuable line of evidence in the multiple lines of evidence approach. We first used Spearman correlation analysis to examine relationships between response and stressor variables. Correlation analyses identified significant relationships between biological response and nutrient variables. However, correlation may or may not indicate the real relationship. Numerous relationships were examined; only a subset of which were correlated. There were also results that were considered potentially important but showed weaker relationships.

We selected correlations of interest and performed visual scatter plots to further examine the relationships. We used either linear regression or a locally weighted average regression line to examine the trend of change along the environmental gradients. The locally weighted scatterplot

smoothing (LOWESS) technique (Cleveland 1979) models nonlinear relationships where linear methods do not perform well. LOWESS fits simple models to localized subsets of the data to construct a function that describes, essentially, the central tendency of the data. LOWESS fits segments of the data to the model. Tension, which describes the portion of data being used to fit each local function, was set at 0.50 for LOWESS regression.

We also used conditional probability analysis (Paul and MacDonald, 2005) to examine changes in the biological community along stressor gradients. Conditional probability provides the likelihood (probability) of a predefined response when a specific value of a pollutant stressor (condition) is exceeded. Conditional probability is the likelihood of an event when it is known that some other event has occurred. Conditional probability answers the question: for a given threshold of a stressor, what is the cumulative probability of impairment? For example, if the total phosphorus concentration is greater than 30 μg/L, what is the probability of biological impairment (defined as < 8 EPT Taxa) for each site under consideration? All observed stressor values (in this example, all observed values of total phosphorous) are used to develop a curve of conditional probability (Paul and MacDonald, 2005). Because of its ability to identify risks of impact associated with given nutrient concentrations, the approach is suited to identifying nutrient thresholds protective of aquatic biological condition.

To estimate conditional probability of an impairment, we first had to define impairment as a specific value for a response variable (e.g., EPT < 8 genera). We used preexisting biocriteria thresholds as our response thresholds (MDNR 2005). For the Ridge and Valley ecoregion, we used MBSS and EMAP data as well as criteria based on scoring thresholds developed by the state of Maryland for their multimetric index and by EPA EMAP for use in their multimetric index for the Mid-Atlantic Highlands (Klemm et al. 2003). For the Allegheny Plateau, we used EMAP metrics alone because MBSS did not sample in this region. Thresholds used for the EMAP metrics were

the 25th percentile of reference site metric scores for metrics declining with stress and the 75th percentile of reference sites for metrics increasing with stress. These thresholds are commonly used to identify metrics that discriminate between reference and stressed sites (Barbour et al. 1999). We used the same reference criteria developed by Klemm et al. (2003) except we excluded the nutrient criteria they used (to avoid circularity) and used only their cutoffs for chloride, sulfate, acid neutralizing capacity, and habitat.

We also used nonparametric deviance reduction (change point analysis) to identify thresholds in biological responses to nutrients (Qian et al. 2003). This technique is similar to regression tree models, which are used to generate predictive models of response variables for one or more predictors. The change-point, in our application, is the first split of a tree model with a single predictor variable (nutrient concentration). The loss function of regression trees can be evaluated by the proportion of reduction in error (PRE), which is analagous to the multiple R^2 of general linear models.

Data Analysis: Metric Calculation

Macroinvertebrate Metrics

Numerous macroinvertebrate assemblage metrics were assembled from the MBSS and EMAP programs. We selected a subset of benthic macroinvertebrate indicators, focusing on those that composed the MBSS IBI (Ridge and Valley) and/or Highlands EMAP IBI (Allegheny Plateau). Metrics considered included Ephemeroptera, Plecoptera, Trichoptera (EPT) richness, Ephemeroptera Richness, Plecoptera Richness, Trichoptera Richness, Tolerant Richness, Percent Tolerant, Scraper Richness, Percent Scrapers, Collector-Filterer Richness, and Percent Dominant 5 taxa.

Results: Benthic Macroinvertebrate Metrics – Nutrient Relationships

The largest datasets available for analyzing macroinvertebrate responses to nutrient concentrations were the Maryland Biological Stream Survey (MBSS) and EMAP Mid-Atlantic Highlands Assessment datasets. We found 50 samples from the EMAP database with corresponding macroinvertebrate metric and nutrient data for the Allegheny Plateau ecoregion. In contrast, we found 242 samples with corresponding macroinvertebrate metrics and nutrient samples from the MBSS dataset, and 320 comparable samples from the EMAP database in the Ridge and Valley ecoregion. For each metric, scoring criteria were developed based on the distribution of values from least disturbed reference sites (Table 2). For the MBSS, we selected the middle point of the distribution as the impairment threshold for each metric, since this is consistent with their methodology (Southerland et al. 2005, Table 2). For the EMAP data, we used a standard practice, namely using the 25th percentile of reference site metric scores (for metrics decreasing with stress) or the 75th percentile of reference site metrics cores (for metrics increasing with stress) as our thresholds (Table 2, Barbour et al. 1999).

Of the metrics considered in the Allegheny Plateau, none exhibited a strong enough response to nutrient concentrations to merit development of potential endpoints using the stressor-response approach. For the Ridge and Valley, however, several exhibited a strong response to TP and we used the following metrics: MBSS – EPT Richness, Percent Scrapers, and Number of Taxa; EMAP – EPT Richness, Ephemeroptera Richness, Trichoptera Richness, and Percent Dominant 5 Taxa.

Table 2 – Threshold values for the MBSS and EMAP benthic macroinvertebrate IBI metrics in the Ridge and Valley ecoregion (Southerland et al. 2005, Klemm et al. 2003).

MBSS Scoring criteria	**5**	**3**	**1**	**Mid Point**
Number of Taxa	≥ 24	15 – 23	<15	19
Number of EPT	≥ 14	8 – 13	< 8	10.5
% Scrapers	≥ 13	3 – 12	< 3	7.5
EMAP Scoring criteria	25th Percentile of Reference		75th Percentile of Reference	
Number of EPT	16			
Number of Ephemeroptera	7			

Number of Trichoptera	4	
Percent Dominant 5 Taxa		60.75

MBSS Metrics

The three MBSS metrics (Total Taxa, EPT Taxa, and Percent Scrapers) all declined with increased TP concentrations (Figure 4). The scatterplots exhibited a traditional wedge shape decline, while the conditional probability graphs clearly indicated the probability of impairment increasing as TP concentrations increased from 10 to 50 μg/L TP. Change point analyses indicated thresholds at 14, 14, and 16 μg/L TP for these three metrics, respectively.

EMAP Metrics

Similarly, the first three EMAP metrics all declined with increasing TP concentrations, also exhibiting the typical wedge shaped response (Figure 5). The same data expressed as conditional probabilities exhibited increasing risk of impacts between 8 and 50 μg/L TP. Change point analyses indicated thresholds at 19 μg/L TP for all three metrics. The last EMAP metric, Percent Dominant 5 taxa, increased with increasing TP concentration, as expected (Figure 6). As macroinvertebrate communities become stressed, there is a predictable decline in diversity and evenness, as a few tolerant taxa (e.g., weedy species), take advantage of the loss of more sensitive taxa and begin to dominate the assemblage (Klemm et al. 2003). Change point analyses indicated a threshold at 23 μg/L TP for this metric.

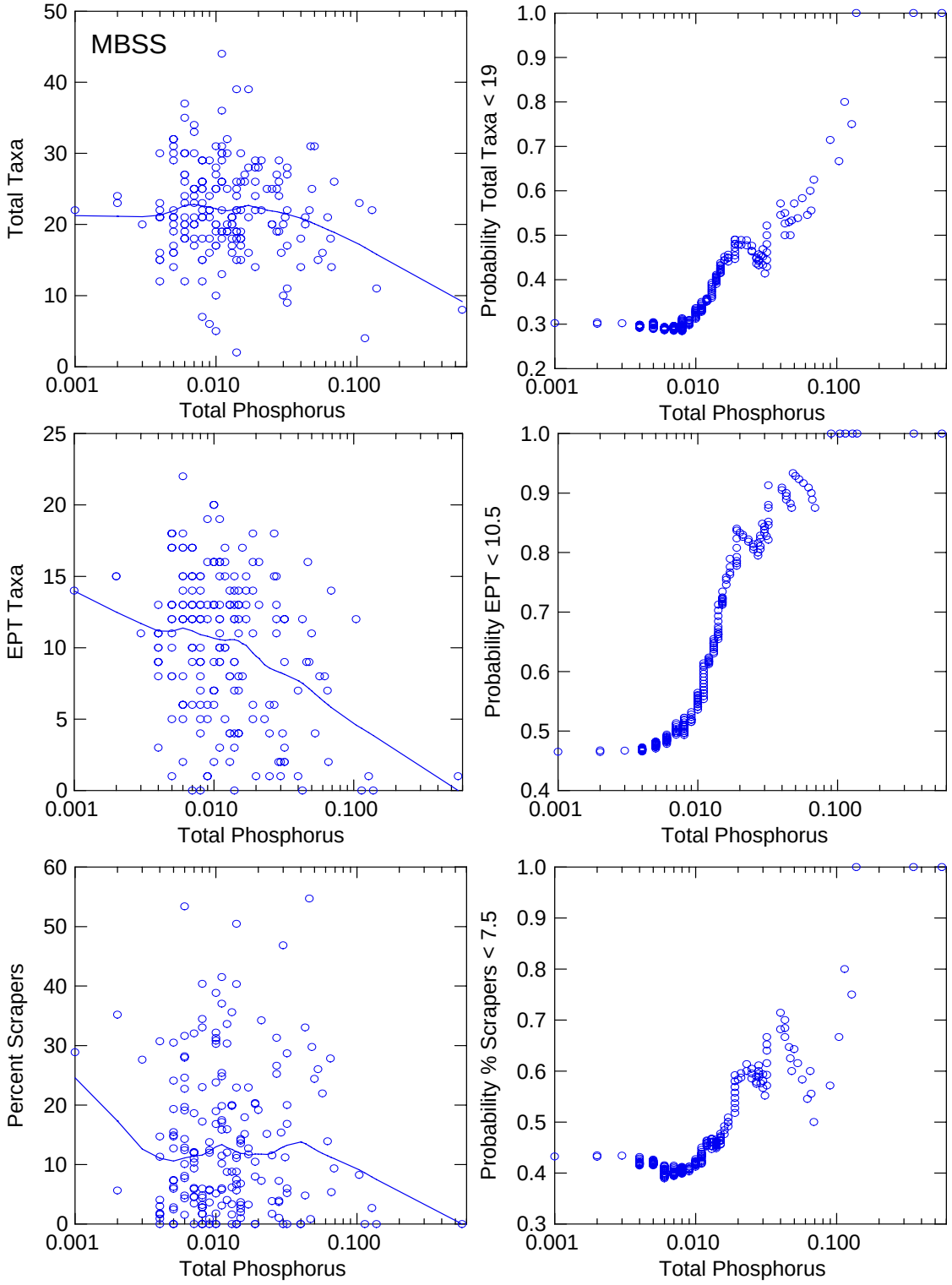


Figure 8 – Response of the three MBSS invertebrate metrics to increases in phosphorus concentration. Plots on the left are raw data with a lowess curve fit. Plots on the right are the same raw data expressed as conditional probabilities.

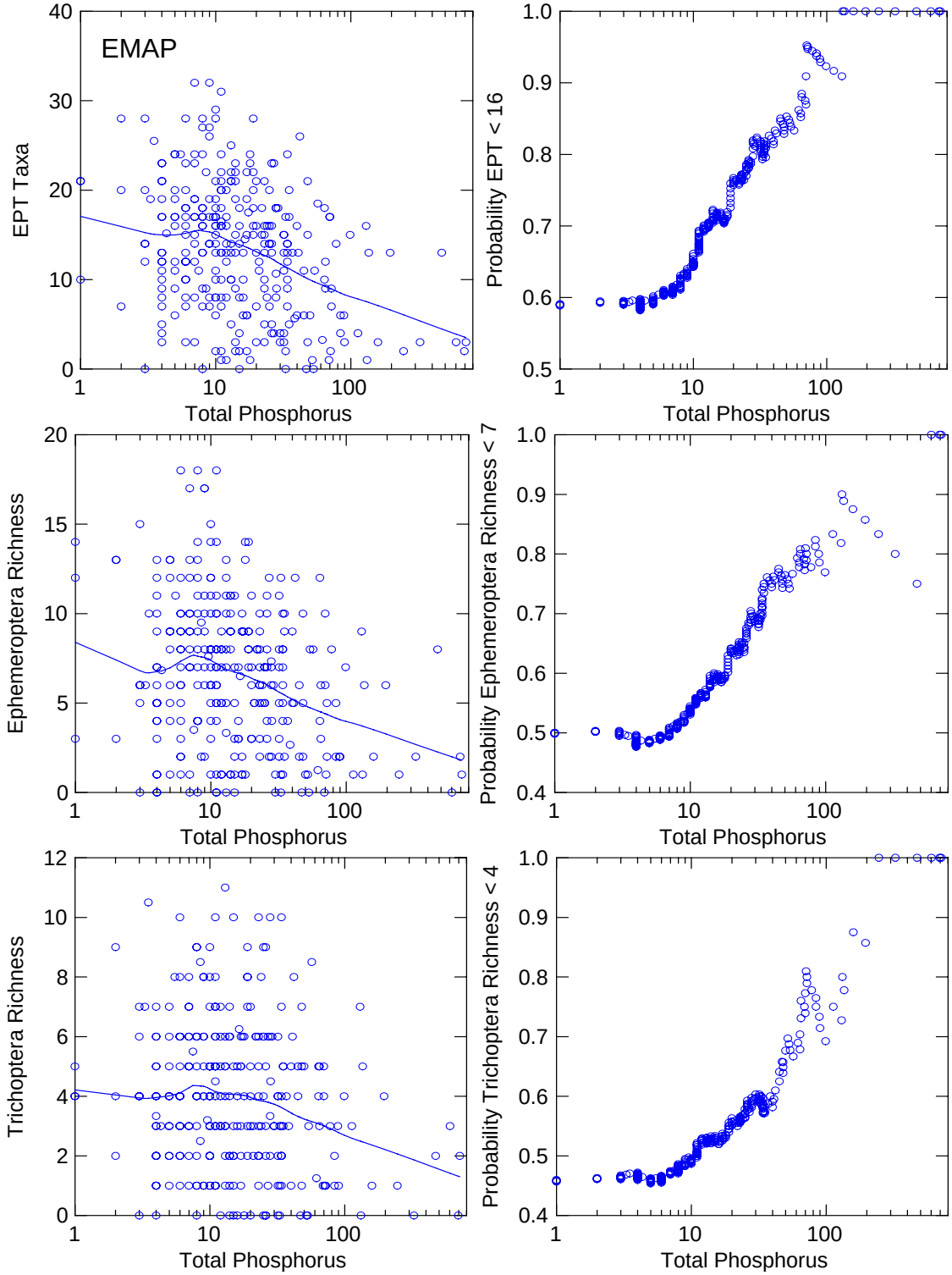


Figure 9 - Response of three EMAP invertebrate metrics to increases in phosphorus concentration. Plots on the left are raw data with a lowess curve fit. Plots on the right are the same raw data expressed as conditional probabilities.

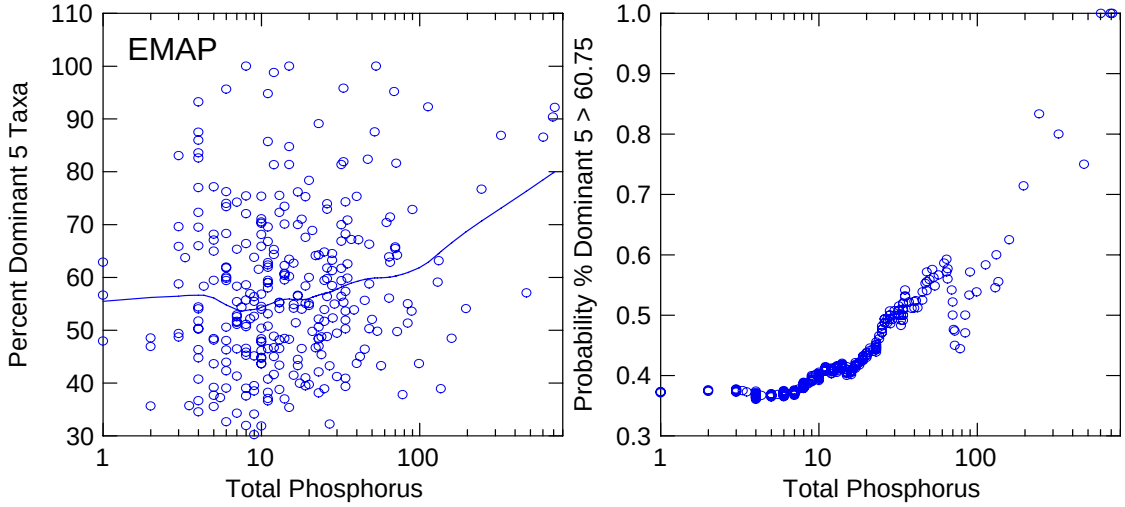


Figure 10 - Response of the last EMAP invertebrate metric to an increase in phosphorus concentration. Plot on the left is raw data with a lowess curve fit. Plot on the right is the same raw data expressed as conditional probabilities.

Literature Based Analysis: Current Existing Endpoints or Threshold Values

In this last analytical section, we present several studies relevant to the development of nutrient endpoints in the Allegheny Plateau and Ridge and Valley ecoregions of Pennsylvania. These are taken principally from the peer-reviewed and federal agency technical literature and reflect increasing experimental and theoretical interest in the impact of nutrients on natural stream systems. We attempted to extract information from these studies that could recommend specific endpoints.

In natural, shaded streams [such as those evaluated in the Dodds et al. (2002) model], it is difficult to assess the full growth potential of algae. Algal growth potential has been evaluated using artificial stream channels that are fully exposed to nutrient and light gradients. Previous studies (Horner et al. 1983, Bothwell 1989) demonstrated that in artificial streams, algal growth could be saturated (i.e., achieved maximum growth rate) at 25–50 µg/l phosphorus. Rier and Stevenson (2006) found that at 16 µg/L soluble reactive phosphorus (SRP) or 86 µg/L dissolved inorganic nitrogen (DIN), algal growth was at 90% of its maximum rate. They also found that saturation concentrations were 3– 5 times lower than concentrations needed to produce maximum

algal biomass (i.e., 430 μg/L DIN and 80 μg/L SRP for growth saturation). However, these values were derived mostly on the basis of diatom and bluegreen algae growth. We expect that green algae (i.e., *Cladophora*) would have higher nutrient saturation concentrations for peak growth **(**Borchardt 1996**).**

USEPA's nutrient threshold recommendations for the Allegheny Plateau and Ridge and Valley nutrient ecoregion were 310 μg/L for TN and 10 μg/L for TP.

Dodds and Welch (2000) conducted a meta-study including values from a range of areas nationwide. These were combined into regression equations to predict chlorophyll. They found that if a mean of 50 mg/m^2 of chlorophyll is the target (thus insuring chlorophyll is less than 100 mg/m^2 most of the time), TN should be 470 μg/L and TP should be 60 μg/L. Even lower numbers should be considered for more pristine waters. These estimates were more general in scope. These authors further noted that lower TN and TP values associated with these chlorophyll concentrations were obtained when using a detailed, smaller data set than those from a larger data set (55 μg/L TP from a large dataset versus 21 μg/L for a more specific, local data set).

USGS conducted a study in 2001 for a broad area of the US, including the New River and Big Sandy River in Virginia (Robertson et al. 2001). They looked at 234 sites using the reference approach and found that a TP of 20 μg/L was appropriate for what they define as Environmental Nutrient Zone 2.

Rohm et al. (2002) conducted a national study to demonstrate how regional reference conditions and draft nutrient endpoints could be developed. They divided the country into 14 regions and analyzed available nutrient data as a case study, using EMAP data from Central and Eastern Forested Uplands, an area that includes much of central Pennsylvania. This case study suggested a criterion of 375 μg/L for TN and 13 μg/L for TP. Rough estimates from the data presented for their Region IX that includes Eastern Pennsylvania gives estimates of 500 μg/L TN and 20 μg/L TP.

Recommended Endpoints

Total Phosphorus (TP)

Endpoint (magnitude) – Allegheny Plateau

Our analyses relied on a weight-of-evidence analysis drawing on many different analytical approaches. Each of the different approaches produced slightly different endpoints and these are summarized in Table 3.

In a weight-of-evidence approach, the different analyses are weighted on their applicability and the strength of the analysis. For the Allegheny Plateau, we had insufficient data to produce significant stressor-response relationships. As a result, we were left weighting the distribution based, modeled reference expectation, and scientific literature lines.

For the distribution based approach, we assembled a large population of nutrient concentration from sites ranging in quality from various databases. We identified the entire population of sites for one estimate, and identified a subset of minimally disturbed sites for a second estimate. The values estimated from these populations were between 19 and 36 μg/L TP.

The modeled reference expectation did not produce a significant model for TP in this ecoregion, but did for TN (302 μg/L). We used the molar ratio of N:P to identify an appropriate TP target associated with this TN concentration. The average Allegheny Plateau stream N:P from our dataset was 86:1. The ratio of N:P based on USEPA's recommended endpoints was similar (68:1). Using these two, and the Redfield ratio (16:1), resulted in TP endpoints of 8, 10, and 42 μg/L respectively.

Finally, literature relevant to nutrient endpoints for this region ranged from approximately 10 μg/L TP (USEPA recommended criteria) to 60 μg/L (Dodds and Welch 2000), but most values were centered around 30 μg/L TP.

We weighted the reference criteria line of evidence most highly of the three lines we had available and we recommend a TP endpoint of 35 μg/L TP for streams of this region.

• Allegheny Plateau recommended endpoint: 35 μg/L TP

Table 3 – Summary of candidate endpoints for each of the analytical approaches discussed for the Allegheny Plateau.

	Approach	TP Endpoint (μg/L)
Reference Approach		**19-36**
	Reference Site 75th Percentile	33-36
	All Sites 25th Percentile	19
Modeled Reference		**8-42**
Stressor-Response		**NA**
Other Literature		**13-100**
	USEPA Recommended Regional Criteria	10
	USEPA Regional Criteria Approach – Local Data	13
	Algal Growth Saturation	25-50
	Nationwide Meta-Study TP-Chlorophyll	21-60
	USGS Regional Reference Study	20
	USGS National Nutrient Criteria Study	13-20

Endpoint (magnitude) – Ridge and Valley

As above, our analyses relied on a weight-of-evidence analysis drawing on many different analytical approaches. Each of the different approaches produced slightly different endpoints and these are summarized in Table 4.

In a weight-of-evidence approach, the different analyses are weighted based, essentially, on their applicability and the strength of the analysis. For the Ridge and Valley, we had substantially more data, including abundant data on stressor-response relationships. As a result, we were able to use all four lines of evidence: distribution based, modeled reference expectation, stressor-response and scientific literature based approaches.

Similar to the Allegheny Plateau distribution based approach, we assembled a large population of nutrient concentrations from various databases for sites ranging in quality. We identified the entire population of sites for one estimate, and identified a subset of minimally disturbed sites for a second estimate. The values estimated from these populations were between 10 and 15 μg/L TP in this ecoregion.

The modeled reference expectation produced significant models for both TP and TN in this ecoregion, so we did not have to rely on N:P ratios to estimate a TP endpoint using this line of evidence. The TP endpoint from modeled reference expectation was 7 μg/L. The TN generated from this approach was 209 μg/L. Most streams in the Ridge and Valley ecoregion, similar to the Allegheny Plateau and Piedmont, appear to be P limited systems. The median N:P ratio across the streams sampled was well above Redfield (16:1) and was actually 88:1. Using this ratio along with the TN endpoint, the TP endpoint would be 5 μg/L. Using the more conservative Redfield Ratio (16:1), combined with the TN endpoint, results in a TP value of 29 μg/L.

The stressor-response analyses led to a variety of endpoints that varied between 14 and 23 μg/L TP. The lowest threshold (14 μg/L) was observed in the EPT taxa response for the MBSS data and the highest threshold for the Percent Dominant 5 Taxa metric from the EMAP dataset (23 μg/L).

Finally, literature relevant to nutrient endpoints for this region ranged from approximately 10 μg/L TP (USEPA recommended criteria) to 60 μg/L (Dodds and Welch 2000), but most values were centered around 30 μg/L TP.

We weighted the stressor-response line of evidence most highly of the four lines we had available as it provided a direct linkage to use measures, and these results were higher than the distribution based and modeled reference values. Literature based values were, in terms of central

tendency, closer to the upper end of the stressor-response derived values. As a result, we recommend a TP endpoint of 25 μg/L TP for streams of the Ridge and Valley.

• Ridge and Valley recommended endpoint: 25 μg/L TP

Table 3 – Summary of candidate endpoints for each of the analytical approaches discussed for the Ridge and Valley.

	Approach	TP Endpoint (μg/L)
Distribution Based		**10-15**
	Reference Site 75th Percentile	13-15
	All Sites 25th Percentile	10
Modeled Reference		**10-15**
Stressor-Response		**14-23**
	MBSS	
	Total Taxa	14
	EPT Taxa	14
	Percent Scrapers	16
	EMAP	
	EPT Taxa	19
	Ephemeroptera Taxa	19
	Trichoptera Taxa	19
	Percent Dominant 5 Taxa	23
Other Literature		**13-100**
	USEPA Recommended Regional Criteria	10
	USEPA Regional Criteria Approach – Local Data	13
	Algal Growth Saturation	25-50
	Nationwide Meta-Study TP-Chlorophyll	21-60
	USGS Regional Reference Study	20
	USGS National Nutrient Criteria Study	13-20

Sample period

We recommend applying the endpoint over the algal growing season (April to October), which in streams is typically the time during which the greatest risk of deleterious algal growth exists.

• Endpoint applies from April to October

Sample duration

Unlike toxics, there is less literature to recommend appropriate sample duration and frequencies for nutrients. Toxics, with chronic and acute criteria, have a longer history of implementation. Their mode of action is also very different than nutrients. As a result, it was more difficult to recommend an appropriate sample period than to derive the endpoints themselves.

Humans tend to sample nutrients at temporal scales that are different than those to which stream organisms respond. Streams respond both to pulsed as well as chronic nutrient concentrations. For example, algae possess mechanisms to store nutrients and use these stored nutrients for growth over time – so they can respond to episodic inputs. Moreover, the responses to episodic inputs include both assemblage responses (for example, development the nuisance algal taxa) as well as population and individual responses (biomass).

The nutrient data we analyzed for the invertebrate and plant responses were based primarily on single grab samples associated with biological sampling. These analyses, therefore, represent a space for time substitution of sorts, estimating what would occur in a piedmont stream as nutrient concentrations increase.

These factors would recommend a not-to-exceed criterion. However, water velocity affects nutrient delivery in streams and elevated nutrients associated with high flows may not be as accessible to benthic algae. We also recognize that there is resistance to not-to-exceed standards and concern about the risk of capturing false positives, even though the risk of false negatives is similarly great. These concerns would recommend averaging multiple samples over some time period. Algal and microbial responses to nutrients can occur rapidly, but these can be offset by floods that scour the bottom and remove algae. At this time, there is limited information and we have had insufficient time to investigate appropriate averaging periods, especially those that result in conditions detrimental to uses.

As a result, for the purposes of these TMDLs, we recommend that the TP endpoint be applied as an average of water samples taken over the growing season. Realize, again, that there is less information to guide this recommendation, which is based principally on our professional judgment and in an attempt to be consistent with other typical duration procedures. A more conservative alternative would be to use the recommended endpoint as a not-to-exceed value, but again, we have had insufficient time to evaluate this.

• Endpoint is assessed as the average TP concentration during the growing period over one year.

We feel that this approach will be protective, but we strongly encourage the state and USEPA to investigate this issue more fully for the purposes of regional criteria development. For the TMDLs, this approach is sufficient, but it deserves more attention and resources before being applied to regional criteria.

Literature Cited

Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Revision to rapid bioassessment protocols for use in stream and rivers: periphyton, BMIs and fish. EPA 841-D-97-002. U.S. Environmental Protection Agency. Washington DC.

Borchardt, M. A. 1996. Nutrients. Pages 183–227 in R. J. Stevenson, M. L. Bothwell, and R. L. Lowe, editors. Algal ecology: freshwater benthic ecosystems. Academic Press, San Diego.

Bothwell, M. L. 1989. Phosphorus Limited Growth Dynamics of Lotic Periphytic Diatom Communities - Areal Biomass and Cellular Growth-Rate Responses. Canadian Journal of Fisheries and Aquatic Sciences 8(46): 1293-1301.

Cleveland, W. S. 1979. Robust locally weighted regression and smoothing scatterplots. Journal of American Statistical Association 74: 829-836.

Dodds, W.K. 2002. Freshwater Ecology: Concepts and Environmental Applications. Academic Press, San Diego.

Dodds, W. K. and R. M. Oakes,. 2004. A technique for establishing reference nutrient concentrations across watersheds affected by humans. Limnology and Oceanography-Methods (2): 333-341.

Dodds, W. K., V. H. Smith, and K. Lohman. 2002. Nitrogen and phosphorus relationships to benthic algal biomass in temperate streams. Canadian Journal of Fisheries and Aquatic Sciences 59: 865-874.

Dodds, W. K., V. H. Smith and K. Lohman. 2006. Erratum: Nitrogen and phosphorus relationships to benthic algal biomass in temperate streams. Canadian Journal of Fisheries and Aquatic Sciences 63:1190-1191.

Dodds, W.K. and E.B. Welch. 2000. Establishing nutrient criteria in streams. Journal of the North American Benthological Society 19:186-196

ENSR, International. 2003. Collection and evaluation of ambient nutrient data for rivers and streams in New England. New England Interstate Water Pollution Control Commission, Technical Report. http://www.neiwpcc.org/ncreports.asp

Hill, J. and G. Devlin. 2003. Memorandum: Associations Between Biological, Habitat, and Ambient Data in Upland Western Virginia Ecoregions. Virginia Department of Environmental Quality, West Central Regional Office. Roanoke, VA. (December 17, 2003).

Horner, R.R., E.B. Welch, and R.B. Veenstra. 1983. Development of nuisance periphytic algae in laboratory streams in relation to enrichment and velocity. Pages 121-134 in R.G. Wetzel (ed.). Periphyton of Freshwater Ecosystems. Dr. W. Junk Publishers. The Hague.

Klemm, D.J., K.A. Blocksom, F.A. Fulk, A.T. Herlihy, R.M. Hughes, P.R. Kaufmann, D.V. Peck, J.L. Stoddard, W.T. Thoeny, M.B. Griffith and W.S. Davis. 2003. Development and evaluation of a macroinvertebrate biotic integrity index (MBII) for regionally assessing Mid-Atlantic Highland streams. Environmental Management 31:656-669.

Maryland Department of Natural Resources (MDNR). 2005. New Biological Indicators to Better Assess the Condition of Maryland Streams. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment, Annapolis, MD. CBWP-MANTA-EQ-05-13.

Pan, Y. D., R. J. Stevenson, B. H. Hill, A. T. Herlihy and G. B. Collins,. 1996. Using diatoms as indicators of ecological conditions in lotic systems: A regional assessment. Journal of the North American Benthological Society 4(15): 481-495.

Paul, J.F. and M. E. McDonald. 2005. Development of empirical, geographically specific water quality criteria: a conditional probability analysis approach. Journal of the American Water Resources Association 41: 1211–1223

Ponader, K. & D. F. Charles. 2003. Understanding the relationship between natural conditions and loadings on eutrophication: Algal indicators of eutrophication for New Jersey streams. Final Report Year 2. Report No. 03-04. Patrick Center for Environmental Research, Academy of Natural Sciences. Philadelphia, PA.

Ponader, K., C. Flinders, and D. Charles. 2005. The Development of Algae-based Water Quality Monitoring Tools for Virginia Streams. Report No. 05-09 for the West Central Regional Office, Virginia Department of Environmental Quality. Patrick Center for Environmental Research, Academy of Natural Sciences. Philadelphia, PA.

Qian, S.S., King, R.S., Richardson, C.J., 2003. Two statistical methods for the detection of environmental thresholds. Ecological Modeling 166: 87–97.

Redfield, A.C. 1958. The biological control of chemical factors in the environment. American Scientist 46, 205-221.

Rier, S. T. and R. J. Stevenson. 2006. Response of periphytic algae to gradients in nitrogen and phosphorus in streamside mesocosms. Hydrobiologia 561:131-147.

Robertson, D.M., D.A. Saad, A.M. Wieben, U.S. Environmental Protection Agency Region V, U.S. Environmental Protection Agency Region VII, and U.S. Geological Survey. 2001. An Alternative Regionalization Scheme for Defining Nutrient Criteria for Rivers and Streams. U.S. Geological Survey Water-Resources Investigations Report 01-4073. Middleton, WI.

Rohm, C.M., J.M. Omernik, A.J. Woods, and J.L. Stoddard. 2002. Regional characteristics of nutrient concentrations in streams and their application to nutrient criteria development. Journal of the American Water Resources Association 38: 213-239.

Stoddard, J.L., D.P. Larsen, C.P. Hawkins, R.K. Johnson and R.H. Norris. 2006. Setting expectations for the ecological condition of streams: the concept of reference condition. Ecological Applications 16(4):1267-1276.

United States Environmental Protection Agency (USEPA). 2000a. Nutrient Criteria Technical Guidance Manual. Rivers and Streams. United States Environmental Protection Agency, Office of Water, Washington, DC. EPA-822-B-00-002

United States Environmental Protection Agency (USEPA). 2000b. Nutrient Criteria Technical Guidance Manual. Lakes and Reservoirs. United States Environmental Protection Agency, Office of Water, Washington, DC. EPA-822-B-00-001

United States Environmental Protection Agency (USEPA). 2001. Nutrient Criteria Technical Guidance Manual. Estuarine and Coastal Marine Waters. United States Environmental Protection Agency, Office of Water, Washington, DC. EPA-822-B-01-003

United States Environmental Protection Agency (USEPA). 2007. Nutrient Criteria Technical Guidance Manual. Estuarine and Coastal Marine Waters. United States Environmental Protection Agency, Office of Water, Washington, DC. EPA-822-R-07-004

Van Dam, H., Mertens, A. & Sinkeldam, J. 1994. A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands. Netherlands Journal of Aquatic Ecology, 28 (1): 117-133.

General Response #8: MS4 and Other NPDES-regulated Storm Water implementation

EPA clarification memorandum dated November 22, 2002, has clarified existing EPA regulatory requirements for, and provides guidance on, establishing wasteload allocations (WLAs) for storm water discharges in TMDLs approved or established by EPA. It made it clear that:

- The WLAs are to be expressed in numeric form.
- NPDES permit conditions must be consistent with the assumptions and requirements of available WLAs.
- Water quality-based effluent limits (WQBEL) for NPDES-regulated storm water discharges that implement WLAs in TMDLs may be expressed in the form of best management practices (BMPs) under specified circumstances. If BMPs alone adequately implement the WLAs, then additional controls are not necessary.
- EPA expects that most WQBELs for NPDES-regulated municipal and small construction storm water discharges will be in the form of BMPs and that numeric limits will be use only in rare instances.
- When a non-numeric WQBEL is imposed, the permit's administrative record, including the fact sheet when one is required, needs to support that the BMPs are expected to be sufficient to implement the WLA in the TMDL.
- The NPDES permit must also specify the monitoring necessary to determine compliance with the effluent limitations. Where effluent limits are specified as BMPs, the permit should also specify the monitoring necessary to assess if the expected load reductions attributed to BMP implementation are achieved.
- The permit should also provide a mechanism to make adjustments to the required BMPs as necessary to ensure their adequate performance.

EPA expects that the NPDES permitting authority will review the information provided by the TMDL and determine whether the effluent limit is appropriately expressed using a BMP approach, including an iterative BMP approach or a numeric limit. Where BMPs are used EPA recommends that the permit provide a mechanism to require use of expanded or better-tailored BMPs when monitoring demonstrates they are necessary to implement the WLA.

The above noted clarification memorandum affirms the appropriateness of an iterative, adaptive management BMP approach, whereby permits include effluent limits (a combination of structural and non-structural BMPs) that address storm water discharges, implement mechanisms to evaluate the performance of such controls, and make adjustments as necessary to protect water quality.

Where long term control plans (LTCP) are in development or approved, the permittee can use the WLA in the post-implementation monitoring as a goal to be met. The LTCPs should include a full consideration of the impairments that were included on the state's section 303(d) list of

impaired waters at the time the LTCP is prepared. This was made clear in a letter from PADEP SouthCentral Regional Office, dated August 26, 2003 from Leon Oberdick to The Harrisburg Authority engineers – "I have not listed Paxton Creek. However, it is included on the 303(d) list of impaired waters and one of the causes for listing is the existence of CSOs. Although this stretch of creek through Harrisburg may not be 'sensitive', it is important to work on its recovery as a viable aquatic community resource." A copy of this letter is included in the supporting information section of this Response Document.

Commenters are referred to EPA's WEB site at www.epa.gov/owow/tmdl/stormwater for additional information concerning stormwater and TMDLs. One summary of interest would be "Understanding Impaired Waters and Total Maximum Daily Load (TMDL) Requirements for Municipal Stormwater Programs".

General Response #9: Scope of Chester Creek TMDL

During the public comment period, the Pennsylvania Department of Environmental Protection (PADEP) informed EPA that certain errors occurred in the development of the state's section 303(d) impaired waters list. Apparently, in the state's listings the Unnamed Tributary to Chester Creek was inaccurately defined and is actually Goose Creek and the East Branch Chester Creek is now a separate segment. Based on PADEP's comments Goose Creek was the only 1996 listing remaining on the section 303(d) list as impaired by municipal point sources.

After review of the data, PADEP has indicted that, based on macro-invertebrate data and chlorophyll 'a' data the state can only support the section of Chester Creek known as Goose Creek as impaired by nutrients. Although total phosphorus concentrations are extremely high throughout the watershed (see the graph at the end of the Response Document), PADEP believes that they need additional macro-invertebrate data to accurately define other waters of the watershed as nutrient impaired.

EPA believes that various sources, including municipal wastewater treatment facilities (WWTPs) and runoff from MS4 areas as well as agricultural areas are causing excessive levels of phosphorus in many of the waters within the Chester Creek watershed. Existing concentrations far exceed EPA's endpoint used in these TMDLs. In stream phosphorus concentrations will only increase as the WWTPs near their design capacity. Continued growth will exacerbate the issue. See General Response #10 for a further discussion. EPA has reluctantly narrowed the area of the TMDL to include Goose Creek only. EPA continues to urge PADEP to design and implement a monitoring plan that will fill the voids PADEP believes exist for the Chester Creek watershed. EPA also recommends that PADEP, following the additional data collection, complete the necessary TMDL that EPA has begun in the watershed.

General Response #10: EPA's Watershed Report for Chester Creek

EPA has limited the nutrient TMDL to include Goose Creek only. Please see general response #9 for a discussion on that decision. However, EPA still believes there are, or will be, water quality issues in the remaining Chester Creek Watershed. These issues relate mostly to habitat and aquatic life impairment resulting from excessive amounts of nutrients and sediment, brought about by increasing development, increasing municipal wastewater along with a decrease in impervious lands resulting in increased runoff volume and velocity which in turn results in stream bank erosion, land runoff of sediment and less subsurface recharge and stream baseflow. Municipal wastewater treatment facilities, which account for much of the stream flow during low flow periods, are major contributors to the environmental issues within the watershed. As a way to initially evaluate these problems, EPA has developed a watershed report.

The Chester Creek Watershed Report is a preliminary evaluation of the nutrient and sediment impairments in the watershed. The report includes the evaluation of the existing loadings of nitrogen, phosphorus and sediment from point and nonpoint sources. The report is similar to a TMDL report yet has none of the regulatory implications. The report includes a discussion on existing water quality conditions, observed impairments and recommended reductions of TN, TP and sediment from all sources in order to attain and maintain existing and applicable state water quality standards.

EPA is recommending that the Pennsylvania Department of Environmental Protection continue to monitor and evaluate the Chester Creek watershed with respect to nutrient and sediment impacts. We also suggest that the PADEP use our Watershed Report as a starting point to develop and implement watershed-wide TMDLs for those pollutants.

General Response #11: EPA's Consideration of Algal Biomass in Establishing the TMDLs

Nitrogen and phosphorus are the two main causal agents of enrichment and chlorophyll 'a' is a response variable. EPA recognizes that as nutrient concentrations increase ecological impacts cascade to impairment of benthic invertebrates and fish species. Algae may affect the benthic macroinvertebrate community by providing an increased food supply for opportunistic invertebrates that use algae as a food source. Consequently, the community would shift in such a way that the opportunistic species would thrive and out-compete other, less opportunistic species. In short, a healthy macroinvertebarte community will result in a healthy population of higher order aquatic life and a general well balanced community. Macroinvertebrate data shows long term impacts where algal biomass shows short term impacts.

Some would want EPA to consider controlling nutrients based only on the prevention of minimum dissolved oxygen (DO) violations or simply to reduce the levels of algal biomass. However in some streams algal growths may develop into nuisance levels but the stream may not have a DO problem, particularly if physical reaeration occurs at high levels. Control of nutrients solely for the reduction of nuisance algal biomass may not be protective of the spectrum of aquatic life. However, EPA found that end points developed to protect aquatic life are also sufficient to reduce algal biomass to recommended levels. EPA based these TMDLs on the protection of aquatic life recognizing that biological assemblages vary less in space and time than most physical and chemical characteristics, allowing for fewer mistakes in assessment. As will be seen below, PADEP also recognizes that nutrient impairment does not always result in minimum DO violations.

EPA would like to note that, although the endpoint is based on aquatic life protection, with the goal of a healthy, diverse aquatic community, EPA did evaluate the expected instream biomass and dissolved oxygen through the predictive modeling. If one would review the available literature, as 14EPA has done, it would be found that TP ranges of about 10 to 100ug/L have been suggested to reduce algal biomass to acceptable levels. The end point for these TMDLs falls within that range. EPA has suggested that a biomass of 150mg/m2 is a point that, although cannot be supported as an absolute threshold above which adverse effects on water quality and benthic habitat readily occur, it is a level below which an aesthetic effects use will probably not be appreciably degraded. The literature review shows that there is consistency in the levels of biomass that prevent nuisance conditions with a maximum of about 150 mg/m2 chl 'a' being a generally agreed upon criterion. University of Montana evaluated instream biomass impacts on public perceptions based on visual observations by the public. The results are shown in the attachment to this Response Document. Generally in streams where the biomass was above 150 to 200mg/m2, the observers considered the waters as undesirable.

As noted several times, the end point was based on aquatic life protection, but EPA also was interested in keeping the biomass below the 150 to 200 mg/m2 range. In a decision memorandum dated October 10, 2007, EPA indicated that 100mg/m2 would be used as a guide and not a strict end point. EPA directed the contractors that it would be acceptable, at the TP and TN end points, for the Chlorophyl 'a' to range as high as 200 mg/m2 on a seasonal average or 300 mg/m2 maximum. However EPA would have to reevaluate the TMDL end points if the chl 'a' average goes above 200 mg/m2 or a maximum of 300 mg/m2 in order to keep the chl 'a'

below those values. Using Indian Creek modeling results as an example, the graph included in the attachment to this Response Document shows that the biomass, under the design conditions, will remain comfortably below the values cited above. Therefore, basing the end point on the aquatic life protection will also be sufficient to reduce the biomass to below the recommended literature values as well as attain the minimum DO criterion.

The protection of aquatic life is consistent with present PADEP regulations and procedures. Pennsylvania code at 25 PA section 93.6 defines the general water quality criteria. This criteria requires that "Waters may not contain substances attributable to point or nonpoint source discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life." The specific uses to be protected in the 5 waters for which TMDLs have been developed include warmwater fisheries and trout stocking fisheries. Further PA Code 25 PA section 96.5(c) defines the needs for nutrient discharges to free flowing streams. "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 2mg/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." EPA knows of no cite in the PA code that refers to a chlorophyll 'a', or an algal biomass, requirement.

The Pennsylvania 2007 Assessment Methodology specifies the need to include nutrient data in evaluating the impairment status of a waterbody. Appendix A of the method notes under the source and cause definitions that that "…Presence of excessive quantities of Phosphorus and/or Nitrogen that under the proper conditions may result in dense algal or macrophyte growth and wide fluctuations in Dissolved Oxygen levels. Average daily DO may be relatively normal. Biological impairment may occur without Chapter 93 criteria violations." This makes it clear that Pennsylvania understands that biological impairment due to nutrient levels may occur even when DO standards are being met.

Finally, the Bureau of Water Quality Standards and Facility Regulation guidance on *Instream Comprehensive Evaluation (ICE) Surveys (Updated October 5, 2007)* directs field staff to collect nutrient and biological data. Phosphorus data is to be collected for municipal point sources and, total and dissolved nutrients for stormwater discharges and, "if deemed necessary by the investigator, nutrient sampling will occur during the growing season at least once a month from May through October…Water quality analysis should be conducted for total and dissolved nutrients…" These directions to the field staff indicates the state's concern with the impacts of nutrients from both point and nonpoint sources.

The ICE guidance continues to direct the staff on biological data. "1) Benthic macroinvertebrates (required). Because aquatic organisms are excellent indicators of water quality, and are routinely sampled as part of Pennsylvania's ongoing water quality management program, benthic macroinvertebrates will be collected in most instances to assess the attainment of aquatic life uses." It is clear that macroinvertebrates are a major consideration in determining water impairment with respect to aquatic life.

PADEP has used aquatic biology investigations for many years to identify impaired waters. An almost unlimited number of examples exist, but we will use a survey conducted on Indian Creek at the Lower Salford Authority wastewater treatment facility in Harleysville as an example here. An aquatic biology investigation was conducted by PADEP on April 14, 2003. During that survey benthic and chemical samples were obtained above and below the facility. Above the facility the chemical data indicated good water quality. The invertebrate community was fair to poor. Below the facility the chemical data results revealed a site moderately polluted from municipal wastewater and the macroinvertebrate community was mostly facultative and tolerant taxa resulting in a poor community. The investigators conclusion was that the stream was impaired from the Lower Salford Authority facility and the cause was nutrients. Similar results were obtained in 2001.

Total phosphorus concentrations above and below the facility were 61ug/L and 211ug/L respectively. EPA notes that the field DO depletion was less than 2mg/L with an instream value of over 12mg/l below the plant. EPA also notes that **NO** algal biomass, chlorophyll 'a', was collected during this survey. The PADEP made an impairment decision based on chemical data, the health of the macroinvertebrate community, no DO violations and with no biomass data. The results of these field investigations were that PADEP placed the water on the CWA Section 303(d) list of impaired waters for nutrients from municipal wasterwater. Similar results were found for the Telford Authority facility

The above demonstrates that there are no PADEP regulations that specify a biomass requirement, that nutrient controls can be more stringent than 2mg/l if determined necessary by a TMDL and that the PADEP uses macroinvertebrate community health and chemical data to determine if a water is impaired. It also shows that PADEP recognizes that biological impairment can exist even when there are no violations of the DO standards and when there is no biomass data to support the impairment. This further supports EPA's procedures and approach of aquatic life protection and demonstrates the approaches consistency with state existing regulations and procedures. Some commenters argued that since EPA used a different end point approach for previous TMDLs, we had no justification for changing that approach for these TMDLs. The previous approach relied on meeting the state's DO criteria based on algal activity and did not consider effects of nutrient concentrations on macroinvertebrates. One of the major points related to previous modeling (such as for the Wissahickon Creek watershed) analysis is that since it was based on controlling DO through algal activity (growth and decay) the half-saturation constant played a more critical role in the predictive capabilities of the modeling An important aspect of this approach with respect to modeling was the selection of the half-saturation constant. During the development of the previous TMDLs, much discussion surrounded the selection of the appropriate constant. The half-saturation constant varies considerably by algal species. For the Wissahickon Creek TMDL, for example, based on information received from PADEP, it was determined that the dominant species was Cladophora glomerata. The modeling foundation was not available to model competing species, so the half-saturation constant selected was based on Cladophora. A review of the literature showed that there was a wide range of half-saturation constants for that species, ranging from 0.5 ug/l P to a high of 508 ug/L P. An average value was calculated as 125 ug/L P. This was the value used for the Wissahickon Creek modeling. The problem in using this one constant is that the approach cannot consider other species explicitly at the same time, i.e., it uses a value representative of the dominant species present. It also is not capable of predicting a species composition change (and associated change in half saturation

constant) under a scenario with significantly altered nutrient contributions such as implementation of the TMDL.

The above approach was discussed as an option for the Skippack Creek TMDL but was discarded after deciding that an approach that focused on meeting DO criteria by controlling algal activity yet considered just one species of algae was not appropriate. The decision to use actual instream algal growth data and an empirical equation was made. The Dodds equation, along with a chlorophyl 'a' value of 100 mg/m2 as a goal based on esthetics, was selected as the basis for the end point for the Skippack Creek TMDL. Immediately following the EPA establishment of the Skippack Creek TMDL, EPA became aware of a revised Dodds equation that would significantly change any end points based on the original equation. At the same time the initial work had begun on the present TMDLs (Southampton Creek, Indian Creek et.al.) using the original Dodds equation as the basis for the end point. EPA eventually withdrew the Skippack Creek TMDL and requested an extension from the Courts for the completion of the other TMDLs with the expectation that the TMDL would be modified based on the revised equation.

There were several comments submitted to EPA on the Skippack Creek TMDL opposing the use of a general empirical equation such as the Dodds equation for the development of TMDLs. EPA evaluated those comments in depth, resulting in the decision that there was a better approach for determining the nutrient end points than using an empirical equation or a modeling approach that simply recognized one species of algae. This new direction was based on the detailed and scientifically-based nutrient criteria development guidance published by EPA. Use of the EPA guidance would serve several purposes: 1) it would eliminate the inability to evaluate the future conditions as the single species approach had, 2) it would eliminate the use of a generalized empirical equation that was not based on site-specific data, 3) it would allow for the development of a nutrient end point that is rooted in EPA's peer-reviewed guidance, 4) it would set an endpoint based on a procedure that will more closely follow the PADEP approach for developing nutrient criteria, 5) would consider the long term impacts based on aquatic life uses and not just the short term impacts of algal biomass growth, 6) it would eliminate the need to predicate the anlaysis on the determination of a single half-saturation constant that would not only represent existing algal species but what would be expected after the TMDL is implemented (thereby eliminating the need to guess at what species might thrive, and at what level, under the TMDL plan), and 7) it would allow consideration of multiple-lines-of-evidence.

General Response #12: Spatial Extent of the Paxton Creek Nutrient TMDL

EPA has reviewed the comments received during the public comment period and conducted additional evaluations of the data available for Paxton Creek. EPA has received chemical and biological data for the watershed from the Susquehanna River Basin Commission (SRBC) during the comment period. The reader is referred to General response #13 for EPA's review of that data. In addition, The City of Harrisburg Authority submitted clarifying comments on May 21, 2008. EPA's response to that letter can be found in the responses to letter #55.

The final nutrient TMDL for Paxton Creek includes the entire segment as listed by PADEP. EPA has determined that the storm sewer overflows (CSOs) occurring in the concrete channel section of the Paxton Creek may not be a significant source of the aquatic life use impairment with respect to TP. During storm events when the CSOs overflow, the residence time of those overflows in the Paxton channel is not sufficient to impact biological health. It has been argued by the City, without any supporting evidence or information, that the overflows will have a short detention time in Paxton Creek and are not constant flows thereby providing no opportunity to impact aquatic life. However, the City's overflow data shows trailing end of the overflows to contain high TP concentrations, ranging from 225ug/l to 637ug/L. These values are much above the EPA endpoint of 40ug/L. This trailing end of the overflows may or may not remain sufficiently long to impact aquatic life.

The Susquehanna River Basin Commission (SRBC) data shows aquatic life impairments in this section of Paxton Creek. EPA also has minimal data showing high levels of chlorophyll 'a' in the creek as well, ranging from 36 mg/m2 to 287 mg/m2 for baseline conditions and 74 mg/m2 to 179 mg/m2 for wet weather conditions. The City also has data showing dissolved oxygen violations in Paxton Creek. EPA believes this is sufficient evidence to show that Paxton Creek is impaired by nutrients. EPA, after evaluating all of the data and information, also believes that the information available supports the need for some level of TP controls for the City's CSOs and other sources.

Therefore, EPA is allocating TP loads to the various land uses (including the MS4s) as described in the draft TMDL. EPA is also allocating a load of 500Lb/Yr of TP to the CSOs discharging to Paxton Creek based on the information presented in the City's May 21, 2008 letter to EPA. That letter identified a 14% reduction in combined sewer overflow volume (159 million gallons to 137 million gallons) after the implementation of the selected long term control plan (LTCP) alternative 1A. This 500 Lb/Yr was based on applying the 14% reduction to the TP and using the City's own estimate of 440ug/L of TP as an event mean concentration. This compares to the 300Lb/Yr of TP contained in the draft TMDL.

According to the City's May 21, 2008 letter, this reduction can be achieved through the implementation of the LTCP. The City should seek additional opportunities to reduce the TP below the 500Lb/Yr. In addition, the City should be required to monitor their outfalls for TP during the post-implementation monitoring to assure that the 500Lb/Yr is being met. SRBC's biological monitoring data showed a significant impairment to aquatic life at the mouth of Paxton Creek. In order to assure that this condition is reversed, the City should be required to include biological monitoring as part of the post-implementation monitoring plan. If conditions

do not improve following the implementation of the LTCP then the LTCP and/or the TMDL should be revisited.

EPA does not accept some of the commenters' position that the Paxton Creek in the vicinity of the City of Harrisburg should be "written off" simply because it is an industrialized and channelized stream. EPA points out that the LTCP did not write this section of the creek off and in fact PADEP, in a letter dated August 26, 2003 and sent to the City's contractors emphasized the need to protect the Paxton Creek - "Although this stretch of creek through Harrisburg may not be "sensitive," it is important to work on its recovery as a viable aquatic community/resource." EPA agrees with this concern to attain water uses. Implementation of the LTCP plus the sediment and nutrient TMDLs should provide the protection needed for Paxton Creek.

General Response #13: Paxton Creek Water Quality and Biological Data – Susquehanna River Basin Commission, 2006 and 2007

The Susquehanna River Basin Commission (SRBC) conducted biologic monitoring in the Paxton Creek watershed on two occasions at even stations in the fall of 2006 and twelve stations in the spring of 2007. SRBC also collected chemical data including total nitrogen, total phosphorus, dissolved oxygen (DO), conductivity, pH, turbidity, and temperature as well as flow. This data was provided to EPA during the comment period for the Paxton Creek TMDL. The biological monitoring included the collection of macroinvertebrates and assessment of habitat. SRBC also provided EPA with continuous DO data that was collected over an 8 month period. The station locations are shown on Figure 1 below.

The macroinvertebrate monitoring analysis revealed significant differences in the total number of macroinvertebrates and the number of pollutant sensitive macroinvertebrates between monitoring stations located within the impaired segment and unimpaired segments of Paxton Creek.

- High numbers of macroinvertebrates were measured within unimpaired segments (on average 1237) and low numbers (on average 468) of macroinvertebrates within the impaired segments.

- High numbers of sensitive macroinvertebrates (Ephemeroptera, Plecoptera and Trichoptera) were collected in the unimpaired segments (138) and low numbers in the impaired segments (41).

Habitat parameters that were examined along the impaired segments include epifuanal substrate, embeddedness, velocity, sedimentation, channel flow, channel alteration, frequency of riffles, bank stability, vegetative protection and riparian zone. During each sampling event parameters were assigned a score from 0 to 0, with 20 indicating optimal conditions and 0 indicating very poor conditions.

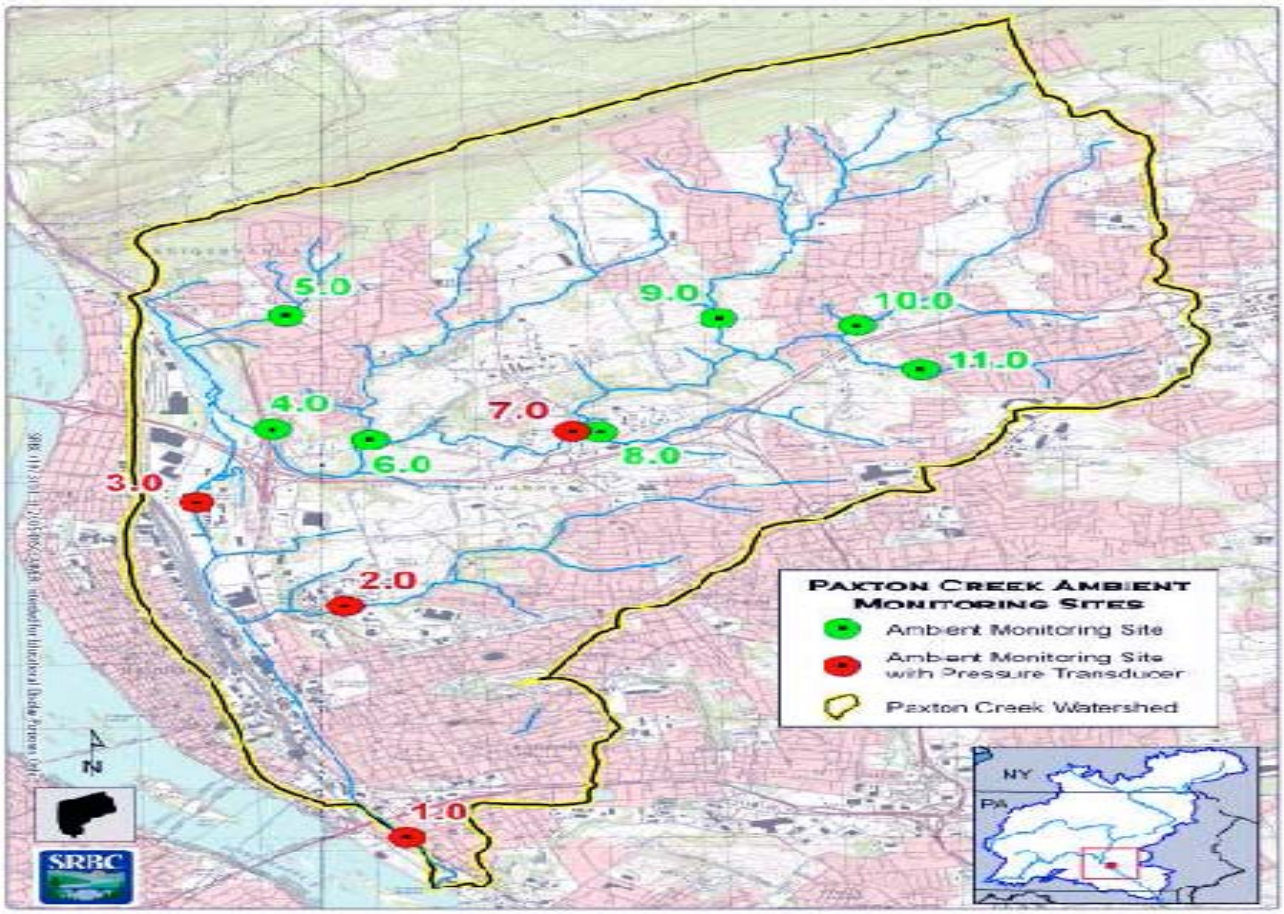
Overall habitat assessment scores from the fall of 2006 and spring 2007 were consistently low at the two monitoring stations in Paxton Creek (Station 1at the mouth and Station 3 at the upper side of the City of Harrisburg), with scores ranging from 66 to 91 and an average score of 76. Scores for habitat metrics such as epifaunal substrate, embeddedness, sediment deposits and bank stability were consistently and considerably low for the monitoring stations in the impaired segments of Paxton Creek.

The chemical data shows several violations of the PADEP's water quality criteria. At Station 1, the continuous DO monitoring data shows considerable minimum DO violations, with concentrations much below the 4 mg/L criterion. Some concentrations fell close to zero (0) mg/L. The DO concentrations at Station 3 were not quit as low, falling to just above 4 mg/L at times. The DO measured in Asylum Run showed concentrations above the minimum as specified by PADEP's water quality standards for most of the time. However, toward the end of the monitoring period the DO dropped off dramatically to almost zero (0) mg/L. These recordings should be verified since they occurred at the end of the monitoring period and there may have been equipment issues at that time.

The total phosphorus concentrations for Station 1 ranged from 48ug/L to 289ug/L. There were no measurements that were below the EPA developed TMDL endpoint of 40ug/L. Station 3 had a few concentrations below the 40ug/L but ranged from 10ug/L to 212ug/L. Plotting concentration versus flow, it appears that there is a relationship between stream flow and instream TP concentrations. Many of the other stations monitored by SRBC showed elevated concentrations of TP as well.

The results of the SRBC monitoring efforts clearly show that the impaired segment of Paxton Creek provide a poor habitat for macroinvertebrates. Additionally, as a result of the poor habitat and potential adverse effect of pollutant(s), the total number of macroinvertebrates and pollution intolerant macroinvertebrates are significantly low. Nutrients, particularly Total Phosphorus is elevated in much of the watershed and may be adding to the poor aquatic community.

Figure 1 - SRBC Sampling Station Locations



Phosphorus, Nitrogen and Dissolved Oxygen Data - SRBC

Map ID	Date	Nitrogen TOT	Phosphorus T	Dissolved Oxygen	Flow
1	09-20-2006	1.48	0.067	4.66	5.062
1	09-20-2006	1.49	0.068		
1	11-29-2006	2.05	0.047	6.90	8.773
1	11-29-2006	2.06	0.048		
1	02-12-2007	1.86	0.111	13.14	5.774
1	02-12-2007	1.82	0.117		
1	03-02-2007	2.20	0.289	20.84	380.79
1	04-30-2007	1.89	0.063	7.93	8.948
1	04-30-2007	1.85	0.058		
1	08-28-2007	1.74	0.053	6.89	6.282
1	08-28-2007	1.72	0.052		
1	08-09-2007	1.99	0.181	6.22	72.56
1	08-09-2007	2.04	0.209		
1	10-24-2007	1.41	0.194	8.98	90.90
1	10-24-2007	1.45	0.181		
2	09-20-2006	1.50	0.036	6.67	1.19
2	11-29-2006	2.33	0.156	8.12	3.47
2	02-12-2007	1.68	0.018	15.42	3.77
2	03-02-2007	2.05	0.191	10.85	131.41
2	04-30-2007	2.12	0.017	11.80	1.964
2	08-09-2007	2.04	0.513	7.10	46.33
2	08-28-2007	2.07	0.120	9.45	1.398
2	10-24-2007	1.02	0.153	7.34	42.275
3	09-20-2006	1.32	0.024	5.66	4.583
3	11-29-2006	1.78	0.121	6.54	5.761
3	02-12-2007	1.81	0.010	14.33	3.097
3	03-02-2007	1.89	0.212	11.15	259.75
3	04-30-2007	1.45	0.018	10.29	2.233
3	08-09-2007	1.17	0.064	6.55	14.700
3	08-28-2007	1.67	0.032	8.83	3.863
3	10-24-2007	0.91	0.085	10.30	23.693
4	09-20-2006	0.97	0.019	6.68	4.162
4	11-29-2006	1.36	0.062	8.30	8.130
4	02-12-2007	1.39	PBQ	14.55	6.416
4	03-02-2007	1.99	0.272	13.48	NA
4	04-30-2007	1.04	0.020	10.36	14.517
4	08-09-2007	1.30	0.057	7.13	44.53
4	08-28-2007	1.50	0.027	9.22	5.474
4	10-24-2007	0.86	0.101	7.09	129.478
5	09-20-2006	0.76	0.011	7.66	0.477
5	11-29-2006	1.23	0.146	7.90	0.874

Map ID	Date	Nitrogen TOT	Phosphorus T	Dissolved Oxygen	Flow
5	02-12-2007	0.97	PBQ	14.42	0.608
5	03-02-2007	2.24	0.129	13.33	21.17
5	04-30-2007	1.20	PBQ	11.35	0.799
5	08-09-2007	1.72	0.105	7.59	6.905
5	08-28-2007	1.27	0.015	9.93	0.378
5	10-24-2007	0.98	0.072	8.72	8.860
6	09-20-2006	0.85	0.016	7.50	1.013
6	11-29-2006	1.21	0.149	8.66	1.255
6	02-12-2007	1.01	PBQ	15.93	1.072
6	03-02-2007	1.45	0.441	12.7	NA
6	04-30-2007	0.87	PBQ	12.41	3.934
6	08-09-2007	1.30	0.051	7.22	9.936
6	08-28-2007	1.20	0.018	10.55	1.299
6	410-24-2007	1.26	0.144	7.65	36.957
7	09-20-2006	0.96	0.015	8.32	2.608
7	11-30-2006	1.26	0.029	8.49	6.571
7	02-12-2007	1.22	PBQ	16.64	2.129
7	03-02-2007	1.74	0.206	9.92	781.90
7	04-30-2007	0.80	0.012	13.54	8.754
7	08-09-2007	1.81	0.085	6.71	32.700
7	08-28-2007	1.54	0.021	11.50	3.397
7	10-24-2007	0.92	0.091		
8	09-21-2006	2.07	0.018	8.10	0.671
8	11-30-2006	2.17	0.1	7.46	1.425
8	02-12-2007	2.28	0.014	14.14	0.655
8	03-02-2007	1.48	0.210	12.02	39.25
8	04-30-2007	1.68	0.016	13.50	1.237
8	08-09-2007	1.76	0.095	7.06	13.480
8	08-28-2007	3.11	0.019	9.74	0.653
8	10-24-2007	1.51	0.093	8.42	7.068
9	09-21-2006	0.79	0.011	6.71	1.524
9	11-29-2006	0.93	0.119	8.90	
9	02-13-2007	0.79	PBQ	13.46	1.255
9	03-02-2007	2.22	0.177	12.44	
9	04-30-2007	0.58	0.015	12.80	5.050
9	08-09-2007	1.61	0.152	6.25	18.896
9	08-28-2007	0.93	0.012	9.58	1.614
9	10-24-2007	1.10	0.136		
10	11-30-2006	1.54	0.028	8.10	2.056
10	02-13-2007	1.41	0.013	12.71	0.360
10	03-02-2007	1.97	0.253	12.38	35.23
10	03-02-2007	1.97	0.276		
10	04-30-2007	1.05	0.018	11.31	2.231
10	08-09-2007	1.48	0.141	6.48	10.705

Map ID	Date	Nitrogen TOT	Phosphorus T	Dissolved Oxygen	Flow
10	08-28-2007	1.32	0.037	9.24	0.809
10	10-24-2007	1.18	0.128	8.29	16.983
11	09-21-2006	1.10	0.041		
11	11-30-2006	1.65	0.063	6.62	0.810
11	02-13-2007	1.17	0.013	13.81	0.344
11	03-02-2007	1.70	0.537	12.37	NA
11	04-30-2007	1.30	0.017	10.87	0.483
11	08-09-2007	2.37	0.239	6.40	18.430
11	08-28-2007	1.36	0.027	8.82	0.463
11	10-24-2007	0.96	0.113	8.29	13.392
12	09-21-2006	0.75	0.035		
12	09-21-2006	PBQ	PBQ		

Chemical and Habitat Scores - SRBC

Site	Alias	Date	Temp	Cond.	DO	pH	Turbid	Habitat Score
Pax1.0	**Mainstem Mouth at Sycamore Street**	10/13/2006	12	524	7.1	7.15	3.06	66
Pax1.0		5/3/2007	15.8	666	9.51	7.4	2.98	63
Pax2.0	**Asylum Run at State Hospital Grounds**	10/13/2006	11.5	428	10.39	7.75	0.44	101
Pax2.0		5/2/2007	17.3	543	12.76	8.35	1.39	131
Pax3.0	**Mainstem at HACC**	10/11/2006	16	678	7.05	7.4	4.32	84
Pax3.0		5/2/2007	20.1	476	8.77	7.45	4.93	91
Pax4.0	**Pax North Above Wildwood Lake off Crooked Hill Road**	10/11/2006	16	478	8.62	7.7	1.81	94
Pax4.0		5/3/2007	14.5	460	9.38	7.35	14.6	111
Pax5.0	**Mountaindale Trib off of Fargreen Road**	10/10/2006	15.8	634	11.13	7.3	2.45	115
Pax5.0		5/1/2007	13.4	471	11.29	7.55	3.28	122
Pax6.0	**Black Run off of Paxton Church Road**	10/13/2006	10.5	330	10.52	7.9	3.68	111
Pax6.0		5/3/2007	12.7	348	11.16	7.9	2.89	139
Pax7.0	**Pax North DS of Devonshire Trib off of Progress Ave.**	10/11/2006	14.5	556	9.81	7.7	0.97	116
Pax7.0		5/1/2007	19.7	418	12.35	8.4	3.51	127
Pax8.0	**Devonshire Trib off of Interstate Road**	10/16/2006	11.3	778	13.92	7.7	0.81	119
Pax8.0		5/1/2007	17.8	639	13.42	8.05	3.98	123
Pax9.0	**Pax North US Lingelstown Trib off of McIntosh Road**	10/10/2006	18	488	13.78	7.2	228	133
Pax9.0		4/30/2007	13.1	341	11.28	7.8	5.51	159
Pax10.0	**Linglestown Trib off of Goosevalley**	10/19/2006	13	531	9.25	7.8	2.15	110

Site	Alias	Date	Temp	Cond.	DO	pH	Turbid	Habitat Score
	Road							
Pax10.0		4/30/2007	14.1	470	11.81	7.9	1.5	122
Pax12.0	Paxtonia Trib off of Curvin Drive	10/19/2006	13.6	465	8.36	7.5	4.42	135
Pax12.0		4/30/2007	15.6	697	9.59	7.2	2.45	127
HW	Headwaters Paxton Creek off of Parkway West	6/6/2007	18.1	320	9.12	6.7	7.19	179

Habitat Data - SRBC

Site		Epifaunal Substrate/Available Cover	Embeddedness	Velocity/ Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration	Frequency of Riffles	Bank Stability		Vegtative Protection		Riparian Vegetative Zone Width		Total Score
									LB	RB	LB	RB	LB	RB	
Pax1.0	Fall 06	6	7	11	6	10	0	1	10	10	3	0	2	0	66
Pax1.0	Spring 07	3	12	11	4	13	0	0	9	9	0	0	0	2	63
Pax2.0	Fall 06	11	9	14	9	13	4	16	8	8	4	3	1	1	101
Pax2.0	Spring 07	16	8	14	5	12	19	17	7	6	6	6	9	6	131
Pax3.0	Fall 06	5	7	8	4	9	12	7	6	8	6	8	1	3	84
Pax3.0	Spring 07	6	9	7	2	11	14	5	7	8	8	9	2	3	91
Pax4.0	Fall 06	8	4	8	6	12	7	12	7	7	8	8	2	5	94
Pax4.0	Spring 07	5	3	18	4	14	17	3	9	8	7	10	3	10	111
Pax5.0	Fall 06	13	12	14	11	7	14	16	8	2	9	1	7	1	115
Pax5.0	Spring 07	12	17	14	14	10	17	17	4	1	6	1	9	0	122
Pax6.0	Fall 06	8	6	15	9	8	15	18	3	3	8	9	5	4	111
Pax6.0	Spring 07	18	16	13	13	14	17	16	3	4	4	6	9	6	139
Pax7.0	Fall 06	11	9	12	9	10	7	15	9	9	8	8	4	5	116
Pax7.0	Spring 07	13	11	18	14	18	9	10	8	8	3	6	3	6	127
Pax8.0	Fall 06	9	13	10	14	16	16	16	3	3	7	4	6	2	119
Pax8.0	Spring	10	18	14	16	16	17	16	3	2	4	3	3	1	123

Site		Epifaunal Substrate/Available Cover	Embeddedness	Velocity/ Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration	Frequency of Riffles	Bank Stability		Vegtative Protection		Riparian Vegetative Zone Width		Total Score
	07														
Pax9.0	Fall 06	16	6	15	8	13	16	11	8	7	9	8	8	8	133
Pax9.0	Spring 07	16	13	15	10	20	19	15	8	8	10	10	10	5	159
Pax10.0	Fall 06	6	9	14	4	18	14	8	9	7	8	6	6	1	110
Pax10.0	Spring 07	13	8	14	12	15	18	16	5	6	3	5	6	1	122
Pax12.0	Fall 06	17	16	11	12	19	15	17	6	5	6	6	3	2	135
Pax12.0	Spring 07	15	11	13	11	8	19	16	5	5	6	6	6	6	127
HW	Spring 07	20	18	15	15	14	19	18	10	10	10	10	10	10	179

Biological Data – 2006 – SRBC

Order	**Family**	***Genus***	**PAX 1.0**	**PAX 2.0**	**PAX 3.0**	**PAX 4.0**	**PAX 5.0**	**PAX 6.0**	**PAX 7.0**	**PAX 8.0**	**PAX 9.0**	**PAX 10.0**	**PAX 12.0**
Coleoptera	**Dytiscidae**	*Agabus*											
		Hydroporus											
	Elmidae	*Dubiraphia*			23	1			1		2	7	
		Macronychus										0	
		Optioservus		25	3	154	149	234	51	279	79	114	
		Stenelmis	10	112	3	158	19	83	57	59	27	52	176
	Gyrinidae	*Dinetus*		0	0	0	0	0	0	0	0	0	0
		Peltodytes		0		0	0	0	0	0	0	0	0
	Hydrophilidae	*Hydrobius*		0		0	2	0	0	0	1	0	0
	Psephenidae	*Ectopria*		0		0	0	0	0	2	1	2	0
		Psephenus		122	1	52	19	16	34	14	9	18	0
Diptera	**Ceratopogonidae**	*Bezzia*		0		0	0	0	0	0	0	0	0
Haliplidae	**Chironomidae**		175	124	168	132	8	43	137	142	5	580	117
				0		0	0	0	0	0	0	0	0
		Chelifera		0		0	0	0	0	0	0	0	0
		Hemerodromia		0		0	0	1	2	0	0	0	1
	Muscidae			0		0	0	0	0	0	0	0	0
	Psychodidae	*Psychoda*	2	0		0	0	0	0	0	0	0	0
Culicidae		*Simulium*		24		0	0	10	14	2	1	0	6
Empididae		*Antocha*	1	18		1	2	3	3	39	4	0	1
		Dicranota		0		0	0	0	0	0	0	0	0
		Limnophila		0		0	0	0	0	0	0	0	0
		Tipula	2	3		4	1	6	1	2	0	4	5
Ephemeroptera	**Baetidae**	*Baetis*		42		8	7	18	9	4	1	4	0
Simulidae	**Caenidae**	*Caenis*		0	4	10	0	1	13	3	0	98	0
Tipulidae													

Order	Family	Genus	PAX 1.0	PAX 2.0	PAX 3.0	PAX 4.0	PAX 5.0	PAX 6.0	PAX 7.0	PAX 8.0	PAX 9.0	PAX 10.0	PAX 12.0
		Ephemerella		0		0	0	0	0	0	0	0	0
		Eurylophella		0		0	0	0	0	0	0	0	0
	Ephemeridae	*Ephemera*		0		1	0	0	0	0	0	0	0
	Heptagenidae	*Leucrocuta*		0		0	0	0	0	0	0	0	0
		Stenacron		0		0	0	1	0	0	0	0	0
Ephemerellidae		*Stenonema*		12	1	12	2	9	25	0	18	32	0
	Isonychiidae	*Isonychia*		1		1	0	0	0	0	0	0	0
	Leptophlebiidae	*Paraleptophlebia*		0		0	0	0	0	0	0	0	0
	Tricorythidae	*Tricorythodes*		0		1	0	0	0	0	0	0	0
Magaloptera	**Corydalidae**	*Nigronia*		0		0	0	0	0	0	0	0	0
Odonata	**Aeshinidae**	*Boyeria*		0	1	0	0	0	0	0	1	0	0
	Calopterygidae	*Calopteryx*		0		0	2	3	0	0	0	1	0
	Coenagrionidae	*Argia*		0	1	1	0	0	4	0	1	0	1
	Cordulegastridae	*Cordulegaster*		0		0	0	0	0	0	0	0	0
		Ophiogomphus		0		0	2	0	0	0	0	0	0
		Stylogomphus		0		0	0	0	0	0	1	2	0
Plecoptera	**Leuctridae**	*Leuctra*		0		0	0	0	0	0	0	0	0
	Nemouridae	*Amphinemura*		0		0	0	0	0	0	0	0	0
		Acroneuria		0		0	0	0	0	0	0	0	0
Gomphidae		*Eccoptura*		0		0	0	0	0	0	0	0	0
		Perlesta		0		0	0	0	0	0	0	0	0
		Isoperla		0		0	0	0	0	0	0	0	0
Trichoptera	**Glossosomatidae**	*Glossosoma*		0		0	0	0	0	0	0	0	0
Perlidae	**Helicopsychidae**	*Helicopsyche*		0		0	0	0	0	0	0	0	0
	Hydropsychidae	*Ceratopsyche*		13		5	0	5	6	8	8	0	0
		Cheumatopsyche		7	1	24	36	11	1	5	23	1	7
Perlodidae		*Diplectrona*		0		0	0	0	0	0	0	0	0
		Hydropsyche		114		4	23	9	1	14	6	2	4
	Hydroptillidae	*Hydroptila*		0		0	0	0	1	0	0	0	0
		Chimarra		78		69	2	76	46	4	64	136	358

Order	Family	*Genus*	PAX 1.0	PAX 2.0	PAX 3.0	PAX 4.0	PAX 5.0	PAX 6.0	PAX 7.0	PAX 8.0	PAX 9.0	PAX 10.0	PAX 12.0
	Polycentropodidae	*Polycentropus*		0	1	0	0	0	0	0	0	0	0
Amphipoda	**Gammaridae**	*Gammarus*	9	17	20	28	256	41	25	624	33	41	16
Decapoda	**Cambaridae**	*Orconectes*		0		0		0	0	0	0	0	0
Gastropoda	**Ancylidae**	*Ferrissia*	1	0		6		0	9	3	0	3	0
	Lymnaeidae	*Fossaria*		0		0		0	0	0	0	0	0
	Physidae	*Physella*		0		2		0	1	1	0	5	0
	Planorbidae	*Gyralus*		0		0		0	0	0	0	5	0
Hiru.	**Erpodellidae**	*Erpobdella*		0		0		0	2	0	0	0	0
		Mooreobdella	5	0	1	0		0	0	0	0	1	0
Isopoda	**Asellidae**	*Caecidotea*	3	0	58	9		3	0	1	0	0	0
Oligo.	**Enchytraeidae**			0		0		0	0	0	0	0	0
	Lumbriculidae		2	0					10	0	0	0	16
				14		0		0	0	0	0	0	0
Pelecypoda	**Corbiculidae**	*Corbicula*	1	0	7	29	1	1	0	0	0	0	0
		Pisidium		0		0		0	0	0	0	0	0
Tricladia	**Planariidae**	*Dugesia*	3	17					20	1	3	18	28
Tubificidae					0								
Sphaeriidae					5		3						

Biological Data – 2007 – SRBC

Order	**Family**	***Genus***	**PAX 1.0**	**PAX 2.0**	**PAX 2.0-D**	**PAX 3.0**	**PAX 4.0**	**PAX 5.0**	**PAX 6.0**	**PAX 7.0**	**PAX 8.0**	**PAX 9.0**	**PAX 10.0**	**PAX 12.0**	**HW**
Coleoptera	**Dytiscidae**	*Agabus*													1
	Elmidae	*Ancryonyx*				4									
		Dubiraphia				55	14		2			8	5		108
		Macronychus				8			0						3
		Optioservus		8	12		45	206	40	92	163	125	121		76
		Stenelmis	4	434	358	30	233	160	94	347	271	332	241	308	121
	Haliplidae	*Peltodytes*													3
	Hydrophilidae	*Hydrobius*													2
		Tropisternus													
	Psephenidae	*Ectopria*											1		1
		Psephenus		36	49	1	35	54	49	190	46	138	35	1	5
Diptera	**Ceratopogonidae**	*Probezzia*						1							
		Bezzia					1								8
	Chironomidae		33	561	908	859	633	474	344	525	134	574	842	1790	1363
	Culicidae														4
	Empididae	*Chelifera*			3			5		6	1		4		1
		Hemerodromia					5	4	1	16	3	34	2	1	
	Muscidae														2
	Psychodidae	*Psychoda*	3												
	Simulidae	*Simulium*		3	6	2	6	28	6	125	4	36	13	29	
	Stratiomyidae	*Nemotelus*						1							
	Tabanidae	*Tabanus*													
	Tipulidae	*Antocha*		4	7		2	16	2	27	31	42	1		
		Hexatoma													
		Limnophila													
		Tipula		1				6	5			2	3	10	12

Order	Family	Genus	PAX 1.0	PAX 2.0	PAX 2.0-D	PAX 3.0	PAX 4.0	PAX 5.0	PAX 6.0	PAX 7.0	PAX 8.0	PAX 9.0	PAX 10.0	PAX 12.0	HW
Ephemeroptera	**Baetidae**	*Acentrella*								1					
		Baetis					11	3	2	2	1				20
	Caenidae	*Caenis*				29	23	2	21	50	14	60	204		25
	Ephemerellidae	*Ephemerella*					3	33	40			12			
		Eurylophella		1		1		3	6	1	1	6	16		4
	Heptagenidae	*Leucrocuta*				2			3	3					
		Stenacron							1						
		Stenonema				3	14	9	35	21		102	27		35
	Leptophlebiidae	*Paraleptophlebia*													9
	Tricorythidae	*Tricorythodes*					3								
Megaloptera	**Corydalidae**	*Nigronia*													1
Odonata	**Aeshinidae**	*Boyeria*				1	3		1	1					12
	Calopterygidae	*Calopteryx*		1	2		1	12	2		5	3	1		10
	Coenagrionidae	*Argia*				1							1		1
	Cordulegastridae	*Cordulegaster*													1
	Gomphidae	*Stylogomphus*						9	1	1		2			13
Plecoptera	**Chloroperlidae**	*Alloperla*						1							
	Leuctridae	*Leuctra*						13							6
	Nemouridae	*Amphinemura*					1	6	2	1		2	1		2
	Perlidae	*Acroneuria*													2
		Eccoptura													6
		Perlesta					5		8	5		20	2		1
	Perlodidae	*Isoperla*							1			1			
Trichoptera	**Glossosomatidae**	*Glossosoma*													1
	Helicopsychidae	*Helicopsyche*					2								
	Hydropsychidae	*Ceratopsyche*		2	2				2	1		40			
		Cheumatopsyche		3	7		1	51	32	2		22			180
		Diplectrona						8							1
		Hydropsyche		2	4		1	22		2	28	3	1		7
	Hydroptillidae	*Dibusa*										4			

Order	**Family**	***Genus***	**PAX 1.0**	**PAX 2.0**	**PAX 2.0-D**	**PAX 3.0**	**PAX 4.0**	**PAX 5.0**	**PAX 6.0**	**PAX 7.0**	**PAX 8.0**	**PAX 9.0**	**PAX 10.0**	**PAX 12.0**	**HW**
	Limnephilidae	*Pycnopsyche*								1					
	Philopotamidae	*Chimarra*		5	3		1	2	21	22	3	32	22	30	21
	Polycentropodidae	*Polycentropus*				1	1								
	Uenoidae	*Neophylax*						3							
Amphipoda	**Gammaridae**	*Gammarus*		106	64	62	78	1961	92	376	1329	472	119	1	29
Decapoda	**Cambaridae**	*Cambarus*													
		Orconectes													4
Gastropoda	**Ancylidae**	*Ferrissia*					2		1	3					
	Lymnaeidae	*Fossaria*				8									
	Physidae	*Physella*				16	1	1		3	1				4
	Planorbidae	*Gyralus*				6	1	5		2					
Hiru.	**Erpodellidae**	*Mooreobdella*				4			3						
	Glossiphoniidae	*Helobdella*											2		
Isopoda	**Asellidae**	*Caecidotea*		1		95	2		2						
Oligo.	**Lumbriculidae**		7	7	1	14		4	1	5		2	2	5	
	Tubificidae		76	66	21						615		200		
Pelecypoda	**Corbiculidae**	*Corbicula*	1			9	9		1			1			
	Sphaeriidae	*Pisidium*				30		2					2		
Tricladia	**Planariidae**	*Dugesia*					2			9	3	25	14	109	

Figure 2 - Station 1 Dissolved Oxygen - SRBC

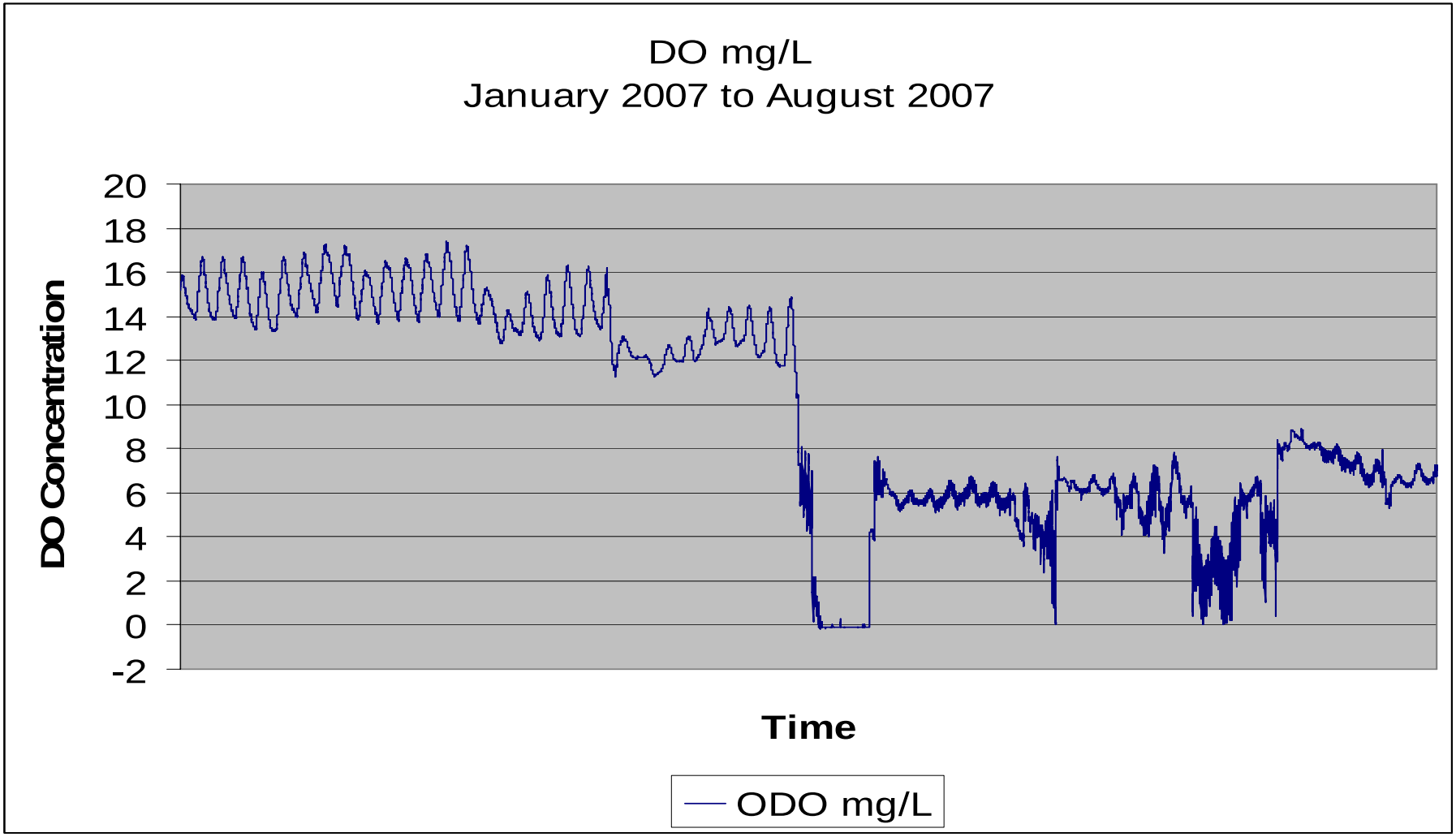


Figure 3 - Station 2 Dissolved Oxygen – SRBC

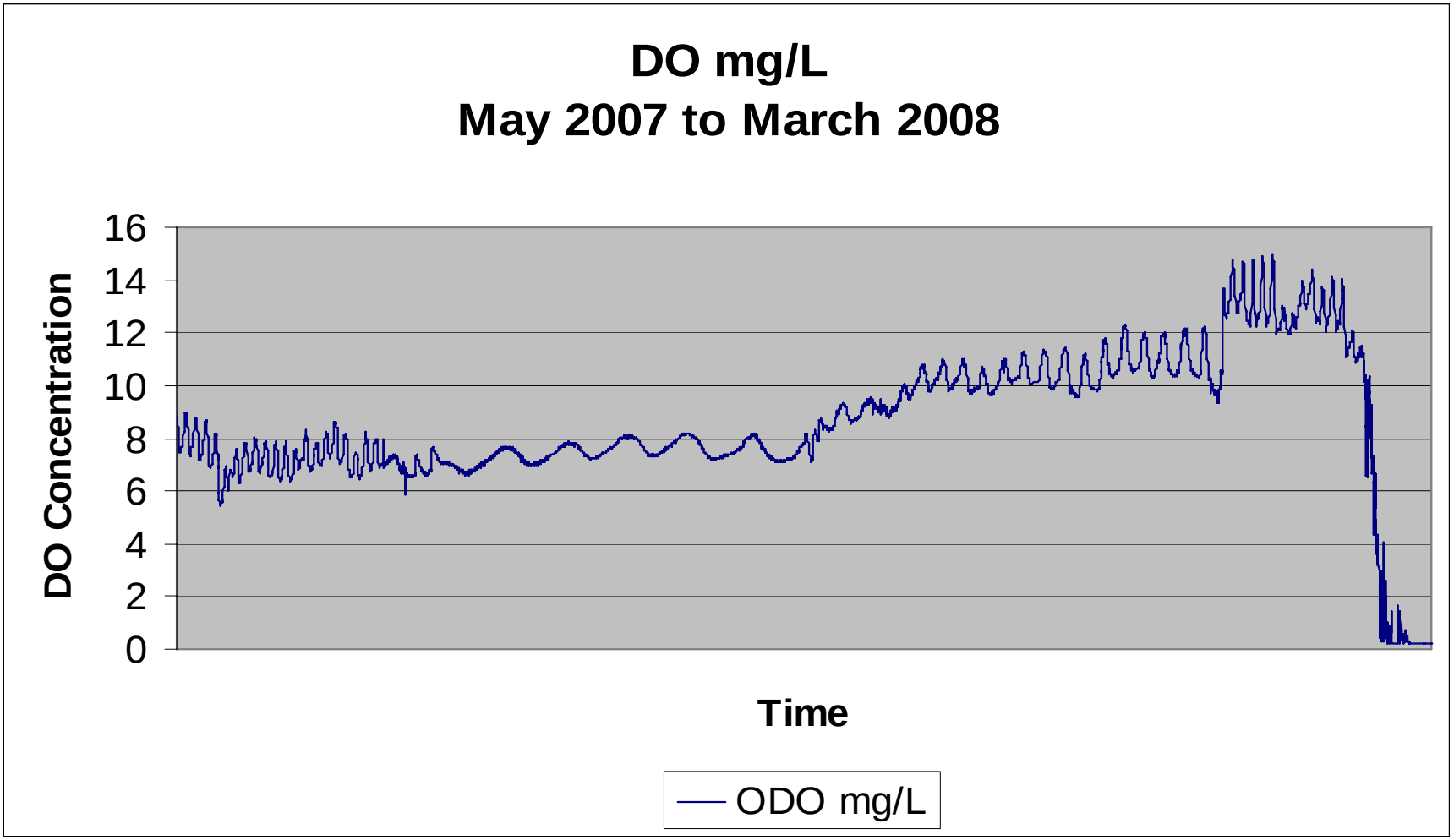
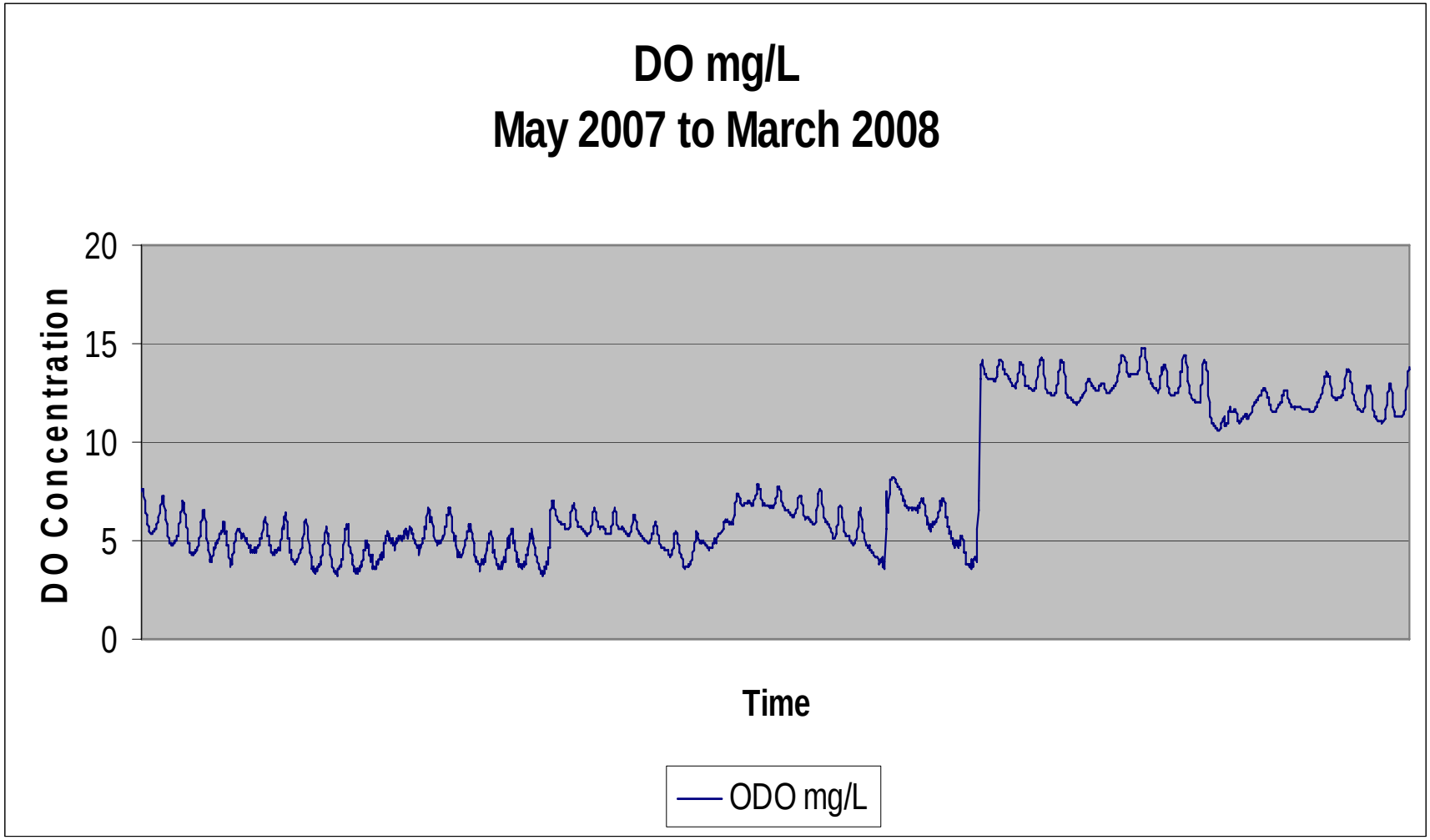
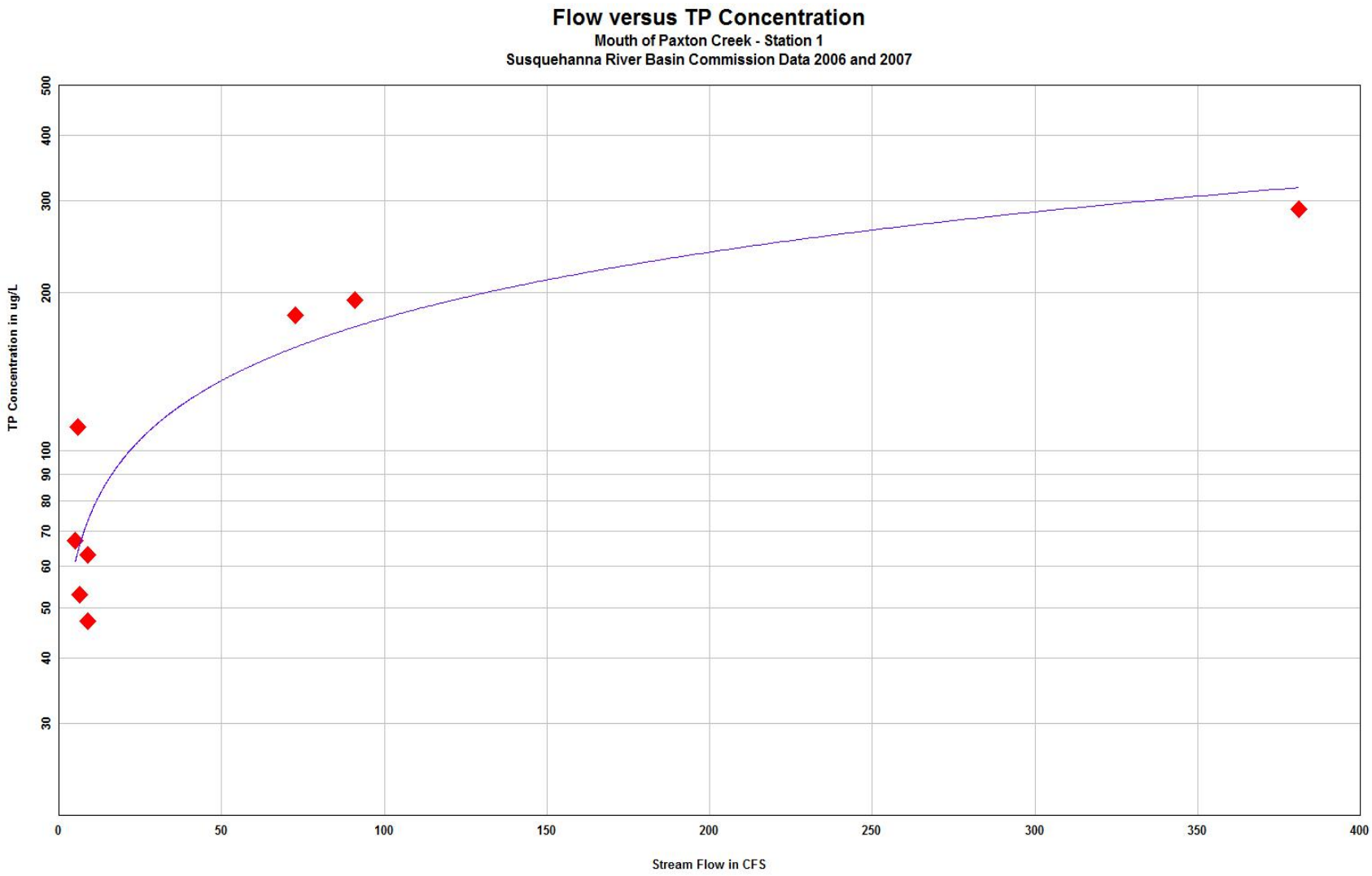
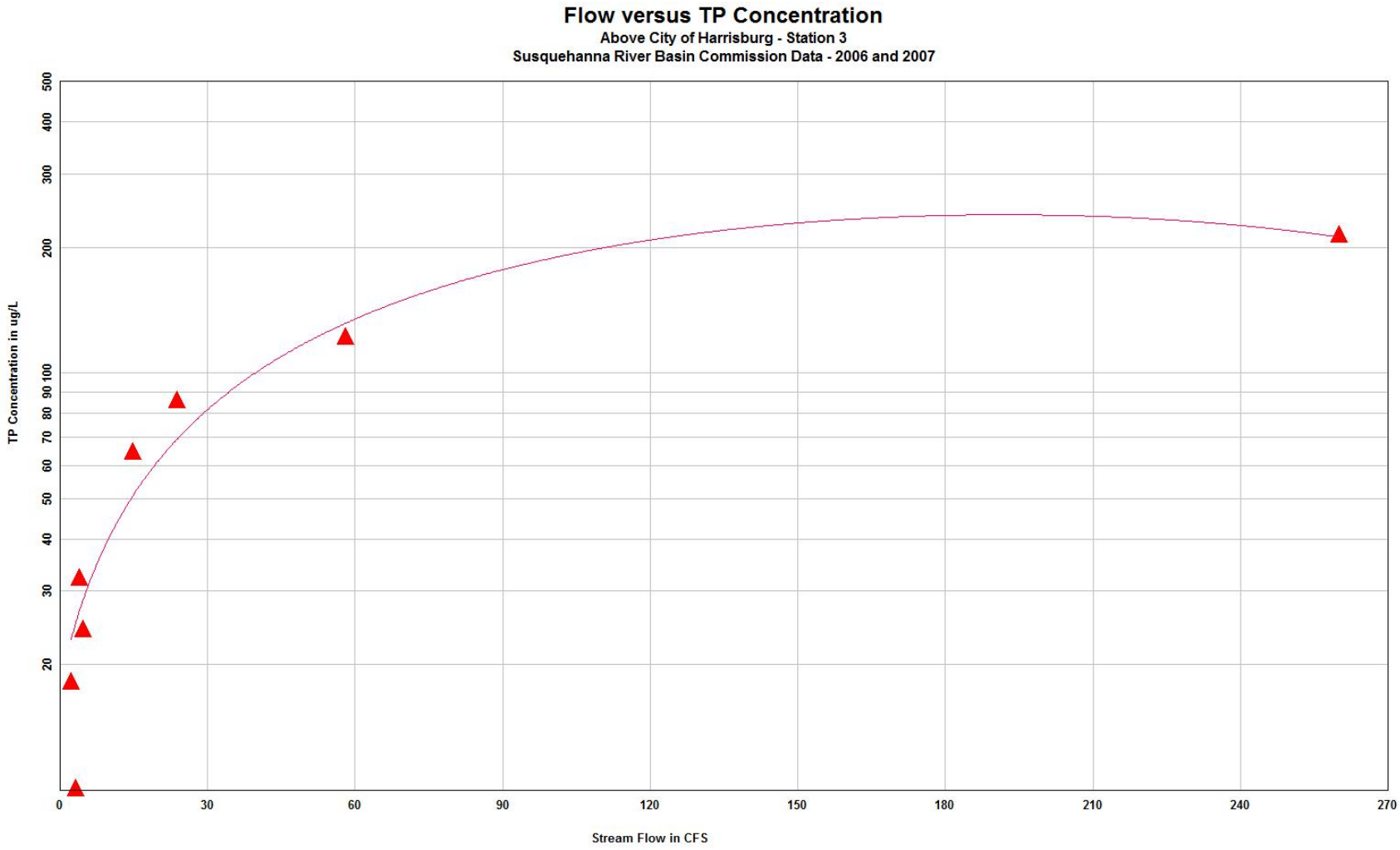


Figure 4 - Station 3 Dissolved Oxygen - SRBC




Flow versus TP Concentration
Mouth of Paxton Creek - Station 1
Susquehanna River Basin Commission Data 2006 and 2007
TP Concentration in ug/L
500
400
300
200
100
90
80
70
60
50
40
30
0
50
100
150
200
250
300
350
400
Stream Flow in CFS


Flow versus TP Concentration
Above City of Harrisburg - Station 3
Susquehanna River Basin Commission Data - 2006 and 2007
TP Concentration in ug/L
500
400
300
200
100
90
80
70
60
50
40
30
20
0
30
60
90
120
150
180
210
240
270
Stream Flow in CFS

PADEP Water Quality Data

Date	Time	Location	Station	Temp	Sp Cond	pH	DO	%DO	Alkalinity	Phosphorus T	Nitrogen T
									MG/L	MG/L	MG/L
05/08/06	11:00	Paxton Creek @ Crooked Hill and Paxton Church	PS0						175.2	0.056	1.01
05/08/06	11:25	Black Creek @ Sarkuni							147.2	0.016	0.96
05/08/06	11:45	Wildwood Lake Tributary @ pump station							126.2	0.015	0.87
05/08/06	12:00	Wildwood Lake Outlet							176.8	<0.01	0.86
05/08/06	12:45	Paxton Creek @ Industrial Rd	PC1.5						150.2	0.032	1.62
05/08/06	12:55	Asylum Run @ Cameron St							174	0.061	1.44
05/08/06	13:15	Paxton Creek @ Sycamore	PC2						142.6	0.039	1.45
05/08/06	13:20	Discharge @ Sycamore St							169.4	0.057	2.61
05/08/06	13:30	Paxton Creek @ mouth	PC3						255.2	<0.01	1.44
07/18/06		Paxton Creek @ mouth	PC3	22.4	0.694	6.98	5.98	69			
07/18/06		Paxton Creek @ Sycamore	PC2	23.1	0.675	7.04	5.97	69.9			

Date	Time	Location	Station	Temp	Sp Cond	pH	DO	%DO	Alkalinity	Phosphorus T	Nitrogen T
07/18/06		Paxton Creek @ Industrial Rd	PC1.5	23.9	0.661	6.96	4.58	54.7			
07/18/06		Paxton Creek @ Industrial Rd Duplicate	PC1.5	23.9	0.661	6.96	4.58	54.7			
07/18/06		Wildwood Lake	WWL	23.2	0.387	7.38	6.74	79			
07/18/06		Paxton Creek @ Crooked Hill and Paxton Church	PS0	23.9	0.565	7.29	7.55	89.6			
07/18/06		Paxton Creek @ Off Paxton Church	PS1	23.4	0.59	7.6	8.26	97.1			
08/07/06		Paxton Creek @ mouth	PC3	21.4	0.769	6.97	4.56	51.8			
8/7/2006		Paxton Creek @ Sycamore	PC2	21.3	0.774	7.05	4.34	48.7			
08/07/06		Paxton Creek @ Sycamore Duplicate	PC2	21.3	0.774	7.4	5.64	67.5			
8/7/2006		Paxton Creek @ Industrial Rd	PC1.5	24.4	0.726	7.4	5.64	67.5			
08/07/06		Wildwood Lake	WWL	25.1	0.602	7.46	6.14	74.7			

Date	Time	Location	Station	Temp	Sp Cond	pH	DO	%DO	Alkalinity	Phosphorus T	Nitrogen T
8/7/2006		Paxton Creek @ Crooked Hill and Paxton Church	PS0	23.5	0.61	7.6	6.56	77.4			
08/07/06		Paxton Creek @ Off Paxton Church	PS1	23.1	0.634	7.7	6.69	78			

This page left intentionally blank

General Response #14: Consideration of Nonpoint Sources

Several commenters were concerned that the TMDLs did not properly consider the impacts of nonpoint sources. EPA contracted with TetraTech to develop nonpoint source loads for each of the watersheds in Southeast Pennsylvania. The analysis was performed to support evaluation of the potential impacts of nonpoint sources, which can be significant at different times and locations, to nutrient loading in the watersheds and to provide some basis for comparing the importance of nonpoint source loading of nutrients relative to point source loadings. Note that this analysis was based on land use which, in some cases, because of the requirements of the MS4 program may actually be permitted as a point source. The report follows.

Nonpoint Source Nutrients Loading Simulation for Chester, Indian, Neshaminy, Skippack, Southampton and Wissahickon Creeks, Pennsylvania

January 2008

Prepared for:
United States Environmental Protection Agency, Region 3
Contract 68-C-02-108, Task Order #165

Prepared by:

Tetra Tech, Inc.
10306 Eaton Place, Suite 340
Fairfax, VA 22030

Table of Contents

1. Introduction 1
2. General Model Setup and Assumptions 1
   2.1. Land Use 2
   2.2. Soils 2
   2.3. Weather 4
   2.4. Nonpoint Source Characterization 7
   2.5. Hydrology Calibration 10
   2.6. Point Source Contributions 13
3. Watershed Specific Setup and Results 14
   3.1. Chester Creek 14
   3.2. Indian Creek 18
   3.3. Neshaminy Creek 22
   3.4. Skippack Creek 26
   3.5. Southampton Creek 30
   3.6. Wissahickon Creek 33
4. References 36

Appendix A Hydrology Calibration Plots

List of Tables

Table 1. Weather data used to drive GWLF simulations by watershed 4
Table 2. Weather Station Details and Patching Stations 4
Table 3. Assigned C and P Factors for Chester, Neshaminy, Skippack, Southampton and Wissahickon Creek Watersheds 8
Table 4. Nitrogen and Phosphorus Concentrations in Runoff 9
Table 5. Per Capita loading and uptake (g/day) 10
Table 6. Gage data used for hydrology calibrations 11
Table 7. Example Error Analysis Results Gage 01477000 11
Table 8. Chester Creek Septics Representation by Subbasin 16
Table 9. Assigned C and P Factor Values for the Indian Creek Watershed 18
Table 10. Indian Creek Septics Estimation by Subbasin 20
Table 11. Neshaminy Creek septics representation by subbasin 24
Table 12. Skippack Creek septics representation by subbasin 28
Table 13. Southampton Creek septics representation by subbasin 31
Table 14. Wissahickon Creek septics representation by subbasin 34

List of Figures

Figure 1. Location of Watersheds 3
Figure 2. Thiessen polygons used to assign weather station data for watershed simulations 6
Figure 3. USGS Gages used in hydrology calibration 12
Figure 4. Chester Creek Subbasins 15
Figure 5. Landuses in Chester Creek 16
Figure 6. Average Monthly Nutrient Loads for Modeled Period 17
Figure 7. Total Annual Nutrient Loads for Modeled Period 17
Figure 8. Indian Creek Subbasins 19
Figure 9. Indian Creek Landuses (2001 NLCD) 20

Figure 10. Average Monthly Watershed Nutrient Loads for Modeled Period....21
Figure 11. Total Annual Watershed Nutrient Loads for Modeled Period....21
Figure 12. Neshaminy Creek Subbasins....23
Figure 13. Landuses in Neshaminy Creek....24
Figure 14. Average Monthly Watershed Nutrient Loads for Modeled Period....25
Figure 15. Total Annual Watershed Nutrient Loads for Modeled Period....25
Figure 16. Skippack Creek subbasins....27
Figure 17. Landuses in the Skippack Creek watershed....28
Figure 18. Average Monthly Nutrient Loads for Modeled Period....29
Figure 19. Total Annual Nutrient Loads for Modeled Period....29
Figure 20. Southamption Creek subbasins....30
Figure 21. Landuses in Southampton Creek....31
Figure 22. Average Monthly Nutrient Loads for Modeled Period....32
Figure 23. Total Annual Nutrient Loads for Modeled Period....32
Figure 24. Wissahickon Creek subbasins....33
Figure 25. Landuses in the Wissahickon Creek Watershed....34
Figure 26. Average Monthly Nutrient Loads for Modeled Period....35
Figure 27. Total Annual Nutrient Loads for Modeled Period....35

1. INTRODUCTION

This document describes the results of the watershed modeling conducted by Tetra Tech (Tt) to determine the contributions of nutrients from various nonpoint sources in the six target watersheds – Chester Creek, Indian Creek, Neshaminy Creek, Skippack Creek, Southampton Creek, and Wissahickon Creek. This analysis was performed to support evaluation of the potential impacts of nonpoint sources, which can be significant at different times and locations, to nutrient loading in these areas and to provide some basis for comparing the importance of nonpoint source loading of nutrients relative to point sources.

GWLF (BasinSim) was used to simulate nonpoint source nutrient loads in each watershed. A discussion of important model setup issues and assumptions is provided, followed by, for each watershed modeled, a general description of landuses, source characterization and modeling results. Figure 1 presents an overview map of the modeled watersheds.

2. GENERAL MODEL SETUP AND ASSUMPTIONS

Nonpoint source modeling for the six watersheds was performed using the BasinSim modeling application. BasinSim integrates a graphic Windows interface, underlying databases and the GWLF model (with modifications) into a single software package. For this study, it was applied to develop dynamic nutrient load estimates from the six target watersheds for the period from 2000 to 2006.

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

Watershed data needed to run the GWLF model were generated using GIS spatial coverages, US census data, streamflow data, local weather data, and literature values. Each of the six watersheds were subdivided into subbasins to represent nutrient loadings. Delineations were based on USGS Digital Elevation Model (DEM) data, USGS 7.5 minute digital topographic maps (24K DRG - Digital Raster Graphics), and Pennsylvania's eMap stream coverage, taking into consideration major tributaries and USGS flow gage locations.

The following sections describe the data and information used for model setup, including watershed conditions (e.g., land use, soils), weather inputs, simulation of streamflow and nonpoint source representation.

2.1. Land Use

NLCD 2001 land use information from the MRLC was available for the each of the watersheds. NLCD land use coverages were used to calculate the area of each land use category in the watersheds.

2.2. Soils

Soils data were obtained from the Natural Resources Conservation Services (NRCS) State Soil Geographic (STATSGO) database for the respective watersheds.

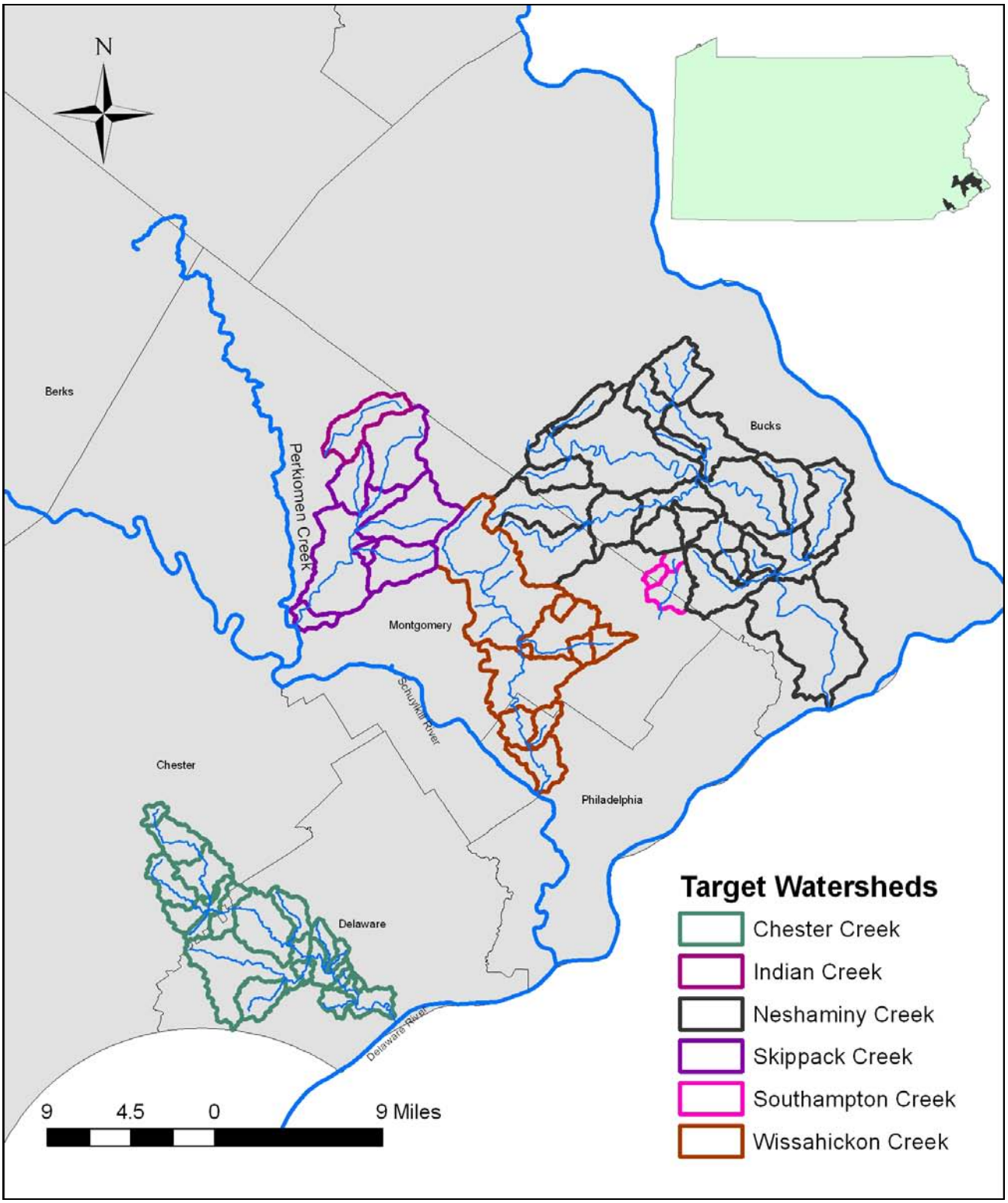


Figure 11. Location of Watersheds

2.3. Weather

Nonpoint source pollution is rainfall driven; therefore precipitation data are necessary to drive the watershed models. Local rainfall and temperature data were used to simulate flow conditions in modeled watersheds. Daily precipitation and temperature data were obtained from local National Climatic Data Center (NCDC) weather stations.

Table 4 lists the weather stations that were used to generate weather data time series for each watershed. Thiessen polygons were developed to assign specific station time series to subbasins (Figure 12). Final weather station assignments were adjusted during hydrology calibration.

Table 4. Weather data used to drive GWLF simulations by watershed

Watershed	Weather Station
Chester	14793 - Willow Grove NAS
	5390 - Marcus Hook
	9464 - West Chester 2NW
Indian	7938 - Sellersville
	3437 - Graterford 1E
	14793- Willow Grove NAS
Neshaminy	14793- Willow Grove NAS 6194 - Neshaminy Falls
	7938 - Sellersville
	14792 - Trenton Mercer Airport
	54786 - Doylestown Airport
Skippack	14793 - Willow Grove NAS
	3437 - Graterford 1E
	7938 - Sellersville
Southampton	94732 - NE Philadelphia Airport
Wissahickon	1737 - Conshohocken
	6370 - Norristown

For cases where the data record for a given weather station was not continuous, data gaps were patched with data from nearby stations to create a composite weather data file. For each weather file, Table 5 describes what stations were used to patch data gaps.

Table 5. Weather Station Details and Patching Stations

Weather File	Station Type	Station Description and Patch Station
weather_3437.dat	Summary of the day	Graterford 1E (No data values patched with 54782)
weather_5390.dat	Summary of the day	Marcus Hook (No data values patched with PA6889)
weather_6194.dat	Summary of the day	Neshaminy Falls (No data values patched with 94732)
weather_6370.dat	Summary of the day	Norristown (No data values patched with 64725 and PA1737)
weather_6889.dat	Summary of the day	Philadelphia WSCMO AP (International Airport)
weather_7938.dat	Summary of the day	Sellersville (No data values patched with 54786)
weather_9464.dat	Summary of the day	West Chester 2NW (No data values patched with PA 5390)
weather_1737prc	Summary of the day	Conshohocken (had only precipitation data,

Weather File	Station Type	Station Description and Patch Station
with6379temp.dat		this weather data file was created using temperature from PA6379 and No data values were patched with PA6370)
weather_64752.dat (starts at 2003)	Surface Airways	Wings Field Airport
weather_54786.dat	Surface Airways	Doylestown Airport
weather_94732.dat	Surface Airways	NE Philadelphia Airport
weather_54782.dat	Surface Airways	Pottstown Limerick Airport
weather_14792.dat	Surface Airways	Trenton Mercer Airport

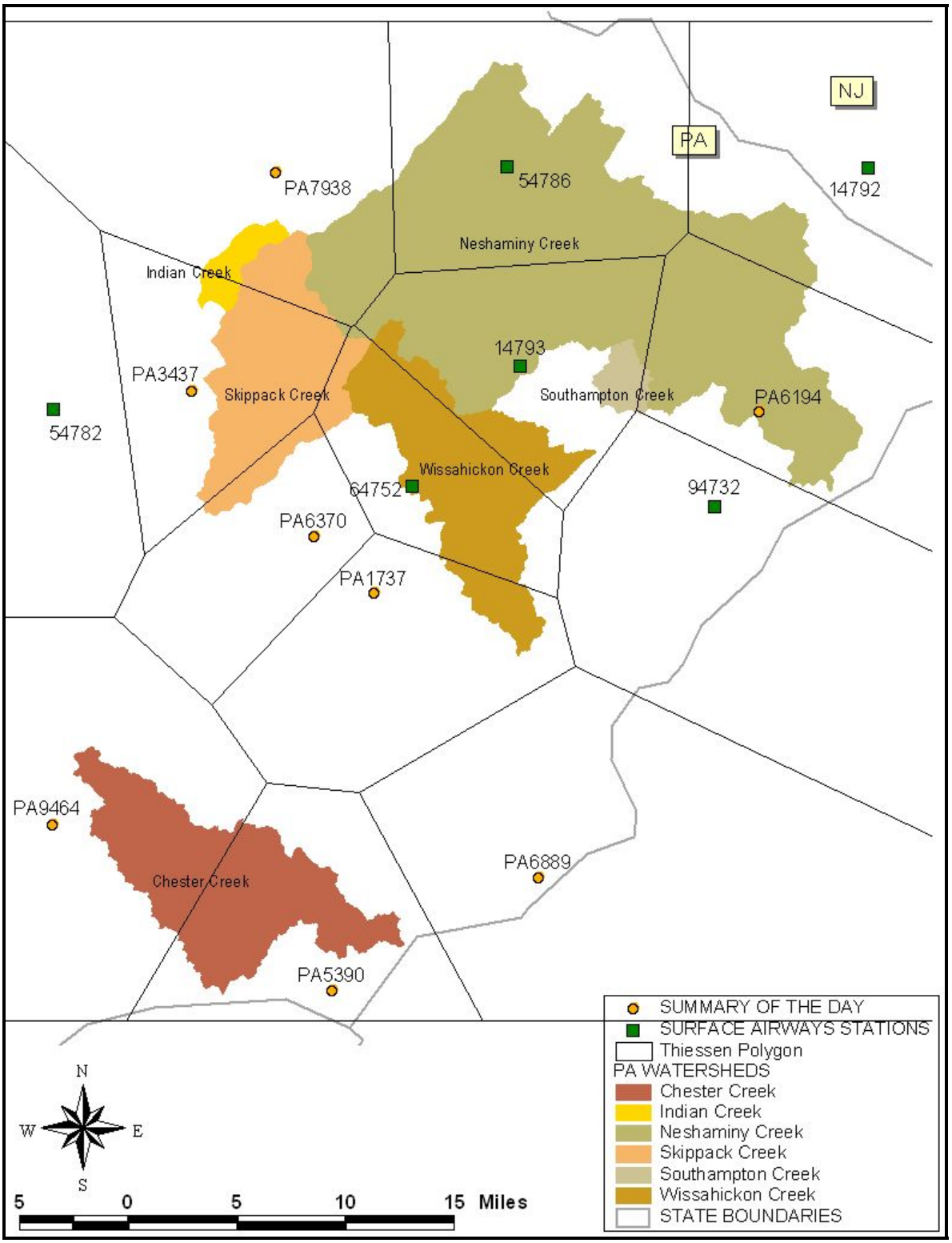


Figure 12. Thiessen polygons used to assign weather station data for watershed simulations

2.4. Nonpoint Source Characterization

In the GWLF model, the nonpoint source load calculation is affected by terrain, such as the amount of agricultural land, land slope, soil erodibility, farming practices used in the area, and by background concentrations of nutrients (nitrogen and phosphorus) 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 in the following paragraphs.

Curve number: This parameter 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 and soils coverages. CNs for the GWLF models were obtained by matching the GWLF land uses and those in the look-up tables B-1 to B-5 in the BasinSim user's manual.

Universal Soil Loss Equation (USLE): The USLE is used in GWLF to estimate the sediment contribution from the various land uses in the watershed. The USLE is calculated as:

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

where A is soil loss (tons/acre/year). R is the rainfall and runoff factor in erosion index units. GWLF calculates the R factor, but the remaining values must be entered as input. K is the soil erodibility factor, which affects the amount of soil erosion on a given unit of land. The LS factor signifies the steepness and length of slopes and directly affects the amount of soil erosion. The C factor is related to the amount of vegetative cover in an area. C values range from 0 to 1.0, with the larger values indicating greater potential for erosion. The P factor is directly related to the conservation practices used in agricultural areas. P values range from 0 to 1.0, with larger values indicating a greater potential for erosion.

The R, K and LS values vary by subwatershed, and were estimated using ArcMap. The values for C and P factors used for modeling the target watersheds were estimated based on modeled sediment erosion and are presented in Table 6. 0.5 was assigned to all the P values on the pervious land. P for urban (impervious) land is 0 since USLE is not used for urban land calculation. Soil erodibility factor (K) values were derived from the STATSGO soil layer and component database. The LS values were determined for each land use type within each subwatershed using DEM data together with the subwatershed boundaries.

Table 6. Assigned C and P Factors for Chester, Neshaminy, Skippack, Southampton and Wissahickon Creek Watersheds

Landuse	C factor	P factor
Pasture/Hay	0.04	0.50
Crop	0.20	0.50
Open Water	0.03	0.50
Developed Open Space	0.03	0.50
Developed Low Intensity	0.03	0.50
Developed Medium Intensity	0.03	0.50
Developed High Intensity	0.03	0.50
Barren	0.03	0.50
Deciduous Forest	0.02	0.50
Evergreen Forest	0.02	0.50
Mixed Forest	0.02	0.50
Woody Wetland	0.02	0.50
Herbaceous Wetland	0.02	0.50
Impervious Lands	0.0	0.0

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

Unsaturated available water-holding capacity: This parameter relates to the amount of water that can be stored in the soil and affects runoff and infiltration.

Dissolved nitrogen and phosphorus in runoff: This parameter varies according to land use/cover type. Reasonable values have been established in the literature. This rate, reported in milligrams per liter, can be readjusted based on local conditions such as rates of fertilizer application and farm animal populations. Default values reported in literature (tables B-15 and B-16 in the GWLF manual) were identified and used for the various land uses in the modeled watersheds as shown in Table 7.

Table 7. Nitrogen and Phosphorus Concentrations in Runoff

Land Use	N (mg/L)	P (mg/L)
Pasture/Hay	3.00	0.25
Crop	2.90	0.26
Open Water	0.19	0.006
Developed Open Space	1.50	0.12
Developed Low Intensity	1.50	0.12
Developed Medium Intensity	1.50	0.12
Developed High Intensity	1.50	0.12
Barren	0.19	0.006
Deciduous Forest	0.19	0.006
Evergreen Forest	0.19	0.006
Mixed Forest	0.19	0.006
Woody Wetland	0.19	0.006
Herbaceous Wetland	0.19	0.006
Open Space_IMP	0.09	0.0112
Low Intensity _IMP	0.09	0.0112
Medium Intensity _IMP	0.056	0.0067
High Intensity _IMP	0.056	0.0067

Nutrient concentrations in runoff over manured areas: These concentrations are user-specified concentrations for nitrogen and phosphorus 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 concentrations 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. Limited information regarding manure application location and rates was available from a local conservation district (Montgomery County). Because agricultural lands in the watershed are generally low-intensity, manure application was only simulated based on values for cropland. The default values reported in literature for cropland were used (Table B-15 from the GWLF manual for manure left on soil surface for the land use category Corn – 12.2 mg/L N and 1.90 mg/L P).

Background nitrogen and phosphorus concentrations in groundwater: Subsurface concentrations of nutrients (primarily nitrogen and phosphorus) contribute to the nutrient loads in streams. Nutrient concentrations in groundwater were based on the results from a nationwide study of mean dissolved nutrients as measured in streamflow (as reported in Haith et al. 1992). For the modeled watersheds the groundwater concentrations were assumed to be approximately 0.021 mg/L for phosphorus and 0.71 mg/L for nitrogen, based on values for eastern U.S. watersheds (Table B-16 in the GWLF manual).

Background nitrogen and phosphorus concentrations in soil: Because soil erosion results in the transport of nutrient-laden sediment to nearby surface waterbodies, reasonable estimates of background concentrations in soil must be provided. Because there were no local soil concentration data to support the modeling effort, literature values were used. The percent sediment weight of nitrogen and phosphorus in the top 30 cm of soil was calculated based on maps in the GWLF manual (Figures B-3 and B-4 in the GWLF manual) as 1,500 mg/kg and 660 mg/kg, respectively.

Septic Characterization: The population estimated to be served by septics within each subwatershed was determined based on US Census data, the land use coverage, and the watershed delineation shapefile. Septics were assumed only on developed low and medium intensity land uses. Failure rates were assumed based on the following breakdown of functioning categories:

- Failing assumed 10% of total number of septic systems
- Direct Discharging assumed 10% of failing septic systems
- Normal assumed to be remaining systems
- Short-circuited systems were not simulated

Assumptions used for estimating septic contributions are described in Table 8:

Table 8. Per Capita loading and uptake (g/day)

Per Capita Daily N Load		12
Per Capita Daily P Load		1.5
Per Capita Daily N uptake by plants	*Growing Season*	1.6
	Non Growing Season	0
Per Capita Daily P uptake by plants	*Growing Season*	0.4
	Non Growing Season	0

Other less important factors that can affect sediment and nutrient loads in a watershed also are included in the model. More detailed information about these parameters and those outlined above can be obtained from the GWLF User's Manual (Haith et al. 1992). Pages 15 through 41 of the manual provide specific details that describe equations and typical parameter values used in the model.

2.5. Hydrology Calibration

Streamflow data are generally used to test or calibrate watershed hydrologic parameters for the GWLF model. Seven USGS gage stations located in the modeled watersheds were used for hydrology calibration: four in the Neshaminy Creek watershed; 2 stations in the Wissahickon Creek watershed; and 1 in the Chester Creek watershed. An eighth station, located approximately 1.5 miles southwest of the Indian Creek watershed on the East Branch Perkiomen Creek was also used, (Table 9). For calibration, model predicted flows were adjusted to account for point source flows (monthly average flows based on historical monitoring data) then compared to gage flows. Figure 13 shows the subbasins and the locations of the USGS gages used in hydrology calibration

Examination of the topographic map reveals the existence of a reservoir, Lake Galena, in subbasin 11 in the Neshaminy Creek watershed. GWLF does not have the ability to simulate regulated reservoir/lake flows. As a result, modeled flows at station 01464720 were over-predicted significantly. With the exception of this gage, flow results at all the evaluated stations are mainly within recommended hydrology calibration ranges. Table 10 shows example error

analysis results for modeled and observed flows at Gage 01477000. Adjustments to hydrology parameters were made to match as closely as possible the criteria listed in the "Recommended Criteria" column. See Appendix A for plots showing results of the hydrology calibration and error results.

Table 9. Gage data used for hydrology calibrations

Site_Number	Site_Name	Dec_Lat.	Dec_Lon	Drainage
01464720	NB Neshaminy Creek at Chalfont, PA	40.288162	-75.203785	31.5
01464750	Neshaminy Creek near Rushland, PA	40.260385	-75.034892	91
01465200	Neshaminy Creek near Penns Park, PA	40.251950	-75.008321	157.46
01465500	Neshaminy Creek near Langhorne, PA	40.173998	-74.956834	210
01472810	East Br. Perkiomen Creek near Schwenksville, PA	40.258714	-75.428787	59
01473900	Wissahickon Creek at Fort Washington, PA	40.123999	-75.219899	40.8
01474000	Wissahickon Creek at Mouth, Philadelphia, PA	40.015390	-75.206846	64
01477000	Chester Creek near Chester, PA	39.869001	-75.408249	61.1

Table 10. Example Error Analysis Results Gage 01477000

Errors (Simulated-Observed)	Error Statistics	Recommended Criteria
Error in total volume	1.08	10
Error in 50% lowest flows	-7.49	10
Error in 10% highest flows	-5.37	15
Seasonal volume error - Summer	13.71	30
Seasonal volume error - Fall	28.72	30
Seasonal volume error - Winter	-9.69	30
Seasonal volume error - Spring	-21.28	30
Error in storm volumes	-10.65	20
Error in summer storm volumes:	8.49	50

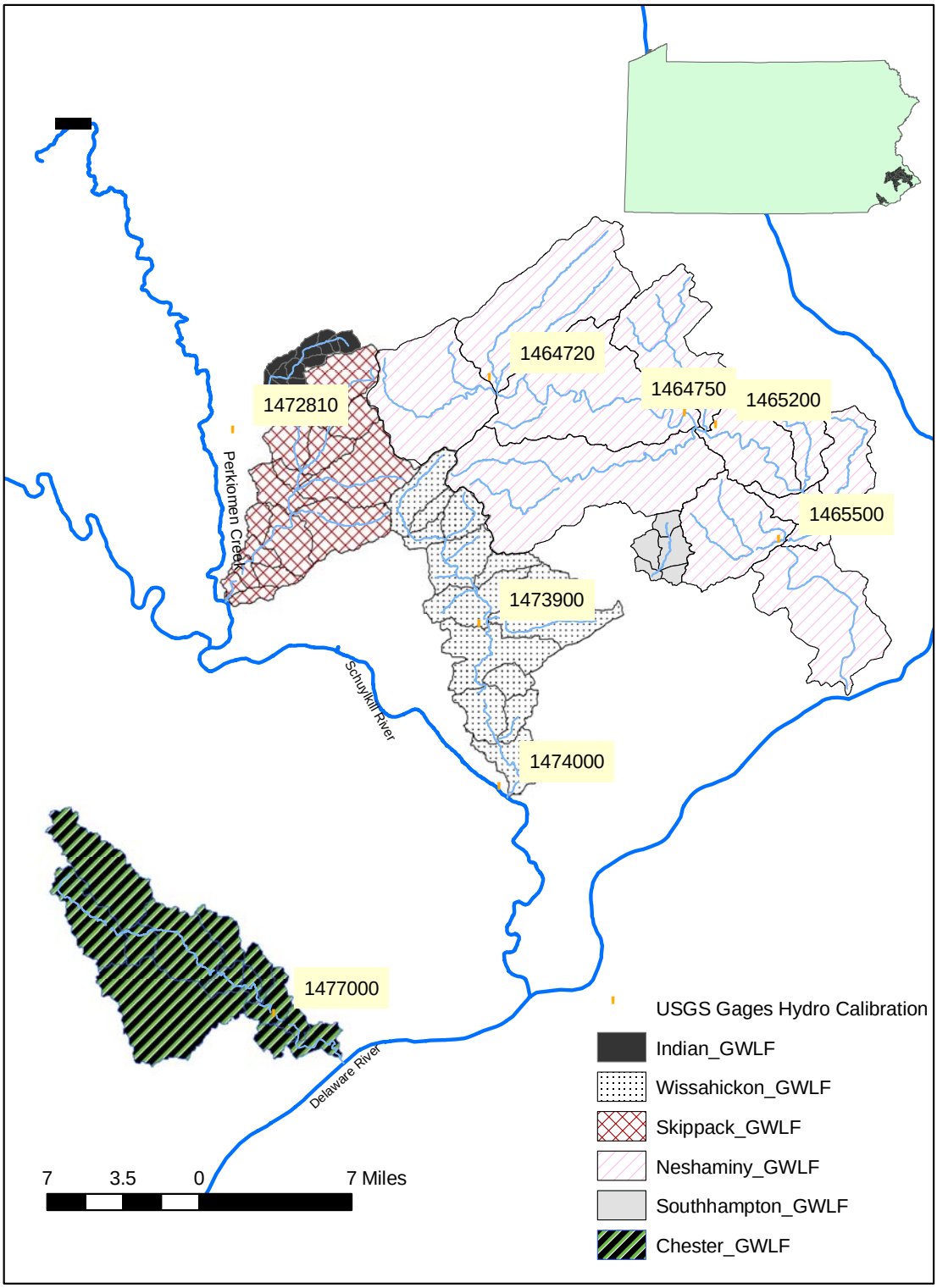


Figure 13. USGS Gages used in hydrology calibration

2.6. Point Source Contributions

Overall, point sources are considered to be the major contributor of nutrients to the modeled watersheds. For each of the six watersheds, Total Maximum Daily Loads are being completed, which will include interpretation of these watershed modeling results in developing appropriate loading allocations for nonpoint and point sources. Because it is expected that each of those studies will make use of more detailed point source monitoring data than were available for this exercise, and to avoid duplication of effort, an in-depth comparison of watershed loading and point source loading is not included in this report. For this modeling effort, point source discharges were only represented with respect to effluent volumes in an effort to perform the hydrology calibration. For a thorough comparison of the two types of loading in each watershed, the reader is referred to the appropriate TMDL.

3. WATERSHED SPECIFIC SETUP AND RESULTS

General assumptions and procedures for model setup for each watershed were discussed in the previous section. The following paragraphs provide discussion of any specific setup details for a particular watershed, the landuse breakdown and septics representation in each watershed, as well as the subbasin delineation used for the GWLF simulation. Average monthly and annual watershed load results for each watershed are presented.

3.1. Chester Creek

The Chester Creek watershed is approximately 66 square miles and is located in Delaware and Chester Counties, south and west of Philadelphia. Chester Creek and its tributaries were included on the 1996 Pennsylvania 303(d) list as impaired due to other organics and subsequent listing cycles also include priority organics, suspended solids, and unknown causes. The Chester Creek watershed is comprised of urban, residential and agricultural lands between Philadelphia, Pennsylvania and Wilmington, Delaware. A reservoir is located on the East Branch of Chester Creek near Goshen, and Brinton Lake is located in the headwaters of West Branch of Chester Creek. Rocky Run and Green Creek are headwater tributaries to Chester Creek and both are considered high quality cold water fisheries. It encompasses an array of landuses and activities, which range from very urban in the eastern portion to residential and rural in the west. Major landuse categories include 34% developed, mostly open and low intensity; 34% agricultural; and 29% forested. There are 34 NPDES permitted facilities discharging to Chester Creek and its tributaries. Figure 14 shows the subbasin delineation used in the GWLF simulation;

Figure 15 shows the landuses in the waterhsed. Table 11 provides values used to represent septics in the watershed. Figure 16 and Figure 17 show average monthly and total annual watershed loads for the period modeled. Average annual watershed nitrogen loading in Chester Creek is approximately 533,661 lb/yr while average annual phosphorus loading is 35,016 lb/yr.

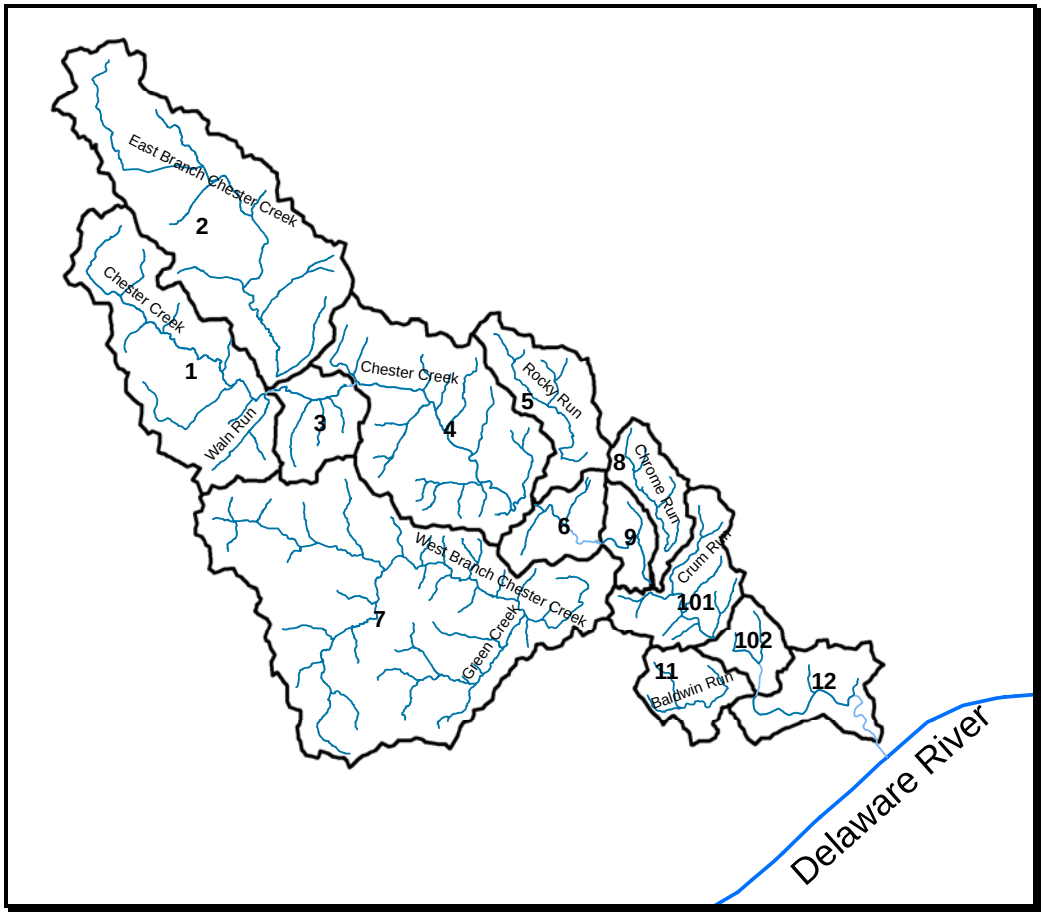


Figure 14. Chester Creek Subbasins

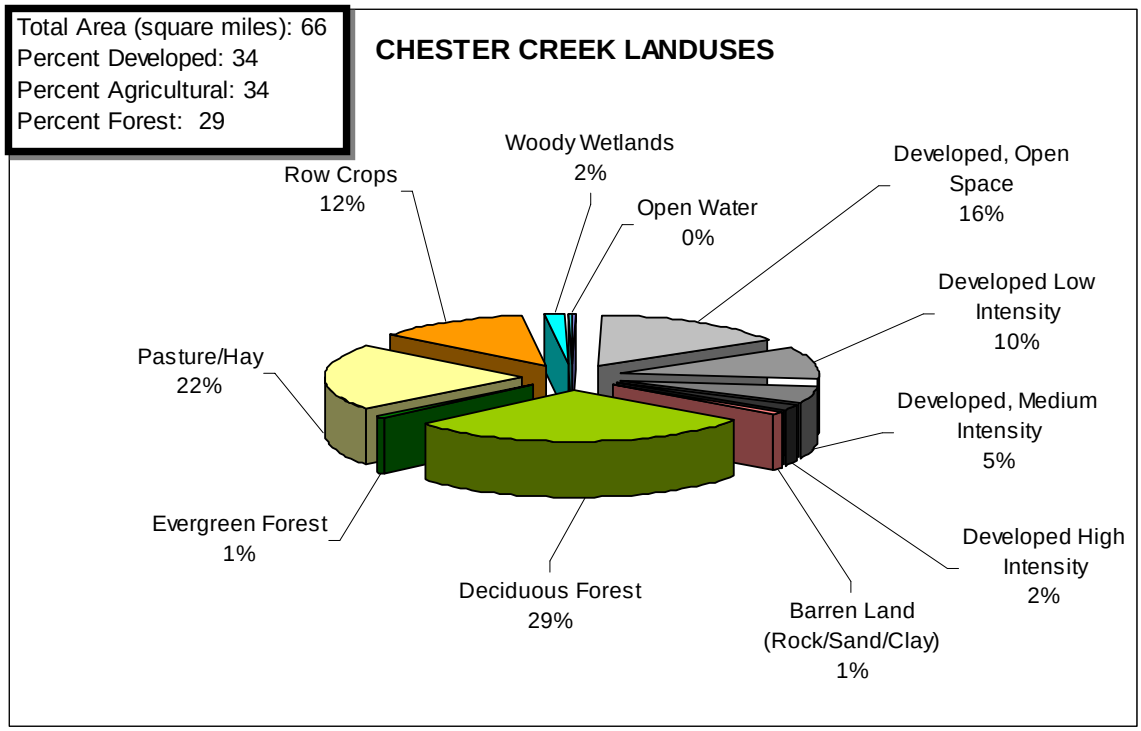


Figure 15. Landuses in Chester Creek

Table 11. Chester Creek Septics Representation by Subbasin

Subbasin	Normal (89%)	Ponding (10%)	Short-circuit (0%)	Direct (1%)	Total
1	6412	720	0	72	7204
2	4267	479	0	48	4794
3	2100	236	0	24	2359
4	2874	323	0	32	3229
5	1126	127	0	13	1265
6	556	63	0	6	625
7	11404	1281	0	128	12814
8	1046	118	0	12	1175
9	530	60	0	6	595
101	1163	131	0	13	1307
102	254	29	0	3	285
11	1042	117	0	12	1171
12	92	10	0	1	103

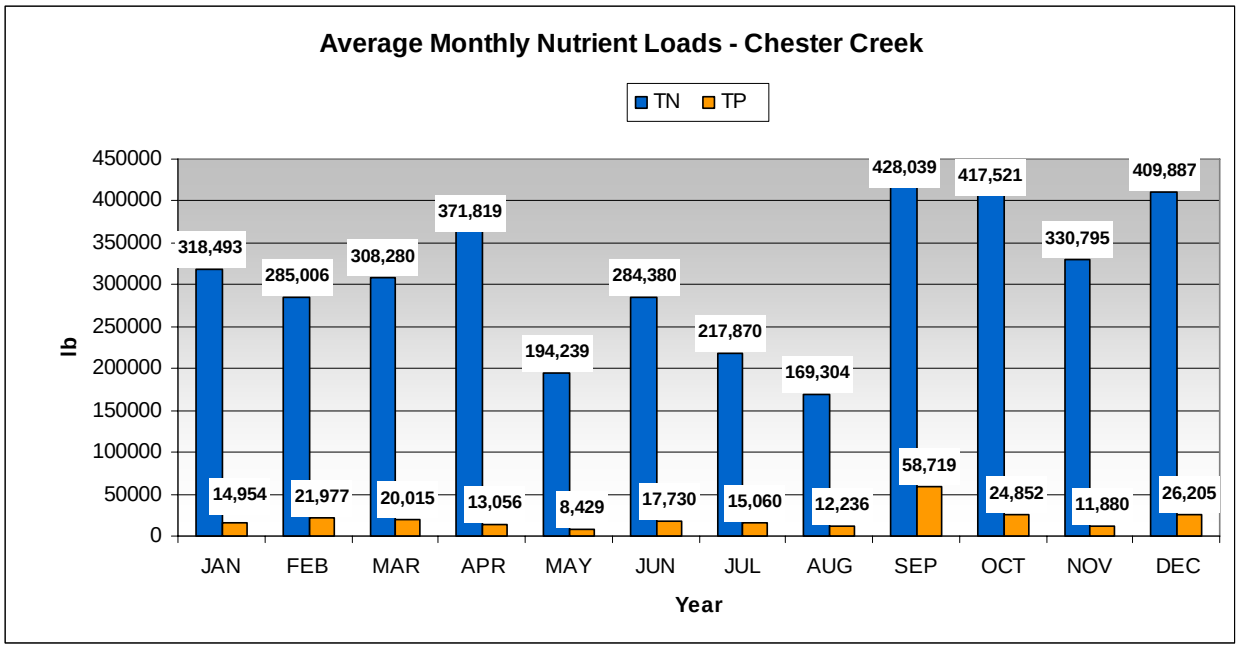


Figure 16. Average Monthly Nutrient Loads for Modeled Period

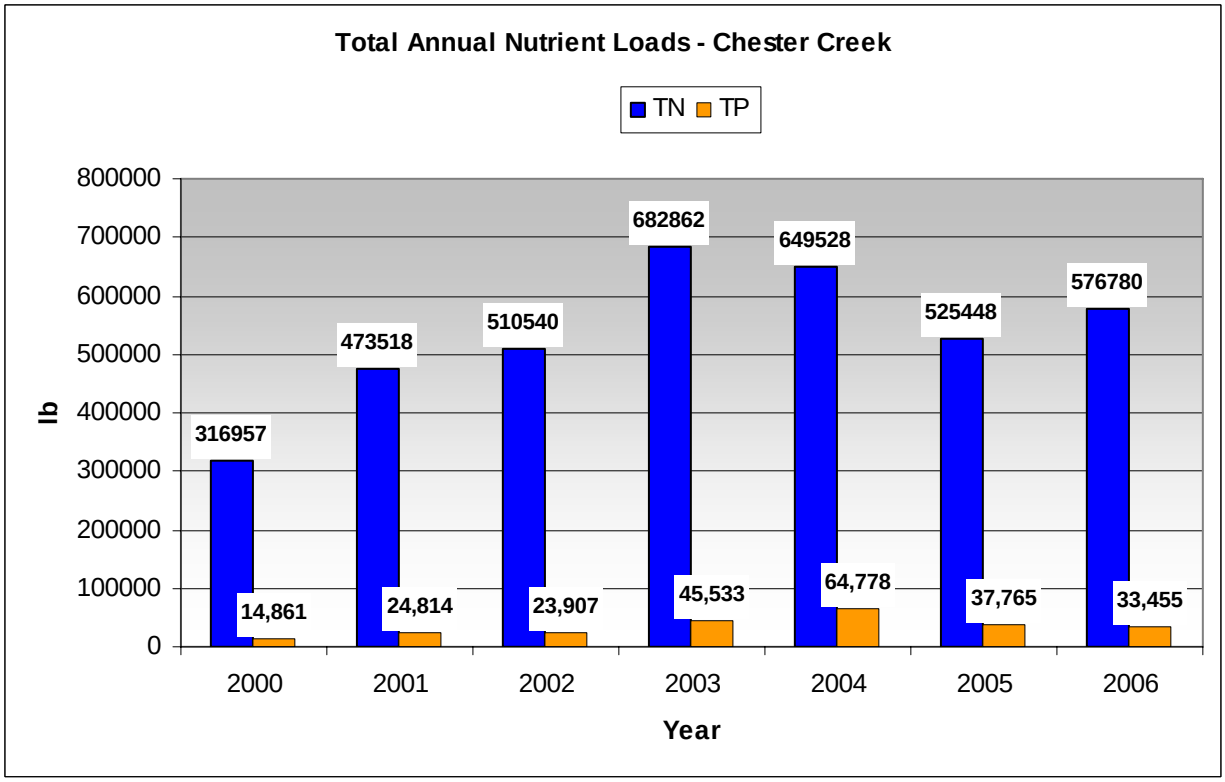


Figure 17. Total Annual Nutrient Loads for Modeled Period

3.2. Indian Creek

Indian Creek, a third-order stream with a drainage area of approximately 7 square miles, flows approximately 6.1 miles, through areas of Montgomery County, Pennsylvania . Its watershed includes portions of eight municipalities and has three National Pollution Discharge Elimination System (NPDES) permitted discharges. About 19 tributaries (tributary 01182 through tributary 01200) drain to Indian Creek, some of which are intermittent. Various degrees of residential development (low intensity residential, medium intensity residential and high intensity residential) are scattered throughout the watershed. The mainstem of Indian Creek flows southwesterly and discharges to the East Branch Perkiomen Creek. The nearest U.S. Geological Survey (USGS) stream gauging station (01472810) is located on East Perkiomen Creek near Schwenksville. The modeled period for the Indian Creek watershed differed from that of the other watersheds modeled; it coincided with the time period modeled for the Indian Creek TMDL and covered the period from April 2004 to December 2006. Therefore nutrient loading estimates for Indian Creek are based on two years of model results.

Variables used for the USLE equation also differ slightly from those used to represent the other watersheds. The R, K and LS values vary by subwatershed, and were estimated using a GIS tool/ArcView extension based on developed by Tetra Tech. The values for C and P factors used for modeling the Indian Creek watershed are presented in Table 12. Soil erodibility factor (K) values were derived from the STATSGO soil layer and component database. The LS values were determined for each land use type within each subwatershed using DEM together with the subwatershed boundaries. The C value for each land use was determined from the USLE guide book *Predicting Rainfall Erosion Losses, A Guide to Conservation Planning* (USDA 537).

Table 12. Assigned C and P Factor Values for the Indian Creek Watershed

Land Use	C factor	P factor
Low Intensity Residential	0.001	1
High Intensity Residential	0.001	1
High Intensity Commercial/Industrial/Transportation	0.001	1
Paved_Roads	0.01	1
Bare Rock/Sand/Clay	0.1763	
Deciduous Forest	0.0001	1
Evergreen Forest	0.0001	1
Pasture	0.0433	0.88
Agriculture	0.2067	0.725
Wetlands	0.005	1

Daily precipitation and temperature data were obtained from local National Climatic Data Center (NCDC) weather stations in close proximity to the Indian Creek watershed – Sellersville and Graterford. Since the Graterford station had good data coverage (96%) for both precipitation and temperature, it was used to construct the weather file used in modeling. Data gaps in the Graterford station were filled using the Sellersville station and a composite weather file was developed. The Graterford station is located approximately 6.5 miles south of the Indian Creek

watershed, while the Sellersville station is located 4.2 miles north east of the Indian Creek watershed. Since the NCDC summary of the day data at the two stations did not extend beyond 12/31/2004, the Willow Grove NAS surface airways station (14793) located approximately 14 miles south east of the Indian Creek was used to create another set of weather files.

Figure 18 shows the subbasin delineation for watershed modeling; Figure 19 provides the landuse breakdown and Table 13 shows the estimated number of septic systems in the watershed by subbasin. Figure 10 and Figure 11 show results of the model simulation, average monthly and total annual nutrient loads from the watershed.

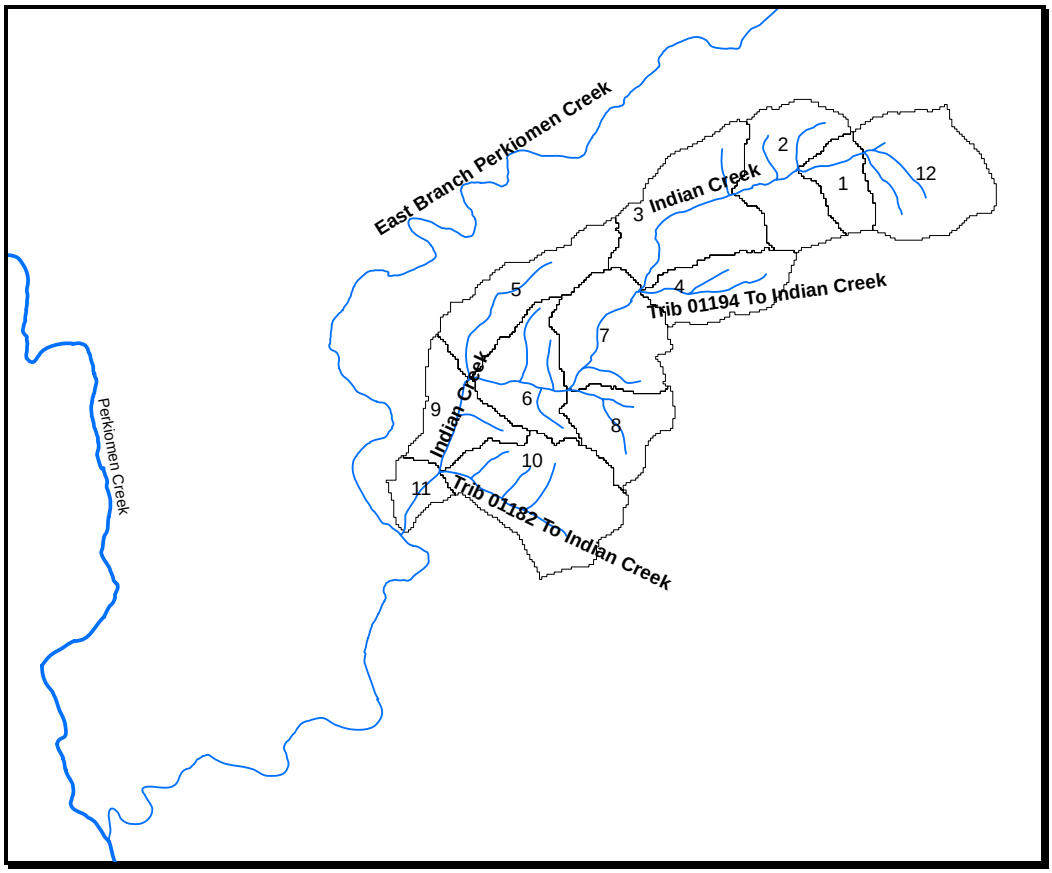


Figure 18. Indian Creek Subbasins

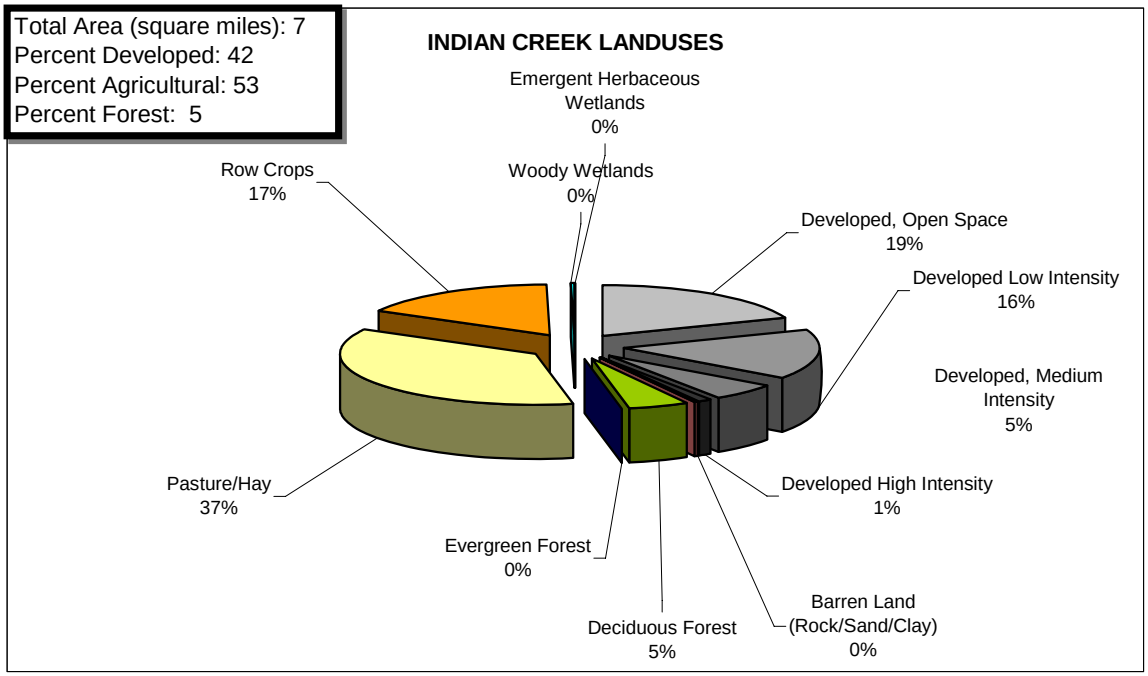


Figure 19. Indian Creek Landuses (2001 NLCD)

Table 13. Indian Creek Septics Estimation by Subbasin

Subbasin	Normal (89%)	Ponding (10%)	Short-circuit (0%)	Direct(1%)	Total
1	332	37	0	4	373
2	451	51	0	5	507
3	492	55	0	6	553
4	428	48	0	5	480
5	160	18	0	2	180
6	323	36	0	4	363
7	195	22	0	2	219
8	418	47	0	5	470
9	80	9	0	1	90
10	834	94	0	9	937
11	12	1	0	0	13
12	280	32	0	3	315

Three point sources are located in the Indian Creek watershed. Combined, they are permitted to discharge approximately 7,500 lb/yr of total phosphorus and 48,000 lb/yr of total nitrogen. Actual discharges are slightly less than permitted levels. Average annual watershed nitrogen loading in Indian Creek is approximately 21,435 lb/yr while average annual phosphorus loading is 3,075 lb/yr.

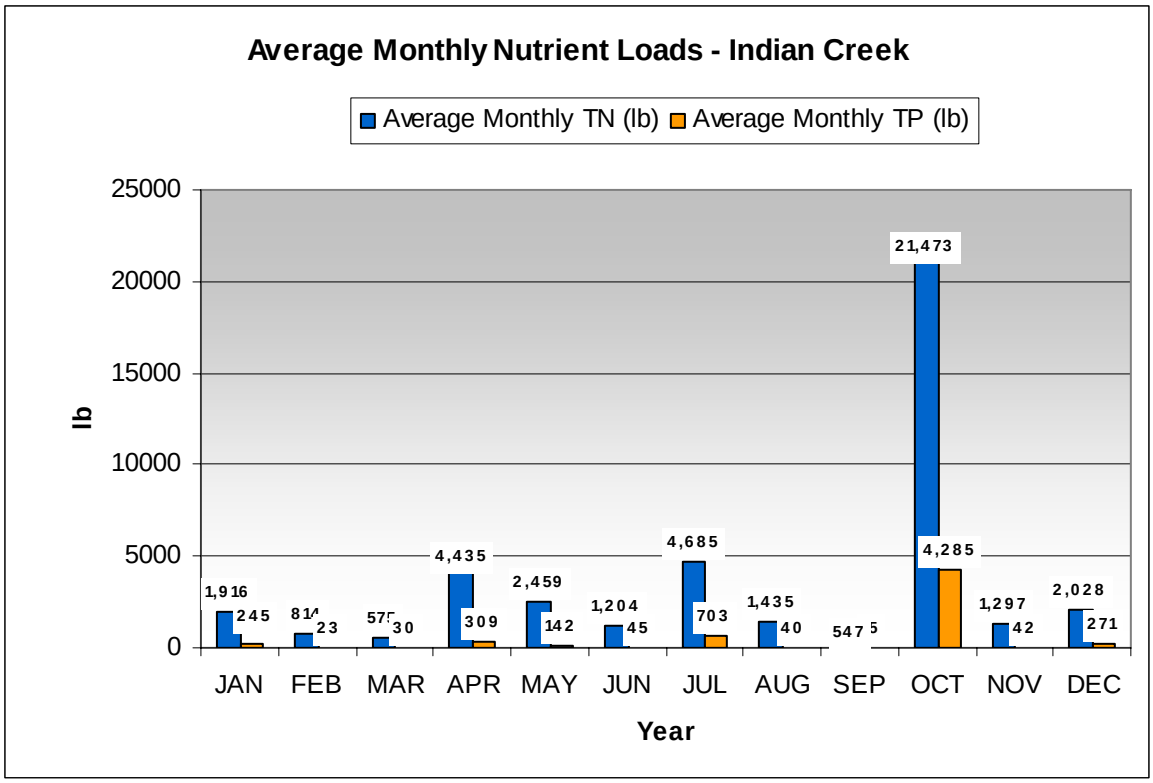


Figure 20. Average Monthly Watershed Nutrient Loads for Modeled Period

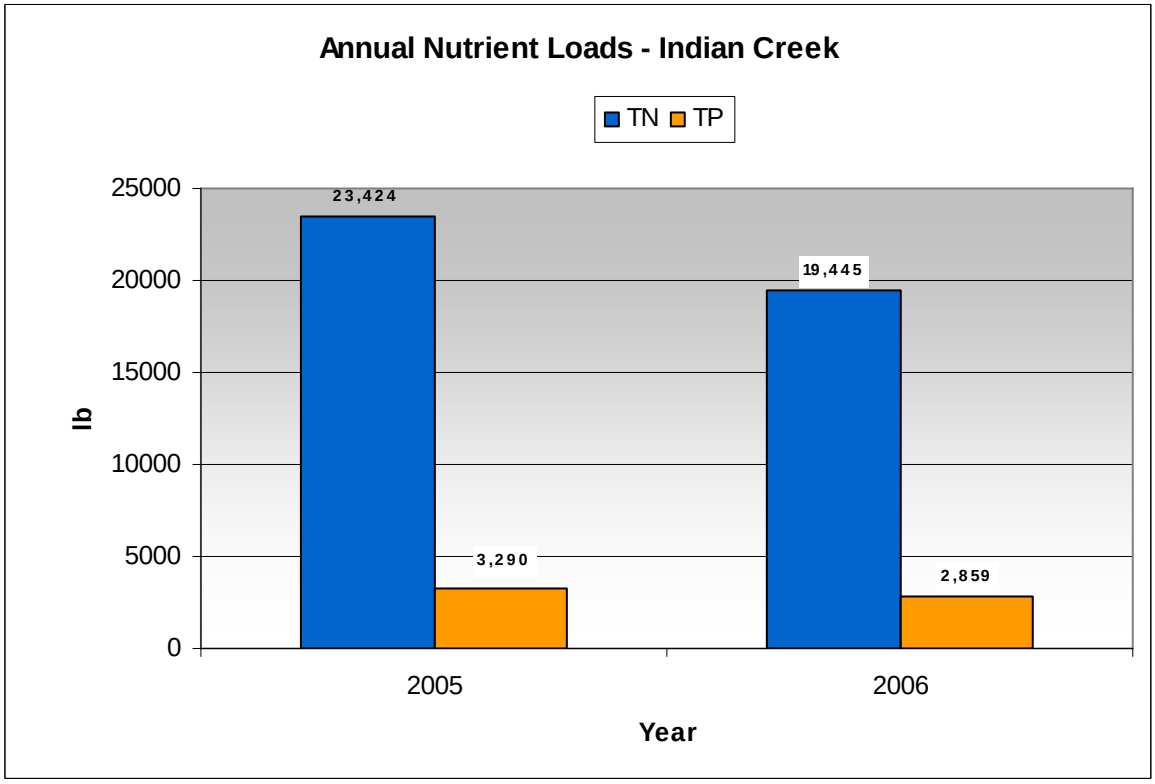


Figure 21. Total Annual Watershed Nutrient Loads for Modeled Period

3.3. Neshaminy Creek

The Neshaminy Creek watershed is located in Bucks and Montgomery Counties, Pennsylvania, north of Philadelphia. The watershed covers approximately 232 square miles, and is largely urbanized. Landuses are approximately 24% developed, 38% agriculture, 36% wooded, and 2% other (primarily wetland and disturbed), and has approximately 418.3 miles of streams. Since 1996, 203.3 miles of these streams (about 48.6%) have been included on Pennsylvania's 303(d) list of streams having aquatic life use
impairments. Past assessments of pollutant loading in the watershed include TMDLs for nutrients and sediment developed in December 2003 (PADEP 2003). From that effort, it was determined that the municipal wastewater treatment plants in the watershed contribute about 25% of the total phosphorus load on an annual basis. During low-flow periods, effluent discharges may make up more than 90% of total stream flow in many reaches. Significant sources of phosphorus and sediment include erosion from developing areas and agriculture, and streambank erosion. Figure 22 provides the subbasin delineation for modeling; Figure 23 shows the landuse breakdown. Table 14 lists the estimated septic systems in the watershed and Figure 24 and Figure 25 provide the watershed model results for monthly and annual nutrient loading. Critical loading months are October to December. Average annual watershed nitrogen loading in Neshaminy Creek is approximately 1,665,316 lb/yr while average annual phosphorus loading is 155,277 lb/yr.

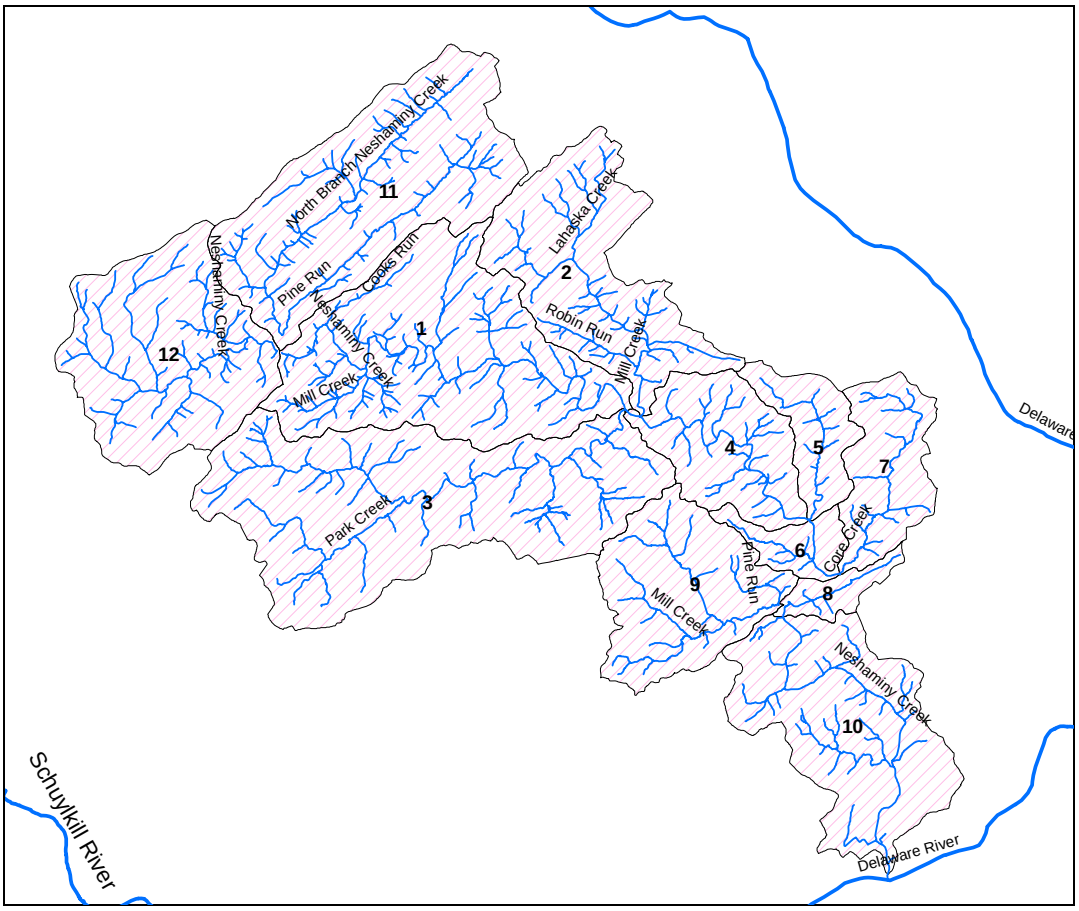


Figure 22. Neshaminy Creek Subbasins

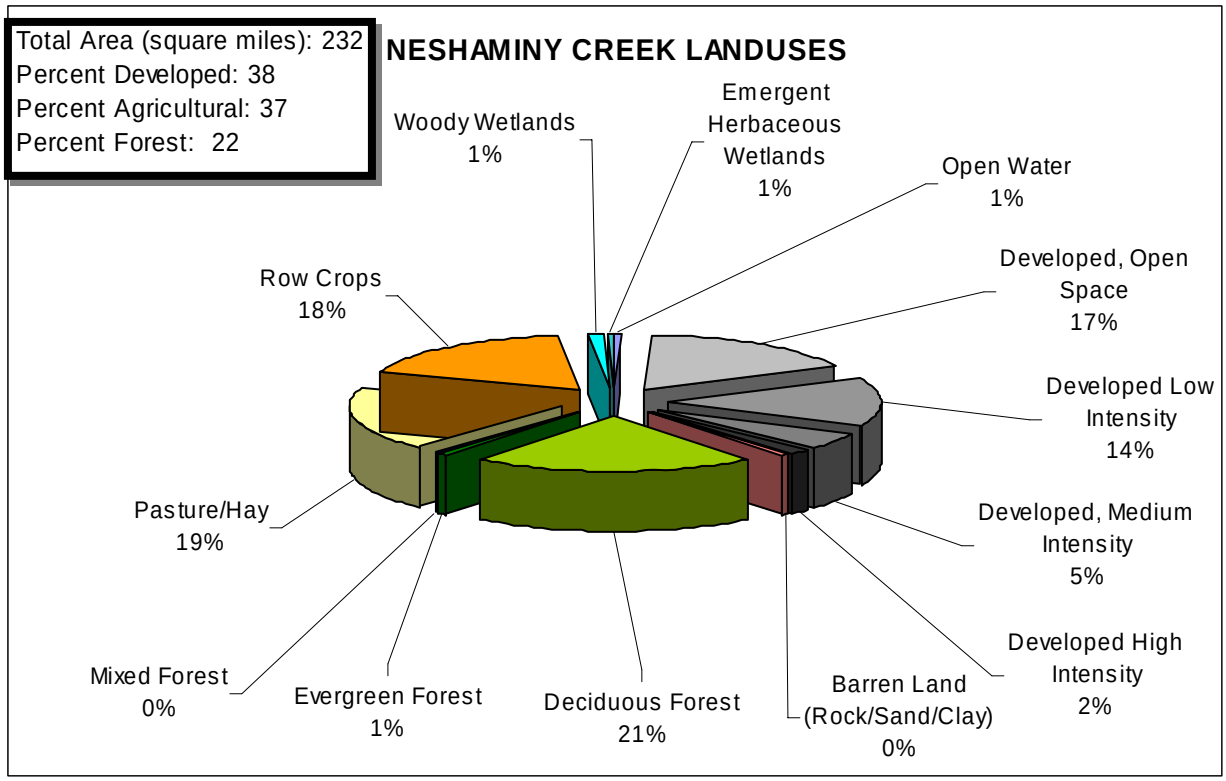


Figure 23. Landuses in Neshaminy Creek

Table 14. Neshaminy Creek septics representation by subbasin

Subbasin	Normal (89%)	Ponding (10%)	Short-circuit (0%)	Direct(1%)	Total
1	16548	1859	0	186	18593
2	8054	905	0	90	9049
3	8330	936	0	94	9359
4	2677	301	0	30	3008
5	951	107	0	11	1069
6	838	94	0	9	942
7	1164	131	0	13	1308
8	170	19	0	2	191
9	2537	285	0	29	2851
10	1249	140	0	14	1403
11	11396	1280	0	128	12804
12	5159	580	0	58	5797

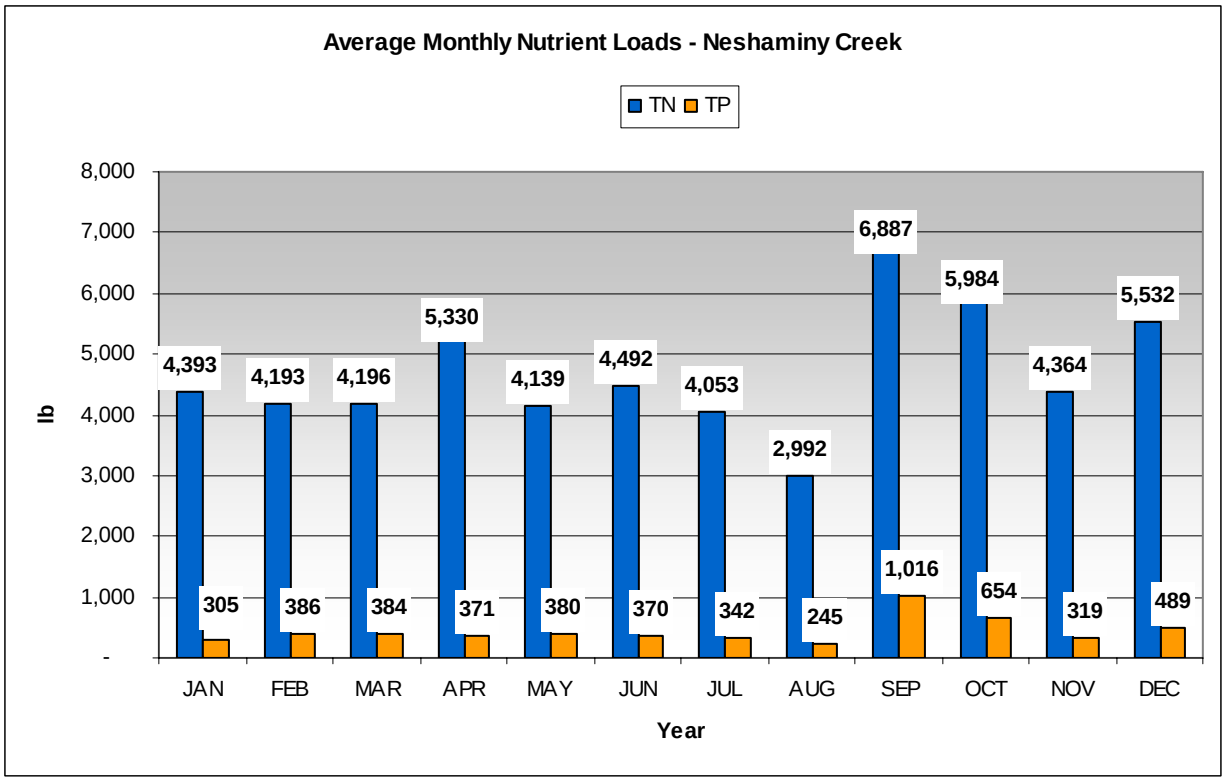


Figure 24. Average Monthly Watershed Nutrient Loads for Modeled Period

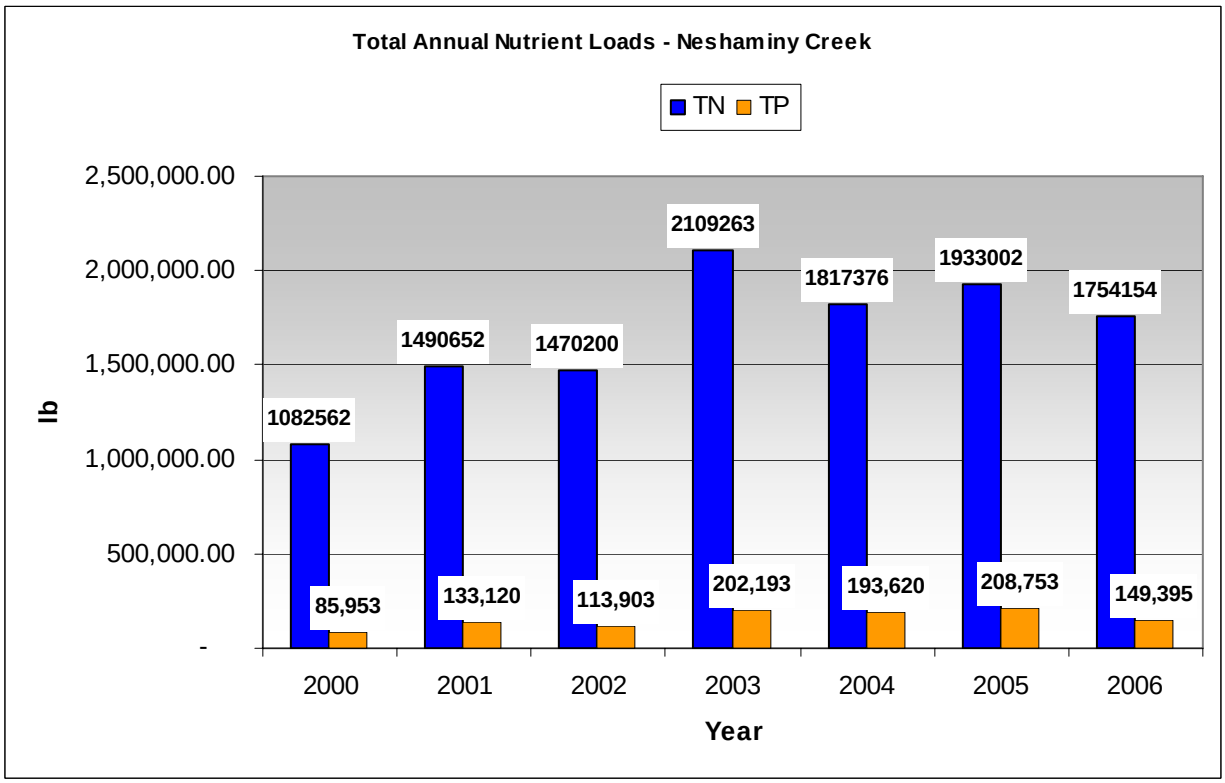


Figure 25. Total Annual Watershed Nutrient Loads for Modeled Period

3.4. Skippack Creek

The following description of the Skippack Creek watershed is partly based on information contained in the existing TMDL for Skippack Creek, established in April 2005 (EPA 2005). Skippack Creek is a 15.2 mile (24.3 kilometer) stream located in sub-subbasin 03E, Montgomery County, Pennsylvania (HUC 02040203; stream code 603E). Approximately 56 square miles, the basin is composed of urban, suburban, agricultural and rural lands. A generous wooded riparian buffer parallels the lower main stem of Skippack Creek, as it flows through Evansburg State Park. There are 11 active NPDES permitted point source discharges in the Skippack Creek Watershed, seven sewage treatment plants, a meat packing plant, a dairy, and two manufacturers.

Based on analysis from the existing TMDL (EPA 2005), annual point source loads of TP in Skippack Creek, are approximately 32, 694.1 lb/year (nitrogen was not addressed). This is based on facility design flows and current permit limits of 2 mg/L TP for all facilities except Moyer Packing Company (0.8 mg/L TP) and the Worcester Valley STP (1.0 mg/L TP). Figure 26 provides the subbasin delineation for modeling of Skippack Creek and Figure 27 shows the landuse breakdown. Table 15 shows the septic estimations for the modeled subwatersheds. Figure 28 and Figure 29 provide results of the modeling simulation. For the period modeled, the average annual TP load from the watershed is 33,472 lb/yr. Average annual nitrogen load is approximately 425,492 lb/yr.

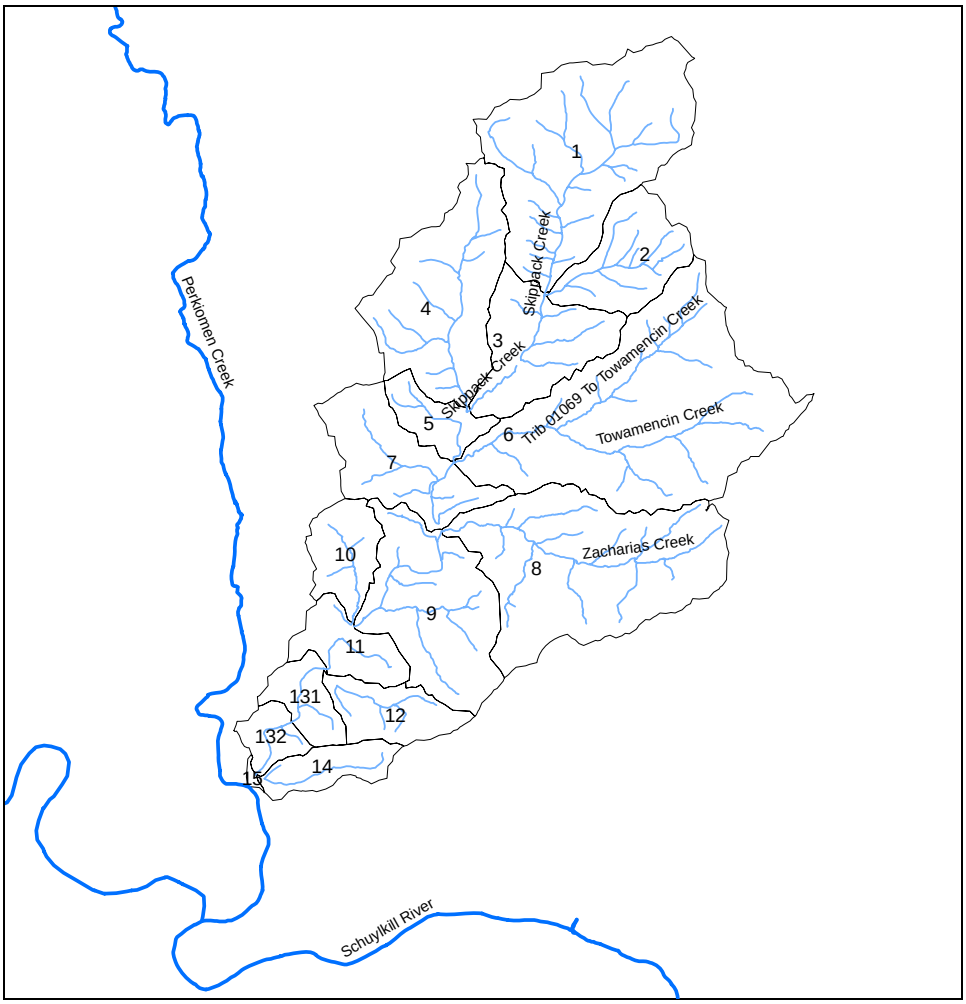


Figure 26. Skippack Creek subbasins

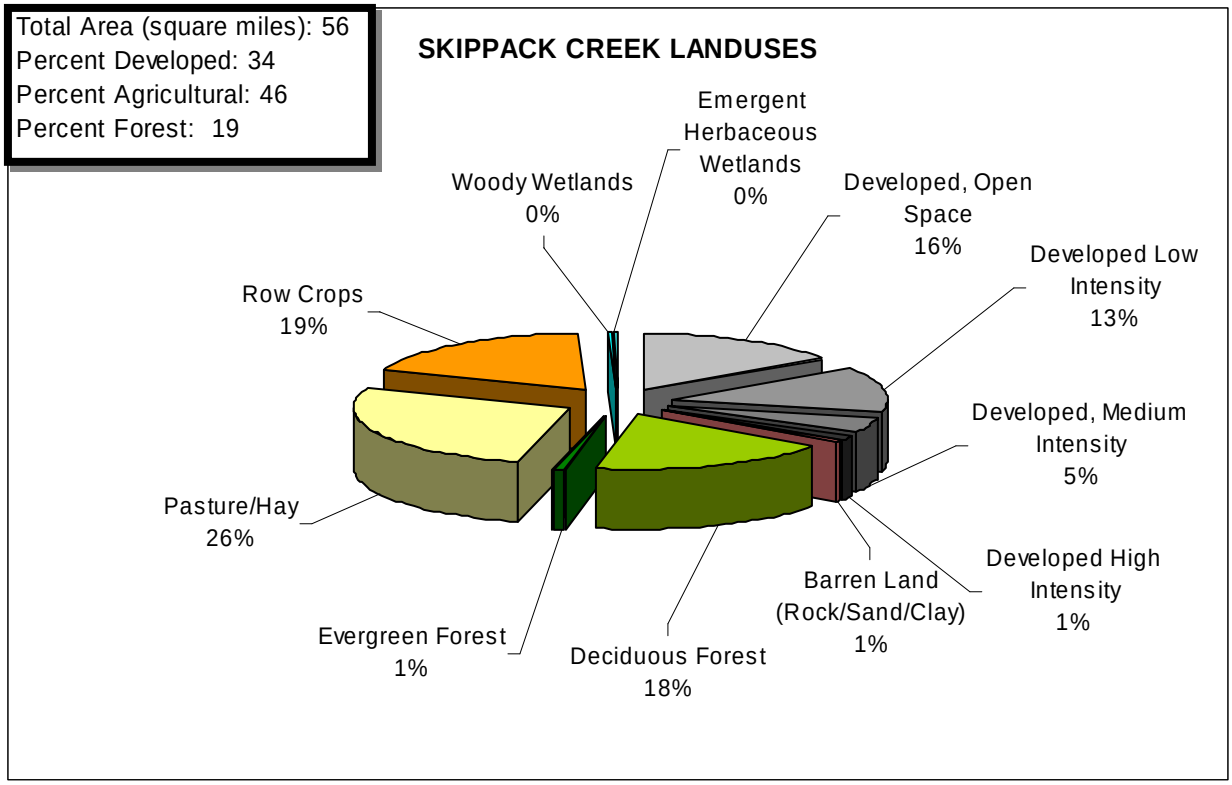


Figure 27. Landuses in the Skippack Creek watershed

Table 15. Skippack Creek septics representation by subbasin

Subbasin	Normal (89%)	Ponding (10%)	Short-circuit (0%)	Direct(1%)	Total
1	4932	554	0	55	5542
2	406	46	0	5	456
3	926	104	0	10	1040
4	2092	235	0	24	2351
5	177	20	0	2	199
6	2281	256	0	26	2563
7	1440	162	0	16	1618
8	3386	380	0	38	3804
9	708	80	0	8	796
10	366	41	0	4	411
11	409	46	0	5	459
12	927	104	0	10	1042
131	103	12	0	1	116
132	95	11	0	1	107
14	355	40	0	4	399
15	10	1	0	0	11

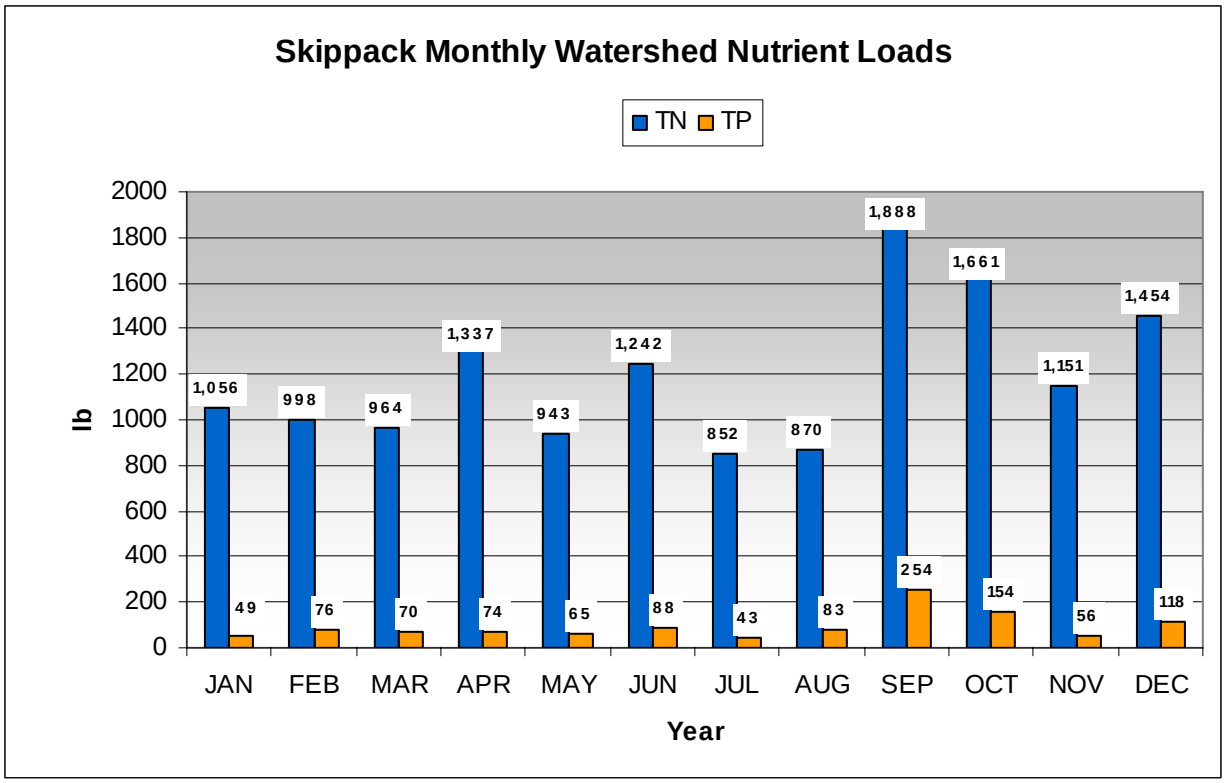


Figure 28. Average Monthly Nutrient Loads for Modeled Period

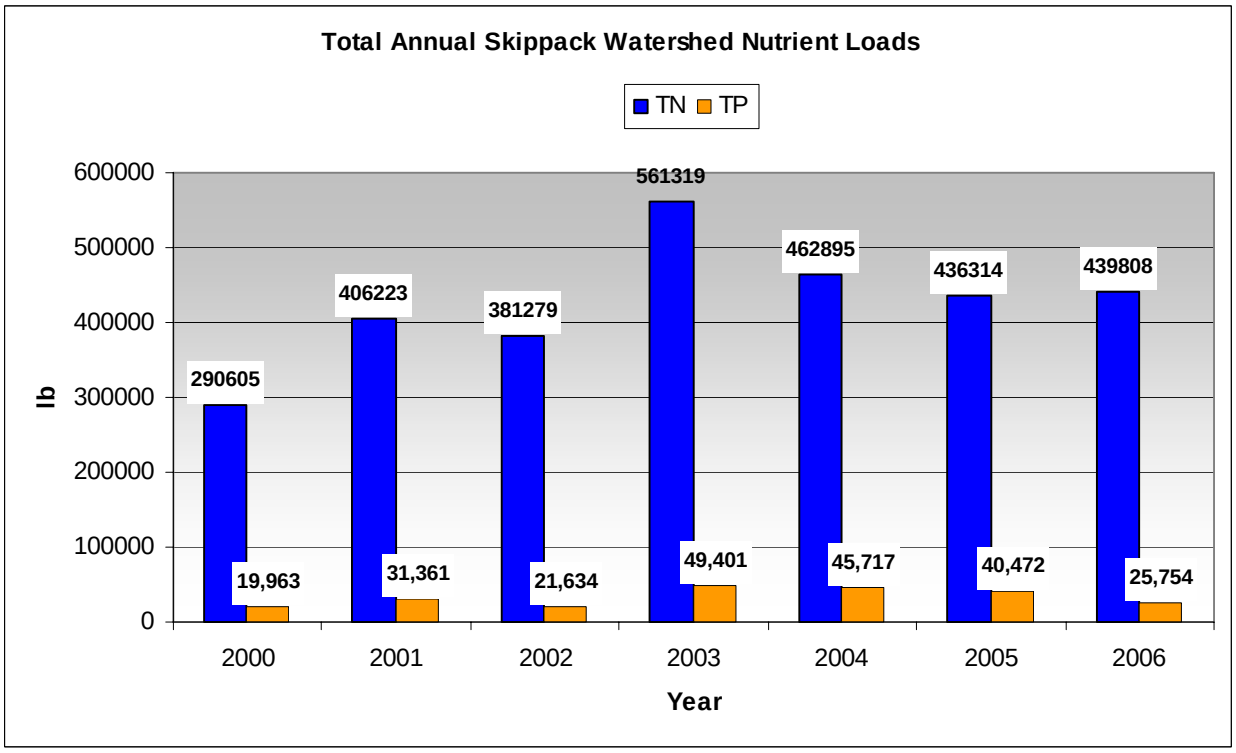


Figure 29. Total Annual Nutrient Loads for Modeled Period

3.5. Southampton Creek

Among the smallest of the evaluated watersheds, Southampton Creek encompasses approximately 6 square miles to the south of the Neshaminy Creek watershed straddling the border of Montgomery and Bucks Counties, Pennsylvania. Southampton Creek drains to Pennypack Creek, which is itself a tributary of the Delaware River. Southampton Creek is eavily urbanized, with 80 percent of the watershed developed, 5 percent agricultural and 14 percent forested. Failing septics are not considered to be a major source of nutrients in the watershed. One permitted point source is located in the Southampton Creek watershed, PA0046868, operated by the Moreland Township Authority. Permit information was not readily available for comparison to watershed loading. Figure 30 provides the subbasin delineation for modeling. Table 16 shows the estimates of septic systems in the watershed , while Figure 31 shows the landuse breakdown. Figure 32 and Figure 33 show average monthly and annual nutrient load predictions for the period modeled. Average annual nitrogen loading is approximately 31,006 lb/yr while average annual phosphorus loading is 2,046 lb/yr.

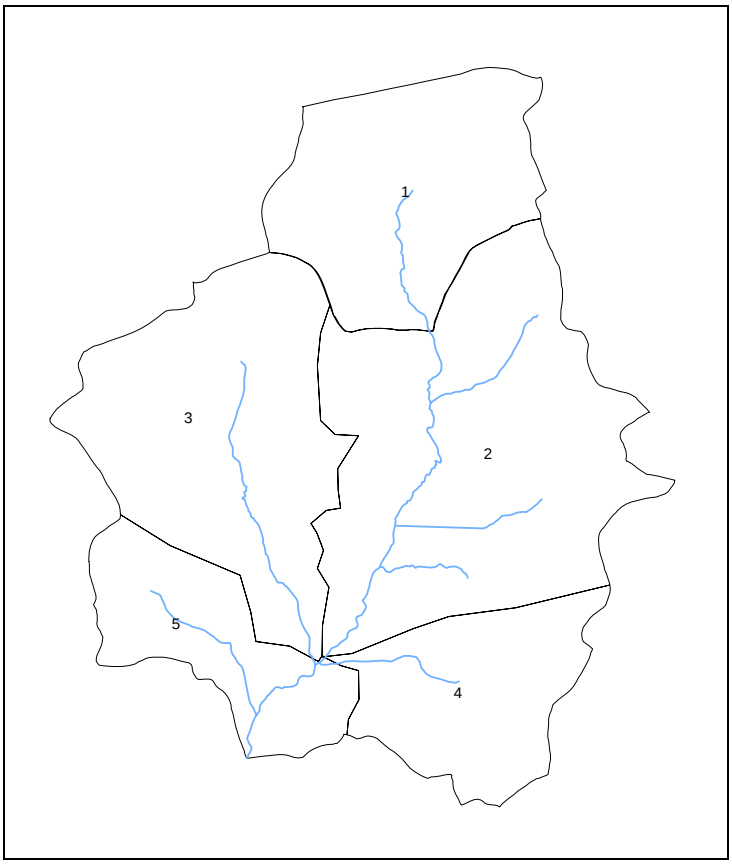


Figure 30. Southamption Creek subbasins

Table 16. Southampton Creek septics representation by subbasin

Subbasin	Normal (89%)	Ponding (10%)	Short-circuit (0%)	Direct(1%)	Total
1	88	10	0	1	99
2	538	60	0	6	604
3	192	22	0	2	216
4	754	85	0	8	847
5	125	14	0	1	140

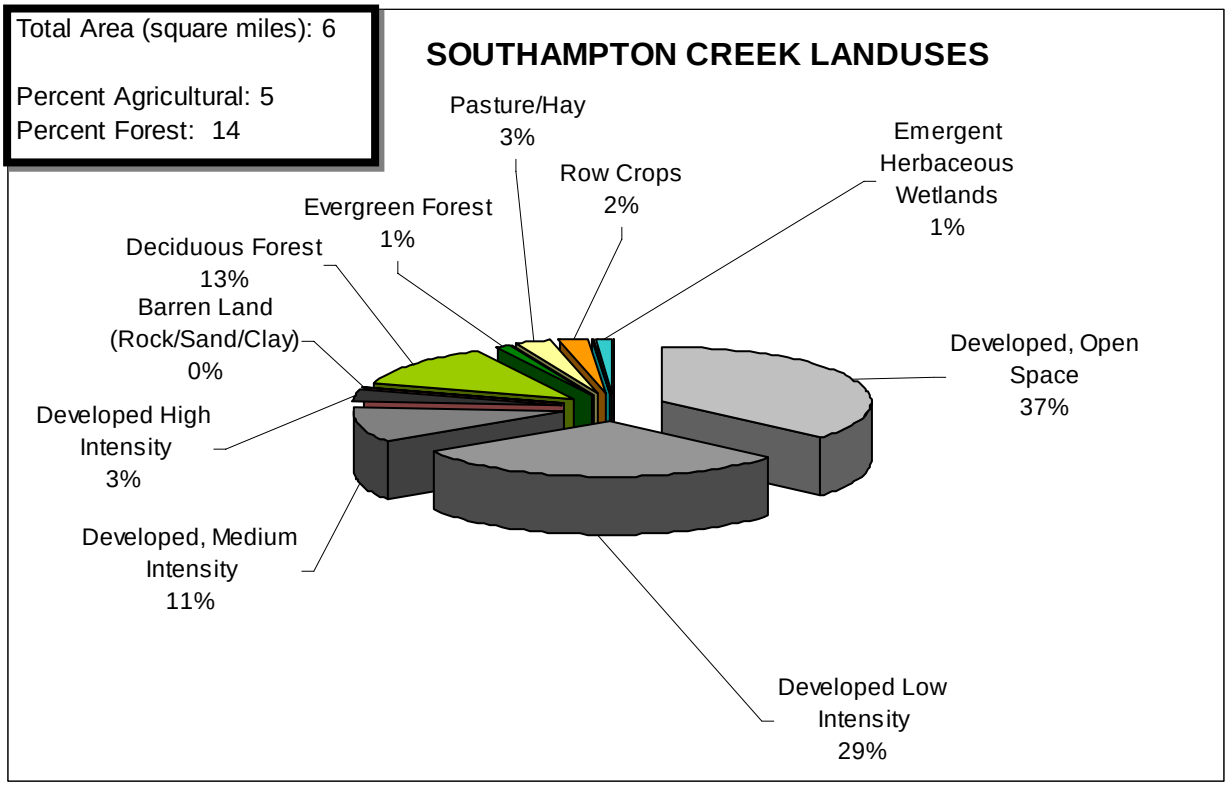


Figure 31. Landuses in Southampton Creek

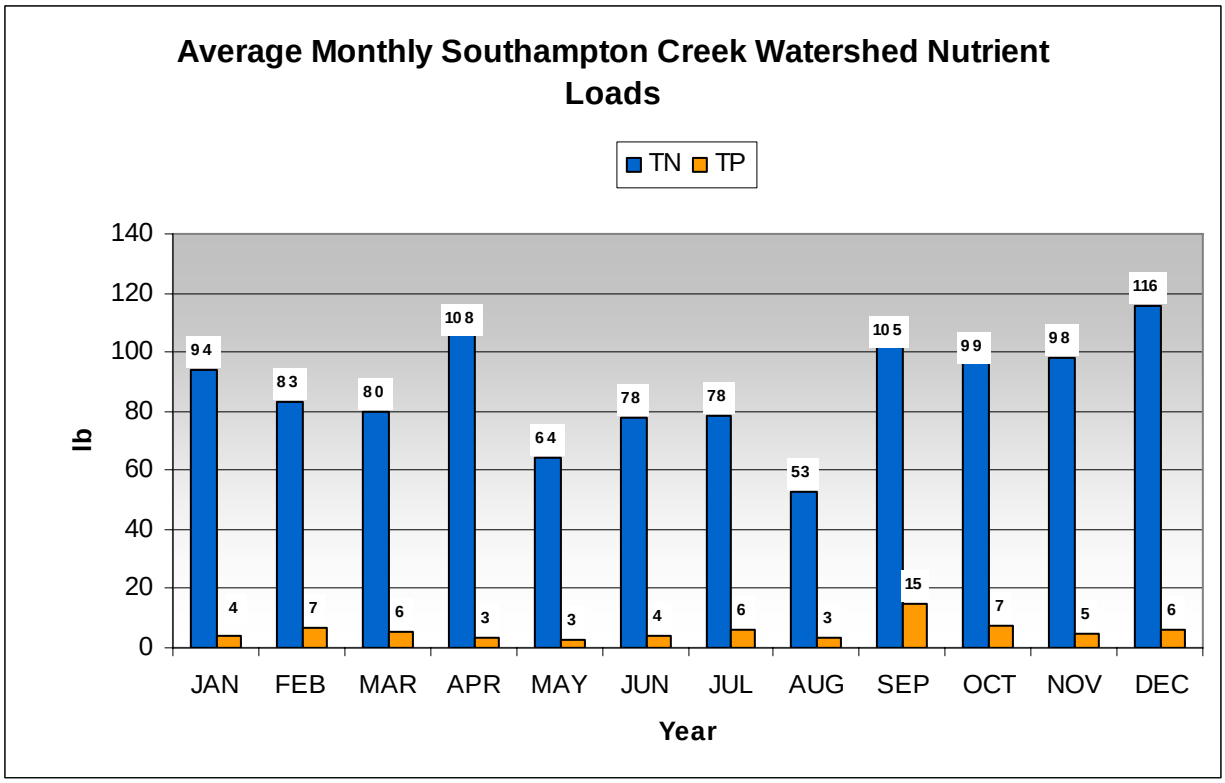


Figure 32. Average Monthly Nutrient Loads for Modeled Period

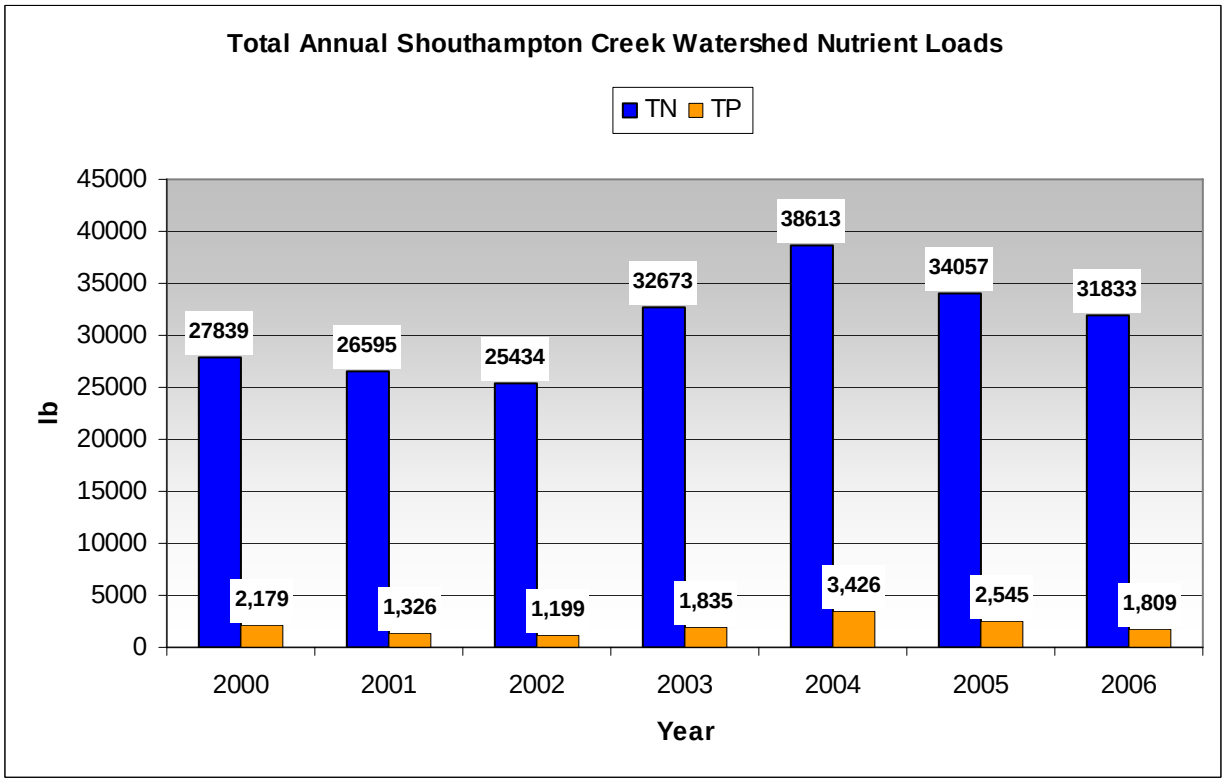


Figure 33. Total Annual Nutrient Loads for Modeled Period

3.6. Wissahickon Creek

Wissahickon Creek is a largely urbanized watershed that encompasses approximately 64 square miles in Montgomery (upper 2/3 of the basin) and Philadelphia (bottom 1/3) Counties, Pennsylvania. Major landuses include mostly developed (55%), agricultural (20%) and forested (23%). Nutrient and siltation TMDLs developed for Wissahickon Creek in 2003 provide information on the watershed setting, pollutant sources and impairment situation. Figure 24 provides the subbasin delineation used in modeling the Wissahickon Creek watershed; Figure 25 provides the landuse breakdown. Septic systems are not considered a significant contributor of nutrient loading in the watershed since the majority of residences are served by sewer systems. However, some septic systems are in use in the watershed; their representation in the GWLF model is shown in Table 17. Figures 26 and 27 provide watershed modeling results. Average annual watershed nitrogen loading in Wissahickon Creek is approximately 250,528 lb/yr while average annual phosphorus loading is 54,603 lb/yr.

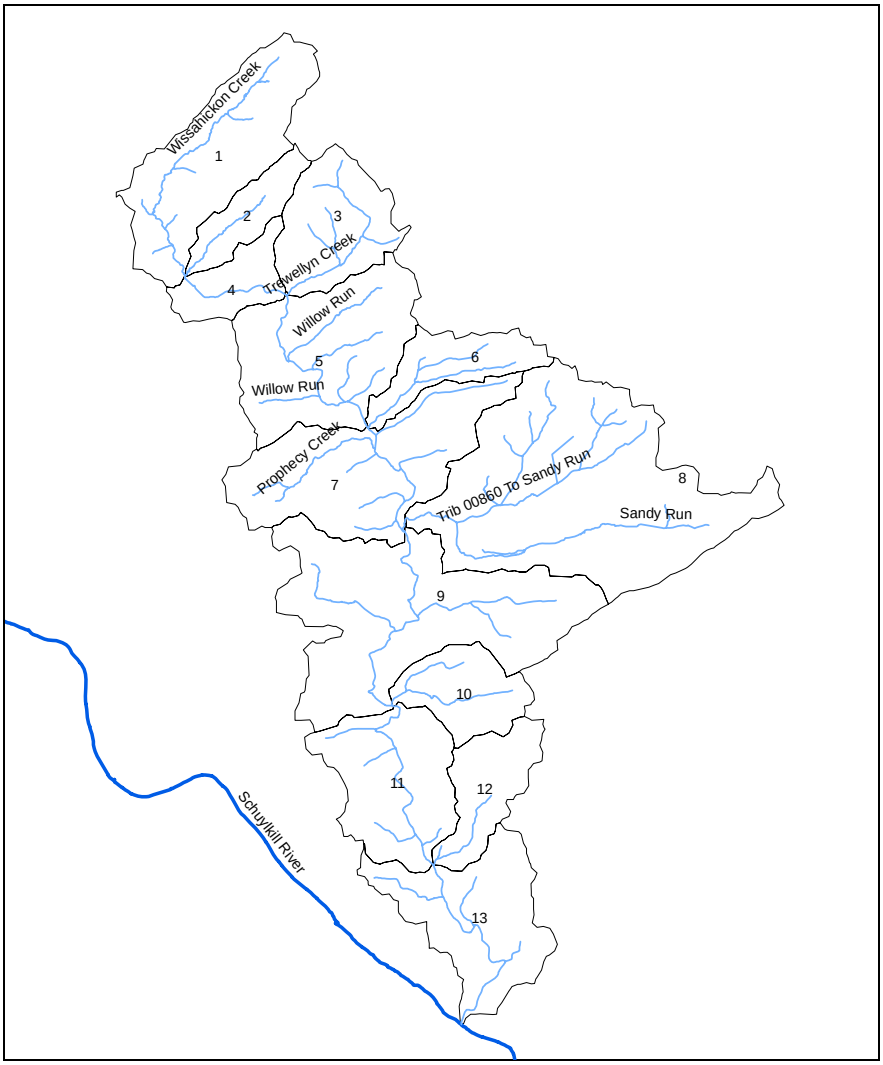


Figure 34. Wissahickon Creek subbasins

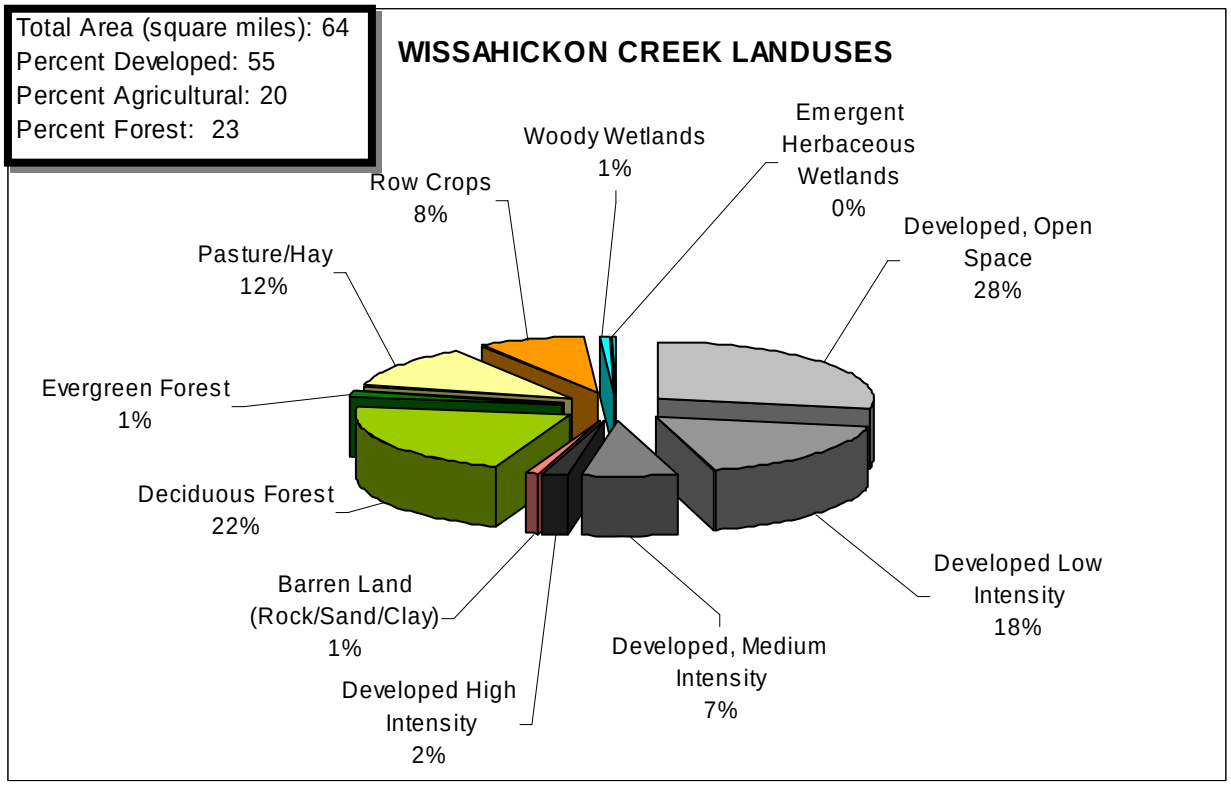


Figure 35. Landuses in the Wissahickon Creek Watershed

Table 17. Wissahickon Creek septics representation by subbasin

Subbasin	Normal (89%)	Ponding (10%)	Short-circuit (0%)	Direct(1%)	Total
1	456	51	0	5	512
2	302	34	0	3	339
3	393	44	0	4	442
4	366	41	0	4	411
5	486	55	0	5	546
6	415	47	0	5	466
7	614	69	0	7	690
8	1162	131	0	13	1306
9	856	96	0	10	962
10	75	8	0	1	84
11	279	31	0	3	314
12	70	8	0	1	79
13	0	0	0	0	0

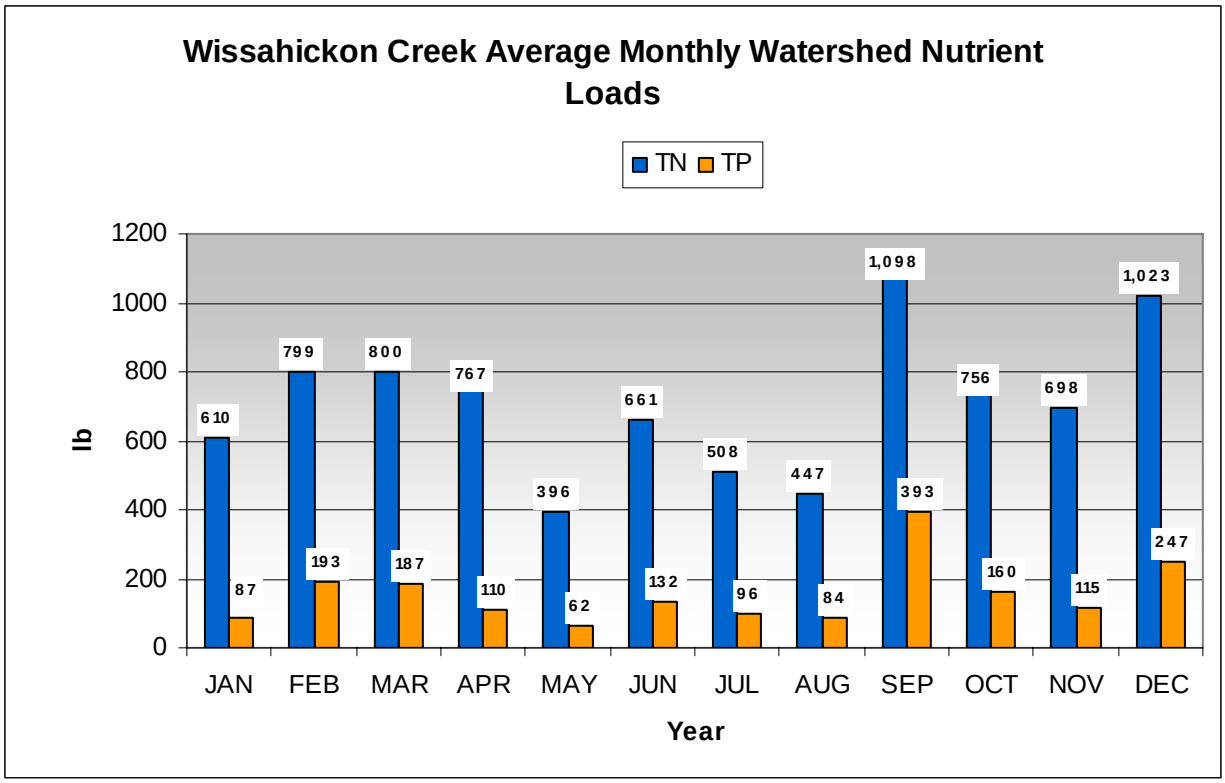


Figure 36. Average Monthly Nutrient Loads for Modeled Period

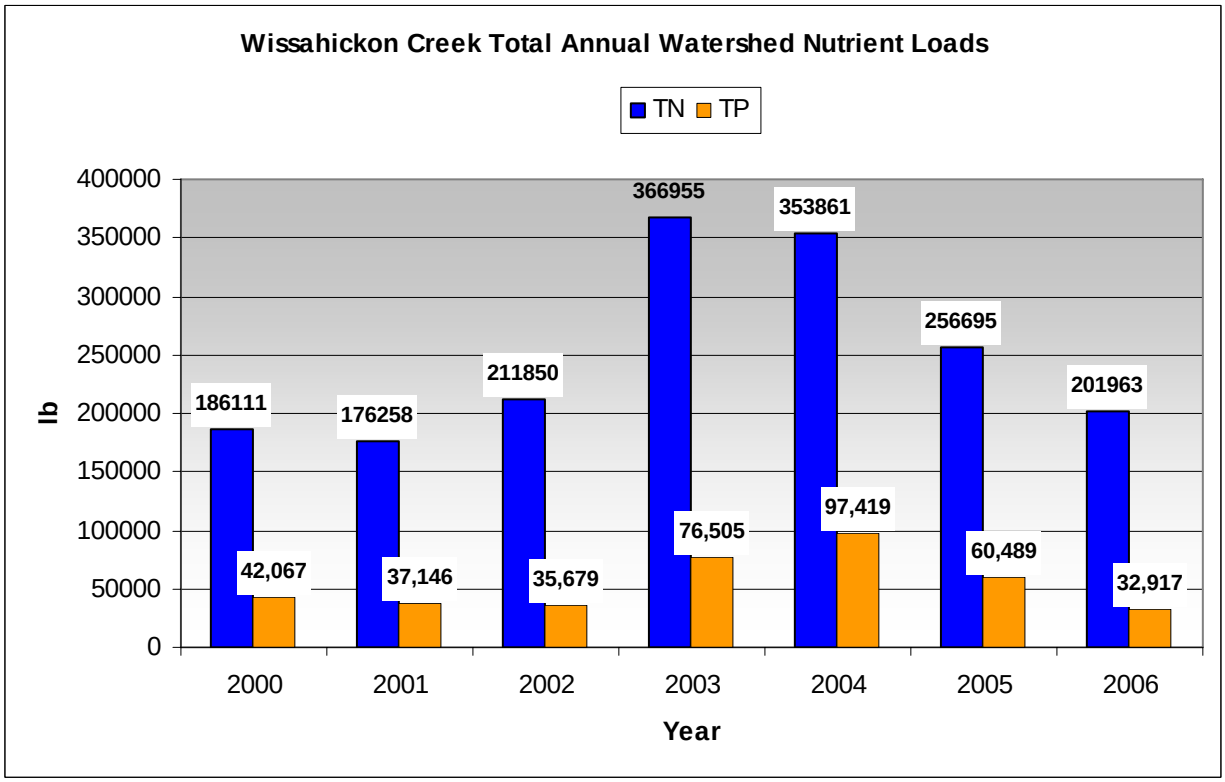


Figure 37. Total Annual Nutrient Loads for Modeled Period

4. REFERENCES

EPA 2005. Total Maximum Daily Load for Skippack Creek, Montgomery County, Pennsylvania. U.S. Environmental Protection Agency, Region III. April 9, 2005.

PADEP 2003. Total Maximum Daily Load (TMDL) Assessment for the Neshaminy Creek Watershed in Southeast Pennsylvania. December, 2003.

EPA 2003. Nutrient and Siltation TMDL Development for Wissahickon Creek, Pennsylvania Final Report. U.S. Environmental Protection Agency Region III. October 2003.

EPA 2008. DRAFT Siltation and Nutrients TMDL Development for the Indian Creek Watershed, Pennsylvania. U.S. Environmental Protection Agency, Region III. January 2008.

Appendix A

Hydrology Calibration

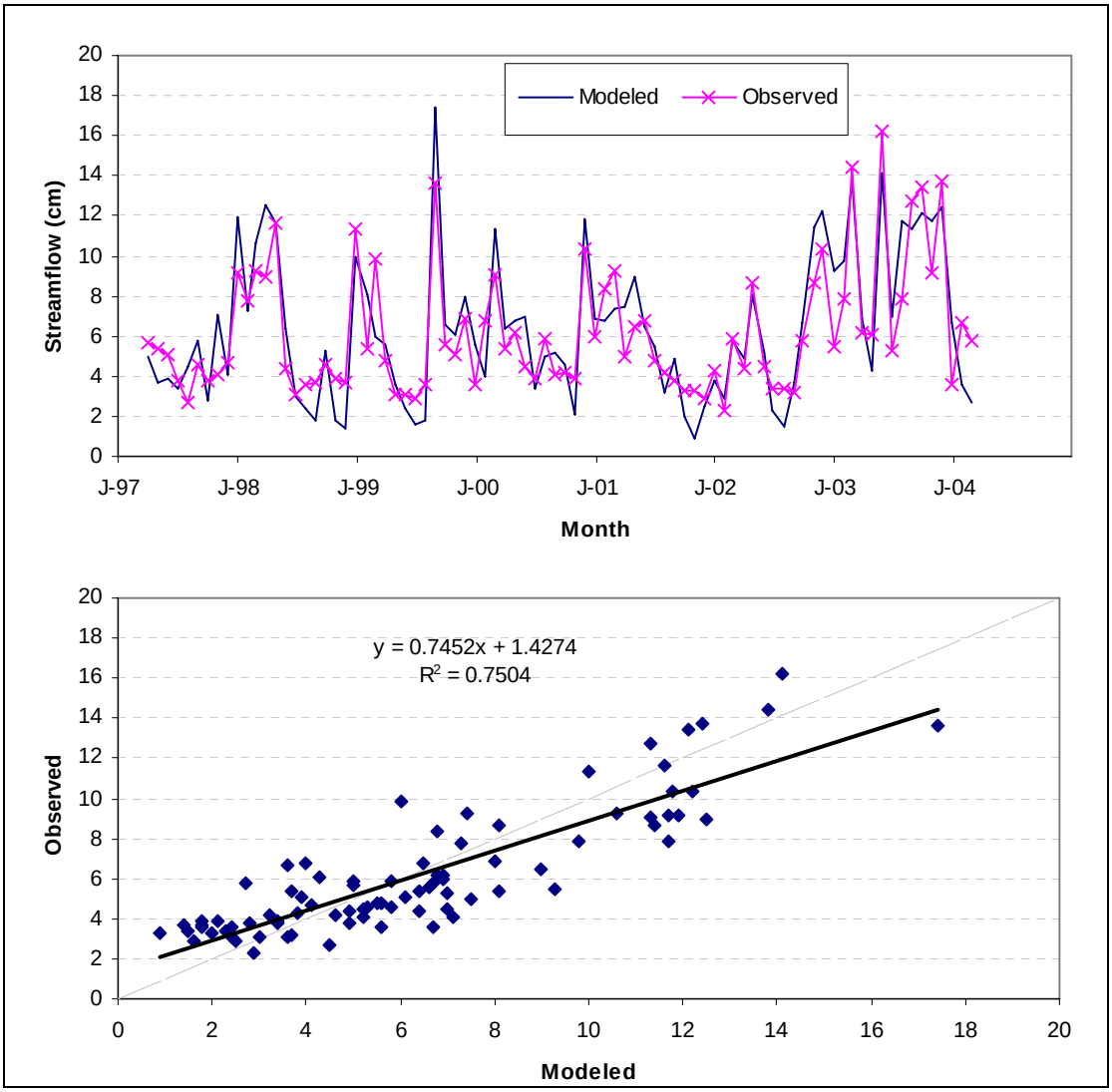


Figure 38. Hydrology Calibration USGS 01472810 (East Br Perkiomen Creek)

Indian Creek Watershed Nutrient and Sediment TMDLs, Southampton Creek Watershed Nutrient and Sediment TMDLs, Chester Creek Watershed Nutrient TMDL, Paxton Creek Watershed Nutrient and Sediment TMDLs and Sawmill Run Watershed Nutrient TMDL

Response to Specific Comments - Part B[1]

[1] All comment letters received were scanned using Optical Character Recognition software. Some misinterpretation of characters may result when using this method. EPA has made every attempt to find and correct any such errors in the scanned comments in this section of the Response Document. EPA apologizes for those we may have missed.

Comment Letter 1: ALCOSAN's Comments on the Sawmill Run TMDL

Comment 1: ALCOSAN believes EPA should suspend any further action on the proposed TMDL until the Wet Weather Plan is developed and submitted for review, to avoid interfering with or undermining the activities required by the Consent Decree and municipal consent orders. Otherwise, a TMDL based on inadequate and inaccurate data (rather than the agreed-upon Consent Decree process) will drive water quality activities in Sawmill Run. This would flatly contradict the regional efforts for the rest of the ALCOSAN service area, in which the Wet Weather Plan will be developed, implemented, and revised if necessary to address water quality in the other receiving waters. Further, given the substantial amount of information that will be obtained by monitoring the receiving streams and preparing the stream models, it is very likely that the proposed Sawmill Run nutrient TMDL would have to be revised, or possibly even eliminated, when considering the additional information. Such a revision would render the EPA's efforts in developing the TMDL moot. We believe suspending further action on the TMDL now eliminates the risks of interfering with the Consent Decree and revising the TMDL.

> **Response: EPA understands ALCOSAN's concerns with the Long Term Control Plan (LTCP). However, EPA is also under court order – the TMDL Consent Decree – that requires the completion of these TMDLs by no later than June 30, 2008. On April 19, 2006 EPA met with representatives of ALCOSAN and the City of Pittsburgh to discuss the TMDLs. We took that opportunity to describe the TMDL process, the goals of the TMDL and the need to coordinate with the LTCP process. At that time we asked the City and ALCOSAN to provide any information that would help with the coordination, including any source identification or location, stream data, effluent data, storm data, modeling information or any other pertinent information. We did not receive any input from ALCOSAN. The TMDL results can be evaluated in the LTCP process going forward and individual allocations adjusted by the state as new information becomes available and as necessary.**

Comment 2: The commenter believes that the endpoints are inappropriate for Saw Mill Run. EPA's Nutrient Endpoints document, *Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application, Prepared for Region 3 EPA by TetraTech Inc, dated November 20, 2007* applies *t*o Southeastern Pennsylvania, not the Pittsburgh region, and therefore does not properly support the proposed TMDL.

The Nutrient Endpoints document is applicable to areas of southeastern Pennsylvania, which are in Ecoregion IX, (Southeastern Temperate Forested Plains and Hills), whereas Pittsburgh and Sawmill Run are in Ecoregion XI (Central and Eastern Forested Upland). EPA developed the document for performing TMDLs in the southeastern part of the state, not in the western part.

The watersheds that the endpoint document was developed to support lie in the Piedmont Upland Section of the Piedmont Physiographic Provence of Eastern PA. This upland area is developed mainly on schists, which are metamorphic rocks. The Sawmill Run Basin lies far west of there in the Waynesburg Hills Section of the Appalachian Plateaus Physiographic Province. The soils are characterized as cyclic sequences of shale, sandstone and coal. The Appalachian Plateaus Province is not even adjacent to the Piedmont as these two Physiographic Provinces are separated by the very large Ridge and Valley Province. The parent rock material, soils, slopes, geomorphology, climate, precipitation, hydrogeology and hydrology all are significantly different. As such, the nutrient endpoints are not applicable in the Pittsburgh area.

For the Sawmill Run TMDL report, the table and the paragraph following the table on selecting the phosphorus endpoint on page 4-2 are lifted directly from the Nutrient Endpoints document. EPA applies the selected nutrient endpoint as a not-to-exceed limit (Total Maximum Daily Load), whereas the Nutrient Endpoints document stresses the value should be used as an average over the growing season. Page 29 of the Nutrient Endpoints document states the following:

> *As a result, for the purposes of these TMDLs, we recommend that the TP endpoint be applied as an average of water samples taken over the growing season.*

Additionally, the draft Sawmill Run TMDL on page 4-2 states similarly:

> *The selected TP endpoint would be applied as an average concentration during the growing season from April to October, which in streams is typically the time during which the greatest risk of deleterious algal growth exists.*

The draft TMDL allocates 1.7 lbs/day as a maximum daily load from CSO. If the average value is used, the CSO allocation would allow ALCOSAN to discharge 620.5 Lbs over a year (1.7 Lbs/day by 365 day). As stated in the Nutrient Endpoints document and the draft TMDL, the TP value should be set as a seasonal average, not as a not-to-exceed limit.

Response: The commenter is correct in that the endpoint is based on a seasonal average and the resulting allocations should also be seasonal averages. The permitting authority – PADEP - must decide how to translate the seasonal allocations into an appropriate permit condition. The multiple lines of evidence approach used to develop TP endpoints for the Piedmont has also been applied for Allegheny Plateau and Ridge and Valley streams and appropriate regional targets have been developed for these streams as well. The approach was identical in scope and analysis and similar data sources were used (namely USGS, EPA, and MBSS data). See General Response #7.

Comment 3: The TMDL is Based on Inadequate and Inaccurate Data.

Comment: Factual Errors: There are several errors of fact in the proposed TMDL. For example, the TMDL states that the City of Pittsburgh is an MS4 community. The City is predominantly combined sewer system and therefore is not an MS4 community.

Response: EPA has corrected this error and removed any reference of the City of Pittsburgh as an MS4 community

Comment 3A: Sampling Data: The proposed TMDL indicates that dry weather samples were collected twice, wet weather samples were collected once, and continuous diurnal dissolved oxygen (DO) measurements were taken at two sampling events. See pages 2-15, 2-16 of the TMDL. ALCOSAN believes this very limited sampling represents only a snapshot in time of conditions in Sawmill Run and is not an adequate database on which to base the TMDL.

Response: The TMDL was developed based on the best available data and was not solely based on the diurnal DO data.

Comment 3B: Dissolved Oxygen Data: The proposed TMDL sampling data found that in-stream DO

did not violate the Pennsylvania water quality standard for a minimum DO concentration of 4 mg/L. The lowest DO concentration found was 4.54 mg/L. Therefore, Sawmill Run is not impaired for DO. The proposed TMDL does not establish a relationship between nutrients (phosphorus and nitrogen) and the DO criterion for a warm water fishery classification.

Response: Whether Sawmill Run is impaired for DO or not is not relevant here. Although DO is an important water quality standard for aquatic life, the nutrient endpoint was not established based on the need to meet a dissolved oxygen standard. As has been mentioned on numerous occasions and in the report –Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application" describing the endpoint development process. The nutrient endpoints were established to protect aquatic life uses, not to produce a certain DO value. Therefore there is no need for EPA to establish a relationship between DO and the endpoints. Further, EPA guidance for the development of nutrient criteria notes that there may be some situations, particularly those were reaeration is significant, that low DO values may not occur even with high levels of algal activity. Nevertheless, a DO diurnal fluctuation of 13.5 mg/L was recorded in August 2006 at Station SMR07 and a DO diurnal fluctuation of 6.3 mg/L was recorded in August 2006 at Station SMR06. EPA considers these dissolved oxygen fluctuations are considerable indicating a highly productive stream. In addition, such extreme diurnal DO variations might cause the oxygen level to fall below the PA DO standard of 4 mg/L.

Comment 3C: CBOD Data: The reported data for CBOD in wet weather was 9.8 mg/L. This is close to the median concentration of CBOD in US national databases of approximately 10 mg/L for storm water without the presence of combined sewage. There is no evidence that this level of CBOD causes DO criteria violations and, as stated above, no such violations were observed. DEP has not adopted an in-stream criterion for CBOD.

Response: EPA has not produced a TMDL that includes allocations for CBOD. This comment is not relevant here. Although the TMDL addresses the nutrient impairment in Sawmill Run, the CBOD data was presented as part of TMDL requirements specifying to list and present all available data in Sawmill Run.

Comment 3D: Algal Growth. The proposed TMDL suggests that excessive algal or periphyton growth for the stream is indicated by the range of DO concentrations observed over diurnal cycles. However, no data are presented on the existing algal or periphyton condition of the stream and, as noted in the draft TMDL, there were no DO violations noted, including during the night time, or respiration-dominated periods of the observations. The observed diurnal ranges of DO concentrations are not unusual for urban streams that typically do not violate DO criterion. DEP has not adopted criteria for DO variation.

Response: Nor has EPA established the nutrient endpoint based on the need to meet a minimum DO value. We refer the commenter to the General Response section for further discussion on the endpoint for nutrients and the consideration of algal biomass. DO diurnal fluctuation of 13.5 mg/L was recorded in August 2006 at SMR07 and a DO diurnal fluctuation of 6.3 mg/L was recorded in August 2006 at SMR06. EPA considers that these dissolved oxygen fluctuations are significant indicating a relatively highly productive stream. In addition, such a range diurnal DO variation might cause the oxygen level to fall below the PA DO standard of 4 mg/L.

Comment 3E: Stream Flow. The TMDL does not recognize other factors that limit the achievement of an aquatic life use in Sawmill Run. In particular, flow variability is a significant factor aquatic life in urban streams. The original impaired waters listing also suggested that high flow impacts were a cause of the impairment. The habitat loss resulting from the effects of urbanization and the associated stream flow modifications likely are the most important causative factor. The Nine Mile Run watershed in Pittsburgh, where habitat restoration resulted in the recovery of the warm water fishery biological resources without reductions in combined sewage or stormwater-related phosphorous discharges, should be regarded as a reference stream when considering the Saw Mill Run impairment.

Response: EPA recognizes that flow variability can be a significant factor affecting the aquatic life in Sawmill Run. The TMDL in Sawmill Run was developed to address nutrients.

Comment 3F: Episodic Nature of Stream Flow: Using the average annual phosphorus target and dividing it by 365 days is not appropriate for CSOs. Algae and periphyton require a relative stable source of nutrients to thrive. Applying the daily limit to CSOs during large storm events is not appropriate

Response: The commenter should understand that the nutrient endpoints are not based on periphyton or algal biomass. Therefore this comment as it relates to these two response variables is not applicable here. The daily limit for CSOs was solely developed as part of the TMDL requirements. All the calculations and analyses development were made on an annual basis. EPA looked at long term impacts by addressing the aquatic life – macroinvertebrates – use protection. Periphyton are indicators of short term impacts.

Comment 3G: Model Input Data: ALCOSAN believes many of the input data for the TMDL model are inaccurate and/or inappropriate. An overly simplistic method is used to characterize the sources of nutrient loads to the stream. For example, the TMDL uses a very crude method to characterize CSO discharges. A more accurate representation of CSO discharge volume and quality is available and should be used.

Response: EPA used the best available data to develop the TMDL. In the revised TMDL, the CSOs overflow volume was adjusted using the 2006 overflow data of 422.3 MGD (*Appendix B, 2006 Statistics for Permitted CSOs)*

Comment 3H: Phosphorus: The TMDL reports that total phosphorous and dissolved phosphate concentrations measured within the mainstem of Sawmill Run averaged 0.04 mg/L and 0.03 mg/L, respectively. TMDL, Section 3.3. Dry weather measurements taken at the mouth of Sawmill Run averaged 0.032 mg/L for total phosphorous and 0.021 mg/L for dissolved phosphate. These levels of phosphorous do not indicate a need for a phosphorous TMDL. A wet weather measurement taken at the mouth of Sawmill Run indicated a total phosphorus level of 0.253 and a dissolved level of 0.030 mg/L. The disparity between the wet and dry weather phosphorous levels is clearly due to increased storm water runoff which is causing overflow conditions at the local treatment plants. The Wet Weather Plan will address overflow conditions and is anticipated to significantly reduce such conditions.

Response: The phosphorus concentrations at the mouth of the steam is well above the EPA endpoint, indicating the need to control storm water sources, be it CSOs, SSOs or overflows at the WWTPs. It would have been advantageous if the commenter would have produced the analysis from the Wet Weather Plan that shows that the implementation of the Plan will

reduce the overflows and resulting increase in phosphorus in stream. Without that information the comment is only an opinion of the commenter and EPA cannot respond. The Plan can use the TMDL allocations as a goal in the post construction monitoring. The Sawmill Run TMDL was developed for the dry- and wet-weather conditions. EPA is aware that the Wet Weather Plan will address overflow conditions to significantly reduce such conditions, however, at the time of developing this TMDL the Wet Weather Plan has not been received by EPA.

Comment 3I: Inappropriate Reference Stream: As discussed above, a Maryland Piedmont Region stream is not an appropriate reference stream for TMDL purposes because of significant differences in land use and stream flow characteristics. ALCOSAN believes an urban stream generally is a more appropriate reference. As noted above, Nine Mile Run in Pittsburgh is a good example of how an urban stream can be restored by addressing flow and in-stream physical conditions rather than a TMDL for nutrients. References in the proposed TMDL to the Chesapeake Bay Tributary Strategy are inappropriate because of the differences in water quality and the causes of impairment in the Bay versus Sawmill Run.

Response: EPA has adjusted the TP endpoint based on an analysis of the Allegheny ecoregion. The commenter is referred to General Response #7 for further information. Based on the reevaluation the TP endpoint for Sawmill Run has been changed to 35ug/L.

Comment 3J: Inappropriate Rulemaking: A TMDL should not be developed for phosphorous unless it is determined through implementation of the activities required by the Consent Order and administrative consent orders that a TMDL is appropriate. The selection of a numeric standard of 0.04 mg/L for phosphorus is arbitrary. The state water quality standard for phosphorus is a narrative standard. The TMDL document is not the location to decide state water quality standards. The state should propose revisions to the state standard and go through the public comment and gain EPA acceptance of a numeric standard for phosphorus before applying the value in a TMDL. The use of a phosphorus limit developed for macroinvertebrates in Piedmont streams in Maryland is not appropriate.

Response: EPA did not establish water quality criteria for nutrients. What we did do was interpret the state‘s narrative criteria in order to establish an endpoint for the TMDL. PADEP is in the process of developing nutrient criteria. The endpoint was based on a scientific and statistical approach that is consistent with EPA guidance and state rules. PADEP has accepted the approach used by EPA for interpreting their narrative standard for the protection of aquatic life. The commenter is referred to the General Response section for further information.

Comment 3K: Nitrogen: No evidence is presented that indicates that nitrogen requires control to achieve water quality standards for Sawmill Run. Therefore, there is no need for a TMDL for nitrogen.

Response: EPA has removed the Total Nitrogen allocations from this TMDL. Please see General Response #3.

Comment 3L: TMDL Allocations: It is not appropriate to lump so much of the phosphorus load into the WLA portion of the TMDL and then force ALCOSAN and the municipalities to prove later how much of the load should be moved to the LA portion. See Section 5.1.2. EPA should develop more data and make this critical determination before finalizing the TMDL. In addition, no information is

presented to establish the rational for selecting the target reductions for CSOs, stormwater and groundwater. The overall target can be achieved with adjustment to the targets for the individual sources. Achieving reductions will be problematic for many of the sources. In fact, the proposed percent reduction for phosphorus may not be achievable at all.

Response: On April 19, 2006 EPA met with representatives of ALCOSAN and the City of Pittsburgh to discuss the TMDLs. We took that opportunity to describe the TMDL process, the goals of the TMDL and the need to coordinate with the LTCP process. At that time we asked the City and ALCOSAN to provide any information that would help with the coordination, including any source identification or location, stream data, effluent data, storm data, modeling information or any other pertinent information. We did not receive any input from ALCOSAN so gross allocations to sources were made. Adjustments to the allocations to specific sources can be made by the state through the LTCP process. The commenter did not provide any data or information to support the observation that the TP reductions cannot be achieved. Therefore, EPA cannot react to that statement. EPA clarifying memorandum points out that it may be reasonable to express allocations for NPDES-regulated storm water discharges from multiple point sources as a single categorical wasteload allocation when data and information are insufficient to assign each source or outfall individual wasteload allocations.

Comment Letter 2: Ambler's Comments on the Chester Creek TMDL

Comment 1: If any numerical limits are recommended for nutrient reductions at wastewater treatment plants (WWTPs), the Borough of Ambler supports only phosphorus limits initially, as opposed to simultaneous issuance of phosphorus and nitrogen limits. Very different processes are utilized to remove these nutrients. Each process requires the transportation, storage and addition of hazardous chemicals, and generates additional sludge. In addition to capital and operating costs, public safety and worker safety, as well as the overall impact to the environment, will be better served by first implementing only phosphorus standards.

> **Response: EPA has removed the total nitrogen discussion form this TMDL. Please see General Response #3.**

Comment 2: The stated purpose of the TMDL is to address nutrient enrichment. Reducing in-stream phosphorus concentrations such that phosphorus is the limiting nutrient will likely make nitrogen reduction unnecessary. Nitrogen reduction could be implemented at some future date if phosphorus reduction alone does not produce satisfactory results.

> **Response: EPA has removed the total nitrogen discussion form this TMDL. Please see General Response #3.**

Comment 3: The TMDL documents indicate that the linkage between nitrogen loading and periphyton densities is not well established. This is yet another reason not to propose total nitrogen endpoints.

> **Response: EPA has removed the total nitrogen discussion form this TMDL. Please see General Response #3.**

Comment 4: In Pennsylvania, outside the Chesapeake Bay region, nitrite-plus-nitrate nitrogen is limited to an in-stream maximum of 10 mg/1 for public water supply purposes; public water supply is not an issue for presently proposed Chester Creek TMDL.

> **Response: EPA understands that Chester Creek is used as a water supply, therefore NO2+NO3 is an issue. However, EPA has limited this TMDL to Gosse Creek only. Please see General Response #9**

Comment 5: EPA has stated that nitrogen reduction is being proposed due to potential effects on the Delaware Bay. This is very presumptive. The Delaware Bay has not been identified as nutrient impaired, and years of studies and analyses will be required to allocate nitrogen loadings throughout the entire drainage basin. Using the Delaware Bay as the basis for very stringent nitrogen limits within a few small, isolated watersheds is not appropriate arid is not justified.

> **Response: Please see General Response # 3**

Comment 6: The Delaware River Basin Commission (DRBC) does not require Phosphorus effluent limits outside of Special Protection Waters. This is yet another reason for not referencing the Delaware Bay as a basis for nutrient reduction.

> **Response: Please see General Response # 3**

Comment 7: EPA has stated that nitrogen reduction is being proposed in advance of statewide nutrient limits. This is also very presumptive. Statewide standards have not yet been proposed, and years of studies and analyses will be required. Using potential and undetermined future statewide nutrient limits as the basis for very stringent nitrogen limits within a few small, isolated watersheds is not appropriate and is not justified.

Response: Please see General Response # 3

Comment 8: If any numerical limits can be justified for nutrient reductions at wastewater treatment plants (WWTPs), the Borough of Ambler supports the restriction of nutrient limits to the growing season (April to October) only, as proposed in the draft TMDL.

Response: The TMDL is seasonal. PADEP has policy and procedures for addressing seasonal pollutants during the remainder of the year. EPA understands that PADEP will apply those policies and procedures.

Comment 9: Any numeric limits proposed for point sources should include a suitable mixing zone, as opposed to being applied directly at the outfall.

Response: EPA understands that PADEP does not provide for mixing zones for conventional and non-conventional pollutants. In most instances for these TMDLs the discharge flow is the majority of the stream flow during critical conditions. A mixing zone would not be appropriate under those situations. PADEP does not use the mixing zone concept but rather uses what they call the time of compliance approach for pollutants that have acute and/or chronic numeric criteria. This does not apply to conventional or non-conventional pollutants.

Comment 10: In the Chester Creek TMDL, the following statement was included on page 6-1:

> *WLAs will be implemented through the NPDES permit process. According to 40 CFR 122.44(d)(l)(vii)(B), the effluent limitations for an NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source.*
>
> *Although TMDLs are not required to include an implementation component, EPA has included for consideration an adaptive management NPDES permitting approach in Appendix CF.*

Although EPA will say that it does not establish effluent limits for WWTPs, each TMDL does set a threshold limit for each WWTP, which Pennsylvania cannot exceed when issuing an NPDES permit. For several WWTPs identified in several of the currently proposed TMDLs, that would necessitate a total phosphorus limit of 0.04 mg/1 and a total nitrogen limit of 3.7 mg/1.

Response: What EPA does in the TMDL is provides an allocated load to each significant source of the pollutant of concern. The permitting authority, in this case PADEP, must then take that allocation and write a permit that is consistent with the assumptions and requirements of the wasteload allocation.

Comment 11: In the TMDL identified above, the following statement was included:

> *In the event that a facility seeks to expand or increase its design capacity, they should be capped at their existing load, consistent with the current design flow within that relevant category.*

While this approach may be appropriate for load allocations prepared for a lake or a bay, it seems misapplied to an effluent dominated stream. Increased flow from a WWTP will increase the flow in the stream, which will increase the assimilative capacity of the stream. Increased flow from a WWTP does not unilaterally necessitate a reduction in nutrient concentration, and could actually facilitate an increase in the allocation to other point sources.

> **Response: It is actually more important in an effluent dominated stream than one with a large dilution factor, particularly where the in-stream concentration is an issue. Increased flow without an increase in pollutant removal will increase the load to the stream. A simple calculation will show that increasing flow in an effluent and holding the concentration constant will result in a higher stream concentration, particularly noticeable in an effluent dominated stream.**

Comment 12: The TMDL identified above includes a recommended implementation schedule which suggests that WWTPs with flows greater than 10,000 gpd can achieve consistent effluent total phosphorus of 0.5 to 1.0 mg/1 almost immediately. The construction of filters will probably be required (Section 5.3.2 of the Treatability Report), with two-stage filtration needed to meet total P limits less than 0.1 mg/1. Considering the very low phosphorus concentrations proposed, before design can commence, pilot testing will be required. Then, after a technology is selected, the design, permitting, public bid and construction process will take 2 to 4 years.

A more readily achievable interim goal would be 1.0 mg/1 ortho-phosphate as P (o-PO4-P) during the growing season.

> **Response: EPA has provided one option for implementing the TMDL. PADEP Southeast office has agreed to meet with each point source to discuss the permitting process and possible interim limits. Capabilities and expectations of each facility can be discussed at that time. Under the TMDL regulations, EPA is not required to include implementation in a TMDL report. EPA notes (Nutrient Criteria Technical Guidance Manual, Rivers and Streams, page 100) that although much of the total nutrient concentrations in the water column of streams are not immediately available total concentrations probably have more general applicability than soluble fractions. While soluble fractions are more readily available, they may also be held at low levels during high-biomass periods due to uptake. EPA recommended ecoregion criteria are in totals. Ortho versus TP in the permitting process can be discussed with PADEP.**

Comment 13: Within the Chester Creek, Indian Creek and Southampton Creek watersheds, 20 WWTPs are allocated less than or equal to 0.1 mg/1 total phosphorus, with 7 of those WWTPs allocated less than or equal to 0.05 mg/1 total phosphorus.

Of the 22 WWTPs listed in Table 5.4 of the Treatability Report, only 1 had a total phosphorus NPDES Permit Limitation less than 0.1 mg/1, and half of the WWTPs reported greater than 0.05 mg/1 total phosphorus. These WWTPs produced low effluent phosphorus, but also were well below their respective permit limits. It is questioned whether some of these effluent numbers are actually median values as

opposed to mean values. Furthermore, the stated "average" values are clarified in a footnote as being the average of monthly averages; this further minimizes utilization of these WWTPs for supporting compliance with a 0.04 mg/1 TP limit every month.

Table 5.5 of the Treatability Report includes Final Effluent Log Normal Average Total Phosphorus, as opposed to average values, and several of the WWTPs have monthly median phosphorus limits (as opposed to average/mean limits). There is precedent for monthly median effluent limits.

Any treatment process submitted for a Part II Construction Permit must include a margin of safety that ensures the proposed permit limit can be met. A permit limit of 0.05 mg/1 total phosphorus means designing for average daily values at or below the practical quantitation limit (PQL), which is also know (sic) as the limit of quantitation (LOQ). This seems impracticable.

> **Response: Although the treatability study was completed by EPA, EPA did not use the results in the TMDL. It is reminded that the concentrations of TP included in the TMDL are seasonal averages and should be permitted that way.**

Comment 14: If 0.04 mg/1 total phosphorus is actually required in-stream and WWTPs at the headwaters of effluent dominated streams must discharge less than 0.05 mg/1 total phosphorus during low flow periods, then a monthly median limit of 0.05 mg/1 would be more appropriate since it would account for the increased assimilative capacity that corresponds to wet weather events. As stated in Comment No. 13, there is precedent for monthly median NPDES limits.

> **Response: Conversion of the TMDL seasonal allocations is part of the permitting process and is not the purview of this TMDL.**

Comment 15: For wastewater treatment plants with effluent total nitrogen limits less than 8 mg/1 and total phosphorus limits less than 0.3 mg/1, a two-stage filtration process, and possibly more, will be required. Recycling the mixed-liquor can produce an effluent total nitrogen of 6 to 8 mg/1, but for lower total nitrogen limits, a denitrification filter will be required. Phosphorus is required for the biology performing denitrification, so an additional filter is required after the denitrification filter to finish removing the phosphorus. Combined demtrification/phosphorus removal filter manufacturers (Parkson, -US Filter, WesTech) will typically propose producing effluent less than 3 mg/1 total nitrogen and 0.3 mg/1 total phosphorus utilizing a single filter with automated chemical addition, and 6.1 mg/1 total phosphorus with a two-stage filter. Performance testing on a site specific basis would be required to validate performance prior to proceeding with the expenditure of millions of dollars from local residents.

> **Response: See General Response #3**

Comment 16: Section 5.6 of the Treatability Report presents an over-simplified statement of the modifications required for denitrification at a trickling filter plant. The Borough of Ambler WWTP has already implemented many of the suggested modifications, including replacing the rock with plastic media, and installing forced ventilation; the WWTP fully nitrifies. However, the nitrified effluent is high not only in nitrates, but also high in dissolved oxygen and low in carbon. The suggestion to add a denitrification tank misses the facts that the dissolved oxygen must be depleted, and all the carbon required for denitrification must be supplemented; this would be cost prohibitive over time. Conversion to an activated sludge process is most likely the only option to meet the total nitrogen limits required to comply with the proposed in-stream concentrations. For the Ambler WWTP, it will cost approximately. $10,000,000.00 in construction costs and increase annual operating costs $250,000.00 to meet the proposed phosphorus limits, with a corresponding cost to local residents of approximately $80.00io

$100.00 per year. To meet both the proposed phosphorus and nitrogen limits it will cost approximately $60,000,000.00 in construction costs and increase annual operating costs $400,000.00 with a corresponding cost to local residents of approximately $400.00 to $500.00 per year.

Response: Please see General Response #3. Nitrogen has been removed from this TMDL

Comment 17: Any numeric limits for phosphorus should be expressed in terms of ortho-phosphate, as opposed to total phosphorus.

Response: Multiple studies have indicated the appropriateness of total nutrient parameters to indicate water quality attainment rather than dissolved or soluble. The Clark Fork River study, in which nutrient targets were developed to control benthic chlorophyll levels in streams, states that —…practical regulations for general external nutrient loading for stream eutrophication control should not be based upon in-stream Soluble Reactive Phosphorus [SRP] or Dissolved Inorganic Nitrogen [DIN] levels, because the prediction uncertainty inherent in such an approach may preclude the satisfactory management of benthic chlorophyll a (Dodds et al. 1997, p. 1740)." The study further states: –Our analyses revealed that both total N and total P are related more strongly with benthic algal biomass than are dissolved inorganic N or P (Dodds et al. 1997, p. 1740)." In-stream TN and TP concentrations are more indicative of the nutrients that are ultimately available for the growth of algae.

Dodds (2003) suggests that control based on measured levels of dissolved inorganic nitrogen and phosphorus may not be effective because these pools are replenished rapidly by remineralization in surface waters. Dodds (2003) indicated that at high TN (i.e., .5 mg/L) and TP (i.e., .2 mg/L) concentrations, more than 60 percent of the nutrient is usually made up of dissolved inorganic forms, but at low levels the ratio of dissolved inorganic to total nutrients is highly variable. Therefore, DIN:SRP is a weak surrogate for TN:TP and should be used with caution to indicate nutrient limitation. Calculating TMDLs based on TN and TP criteria is also more practical than using dissolved forms of phosphorus and nitrogen because more total nitrogen and phosphorus water quality data are available than dissolved. Therefore, TP is the preferred endpoint for the TMDL.

While the TMDL endpoint is appropriately expressed as Total Phosphorus, the PADEP Permitting authority has discretion to interpret these TMDL allocations as necessary and appropriate for purposes of permit limitations.

Comment Letter # 3: Ambler on Indian Creek TMDL

Comment 1: If any numerical limits are recommended for nutrient reductions at wastewater treatment plants (WWTPs), the Borough of Ambler supports only phosphorus limits initially, as opposed to simultaneous issuance of phosphorus and nitrogen limits. Very different processes are utilized to remove these nutrients. Each process requires the transportation, storage and addition of hazardous chemicals, and generates additional sludge. In addition to capital and operating costs, public safety and worker safety, as well as the overall impact to the environment, will be better served by first implementing only phosphorus standards.

Response: See General Response #3

Comment 2: The stated purpose of the TMDL is to address nutrient enrichment. Reducing in-stream phosphorus concentrations such that phosphorus is the limiting nutrient will likely make nitrogen reduction unnecessary. Nitrogen reduction could be implemented at some future date if phosphorus reduction alone does not produce satisfactory results.

Response: See General Response #3

Comment 3: The TMDL documents indicate that the linkage between nitrogen loading and periphyton densities is not well established. This is yet another reason not to propose total nitrogen endpoints.

Response: See General Response #3

Comment 4: In Pennsylvania, outside the Chesapeake Bay region, nitrite-plus-nitrate nitrogen is limited to an in-stream maximum of 10 mg/1 for public water supply purposes; public water supply is not an issue for presently proposed Indian Creek TMDL.

Response: PADEP standards require NO2+NO3 to be 10mg/L or less for water supplies.

Comment 5: EPA has stated that nitrogen reduction is being proposed due to potential effects on the Delaware Bay. This is very presumptive. The Delaware Bay has not been identified as nutrient impaired, and years of studies and analyses will be required to -allocate nitrogen loadings throughout the entire drainage basin. Using the Delaware Bay as the basis for very stringent nitrogen limits within a few small, isolated watersheds is not appropriate and is not justified.

Response: See General Response #3

Comment 6: The Delaware River Basin Commission (DRBC) does not require Phosphorus effluent limits outside of Special Protection Waters. This is yet another reason for not referencing the Delaware Bay as "a basis for nutrient reduction.

Response: See General Response #3

Comment 7: EPA has stated that nitrogen reduction is being proposed in advance of statewide nutrient limits. This is also very presumptive. Statewide standards have not yet been proposed, and years of studies and analyses will be required. Using potential and undetermined future statewide nutrient limits as the basis-for very stringent nitrogen limits within a few' small, isolated watersheds is not appropriate and is not justified.

Response: See General Response #3

Comment 8: If any numerical limits can be justified for nutrient reductions at wastewater treatment plants (WWTPs), the Borough of Ambler supports the restriction of nutrient limits to the growing season (April to October) only, as proposed in the draft TMDL.

Response: See letter #2, response #8

Comment 9: Any numeric limits proposed for point sources should include a suitable mixing zone, as opposed to being applied directly at the outfall.

Response: See letter #2, response #9

Comment 10: In the Indian Creek TMDL, the following statement was included on page 73:

> *WLAs will be implemented through the NPDES permit process. According to 40 CFR 122.44(d)(l)(vii)(B), the effluent limitations for an NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source. Although TMDLs are not required to include an implementation component, EPA has included for consideration an adaptive management NPDES permitting approach in Appendix, F.*

Although EPA will say that it does not establish effluent limits for WWTPs, each TMDL does set a threshold limit for each WWTP, which Pennsylvania cannot exceed when issuing an NPDES permit. For several WWTPs in several of the currently proposed TMDLs, that would necessitate a total phosphorus limit of 0.04 mg/1 and a total nitrogen limit of 3.7 mg/1.

Response: See letter #2, response #10

Comment 11: In the TMDL identified above, the following statement was included:

> *In the event that a facility seeks to expand or increase its design capacity, they should be capped at their existing load, consistent with the current design flow within that relevant category.*

While this approach may be appropriate for load allocations prepared for a lake or a bay, it seems misapplied to an effluent dominated stream. Increased flow from a WWTP will increase the flow in the stream, which will increase the assimilative capacity of the stream. Increased flow from a WWTP does not unilaterally necessitate a reduction hi nutrient concentration, and could actually facilitate an increase in the allocation to other point sources.

Response: See letter #2, response #11

Comment 12: The TMDL identified above includes a recommended implementation schedule which suggests that WWTPs with flows greater than 10,000 gpd can achieve consistent effluent total phosphorus of 0.5 to 1.0 mg/1 almost immediately. The construction of filters will probably be required (Section 5.3.2 of the Treatability Report), with two-stage filtration needed to meet total P limits less than 0.1 mg/1.

Considering the very low phosphorus concentrations proposed, before design can commence, pilot testing will be required. Then, after a technology is selected, the design, permitting, public bid and construction process will take 2 to 4 years.

A more readily achievable interim goal would be 1.0 mg/1 ortho-phosphate as P (o-PO4-P) during the growing season.

Response: See letter #2, response #12

Comment 13: Within the Chester Creek, Indian Creek and Southampton Creek watersheds, 20 WWTPs are allocated less than or equal to 0.1 mg/1 total phosphorus, with 7 of those WWTPs allocated less than or equal to 0.05 mg/1 total phosphorus.

Of the 22 WWTPs listed in Table 5.4 of the Treatability Report, only 1 had a total phosphorus NPDES Permit Limitation less than 0.1 mg/1, and half of the WWTPs reported greater than 0.05 mg/1 total phosphorus. These WWTPs produced low effluent phosphorus, but also were well below their respective permit limits. It is questioned whether some of these effluent numbers are actually median values as opposed to mean values. Furthermore, the stated "average" values are clarified in a footnote as being the average of monthly averages; this further minimizes utilization of these WWTPs for supporting compliance with a 0.04 mg/1 TP limit every month.

Table 5.5 of the Treatability Report includes Final Effluent Log Normal Average Total Phosphorus, as opposed to average values, and several of the WWTPs have monthly median phosphorus limits (as opposed to average/mean limits). There is precedent for monthly median effluent limits.

Any treatment process submitted for a Part II Construction Permit must include a margin of safety that ensures the proposed permit limit can be met. A permit limit of 0.05 mg/1 total phosphorus means designing for average daily values at or below the practical quantitation limit (PQL), which is also know (sic) as the limit of quantitation (LOQ). This seems impracticable.

Response: See letter #2, response #13

Comment 14: If 0.04 mg/1 total phosphorus is actually required in-stream and WWTPs at the headwaters of effluent dominated streams must discharge less than 0.05 mg/1 total phosphorus during low flow periods, then a monthly median limit of 0.05 mg/1 would be more appropriate since it would account for the increased assimilative capacity that corresponds to wet weather events. As stated in Comment No. 13, there is precedent for monthly median NPDES limits.

Response: See letter #2, response #14

Comment 15: For wastewater treatment plants with effluent total nitrogen limits less than 8 mg/1 and total phosphorus limits less than 0.3 mg/1, a two-stage filtration process, and possibly more, will be required. Recycling the mixed-liquor can produce an effluent total nitrogen of 6 to 8 mg/1, but for lower total nitrogen limits, a denitrification filter will be required. Phosphorus is required for the biology performing denitrification, so an additional filter is required after the denitrification filter to finish removing the phosphorus. Combined demtrification/phosphorus removal filter manufacturers (Parkson, - US Filter, WesTech) will typically propose producing effluent less than 3 mg/1 total nitrogen and 0.3 mg/1 total phosphorus utilizing a single filter with automated chemical addition, and 6.1 mg/1 total phosphorus with a two-stage filter. Performance testing on a site specific basis would be required to validate performance prior to proceeding with the expenditure of millions of dollars from local residents.

Response: See letter #2, response #15

Comment 16: Section 5.6 of the Treatability Report presents an over-simplified statement of the modifications required for denitrification at a trickling filter plant. The Borough of Ambler WWTP has already implemented many of the suggested modifications, including replacing the rock with plastic media, and installing forced ventilation; the WWTP fully nitrifies. However, the nitrified effluent is high not only in nitrates, but also high in dissolved oxygen and low in carbon. The suggestion to add a denitrification tank misses the facts that the dissolved oxygen must be depleted, and all the carbon required for denitrification must be supplemented; this would be cost prohibitive over time. Conversion to an activated sludge process is most likely the only option to meet the total nitrogen limits required to comply with the proposed in-stream concentrations. For the Ambler WWTP, it will cost approximately. $10,000,000.00 in construction costs and increase annual operating costs $250,000.00 to meet the proposed phosphorus limits, with a corresponding cost to local residents of approximately 80.00io $100.00 per year. To meet both the proposed phosphorus and nitrogen limits it will cost approximately $60,000,000.00 in construction costs and increase annual operating costs $400,000.00 with a corresponding cost to local residents of approximately $400.00 to $500.00 per year.

Response: See letter #2, response #16

Comment 17: Any numeric limits for phosphorus should be expressed in terms of ortho-phosphate, as opposed to total phosphorus.

Response: See letter #2, response #17

Comment Letter #4: Ambler's Comments on Paxton Creek

Comment 1: The stated purpose of the TMDL is to address nutrient enrichment. Reducing in-stream phosphorus concentrations such that phosphorus is the limiting nutrient will likely make nitrogen reduction unnecessary. Nitrogen reduction could be implemented at some future date if phosphorus reduction alone does not produce satisfactory results.

Response: See General Response #3

Comment 2: The TMDL documents indicate that the linkage between nitrogen loading and periphyton densities is not well established. This is yet another reason not to propose total nitrogen endpoints as part of this TMDL.

Response: See General Response #3

Comment 3: EPA has stated that nitrogen reduction is being proposed in advance of statewide nutrient limits. This is also very presumptive. Statewide standards have not yet been proposed, and years of studies and analyses will be required. Using potential and undetermined future statewide nutrient limits as the basis for very stringent nitrogen limits within a few small, isolated watersheds is not appropriate and is not justified.

Response: See General Response #3

Comment 4: Any numeric limits proposed for point sources should include a suitable mixing zone, as opposed to being applied directly at the outfall.

Response: Please see the response to Letter #2, comment #9

Comment 5: Any numeric limits for phosphorus should be expressed in terms of ortho-phosphate, as opposed to total phosphorus.

Response: Please see response to Letter #2, comment #17

Comment 6: The Paxton Creek Watershed TMDL includes the following statement:

> *Using invertebrate taxa metrics, conditional probability analyses evaluated those TP concentrations which increased the risk of exceeding degradation thresholds developed for these macroinvertebrate metrics in Piedmont streams in Maryland.*

It is not clear how EPA determined that the above stated analyses, performed in Piedmont streams in Maryland (proximate to the southeastern portion of Pennsylvania), could be directly utilized for establishing nutrient endpoints in the Northern Shale Valleys and Northern Sandstone Ridges ecoregions located in south-central Pennsylvania.

Response: EPA has reviewed the data for the ecoregion in which Harrisburg falls and has adjusted the endpoints as necessary. The multiple lines of evidence approach used to develop TP endpoints for the Piedmont has also been applied for Allegheny Plateau and Ridge and Valley streams and appropriate regional targets have been developed for these streams as well. The approach was identical in scope and analysis and similar data sources

were used (namely USGS, EPA, and MBSS data).The final TMDL takes this additional analysis into consideration. Please see General Response #1 and General Response #7.

Comment Letter #5: Ambler's Comments on the Sawmill Run TMDLs

Comment 1: The stated purpose of the TMDL is to address nutrient enrichment. Reducing in-stream phosphorus concentrations such that phosphorus is the limiting nutrient will likely make nitrogen reduction unnecessary. Nitrogen reduction could be implemented at some future date if phosphorus reduction alone does not produce satisfactory results.

Response: See General Response #3

Comment 2: The TMDL documents indicate that the linkage between nitrogen loading and periphyton densities is not well established. This is yet another reason not to propose total nitrogen endpoints as part of this TMDL.

Response: See General Response #3

Comment 3: EPA has stated that nitrogen reduction is being proposed in advance of statewide nutrient limits. This is also very presumptive. Statewide standards have not yet been proposed, and years of studies and analyses will be required. Using potential and undetermined future statewide nutrient limits as the basis for very stringent nitrogen limits within a few small, isolated watersheds is not appropriate and is not justified.

Response: See General Response #3

Comment 4: Any numeric limits propose for point sources should include a suitable mixing zone, as opposed to being applied directly at the outfall.

Response: See letter #2 response #9

Comment 5: Any numeric limits for phosphorus should be expressed in terms of ortho-phosphate, as opposed to total phosphorus.

Response: See letter #2 response #12

Comment 6: The Sawmill Run Watershed TMDL includes the following statement:

> *Using invertebrate taxa metrics, conditional probability analyses evaluated those TP concentrations -which increased the risk of exceeding degradation thresholds developed for these macroinvertebrate metrics in Piedmont streams in Maryland.*

It is not clear how EPA determined that the above stated analyses, performed in Piedmont streams in Maryland (proximate to the southeastern portion of Pennsylvania), could be directly utilized for establishing nutrient endpoints in .the Monongahela Transition Zone and Pittsburgh Low Plateau ecoregions, located in southwestern Pennsylvania.

Response: See General Response #1 and General Response #7. The multiple lines of evidence approach used to develop TP endpoints for the Piedmont has also been applied for Allegheny Plateau and Ridge and Valley streams and appropriate regional targets have been developed for these streams as well. The approach was identical in scope and analysis and similar data sources were used (namely USGS, EPA, and MBSS data).

Comment Letter #6: Ambler's Comments on Southampton TMDLs

Comment 1: If any numerical limits are recommended for nutrient reductions at wastewater treatment plants (WWTPs), the Borough of Ambler supports only phosphorus limits initially, as opposed to simultaneous issuance of phosphorus and nitrogen limits. Very different processes are utilized to remove these nutrients. Each process requires the transportation, storage and addition of hazardous chemicals, and generates additional sludge, hi addition to capital and operating costs, public safety and worker safety, as well as the overall impact to the environment, will be better served by first implementing only phosphorus standards.

Response: See General Response #3

Comment 2: The stated purpose of the TMDL is to address nutrient enrichment. Reducing in-stream phosphorus concentrations such that phosphorus is the limiting nutrient will likely make nitrogen reduction unnecessary. Nitrogen reduction could be implemented at some future date if phosphorus reduction alone does not produce satisfactory results.

Response: See General Response #3

Comment 3: The TMDL documents indicate that the linkage between nitrogen loading and periphyton densities is not well established. This is yet another reason not to propose total nitrogen endpoints.

Response: See General Response #3

Comment 4: In Pennsylvania, outside the Chesapeake Bay region, nitrite-plus-nitrate nitrogen is limited to an in-stream maximum of 10 mg/1 for public water supply purposes; public water supply is not an issue for presently proposed Southampton Creek TMDL.

Response: See General Response #3

Comment 5: EPA has stated that nitrogen reduction is being proposed due to potential effects on the Delaware Bay. This is very presumptive. The Delaware Bay has not been identified as nutrient impaired, and years of studies and analyses will be required to allocate nitrogen loadings throughout the entire drainage basin. Using the Delaware Bay as the basis for very stringent nitrogen limits within a few small, isolated watersheds is not appropriate and is not justified.

Response: See General Response #3

Comment 6: The Delaware River Basin Commission (DRBC) does not require Phosphorus effluent limits outside of Special Protection Waters. This is yet another reason or not referencing the Delaware Bay as a basis for nutrient reduction.

Response: See General Response #3

Comment 7: EPA has stated that nitrogen reduction is being proposed in advance of statewide nutrient limits. This is also very presumptive. Statewide standards have not yet been proposed, and years of studies and analyses will be required. Using potential and undetermined future statewide nutrient limits as the basis for very stringent nitrogen limits within a few small, isolated watersheds is not appropriate and is not justified.

Response: See General Response #3

Comment 8: If any numerical limits can be justified for nutrient reductions at wastewater treatment plants (WWTPs), the Borough of Ambler supports the restriction of nutrient limits to the growing season (April to October) only, as proposed in the draft TMDL.

Response: See letter #2, Comment response #8

Comment 9: Any numeric limits proposed for point sources should include a suitable mixing zone, as opposed to being applied directly at the outfall.

Response: See letter #2, Comment response #9

Comment 10: In the proposed TMDL, the following statement was included on page 51:

> *For point sources, WLAs will be implemented through the NPDES permit process. According to 40 CFR 122.44(d)(1)(vii)(B), the effluent limitations for an NPDES permit must be consistent -with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. That is, the WLAs listed in the TMDL should be reflected as NPDES permit requirements for the WWTP and the MS4s identified in the report. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source. Although TMDLs are not required to include an implementation component, EPA has included for consideration an adaptive management NPDES permitting approach in Appendix F.*

Although EPA will say that it does not establish effluent limits for WWTPs, each TMDL does set a threshold limit for each WWTP, which Pennsylvania cannot exceed when issuing an NPDES permit. For several WWTPs identified in several of the currently proposed TMDLs, that would necessitate a total phosphorus limit of 0.04 mg/1 and a total nitrogen limit of 3.7 mg/1.

Response: See letter #2, Comment response #10

Comment 11: In the TMDL identified above, the following statement was included:

> *In the event that a facility seeks to expand or increase its design capacity, they should be capped at their existing load, consistent with the current design flow within that relevant category.*

While this approach may be appropriate for load allocations prepared for a lake or a bay, it seems misapplied to an effluent dominated stream. Increased flow from a WWTP will increase the flow in the stream, which will increase the assimilative capacity of the stream. Increased flow from a WWTP does not unilaterally necessitate a reduction in nutrient concentration, and could actually facilitate an increase in the allocation to other point sources.

Response: See letter #2, Comment response #11

Comment 12: The TMDL identified above includes a recommended implementation schedule which suggests that WWTPs with flows greater than 10,000 gpd can achieve consistent effluent total phosphorus

of 0.5 to 1.0 mg/1 almost immediately. The construction of filters will probably be required (Section 5.3.2 of the Treatability Report), with two-stage filtration needed to meet total P limits less than 0.1 mg/1. Considering the very low phosphorus concentrations proposed, before design can commence, pilot testing will be required. Then, after a technology is selected, the design, permitting, public bid and construction process will take 2 to 4 years.

A more readily achievable interim goal would be 1.0 mg/1 ortho-phosphate as P (o-PO4-P) during the growing season.

Response: See letter #2, Comment response #12

Comment 13: Within the Chester Creek, Indian Creek and Southampton Creek watersheds, 20 WWTPs are allocated less than or equal to 0.1 mg/1 total phosphorus, with 7 of those WWTPs allocated less than or equal to 0.05 mg/1 total phosphorus.

Of the 22 WWTPs listed in Table 5.4 of the Treatability Report, only 1 had a total phosphorus NPDES Permit Limitation less than 0.1 mg/1, and half of the WWTPs reported greater than 0.05 mg/1 total phosphorus. These WWTPs produced low effluent phosphorus, but also were well below their respective permit limits. It is questioned whether some of these effluent numbers are actually median values as opposed to mean values. Furthermore, the stated "average" values are clarified in a footnote as being the average of monthly averages; this further minimizes utilization of these WWTPs for supporting compliance with a 0.04 mg/1 TF limit every month.

Table 5.5 of the Treatability Report includes Final Effluent Log Normal Average Total Phosphorus, as opposed to average values, and several of the WWTPs have monthly median phosphorus limits (as opposed to average/mean limits). There is precedent for monthly median effluent limits.

Any treatment process submitted for a Part II Construction Permit must include a margin of safety that ensures the proposed permit limit can be met. A permit limit of 0.05 mg/1 total phosphorus means designing for average daily values at or below the practical quantitation limit (PQL), which is also know (sic) as the limit of quantitation (LOQ), This seems impracticable.

Response: See letter #2, Comment response #13

Comment 14: If 0.04 mg/1 total phosphorus is actually required in-stream and WWTPs at the headwaters of effluent dominated streams must discharge less than 0.05 mg/1 total phosphorus during low flow periods, then a monthly median limit of 0.05 mg/1 would be more appropriate since it would account for the increased assimilative capacity that corresponds to wet weather events. As stated in Comment No. 13, there is precedent for monthly median NPDES limits.

Response: See letter #2, Comment response #14

Comment 15: For wastewater treatment plants with effluent total nitrogen limits less than 8 mg/1 and total phosphorus limits less than 0.3 mg/1, a two-stage filtration process, and possibly more, will be required. Recycling the mixed-liquor can produce an effluent total nitrogen of 6 to 8 mg/1, but for lower total nitrogen limits, a denitrification filter will be required. Phosphorus is required for the biology performing denitrification, so an additional filter is required after the denitrification filter to finish removing the phosphorus. Combined denitrification/phosphorus removal filter manufacturers (Parkson, US Filter, WesTech) will typically propose producing effluent less than 3 mg/1 total nitrogen and 0.3 mg/1 total phosphorus utilizing a single filter with automated chemical addition, and 0.1 mg/1 total

phosphorus with a two-stage filter. Performance testing on a site specific basis would be required to validate performance prior to proceeding with the expenditure of millions of dollars from local residents.

Response: See letter #2, Comment response #15

Comment 16: Section 5.6 of the Treatability Report presents an over-simplified statement of the modifications required for denitrification at a trickling filter plant. The Borough of Ambler WWTP has already implemented many of the suggested modifications, including replacing the rock with plastic media, and installing forced ventilation; the WWTP fully nitrifies. However, the nitrified effluent is high not only in nitrates, but also high in dissolved oxygen and low in carbon. The suggestion to add a denitrification tank misses the facts that the dissolved oxygen must be depleted, and all the carbon required for denitrification must be supplemented; this would. be cost prohibitive over time. Conversion to an activated sludge process is most likelv the only option to meet the total nitrogen limits required to comply with the proposed in-stream concentrations. For the Ambler WWTP, it -will cost approximately $10,000,000.00 in construction costs and increase annual operating costs $250,000.00 to meet the proposed phosphorus limits, with a corresponding cost to local residents of approximately $80.00 to $100.00 per year. To meet both the proposed phosphorus and nitrogen limits it will cost approximately $60,000,000.00 in construction costs and increase annual operating costs $400,000.00, with a corresponding cost to local residents of approximately $400.00 to $500.00 per year.

Response: See letter #2, Comment response #16

Comment 17: Any numeric limits for phosphorus should be expressed in terms of ortho-phosphate, as opposed to total phosphorus.

Response: See letter #2, Comment response #17

Comment Letter #7: Baldwin Township Comments on Sawmill TMDLs

Comment 1: The EPA report indicates that target nutrient loads were developed using the 10 year average simulated flow model and the nutrient endpoints for total nitrogen and total phosphorus. In table 4-7 of the report indicates that a nitrogen TMDL is not necessary in Sawmill, because the annual nitrogen load is less than the target load 109955 Lbs/yr < 147787 Lbs/year. Therefore, we conclude that TN is not necessary. Also as documented in this report, the linkage between nitrogen and periphyton in the system is somewhat less established.

> **Response: EPA has not included allocation requirements for TN in the final TMDL reports. Please see General Response #3**

Comment 2: The EPA report indicates that the reduction of total phosphorus loadings from each contributing source will cummulatively meet the TMDL endpoint load and therefore restore and maintain the aquatic life use in impaired segments in Sawmill Run Watershed. This expected result, as stated above, was based on a 10 year simulation and the EMPR method was used to make the necessary reductions in WLA. Based on the following comments of Baldwin Township, we do not think that sufficient evidence and data has been collected and analyzed in order to make this conclusion.

> **Response: EPA disagrees. See our responses below and the General Response section.**

Comment 3: No testing or sampling was conducted on the unnamed stream, UNT 37172 which passes through Baldwin Township. The closest PADEP sampling location was SMR_06 which is approximately 1 mile downstream on Sawmill Run Stream. Until aquatic life sampling is performed, we are unable to conclude that TP is affecting aquatic life and appropriate water quality nutrient level. It must be noted that we have conducted past field investigations along UNT 37172 have noted that aquatic life is present in the stream.

> **Response: EPA is not suggesting the all streams are devoid of aquatic life. What we are addressing is the need for a viable, diverse aquatic community that has a minimum of pollutant tolerant species.**

Comment 4: Also, there is no information characterizing the volume or concentrations from the Combined Sewer Overflows (CSO). Figure 2-10 in the report provides the location of these CSO outfalls in the watershed. It must be stated that these CSO structure are owned and operated by Pittsburgh Water and Sewer Authority and are out of the control of Baldwin Township, Pennsylvania. The control and implementation of appropriate levels of TMDL loading would be by PWSA at those point source locations. In order to develop and achieve appropriate water quality levels for aquatic life, a testing, sampling and monitoring program is needed.

> **Response: EPA regulations and clarifying memorandum allow for a gross allocation to stormwater sources. The monitoring and testing process can be achieved through the LTCP.**

Comment 5: It was stated in the Report prepared for the EPA by Berger and Associates that Pennsylvania does not currently have adopted numeric criteria for nutrient. Therefore, the utilization of a weight evidence analysis was chosen by the EPA's consultant using different analytical approaches and using adequately protected nutrient endpoints that were developed by the EPA. We disagree with this method due to the previously stated lack of sufficient monitoring and sampling. We feel in order to determine the appropriate nutrient TMDL endpoints, a complete Watershed-Wide Monitoring Program needs to be

performed in conjunction and implemented with the PADEP. PADEP's efforts to establish actual numeric criteria for the nutrient levels and guidance documents for TMDL TP , procedures for determining ground water values, load reduction procedures and which BMP's should be utilized, should be supported and followed by all stakeholders.

Response: Please see General Response #1. EPA believes that the approach used is appropriate for establishing TMDL endpoints. PADEP has agreed with the approach used by EPA to establish nutrient endpoints. The multiple lines of evidence approach used to develop TP endpoints for the Piedmont has also been applied for Allegheny Plateau and Ridge and Valley streams and appropriate regional targets have been developed for these streams as well. The approach was identical in scope and analysis and similar data sources were used (namely USGS, EPA, and MBSS data). This analysis was based on sound monitoring and assessment techniques. In addition, the decision that aquatic life use impairment existed and nutrients were the stressor responsible was not the role of the endpoint development team.

Comment 6: Also, until the PADEP determines and provides adequate guidelines for implementation of the TMDL and what each watershed, and municipality must enforce as necessary BMP's we cannot offer informed comments and conclusions. We believe that major improvements are needed in the source assessment and load allocation elements of the TMDL. As stated above, sufficient guidance has not been provided to date.

Response: EPA developed the TMDLs based on best available information. EPA met with ALCOSAN and the City of Pittsburgh on April 19, 2006. We took that opportunity to describe the TMDL process and its goals. At that time we indicated the need to coordinate with the LTCP process. We requested any information that would help us better determine the sources and to better understand the specific control needs. We did not receive any information from ALCOSAN, so we were unable to allocate except on a gross allotment basis. More detailed allocations can be made and the TMDL adjusted as necessary by the state as the LTCP is implemented. EPA policy and guidance allows for a general allocation to categories of sources if sufficient data is not available. Any discussion concerning which BMPs are appropriate to meet the required loading is a subject for the permitting process.

Comment 7: Finally, we feel that after appropriate field investigation and testing is conducted that the findings will be that the present streams can support aquatic life.

Response: The question is not if the stream can support any life but rather can it support a quality, diverse aquatic community. We believe that under the critical design conditions there is a high likelihood that the waters will be able to support a high level of pollutant tolerant aquatic life, such as sludge worms. Control of sediment and nutrients will be required to assure a healthy diversified population.

Comment Letter #8 – Lawrence Barrett's Comments on Chester Creek TMDL

Comment 1: EPA asked our input about whether TP and TN nutrient limits and allocations should be required, or only TP. My answer is that both limits are required. This is a drinking water source and TN and TP values are very high in low flow periods. DEP lists Goose Creek; the uppermost portion of the main stem of Chester Creek as an impaired stream. Additionally, this is a feeder stream to Delaware Bay (see Ref 2)

> **Response: PADEP does not regulate Total Nitrogen for drinking water supplies. PADEP regulates only NO2+NO3. Also please see General Response #3.**

Comment 2: As to the proposed endpoints, EPA requested comment. Table 4-3 shows the proposed Chester Creek Nutrient Targets as follows:

Total Nitrogen	3.7 mg/L
Total Phosphorus	0.04 mg/L

The Nitrogen allocation seems higher than would be found in a local unimpaired stream, and the Phosphorus seems lower. A review I received of the presentation of the December 2007 EPA public meeting stated that EPA then proposed a Nitrogen allocation of 1.5 MG/liter.

> **Response: EPA based the endpoints on available data as well as literature reviews. We believe that the selected endpoints are appropriate for Chester Creek. Although the commenter thought the endpoints seemed higher than would be found in a local unimpaired steam, he did not provide any data to justify that belief, so EPA has nothing to which to respond.**

Comment 3: I would recommend allocations equivalent to background level of "exceptional value" streams of this vicinity.

> **Response: This water is not identified as an _exceptional value' water by PADEP. Therefore use of any endpoint that would be consistent with that type of water is not appropriate.**

Comment 4: Is this a Flawed Report?

> **Response: No**

Comment 5: One major flaw in this study appears to be the lack of accounting for water withdrawals. There are two significant withdrawals for drinking water from this Creek and at least two other potentially significant withdrawals. I believe these withdrawals should be considered for an accurate analysis. (See Ref 3)

> **Response: Based on the available information obtained from PADEP, there is only one water withdrawal maintained by Aqua PA on Chester Creek. In addition, PADEP added that there is no continuous withdrawal, because Aqua PA maintains this withdrawal as emergency intake for their Ridley Creek Water Filtration Plant. Therefore, EPA did not consider the water withdrawals in the WASP model as a significant issue in the TMDL development.**

Comment 6: The second major flaw is *the* inaccurate WWTP location used in the WASP7.2 Computer Model. I found that of the four WWTP listed in Table D-l for the East Branch of Chester Creek only one was on the appropriate model segment. One other was displaced approximately .4 miles upstream (above two dams and one water withdrawal) and two did not even belong on the East Branch, but on the mainstem approximately seven miles away. (Ref 4) I doubt if I found the only improper locations in the watershed. In terms of other report apparent inaccuracies, a few are shown below.

Response: The locations of point source effluents defined and used in the TMDL development were based on individual permit information such as the receiving stream and the river mile.

Comment 7: Tables 5.1 and 5.2 (page 5-5) show GPD "Design Flow, gal/day" as 0.0005 for Schramm, Inc and similar values for other facilities.

Response: The design flows in Tables 5-1 and 5-2 were corrected in the revised TMDL report.

Comment 8: Where is Bridgeport (location of USGS Station 7Q10 on Chester Creek)? Page 2-18. Do you mean Brookhaven?

Response: The quoted 7Q10 flow was computed by the USGS at the USGS Quad —Bridgeport". The station is located downstream from USGS Station 01477000. EPA included additional information on this station in the revised TMDL report

Comment 9: Table 2-11 (page 2-19) has a column labeled "Design Flow" and it is more likely "Permitted Flow".

Response: The label —Design Flow" in Table 2-11 is correct, since the column of this table shows the design flow of the point sources in Chester Creek based on the individual permit.

Comment 10: Table 3-12 shows Monitoring Station GC-1 on Chester Creek? (GC-1 is Goose Creek: CC-1 is Chester Creek)

Response: EPA corrected this typo.

Comment 11: And the following may not be an inaccurate calculation but it seems inconceivable that two WWTP facilities 150 yards apart on the creek have baseline analysis for TN concentrations showing one outfall with 0% required reduction in concentration and the adjacent requiring a 58% reduction in concentration. The result is an allocated TN concentration (MG/L) variation of about six to one. Cheyney is shown with an allocation (TN) of 7.55 mg/1 and Thornbury with an allocation of 43.16 mg/1 in Figures 5-1 and 5-3.

Response: The calculations were verified and found to be correct. The difference in reductions and allocation of both point sources is a result of using the PADEP Equal Marginal Percent Reduction (EMPR) approach to develop the allocations.

Comment 12: Recommend a detailed review and correction of this report by USGS or DEP personnel familiar with this watershed and resubmit the report for public comment as a second draft. These recommendations will cost millions of dollars to implement and they should be as accurate as possible.

Response: EPA believes the study to be appropriate and has no plans to _resubmit' a second draft. Please see General response #9 for the revised scope of the TMDL report.

Comment 13: The goal should be fair treatment of each WWTP in cleaning the stream. (In setting each WWTP limits.). I do not think the Wasteload Allocations of this Draft (as mentioned above) does this.

Response: The commenter did not provide any insight as to why he thinks the allocation process was not fair. EPA used the Equal Marginal Percent Removal (EMPR) process as has been used by PADEP for many years in establishing NPDES permits on streams with multiple sources. This process provides for an equitable allocation between sources based on relative impacts and significance of each source.

Comment 14: Recommend study of the variation of cost of implementation vs. nutrient level limitation and setting limits that are achievable with wetland nutrient treatment for ground water replenishment.

Response: The TMDL program is tasked with establishing allowable loadings in order to attain and maintain existing and applicable water quality standards. Costs considerations are not part of the TMDL process.

Comment Letter #9: Bethel Park Comments on Sawmill Run TMDLs

Comment 1: More data collection locations are needed for this watershed for the following reasons:

Sub Comment a: All of the tributaries have not been included in the data collection points. The municipalities located at the headwaters were not accurately represented due to the fact that the nearest data collection points relative to them is approximately 1.4 miles downstream from them.

Response: The TMDL was developed based on the best available data.

Sub Comment b: Some data collection points are located just downstream of physical features such as a golf course, a junk yard and heavily paved areas which could easily skew the data collected and misrepresent other areas in the watershed just upstream of these types of areas.

Response: The TMDL was developed based on the best available data.

Sub Comment c: Data for nutrient levels was only collected five times for a one month period in 2006. Data should be taken at appropriate intervals throughout the year and for two to three year period to get an accurate representation of the actual condition of the streams in the watershed.

Response: EPA believes that sufficient data has been used in the TMDL development. If additional data is collected in the future, PADEP can consider a TMDL reevaluation.

Sub Comment d: The data collected does not include aquatic life samples. Without these samples, the accuracy of the effects of the nutrients in the waterways is inconclusive.

Response: The TMDL was developed based on the best available data.

Sub Comment e: Where are the groundwater monitoring points located? A map showing their locations must be included in the report. One or more groundwater monitoring sites should be located in each municipality in the watershed to accurately depict the condition of the groundwater in the watershed.

Response: EPA did not receive from PADEP any information on groundwater monitoring locations.

Comment 2: The TMDL reduction levels are based on the TP endpoint analysis which needs to be re-evaluated for the following reasons:

Sub Comment a: The assumptions used in the model are based on a piedmont area in Maryland that is not consistent with the geology, soil conditions and climate conditions of western Pennsylvania.

Response: EPA has reviewed the data for the ecoregion in which Pittsburgh falls and has adjusted the nutrient endpoints accordingly. The final TMDL report takes this analysis into consideration. Please see the General Response #7 for more information. The multiple lines of evidence approach used to develop TP endpoints for the Piedmont has also been applied for Allegheny Plateau and Ridge and Valley streams and appropriate regional targets have been developed for these streams as well. The approach was identical in scope and analysis and similar data sources were used (namely USGS, EPA, and MBSS data).

Sub Comment b: The modeling assumptions are based on limited data from this watershed and without more sample data being collected throughout the watershed the TMDL reduction limits are very unreasonable and unrealistic.

Response: The TMDL was developed based on the best available data.

Sub Comment c: More groundwater data is needs to be collected to substantiate the levels of nitrogen and phosphorus in the groundwater and how the levels of these nutrients affect the groundwater and the watershed.

Response: The TMDL was developed based on the best available data.

Sub Comment d: The TMDL levels should be regulated by the Commonwealth of Pennsylvania. Accurate data found through appropriate studies on the affects (sic) on aquatic life shall be completed for the area where the TMDL is to be regulated. Placing arbitrary limits without completing through studies in the actual watershed will place insurmountable burden on the communities within the watershed.

Response: EPA agrees that PADEP should regulate the levels provided for in the TMDL. PADEP identified nutrient impairments in the watershed and included the water on their 1996 list of impaired waters. Biological data collected by the state showed aquatic life impairment. EPA does not agree that the proposed allocations are arbitrary but based on site data and good science. Please see General Response #6 for a discussion on PADEP's impaired waters list.

Sub Comment e: The reduction levels of phosphorus levels are unrealistic for urban areas. The TMDL for total phosphorus and total nitrogen should not be considered until more substantial data showing the affects (sic) on aquatic life in this watershed can be documented.

Response: Please see General Response #3. The TMDL was based on local quality analysis. See response # 2.d above

Comment Letter #10: Brentwood Comments on Sawmill Run TMDLs

Comment 1: Although we generally support the water quality restoration of Sawmill Run, we feel that this report is not appropriate as it relies on significant generalizations when the report should be based on information representing the actual Sawmill Run Watershed. This is especially pertinent since our region is currently under an EPA Consent Order and we are in the process of collecting data that can be used to report this watershed's characteristics and quality. There will be no need for the generalizations, estimates and assumptions used in the draft report you are proposing to use to generate TMDLs.

As you know, the financial impact to our residents to implement the reductions you are proposing will be substantial. We insist that you reconsider your position and allow time for the current consent order requirements be implemented and a subsequent TMDL report be develop based on actual watershed conditions.

Response: EPA is also under a court order – a TMDL-related Consent Decree: one that requires the completion of the TMDLs for Sawmill Run by no later than June 30, 2008. EPA cannot delay development of this TMDL. Site specific data was collected and used in the TMDL process. PADEP, in 1996, identified the stream as impaired due to nutrients, metals and sediment caused by storm water and CSOs, shown below.

Sawmill Run Listing Information

Aquatic Life (8735)	**Combined Sewer Overflow**	**DO/BOD temp**	**1996**
		Nutrients	**1996**
Aquatic Life (8737)	**Abandoned Mine Drainage**	**Metals**	**1996**
	Combined Sewer Overflow	**DO/BOD temp**	**1996**
		Nutrients	**1996**
Aquatic Life (8738)	**Combined Sewer Overflow**	**DO/BOD temp**	**1996**
		Nutrients	**1996**
Aquatic Life (8741)	**Combined Sewer Overflow**	**DO/BOD temp**	**1996**
		Nutrients	**1996**
Aquatic Life (8744)	**Abandoned Mine Drainage**	**Metals**	**1996**
	Combined Sewer Overflow	**Organic Enrichment/Low D.O**	**1996**
Aquatic Life (8755)	**Combined Sewer Overflow**	**Organic Enrichment/Low D.O.**	**1996**

On April 19, 2006, EPA met with representatives from ALCOSAN and the City of Pittsburgh at which time we explained the TMDL process and the goals of the Sawmill Run TMDL. We also indicated the need to coordinate the TMDL process with the LTCP process and requested any information or data that would help that coordination, including source identification, CSO data, modeling information, stream data, effluent data and location, and any other data or information that would be useful in competing the TMDL. We received no data or information from ALCOSAN. EPA used what data was available at the time. PADEP can better define specific allocations to sources as the LTCP process procedures. EPA does not agree that is better to wait for a long period of time to address issues that have been identified by PADEP since 1996.

Comment Letter #11: Brentwood Comments (Gateway Letter) on Sawmill Run TMDL

Comment 1: The model used to determine the amount and sources of total phosphorus and total nitrogen assumes the only sources are CSOs, stormwater runoff and groundwater. The model simulation does not account for the SSOs present in the watershed that will be eliminated in their entirety as part of the consent order work that is taking place in the watershed. Currently flow monitoring and modeling is taking place under the consent order to verify the quantity of CSO and SSO discharges to the watershed. Depending on the quantities determined, significant changes in the model for source reduction could occur since SSOs would most likely be the highest concentration of phosphorus and nitrogen in mg/1. Elimination of the SSOs may have a significant impact on the amount of CSO, stormwater, and groundwater reductions to achieve the desired removal.

> **Response: In the revised TMDL EPA accounted for the SSOs in Sawmill Run. In addition, since SSOs are illegal discharges, the allocations to the SSOs have been set at zero (0).**

Comment 2: The model assumes the CSO volume to be 30% of the urban runoff. The CSOs in this watershed are fed from municipal sewers in which some of the municipal sewers are combined and many are separate sewers. The model CSO volume should be adjusted after the flow monitoring and modeling are completed to determine an accurate quantity of CSO discharge volumes as well as accounting for the amount of reduction to be achieved as part of the consent order requirements

> **Response: In the revised TMDL, the CSOs volumes was revised using monitoring data found in Appendix B of 2006 Statistics for Permitted CSOs)**

Comment 3: In the CSO discharges, the concentrations of total nitrogen and total phosphorus are assumed to be 9 mg/1 and 3 mg/1 respectively. This is a standard number used for combined sewer discharges. The sewers contributing to these structures are a combination of separate and combined sewers that would most likely lead to higher concentrations at the discharge. This higher concentration would also affect the amount of reduction to achieve the levels required.

> **Response: The final TMDL accounts for SSOs. In addition, since SSOs are illegal discharges, the allocations to the SSOs have been set at zero (0).**

Comment 4: The report does not provide a justification for the use of the 0.04 mg/L standard for total phosphorus. The report also does not provide justification that if this value is achieved, the goal in respect to the aquatic life and water quality will be achieve. There is not sufficient date to backup the level of reduction.

> **Response: Please see General Response #1. Also see General Response #7 which describes the adjustment to the endpoint based on the appropriate ecoregion. EPA believes that the endpoints established for this TMDL are justified. EPA did provide a justification for the endpoints - Please see the report –Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application" for a discussion of the approach. The approach used is consistent with EPA guidance for nutrient criteria development. PADEP is developing state numeric criteria for nutrients. EPA believes that the endpoint will be similar to the numeric criteria developed by the state. The state, through comments on the TMDL, supported the approach used by EPA. The commenter did not provide counter-justification or data to show that the endpoints are incorrect.**

Comment 5: The total nitrogen TMDL should not be included since the report itself does not provide

the justification for establishing a limit. In reality according to the report, the existing total nitrogen concentrations are below the target concentrations. In addition, Pennsylvania should not be establishing requirements for total nitrogen until scientific proof has been established tying total nitrogen concentrations to periphyton densities.

Response: Please see General Response #3

Comment 6: In the report, it states that all of the 14 communities in the watershed have MS4 permits. This is not the case, Crafton is a combined community and does not and is not required to have an MS4 permit.

Response: EPA has corrected this in the final TMDL and any reference to Crafton as an MS4 has been removed.

Comment 7: It is our opinion that setting TMDLs for total phosphorus and total nitrogen is premature due to the extensive work occurring with the sanitary sewers in the region as part of the consent decree issues to all communities in the ALCOSAN sewer system. Data is currently being collected to better refine the model used to determine the target concentrations from the various listed sources. At a minimum, the model should be adjusted once all of the data is in, and should account for the improvements required under the consent decree to determine if and how much of a reduction would be required from each source.

Response: Please see Comment Letter #10 Response

Comment Letter #12: Cheyney University Comments on Chester Creek TMDL

Comment: 2-20 Category Cheyney University is an instrumentality of the Commonwealth of Pennsylvania; we share a state-owned designation without qualification, and our sewage is categorized as municipal.

Response: EPA corrected this error.

Comment: 2-23 Table 2-13 lists all MS4 permits located within the Chester Creek Watershed; Cheyney University is an MS4 permit holder—but we are not on the list. In all instances where 21 MS4's are referenced, the number should be 22.

Response: EPA corrected this error and included the Cheyney MS4

Comment: A-26 The temperature of 2.2C attributed to us in August cannot be correct and thus calls into question the accuracy of the test data throughout.

Response: The temperature value of 2.2^{o}C for Cheney University is a typo and meant to be 22 °C. EPA corrected this typo

Comment: B-3 If you are reporting that in the months from January 2000 to December 2004 Cheyney University submitted 56 rather than the required 60 discharge monitoring reports to PADEP, you are incorrect; perhaps what is meant here is that you only had access to 56 out of 60?

Response: EPA received all discharger monitoring reports (DMR) used in this TMDL from PADEP. The total number of received DMRs is 56.

Comment: Descriptions of plant locations show inconsistencies; we are between two plants described as being on Chester Creek while we are described as being on the East Branch (we are) and as being on Goose Creek (we are not).

Response: The locations of point source effluents defined and used in the TMDL development were based on individual permit information such as the receiving stream and the river mile.

Comment: Regarding the requested reductions, it should be noted that the data from Cheyney University was collected when classes were not in session; our flow varies from 30-45,000GPD when classes are not in session and the flow rises to an average of 110,000GPD when classes are in session. Percentages should not have been based on our lowest flow levels.

Response: The recommended reductions for point sources in the draft TMDL were not based on dischargers flows measured during sampling surveys but based on the permitted design flow and permitted nutrient concentration (if permitted) of each facility. In the case for Cheyney University of PA, a flow of 270,000 gpd (permitted design flow) was used for allocation and reduction. This is also described in more detail in Chapter 5 of the draft TMDL report.

Comment: 4-17 –A calibration for BOD could not be performed because observed BOD values were potentially incorrect according to PADEP." Had the public meeting on 5 March been conducted as such,

I would have asked for a clarification of this statement; a literal interpretation puts all of the collected data in a questionable light.

Response: The measured instream concentrations reported by PADEP in May and August 2006 were subject to a Quality Assurance/Quality Control (QA-QC) process. However, only BOD did not meet the stringent requirements of the QA-QC and was deemed not accurate to use. EPA is convinced that all the other measured instream concentrations used for this TMDL are reliable.

Comment: A-3 The table shows conflicting information for date of samples (was it June or August?) and since there have also been inconsistencies in where plants are shown to be (Chester Creek, Goose Creek, East Branch…) it is difficult to credit the significance of the results for each segment.

Response: EPA corrected the typographical date-error. The correct date is August 1st 2006. The locations of point source effluents defined and used in the TMDL development were based on individual permit information such as the receiving stream and the river mile.

Comment: 2-18 There is something wrong with the method used for measuring record low flow; the number cannot be accurate unless several WWTPs contributed a flow of zero GPD to the waste stream. Note also that '02 was not a drought year, '98 was a drought year—data here shows the opposite.

Response: The —record low flow" (lowest weekly average flow) and the lowest average daily flow (compared to 10 year average daily flows; 1998 – 2007) reported in Chapter 2 of the draft TMDL report is based on daily recorded flow measurements at the USGS station 0147000 located approximately 5 miles from the mouth of Chester Creek.

Comment: Appendix B The University is charged with two violations 1/00-12/04; our DMRs show one violation.

Response: Based on our analysis, there are a total of two exceedances (one for Ammonia on October 1, 2004 and one for total residual chlorine on May 1, 2002). An additional figure was included in Appendix B of the revised TMDL report for total residual chlorine.

Comment: I believe both nutrient TMDLs are necessary but the proposed endpoints are not appropriate, nor is it appropriate that they should differ widely between similar, adjacent point sources. Whether or not there are mitigating circumstances dictating a certain leeway, we must at least strive toward a standard goal.

Response: Quit possibly the commenter is somewhat confused between the in-stream endpoint used by EPA and the allocations established by EPA. The endpoints used by EPA were consistent from stream segment to stream segment. EPA used a total phosphorus endpoint of 40ug/L and a total nitrogen endpoint of 3.7mg/L. The commenter, although objecting to the endpoints used, did not provide any other comment on the endpoints or the method used to establish an endpoint. The commenter did not specific why the endpoints are wrong. EPA cannot reasonably respond to such a general _observation'. The commenter is referred to General Response #1 for a further discussion on the endpoint method. If the commenter is referring to the allocations when objecting to inconsistent endpoints, then the establishment of the allocations was based on the PADEP Equal Marginal Percent Removal approach (EMPR). The EMPR was developed and used by

PADEP to allow for an equitable allocation among sources.

Comment Letter #13: Castle Shannon Comments on Sawmill Run TMDLs

Comment 1: Table 1 -1 of the draft TMDL identifies fourteen impaired stream segments located within the Sawmill Run Watershed, the Source of the impairment and the 303(d) listed impairment. For those fourteen stream segments, there are eighteen 303(d) impairments identified. Ten of the eighteen impairments are identified as "Low DO", four as "Nutrients", three as "DO/BOD" and one as "BOD", The drajft TMDL proposes reductions in Total Phosphorus loadings as the mechanism to address the 303(d) listed segments. The draft TMDL does not provide an explanation for selecting Total Phosphorus as opposed to DO when it is apparent that "Low DO" was identified as the primary reason for the segments not meeting the identified designated uses. Further, page 3-9 of the document cites that "Measurements for D.O. did not violate the Pennsylvania standard for a minimum DO concentration of 4.0 mg/L." This appears lo contradict Table 1-1 in that there are no observed/ measured violations of in-stream DO to validate the suggested impairment (i.e. Low DO).

> **Response: The listings presented in Table1-1 include all impairments identified by PADEP in the 1996 and 2002 303(d) list. This TMDL addresses solely the nutrient impairments in Sawmill Run (Section 1-4 of the TMDL report). EPA understands that this might have caused some confusion; therefore, Table1-1 has been edited in the revised TMDL report to include only the nutrient impairments being addressed by this project.**

Comment 2: Table 2-11 of the draft TMDL lists all of the "...M$4 permit holders...". The information contained in this table is inaccurate. A number of state highways, as identified in Figure 2-1 of the draft TMDL, traverse the Sawmill Run Watershed. Castle Shannon Borough understands that the Pennsylvania Department of Transportation (PennDOT) has its own MS4 permit which identifies its responsibilities for stale owned facilities. Although no County owned roadways were identified in the draft TMDL, it is important to note that Allegheny County also has its own MS4 permit, which identifies responsibilities for county owned facilities. Given the allocation of Total Phosphorus loads to MS4 permittees, this information must be accurate and taken into consideration when allocating loads for Total Phosphorus.

> **Response: EPA is aware of the issue associated with MS4 boundaries. In fact and as part of the Phase II stormwater permit process, MS4s will be responsible for evaluating and mapping out areas that are draining to or discharging to storm sewers. Since these systems have not yet been accurately delineated, the revised TMDL lumps all the MS4 nonpoint source loadings into one load allocation. The Allegheny County MS4 will be included in the overall allocation. See General Response #4 describing how MS4s were addressed in the TMDLs.**

Comment 3: Section 3 of the draft TMDL discusses environmental monitoring conducted in support of the development of the TMDL. The raw sampling data is provided in Appendix A of the draft TMDL, Only two dry weather sampling events (August 8 and September 18 2006) and one wet weather sampling event (October 17,2006) were conducted. Continuous in-stream DO readings were also taken over a two-day period on two separate occasions. It is unclear why such a small set of sampling events were taken in support of the development of such a far reaching document proposing TMDL's. Please provide an explanation for the lack of environmental monitoring data collected to support the development of the draft TMDL.

> **Response: The TMDL was developed based on the best available data. EPA believes that these data are sufficient to develop the nutrient TMDL for Sawmill Run.**

Comment 4: Section 3.1.3 of the draft TMDL compares the concentrations of parameters during a wet weather sampling event lo the average concentrations of the same parameters for two dry weather sampling events. Drawing such comparisons based upon such a small data set appears arbitrary. Please advise the statistical basis and science behind using such a small sampling. Without conducting additional sampling it is not clear if these sampling events are representative of conditions in Sawmill Run. Until additional sampling is conducted any decisions and/or comparisons drawn from the sampling performed to date should be excluded from the TMDL. From a statistical perspective, given the variability of environmental data generally, geometric means are typically utilized. This requires an absolute minimum of three wet weather and three dry weather samples. Given the economic and social impact the TMDL will have on dischargers to the watershed substantially more sampling is required to justify any conclusions, draft otherwise. We suggest that a full hydrologic cycle including representative seasonal sampling be conducted pursuant to establishing TMDL's.

Response: The TMDL was based on the best available data.

Comment 5: The draft TMDL identifies using a "weight-of-evidence analysis" to develop endpoints for Total Phosphorus and Total Nitrogen. In reviewing other nutrient TMDLs developed for the Commonwealth of Pennsylvania and approved by EPA, the "Reference Watershed Approach" was used to determine appropriate loadings. Please provide an explanation for the use of the —weight-of-evidence analysis" as opposed to the "Referenced Watershed Approach",

Response: The approach used by EPA is a valid scientific approach and is consistent with the guidance provided by EPA for the establishment of nutrient criteria. While EPA is not establishing criteria in these TMDLs, rather in-stream endpoints to be used to develop appropriate allocations, we believe that the method is more in line with what PADEP, and other states, will be using to develop nutrient criteria than the estimation reference watershed approach previously used. By using a method consistent with the approach recommended for establishing nutrient criteria we hope will minimize differences in the TMDL endpoint and the eventual nutrient criteria established by PADEP. In addition, the reference watershed approach has not been used in similar situations where point source nutrient loads were the significant contributor. See General Response #1 and General Response #7

Comment 6: Section 4 of the draft TMDL contains the following statement, "Data analysis and modeling runs have established a clear linkage between phosphorus loading and periphyton densities in the watershed..." The draft TMDL does not identify any such linkage other than making this statement. Please provide additional information clearly identifying this linkage.

Response: This statement was revised to read: —data analysis of exiting water quality data was used to establish a revised nutrient endpoint for Sawmill Run".

Comment 7: Section 4 of the draft TMDL contains the following statement, "...the linkage between nitrogen and periphyton in this system is somewhat less well-established. Nevertheless, EPA is proposing TN endpoint in this TMDL because of the potential downstream effects of excess nitrogen to coastal and estuarine waters." This statement is very disconcerting. The closest coastal and/or estuarine water to Sawmill Run is the Gulf of Mexico! The TMDL makes no mention that the Gulf of Mexico is impacted by the nutrient discharges from Sawmill Run. Unless a link between Sawmill Run and the Gulf of Mexico can he provided, TN endpoints on this basis are irrelevant and should not be included in the TMDL.

Response: Please see General Response #3

Comment 8: Section 4 of the draft TMDL contains the following statement, "In a similar situation, NPDES permittees within Pennsylvania arc currently receiving both TP and TN effluent limits in order to help meet water quality standards in the Chesapeake Bay." This statement is irrelevant and has no effect on the development of the TMDL for Sawmill Run. This situation is not remotely similar. Sawmill Run does not discharge to the Chesapeake Bay or to any estuary for that matter. This statement should be removed from the TMDL and a more rational science based justification for the selection of TP and TN endpoints should be provided.

Response: Please see General Response #3. The statement has been removed

Comment 9: Section 4 of the draft TMDL indicates that TN endpoints are being selected at this time so that permittees can address and plan for TN limits that PADEP is currently developing, it appears that by establishing an endpoint of TN in this TMDL, EPA is attempting to establish water quality criteria for TP and TN. A TMDL is not the place to establish a water quality criterion, Also, developing a TMDL in anticipation of a water quality criterion is irrational and a misuse of the TMDL process. To our knowledge, PADEP has not provided draft water quality criteria for TP and TN. As such, developing a TMDL to address water quality criteria that are not even in draft form is arbitrary and inappropriate. Therefore, this statement should be removed from the TMDL and should not be used as the basis for selecting TP and TN endpoints.

Response: Please see General Response #3. In addition, EPA is not developing nutrient criteria in this TMDL. EPA is interpreting the state narrative criteria in order to establish an endpoint for the development of the TMDL. Please see the General Response section for a further discussion on EPA's ability to make such a determination in a TMDL. PADEP, through comment on various TMDLs, has supported the approach used by EPA to develop the TP TMDL endpoint.

Comment 10: The TMDL docs not provide sufficient information and documentation for selection of 0.04 mg/L and 3.7 mg/L as the endpoints for TP and TN, respectively. Given the impact selection of these endpoints will have on the dischargers to the Sawmill Run Watershed, additional explanation and information should be provided. As presented it appears that a review of literature and a comparison to Piedmont streams was conducted and then EPA arbitrarily selected the endpoints without any defensible justification.

Response: EPA adjusted the endpoint for TP based on the information available for the ecoregion in which Pittsburgh resides. The selection was not arbitrarily selected but based on a well documented weight of evidence approach. See General Response #1 and General Response #7. The multiple lines of evidence approach used to develop TP endpoints for the Piedmont has also been applied for Allegheny Plateau and Ridge and Valley streams and appropriate regional targets have been developed for these streams as well. The approach was identical in scope and analysis and similar data sources were used (namely USGS, EPA, and MBSS data).

Comment 11*:* The TP endpoint results in a load of approximately 0.128 Lbs/acre/year. The TP endpoint for the Sawmill Run Watershed is four to ten limes more restrictive than other nutrient TMDLs developed in the state of Pennsylvania which, as previously pointed out, were developed using the "Reference Watershed Approach". Please provide an explanation and justification for the development of a more

significantly restrictive TP endpoint for the Sawmill Run Watershed.

Response: Please see our response to comment #5 above.

Comment 12: Tables 2-10 and 4-3 identify NPDES permitted facilities that discharge to the Sawmill Run Watershed. No additional information, such as, discharge parameters, number of outfalls, loadings etc. was provided for these facilities. The TMDL does not assign any load for TP or TN from these facilities and simply states that these facilities can continue to discharge at their current loads. Without actually presenting any data on these discharges, how can it simply be staled that these facilities can continue to discharge at their current loads. Since these are permitted facilities the information to determine the existing loads should be easily attainable. Any TMDL developed for the Sawmill Run Watershed must take into consideration all sources.

Response: The NPDES permitted facilities identified in the report are associated with stormwater and PADEP do not assign design flows or discharge parameters in the permits.

Comment 13: The last bullet on page 3-9 makes reference to specific conductivity levels upstream and downstream of Wildwood Lake. There is no known Wildwood Lake in the Sawmill Run Watershed. Please explain.

Response: This was a mistake and will be corrected in the final TMDL report.

Comment 14: The first bullet on page 3-16 states that temperature measurements exceeded the standard for Cold Water Fish (CWF). Sawmill Run is classified as a warm water fishery (WWF). All temperature measurements were below (i.e. in compliance with) the standard for a WWF.

Response: Sawmill Run is classified as warm water fishery (WWF) (25 §93.92) and EPA has corrected the bullet concerning the temperature measurements.

Comment 15: Given the above comments, Castle Shannon Borough would expect that EPA revisit the development of the nutrient TMDL for the Sawmill Run Watershed and issue another draft TMDL for public comment prior to issuing a final version. As drafted, the TMDL fails to identify a clear linkage between TP and TN as the cause of impairment to the Sawmill Run Watershed. This is of particular importance given the fact that the majority of the impairments listed in the draft TMDL are attributable to "low DO". It further fails to identify a clear linkage between phosphorus loadings and periphyton densities even though the draft TMDL states that such linkage exist.

Response: EPA plans to finalize the TMDLs as proposed, with the exception of the total nitrogen allocation as discussed in General Response #3. The commenter has not provided any compelling evidence or data that the TMDL developed by EPA is invalid. Note that the TMDL for TP was based on the need to protect the water uses consisting of aquatic life protection. Algal biomass, although reduction of excessive algal biomass is desirable, it was not the controlling factor in the TMDL. PADEP has identified, based on stream biological surveys, the watershed as impaired for nutrients and other pollutants. This impairment was identified on the state‘s 1996 list of impaired waters. Please see the response to Comment Letter #11. Also note that since the nutrient impairment was identified in 1996, the LTCP for the area should have considered this pollutant as it was being developed.

Comment Letter #14: Chadds Ford's Comments on the Chester Creek TMDL

Comment 1: The TMDL methodology used in the Draft Report is not consistent with Total Maximum Daily Load (TMDL) Guidance. Specifically, all seven elements of a TMDL (Figure 1 -2, USEPA, 1999) were either inadequately addressed or not addressed at all. The seven elements of a TMDL are: Problem Statement; Numeric Targets; Source Assessment; Linkage Analysis; Allocations; Monitoring/Evaluation Plan; and Implementation Measures.

> **Response: The guidance was developed in 1991 by EPA and is just guidance. EPA develops TMDLs based on the requirements of Section 303(d) of the Clean Water Act (CWA) and the implementing regulations at 40 CFR 130.7. The CWA and regulations require a TMDL to: be designed to meet existing, applicable water quality standards (numeric, narrative, uses and anti-degradation), include wasteload allocations (WLA) for each point source, load allocations (LA) for non-point sources (allocated to specific sources if data allow or gross allotments to source types), consider seasonal impacts, and include a margin of safety. These TMDLs have met the legal requirements.**

Comment 2: The report does not provide justification for adding nutrient and organic enrichment to the impairment parameters, neither of which was noted on any of the 303(d) listed segments.

> **Response: The PADEP included an unknown pollutant from municipal facilities on the 1996 list of impaired waters. This was based on biological surveys. EPA under a Consent Decree was required to complete TMDLs for the waters on the 1996 list of impaired waters. Since it is difficult to complete a TMDL for an unknown, EPA and PADEP further evaluated the watershed in 2006 and based on that data and analysis determined that the unknown pollutant was nutrients. Several graphs can be found at the end of the comment letter; one for the chlorophyll _a' values and the other for total phosphorus (TP) concentrations. The data shows very high levels of TP, much exceeding the EPA determined endpoint throughout the watershed. The chl _a' values are high. A memorandum from Alan Everett, PADEP to Brian Lee, Louis Berger Group dated February 29, 2008 states that 1998 biological data collected by PADEP shows —the macroinvertebrate communities are very much impaired, especially in the headwaters correlating with the nhighest concentrations of impervious surfaces and treated effluent, and the biologists attributed this impairment to a combination of stormwater and point sources." The chl _a' values and TP concentrations found in Goose Creek plus the biological monitoring by PADEP justifies the nutrient impairment identification for that stream. The biological monitoring data can be obtained from PADEP.**

Comment 3: The load allocation element of the nutrient TMDL was inadequate because it unfairly targeted large point source dischargers while dismissing residential point sources. The allocation for non-point sources was too general to be implementable and contained no assurance that it could be achieved.

> **Response: The commenter seems to be confused by the terminology used in the TMDL program. Refer to the response to Comment #1 above where load allocation is defined as allocations to non-point sources and wasteload allocation is defined for point sources. Let's assume that the commenter is referring to the wasteload allocation for point sources. The allocations were based on the significance of impacts by each source. Using the Equal Marginal Percent Reduction (EMPR) approach developed by PADEP and used for establishing permits in multiple discharge situations, loads are fairly allocated based on**

relative impacts. Insignificant sources, one that when viewed alone would have no impact on the in-stream TP concentrations were allocated less stringent loads. The commenter referenced the need to be consistent with the TMDL guidance previously. The guidance states that –Where there are not reasonable assurances, under the CWA, the entire load reduction must be assigned to point sources." Federal regulations allow LAs to be gross allotments when data is not available for more specific allocation. The regulations, EPA policy and guidance make it clear that a TMDL should not be delayed simply because there is not sufficient data to allocate to specific non-point sources. A larger margin of safety would be applied in situations where data was limited. The general allocation to non-point sources allow for flexibility in implementation.

Comment 4: No monitoring/evaluation plan was presented in the report as required by the TMDL Guidance.

Response: The CWA and regulations do not require a monitoring plan. The guidance only suggests a monitoring plan for Phased TMDLs. This is not a phased TMDL.

Comment 5: The need to develop a TMDL was expanded to include all stream reaches in the Chester Creek watershed based upon "habitat impairment." The report determined that the reaches were habitat impaired after analyzing the diversity and general classifications (pollution-tolerance or intolerance) of the aquatic organisms observed during biological stream surveys. The Draft Report states that a non-impaired segment of Chester Creek was noted as biologically impaired due to riffle embeddedness "Riffle embeddedness" is a description of the degree to which rocks are embedded in sediment, thereby reducing optimal habitat for sensitive macroinvertebrate (insect) species. Riffle embeddedness is noted in areas throughout the Chester Creek and has nothing to do with nutrient loading. The connection between nutrient and organic enrichment and habitat impairment was therefore not established in the report and does not justify expanding the scope of the nutrient TMDL from the seven listed segments to the entire Chester Creek watershed.

Response: See Chester Creek General Response #1. In addition EPA has produced a Chester Creek Watershed Report that addresses nutrient and sediment issues for the entire watershed. If recommendations in the report are followed, both the nutrient and sediment impairments will be resolved. Reduction of sediment, whether it be from bank erosion or overland flow, will improve embeddedness and habitat impairment. Sediment together with nutrient load reductions will restore the watershed aquatic life balance.

Comment 6: The TMDL exceeds its authority by establishing limits on stream segments that have not appeared on the 303(d) list. The Draft Report states that the Chester Creek watershed consists of seven stream reaches that were listed on the 303(d) list of waterbodies in 1996, 1998, and 2002. Despite this, the TMDL was established for the entire watershed.

Response: See Chester Creek General Response #1

Comment 7: There are four segments listed as impaired on the 303 (d) list that are isolated unnamed tributaries with no point sources. This contradicts the implication that the point source dischargers are the primary source of impairment despite being required to provide the greatest reduction in load to the Creek.

Response: See Chester Creek General Response #1. The listed water for nutrients is Goose Creek which has a significant point source. EPA modeled loads from both point and non-

point sources. This analysis confirms that during the summer period the point sources represented the major loading of nutrients (85%). The commenter simply does not provide any data or analysis to support his theory that point source loads are not a significant load source in the watershed.

Comment 8: The greatest concentration of point source dischargers is on the West Branch of Chester Creek. However, there are no listed segments on the West Branch of Chester Creek. This contradicts the implication that the point source dischargers are the primary source of impairment despite being required to provide the greatest reduction in load to the Creek.

Response: See response to comment #7 above. The commenter is also referred to the EPA watershed report that supports the need for further controls in all areas of the watershed.

Comment 9: The Draft Report states that the seven impaired reaches were impaired due to "nutrients and organic enrichment." The primary impact of organic enrichment is a lowering of the dissolved oxygen (DO) concentration. The report acknowledges that only one measurement over the last ten years showed a DO concentration below the stream standard. Therefore, the inclusion of organic enrichment as a source of impairment is not justified. The primary impact of nutrient enrichment is the stimulation of aquatic plant growth, which can result in daily variations in the DO concentrations due to plant photosynthesis and respiration. The result is high DO during the day and low DO during the night. In addition, the accumulation of decaying plant materials in the sediments can create a sediment oxygen demand that generally suppresses the DO concentrations at all times. None of these impacts were identified in the report. Therefore, the addition of nutrient enrichment as a parameter that needs to be limited in the Chester Creek watershed is not justified.

Response: See General Response #1, #9 and #11. The commenter simply does not provide any documentation or data to support his statements. Even though the minimum DO values do not fall below the minimum criterion, a large daily fluctuation would indicate algal activity. Therefore relying solely on a minimum DO concentration to claim no algal activity is invalid.

Comment 10: Although the problem statement specifies nutrient and organic enrichment as the constituents that need to be limited in the watershed, numeric limits are only established for total nitrogen (TN) and total phosphorus (TP). No explanation for adding, then subsequently dropping, the organic enrichment parameter is given in the report. The critical linkage between nutrient concentration targets and re-establishment of aquatic habitat, the stated basis for including all stream reaches in the Chester Creek watershed, was not established to a reasonable degree of scientific certainty.

Response: Organic enrichment is generally caused by excessive biomass growth (algae, macrophytes) in the stream due to excessive availability of nutrients. Therefore, by addressing the nutrient impairments the impairment for organic enrichment is addressed as well.

Comment 11: There are multiple inconsistencies and over-simplifications used in the water quality modeling that result in establishing overly conservative load allocations.

Response: The water quality models (WASP, BasinSim) are approved EPA models to develop TMDLs. These models incorporate an implicit margin of safety to account for uncertainty in the TMDL.

Comment 12: The WASP 7.2 model was used to model the flow and chemical constituents in the streams in the Chester Creek Watershed. The model was developed without the benefit of a modeling quality assurance project plan (QAPP). One benefit of a modeling QAPP plan is that it defines the calibration procedures, criteria for calibration, validation procedures, and sensitivity analysis procedures before the modeling task begins. The modeling QAPP applies to hydrologic and chemical constituent calibration.

> **Response: Even though a formal QAPP was not presented in the draft TMDL report, it should be noted that key elements of the QAPP were addressed while implementing the model.**

Comment 13: The calibration procedure for hydrologic/hydraulics was not described. There was no discussion of which parameters were adjusted to achieve calibration.

> **Response: A more detailed description of the hydrology calibration procedure is included in the revised TMDL report**

Comment 14: The hydraulic calibration on the model was poor. This was due in part by the fact that the fifteen dams in the watershed were not properly accounted for in the WASP 7.2 computer model. The increased re-aeration caused by the dams was accounted for in the model, however the storage volume and increased detention time caused by the dams was not accounted for in the model.

> **Response: Organic enrichment is generally caused by excessive biomass growth (algae, macrophytes) in the stream due to excessive availability of nutrients. Therefore, by addressing the nutrient impairments the impairment for organic enrichment is addressed as well.**

Comment 15: Figure 4-3 compares the measured flow at USGS Gage 01477000 with the simulated flow calculated with the WASP 7.2 model. This is presented in the report as a hydrologic calibration. The comparison between the measured and modeled flows is poor. In some periods the modeled flow is two (2) orders of magnitude less than the measured flow (e.g., early April 2006), while at other times the modeled flow is greater than the measured flow by a factor of 60 (early September 2006). In the period September through December 2006 the modeled flow does not match the pattern or structure of the data.

> **Response: EPA is in the process of reassessing and improving the flow calibration in Chester Creek**

Comment 16: The calibration procedure for chemical constituents was not described. There was no description of which model parameters were adjusted to achieve calibration.

> **Response: The model parameters for the Chester Creek nutrient draft TMDL were presented in Table 4-5 of the draft report as well as in Table D-3. EPA will provide additional information the model parameterization in the revised TMDL report**

Comment 17: The temperature used in the model for critical summer low flow conditions was not stated in the report.

> **Response: The daily measured water temperature values used in the model for the existing condition and allocation condition were described in Chapter 4 and Chapter 5 of the draft TMDL report, respectively.**

Comment 18: There was no sediment calibration and no sediment or suspended solids measurements were used in model calibrations, although this could have easily been done.

Response: EPA did not perform sediment calibration during the models calibration, however, the total suspended solids (TSS) were incorporated in the WASP model to account for light extinction in the water column (the light extinction has a direct impact on algae growth).

Comment 19: The model was "calibrated" to only two (2) measured data points. This is inadequate.

Response: The commenter fails to identify what he believes to be adequate. The TMDL was developed based on the best available data.

Comment 20: Global reaction rate data are listed in Table D-3. There were no reach-specific reaction rates listed in the report. Variations in reaction rates would be expected over approximately 132 miles of stream courses in the watershed.

Response: EPA addressed this issue by using reach specific-reaction rates in the revised TMDL report.

Comment 21: The model was not validated with an independent data set. Model validation is used to test the robustness of the calibrated model.

Response: The TMDL was developed based on the best available data.

Comment 22: A sensitivity analysis was not performed. A sensitivity analysis is necessary to evaluate how the uncertainty in the estimation of model parameters will affect the model's result.

Response: EPA performed extensive sensitivity analysis during the TMDL development for several of the water quality parameter. The input and output model files will be available as part of the revised TMDL deliverables.

Comment 23: The Draft Report provides insufficient detail to verify calculations or what was done. Complete input and output files in electronic form should be made available to reviewers to verify model details that are not described in the Draft Report.

Response: EPA performed extensive sensitivity analysis during the TMDL development for several of the water quality parameter. The input and output model files will be available as part of the revised TMDL deliverables.

Comment 24: The load allocation element of the nutrient TMDL was inadequate because it unfairly targeted large point source dischargers while dismissing residential point sources. Residential point source dischargers were dismissed with a qualitative statement that the loads from these sources are "small" with no backup or analysis. In fact, the per capita loads of P and N are well known and quantifiable.

Response: The total nutrient loads from the sixteen residential point sources within the Chester Creek were estimated using their design flow of 500gpd and a conservative assumption of nutrient concentration of 40 mg/L for TN and 10 mg/L for TP. Based on this conservative estimate, the total nutrient load for residential dischargers accounted only for

0.1% of the total wastewater nitrogen load and 0.4% of the total wastewater phosphorus load in Chester Creek. Therefore, the majority of the nutrients load originates from the large point source dischargers and the residential dischargers have an insignificant impact on the total nutrients wastewater load

Comment 25: The methodology used to calculate the $Q_{7\text{-}10}$ flow was incorrect. It assumed that one critical 7-day low flow period occurred in each often years evaluated. The correct $Q_{7\text{-}10}$ flow was cited but it was not clear which low flow value was used in the analysis. The $Q_{7\text{-}10}$ calculated was one-half that of the actual $Q_{7\text{-}10}$ calculated by USGS. This results in an unnecessary reduction in load allocation.

Response: The 7Q10 flow was not calculated as part of the TMDL project. EPA quoted the 7Q10 calculated by the USGS. This USGS-quoted 7Q10 flow was only used to assess the contribution the contribution on point sources and non-point sources in order to determine whether Chester Creek is and effluent dominated waterbody.

Comment 26: The parameters most indicative of nutrient enrichment, periphyton and phytoplankton, were not measured and the computer model used to establish nutrient limits was not calibrated to periphyton or phytoplankton, even though periphyton was the major parameter being used to justify the TN and TP limits.

Response: The commenter has not been paying attention. The algal biomass was not the major parameter being used to justify nutrient limits. The PADEP use classification of aquatic life protection is the basis for the nutrient controls. The commenter is referred to the endpoint paper –Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application" for a full discussion of the endpoint derivation. Also see the chl _a' graph at the end of this comment letter.

Comment 27: Periphyton is a complex mixture of algae, cyanobacteria, heterotrophic bacteria, and detritus attached to submerged surfaces. Methods for in-stream measurement and assessment of periphyton are available. Phytoplankton are floating plants (algae). Phytoplankton concentrations can be assessed through measurement of chlorophyll-a. This was not done.

Response: Please see the chl _a' graph at the end of this comment letter.

Comment 28: The methodology for nutrient reduction is based upon the assumption that the rate of uptake and utilization of TN and TP by plant material in the Creek is controlled by the ration of TN:TP. A recent study by Gelder and LaRoche (2002) reported that the N:P ratio of algae and cyanobacteria is very plastic in nutrient-limited cells. The C:N:P ratio for algae (phytoplankton) is quite different than the ratio for benthic macroalgae (i.e., periphyton). The C:N:P molar ratio for algae is approximately 106:16:1 and is known as the Redfield Ratio. For macroalgae the C:N:P molar ratio is different and more variable with a median of 550:30:1, known as the Atkinson ratio. This difference was not accounted for in the analysis.

Response: EPA believes that the C:N:P ratios, used in the development of the TMDL, represent well the periphyton in an eutrophic stream such as Chester Creek and are similar to recommended ratios found in the WASP7 Benthic Algae- Model Theory and User's Guide (U.S. EPA, 2006). It should be noted that the Atkinson ratio cannot be applied for freshwater systems such as Chester Creek, since this ratio was established using measurements from marine plants. The commenter refers to nutrient ratios of seagrasses and large benthic macroalgae (seaweeds). The same article indicates that small unicellular

algae, such as periphyton and phytoplankton commonly found in streams, generally adhere to Redfield, with some variability.

Comment 29: The total phosphorus simulation, as shown in Figures G-l through G-8 for the post-TMDL simulations, does not appear to be realistic. The dramatic pattern of low constant concentrations of total phosphorus through the summer growing season is highly unusual and is not likely to be achieved in the stream. Due to nutrient cycling, there is a store of phosphorus in the sediments being released into the water column. The Draft Report does not discuss or present information regarding how benthic nutrients were handled in the model.

Response: The WASP model simulates nutrient benthic-water column exchange. This includes mass balances describing algal decomposition and mineralization as well as their areal fluxes from the sediment to the water column. The revised TMDL report will describe how benthic nutrients were handled in the WASP model.

Comment 30: The assumed failing septic systems were not identified in the Draft Report and a methodology or plan for identifying the failing septic systems was not presented.

Response: The failing septic were estimated using the BasinSim model that was specially developed for Pennsylvania‘s streams to include watershed specific information.

Comment 31: A "weight of evidence" approach was used to establish the nutrient TMDL. This is a qualitative approach that compares TN and TP concentrations with macroinvertebrate diversity indices and species tolerance classifications. There is no guarantee that achievement of target concentrations will improve species diversity or shift populations to more pollution intolerant species.

Response: Please see the General Response #1. The commenter does not provide an analysis of the approach to support his theory that populations shifts will not occur.

Comment 32: The "weight of evidence" analysis is questioned for its application to Chester Creek: How representative was the data to Chester Creek? What data was excluded and why? The models used were calibrated to only two data points which may not be representative of actual conditions and are not sufficient to prove a good relationship between the model and actual conditions.

Response: Please see the General Response #1. EPA developed a nutrient endpoint that would be protective of aquatic life uses. The analytical approach used was chosen to maximize the likelihood that the endpoint selected would result in the greatest likelihood of protecting aquatic life uses. The data indicate that the maintenance of diverse and pollutant sensitive taxa if more likely under the endpoint derived and that above the endpoint derived, the likelihood of maintaining this integrity declines sharply.

Comment 33: The different species of N and P and their differing bioavailability were not considered. For example, ammonia-nitrogen exerts an oxygen demand as it is transformed into nitrite-nitrogen and nitrate-nitrogen. Nitrate is available for plant uptake but does not exert an oxygen demand on the system. Inorganic and organic forms of phosphorus are utilized differently by plants and aquatic organisms. Dissolved orthophosphate is more readily available than other forms of phosphorus and stimulates the growth of plants and aquatic organisms more readily. Up to 80% of the phosphorous in stormwater runoff is bound (attached to) the sediment contained in the runoff and therefore not available as a nutrient source.

Response: WASP simulates the transport and transformation reactions of up to eight state variables considering interacting systems such as algae kinetics (phytoplankton, periphyton), phosphorus cycle, and the dissolved oxygen balance. The overall WASP mass balance equation is solved for each state variable. WASP also includes specific transformation processes to customize the general mass balance for the eight state variables in the water column and benthos. For instance the phosphorus cycle includes dissolved or available inorganic phosphorus (DIP), particulate inorganic phosphorus as well as dissolved and particulate organic phosphorus.

Comment 34: The non-point source BMPs to be employed by each non-point source was vague and not specified. The percent reduction for each BMP was not specified bringing into question the ability to achieve the proposed nutrient reductions.

Response: The commenter is referred to the CWA and regulations. There is no requirement for EPA to include implementation issues in a TMDL. Selection of the appropriate BMPs is the source‘s responsibility and certainly not the TMDLs.

Comment 35: The time frame for achievement of beneficial uses was not presented.

Response: The TMDL goal is not to _crystal ball‘ the future. How long it will take for the stream to return to an unimpaired, healthy water depends on many factors - human and natural; factors such as how quickly it will take the point sources to install the necessary treatment, how long it will take to implement controls on the unregulated non-point sources, how effective the communities‘ public education programs are, how the state and communities address the sediment and nutrient issues as a watershed as outlined in EPA‘s Chester Creek Watershed Report, plus others. EPA does believe that if the sediment and nutrients are controlled to the level proposed in the TMDL report and in the watershed report, the aquatic life use, including a healthy, diversified macroinvertabrate community will be possible.

Comment 36: The cost of treatment plant retrofit to achieve the TMDLs is significant. Even if this investment was to be made, there is no assurance that TMDL will re-establish beneficial uses in all reaches or even impaired reaches.

Response: Control of point sources alone will not achieve the goal of a healthy aquatic community. Non-point source load reductions are also necessary. In addition, the stakeholders in the watershed must go beyond the TMDL requirements and look to the issues in the watershed report, particularly sediment control and watershed-wide nutrient reductions. The commenter does not provide any information, other than opinion, to suggest that the aquatic life will not be achieved.

Comment 37: The non-point source loads from MS4 areas were reduced to pound per day (Ib/d) continuous values. This is not how the non-point source loads occur in reality. In reality the non-point source loads occur less frequently but the loads are larger.

Response: This is a statement not a comment or question.

Comment 38: Non-point source loads are estimates. There are no measured bases for the non-point source loads.

Response: EPA believes that the nonpoint source nutrient loads were representative of the watershed, since the estimates are based on a robust and EPA approved watershed model, BasinSim, and the input data were based on data information in the watershed. Appendix E of the draft TMDL provides a detailed description of the BasinSim model development for Chester Creek

Comment 39: The per capita daily total phosphorus loads used in the analysis were too low by 50% compared to literature values (2.5-3.4 g/capita/day versus 1.5 g/capita/day used in the analysis). This puts an unfair burden on the point source dischargers.

Response: The 2.5-3.4 g/capita/day of phosphorus is usually quoted for phosphorus in raw sewage. Therefore, the 1.5 g/capita/day of phosphorus used in the TMDL is a more representative value of the phosphorus content from failing septic systems.

Comment 40: The connection, if any, between the habitat impairment and nutrient loads was not demonstrated. No remedies or allocations for habitat impairment were established.

Response: EPA agrees that habitat issues need to be addressed. To this end, EPA has produced a Chester Creek Watershed Report that addresses the habitat issue through both sediment load evaluations and nutrient loads for the entire watershed. EPA encourages PADEP to build on that report and develop appropriate sediment and watershed nutrient TMDLs at a level that will address the habitat problems. EPA‘s report provides recommended reductions of sediment and nutrients for various sources.

Comment 41: The EPA set the phosphorous TMDL for 7 of the 32 treatment plants at a concentration of 0.05 and 0.04 mg/L which is the current limit of treatment technology. The EPA cited the document "Evaluation of Exemplary WWTPs Practicing High Removal of Phosphorus", prepared for the Spokane River TMDL Collaboration Technical Working Group (November 2005), in its development of the TMDL. This document states that "at this is time, the lowest demonstrated effluent total phosphorus limit for plants of substantial size (>2.5 mgd) is [0.1 mg/L]."

Response: It seems the commenter is suggesting that 40 or 50 ug/L can be met although at limits of technology. Please note that the allocations are a seasonal average and not a monthly or daily number.

Comment 42: The EPA set the phosphorous TMDL for 14 of the 32 treatment plants at 0.10 mg/L. The EPA cited the EPA document "Treatment Performance of Various BNR Process Configurations" (June 2007), in its development of the TMDL. This document states that "[Limit of Technology] levels (i.e. [nitrogen] less than 3 mg/L and [phosphorous] less than 0.1 mg/L) have not been demonstrated at treatment plants with capacities of less than 0.1 mgd. BNR for [nitrogen] removal may be feasible and cost effective. However, BNR for [phosphorous] removal is often not cost effective at small treatment plants."

Response: EPA established the draft allocations based on the need to attain and maintain applicable water quality standards. The dischargers should work with PADEP to determine the best way to assure these allocations are met. The final TMDL has been limited to Goose Greek. Please refer to the General Response section for more information.

Comment 43: Canopy cover, in-stream habitat and streambank erosion are not identified, quantified are included in the establishment of the TMDLs despite having significant impact on algae growth in streams.

Limiting phosphorous and nitrogen will not address these factors.

Response: The canopy cover (shading) is implicitly included as a segment-specific variable in the WASP model and is used to calculate solar radiation at the water surface. Stream bank erosion and the resulting impacts of instream habitat through sediment were covered in a separate report on sediment

Comment 44: The in-stream phosphorous target concentration of 0.04 mg/L is extremely low for a flowing stream. This is recognized in New Jersey where the state-wide in-stream phosphorous target concentration is 0.10 mg/L.

Response: There is a range of phosphorus values in use throughout the country and the commenter appears to have picked one that supports his position. EPA completed a detailed literature review as well as a science-based evaluation of the data to support our number. Referencing one state provides very limited information and does not recognize the other areas where much more stringent values are used. The commenter is referred to the extensive literature review performed by EPA concerning nutrient endpoints. The 40 ug/L value selected by EPA is not the most stringent nor is it the least stringent.

Comment 45: The in-stream nitrogen and phosphorous limits for Chester Creek is half that used in the Chesapeake Bay Watershed. This makes the Creek limits appear overly stringent given the sensitivity of the Chesapeake Bay to nutrient loads.

Response: There are situations where local impacts are significant, particularly in situations of very low dilution, i.e., point source dominated waters. One should not rely on generalities.

Comment 46: The Draft Report states "based on analyses to determine appropriate nutrient endpoints in Southeastern Pennsylvania [emphasis added], a total phosphorus (TP) in-stream target concentration of 0.04 mg/L and a total nitrogen (TN) in-stream target concentration of 3.7 mg/L were used to make reductions of nutrient (TP and TN) loads to major and MS4 point sources (32) and nonpoint sources." This statement implies that any stream PADEP determines is impaired by nutrients, this TMDL is appropriate. For the reasons stated in these comments, the application of these target concentrations is not appropriate and should not be applied universally to southeastern Pennsylvania.

Response: The endpoint was based on an ecosystem evaluation. It is believed that an endpoint for TP for any water that falls within this ecosystem that is similar to the endpoint used in this TMDL would be consistent with the approach used by EPA. The nutrient endpoints developed for Chester Creek were developed to be protective of aquatic life uses in Piedmont streams generally. Therefore, they are applicable to any Piedmont streams where nutrients are an identified source of aquatic life use impairment.

Comment Letter #15: Chester-Ridley-Crum Watershed Comments on Chester Creek TMDL

Comment: Chester Ridley Crum Watershed Association (CRC) is in favor of a significant reduction in the nutrient loadings into Chester Creek. Since this is an effluent dominated stream, with approximately 85% of the loadings of Nitrogen and Phosphorus originating from waste water treatment facilities, the overwhelmingly majority of this reduction would have to come from these facilities.

Response: EPA agrees with this comment.

Comment: We appreciate EPA referencing our data collected monthly along Chester Creek. However, only four of our Chester or Goose Creek stations were sited, instead of the eight, and only data through 2005 was referenced. We request that EPA reference the 2006 and 2007 monthly data from all eight sites, and have attached a copy for your records.

Response: EPA included this new information in the revised TMDL report.

Comment 1: Goose Creek and the East Branch are significantly impaired by hydromodification and loss of in stream habitat, as noted in the 303(d) report, as well as the degradation believed to be linked to excessive nutrient loadings. Stream bottom degradation/siltation resulting from the impervious surfaces and flood plain encroachment (hydromodification/loss of habitat) may be as significant or even more responsible as the impairment from the excessive nutrient loading, as evidenced by the impaired status of Goose Creek above the West Chester Waste Water Plant. However, to our knowledge, no high flow/sediment TMDL has been proposed. If the sediment issue is not addressed, the stream will likely remain impaired despite the significant investments on the part of the treatment plants to remove nearly all of their phosphorus and a large part of the nitrogen from their effluent.

Response: EPA has developed a Chester Creek Watershed Report that includes an analysis of sediment in the watershed. The commenter is referred to that document which can be found on EPA, Region III's web site

Comment 2: The TMDL report does not make an air-tight case linking the nutrient levels to levels and kinds of periphyton, DO violations, or pH violations. In fact, it fails to document any DO or pH violations, in part because only two days of continuous monitoring was done. Moreover, the report states on page 3-30 "measurements of DO at all stations never violated Pennsylvania's minimum standard of 4 mg/L." The use of the word *never* is inappropriate since it implies substantial research which in fact was not done. If more extensive continuous DO monitoring had been done, it would more conclusively determine whether or not DO violations were occurring, and confirm the purported link between the nutrient loadings, the algae, and the violations. An example of a study establishing such a link was Dr. John Davis's study done on the Brandywine which show a link between change in periphyton masses and pH and DO violations.

Response: The TMDL was developed based on the best available data. EPA eliminated the word —never" in the draft TMDL report.

Comment 3: Periphyton data was collected by DEP in May of 2006 and sent to Harrisburg, but this data does not appear to be referenced or listed in the report. CRC had requested this data on several occasions through Alan Everett of DEP, but it was never received by us, nor discussed by EPA's contractor at the hearing. This is a significant weakness, since this link is the rationale for the required reductions. If a discussion of the type and biomass/square meter were presented in the report, it would lend credence to

the argument that the excessive nutrient levels were creating algae harmful to aquatic life.

Response: The commenter is referred to the chl _a‘ graph at the end of this comment responsiveness document.

Comment 4: Pages 2-14 and 2-15 relate to the presentation of data from Private Organizations.

(1) Page 2-14- CRC maintains **seven** (not four) monthly monitoring stations on Chester Creek, from 2004 **through** 2007 (not through 2005) and change the number of samples and collection periods accordingly. This data has been attached.

Response: EPA included this new information in the revised TMDL report.

(2) Page 2-14. Delete "Chester Creek Watershed Association" (I do not believe this organization exists) and replace with "Widener University students /Dr. John Davis" or 'Dr. John Davis/Widener University". The two Widener student studies done in conjunction with CRC were April 2004 and March 2005. Continuous DO data measured at Chester Creek and Locksley April 2004 should be credited to Dr. John Davis, Widener University.

Response: EPA corrected this omission

(3) Page 2-15/ Table 2-8: Delete the four lines which relate to data collected from White Clay, Brandywine, and Ridley Creek at Gradyville or Waterville Rd, since they are not part of Chester Creek.

Response: EPA corrected this omission

(4) It should be documented who did the continuous DO monitoring August 3-5 2005 at Locksley.

Response: EPA included this information in the final TMDL report

Comment 4 (letter had 2 comments identified as #4): Discussion of Violations of Nitrogen Safe Drinking Water standards. The report does state that Goose Creek and Chester Creek violated the 10 mg/L nitrogen standard for drinking water, but if all four years of CRC's data were used, the frequency and range of these violations would be more extensive. The correlation of Nitrogen violations with the low flows, particularly during the drought from August - mid October 2007, apparent in CRC's data (see Dutton Mill Road data set) should be noted. Some discussion of the negative long term health impacts and threats of nitrates to humans, fish, and amphibians should also be included.

Response: Based on the Pennsylvania Code (25§ 93.9g), Chester Creek‘s water uses does not include potable water supply (PWS). Therefore, the water quality criterion for nitrate of 10 mg/L for PWS is not applicable for Chester Creek. EPA corrected this in the revised TMDL report

Comment 5: Targeted Reductions for MS4s. The study calls for 5.7% reduction in Nitrogen loadings and 84% reduction in Phosphorus loadings by MS4s. The 5.7% reduction in Nitrogen is attainable, but the 84% reduction proposed for Phosphorus is not attainable and should not be put in municipal permits. A total ban on phosphorus fertilizers in the state of Minnesota resulted in a 13-18% reduction from participating homes after five years (source: Dr. Fred Lubnow, Princeton Hydro), which would be a more reasonable expectation. Much of the nutrient loadings come from sources difficult to pinpoint or control,

such as septic and legacy settlements. (Land Studies estimates one pound of phosphorus loading for every 700 feet of eroding stream bank).

Response: The reductions allocated to MS4 sources are based on estimated existing conditions and required removal from existing loads. One should not focus on the actual percent reductions but rather on the allocated loads.

Comment 6: Watershed-Wide Applicability. It is not explained in the report why although DEP went to efforts to list certain sections were impaired in the 303(d) listing, but the TMDL reduction criteria were applied to all waste water plants in the watershed. It might be more defensible and politically acceptable to start with the segments that have been designated as clearly impaired, i.e. Goose Creek and the upper part of Chester Creek below Goose Creek, while putting a freeze on additional nutrient contributions in the other segments, in a phased approach.

Response: Please see General Response #9.

Comment 7: The public hearing could have been better organized to allow for more questions and answers instead of repeating the December presentation. The EPA representative stated that these streams were Warm Water Fisheries, whereas in fact the majority of Chester Creek which is being impacted by this TMDL, including sections in Middletown, Thornbury, Aston, and Concord, are Trout Stocking Fishery. CRC is working hard to protect this TSF designation, since we know it represents a major recreational resource to the region. The critical minimum DO values for those TSF segments should be set at 5 mg/L from February through July in the graphs in the appendix.

Response: EPA corrected this omission and all the figures were edited, in the revised TDML report, to reflect the water quality standard for TSF water uses.

Comment Letter #16: Harrisburg (#2) on Paxton Creek TMDLs

Comment: With short notice I was able to attend the March 19, 2008 public hearing regarding the proposed Paxton Creek TMDL. Although a TMDL strategy for Paxton Creek has been a rumor for sometime, we now find ourselves in a tight time-frame to evaluate data derived from a model that can not be calibrated and may not even be applicable to the Paxton Creek. Calculations do not appear to be based on a 24-hour day, and there may be some misunderstanding regarding the predominance of loadings during the non-growth season.

The potential impact to the City of Harrisburg of the proposed Paxton Creek TMDL is significant. I respectfully request an extension to the comment period, currently slated to end April 3, 2008. Thank you.

Response: The public comment period was extended until April 18, 2008

Comment Letter #17: Close for Harrisburg Comments on Paxton TMDLs

Comment 1: The basis of load allocations for EPA's model was used with data that was not derived on the same timescale or during the same season. Will EPA be able to refine the model and possibly the TMDL with additional data collected by the stakeholders in this affected watershed?

> **Response: The Paxton Creek TMDL was based on the best available data and uses a long term simulation (10 years) to predict nutrient target loads and existing loads. The allocation were developed using an annual average load. EPA is revising the existing TMDL with respect to the loads from the CSOs and the MS4s in the lower watershed. This revision stemmed from an analysis of the time of travel in the lower section of Paxton Creek. The analyses suggest that, in the lower channelized portion of the creek, there is a relatively short time of travel for nutrients from stormwater overflows to have significant impact on the water quality in the creek. The revised TMDL focuses on the segment below Wildwood Lake to the confluence with Asylum Run. EPA will include any additional data in the revised TMDL, as long as it has met the QA/QC process.**

Comment 2: Sampling for water quality impacts was performed as part of THA's LTCP at four (4) CSO sites that discharge to the Paxton Creek in 2003. Samples taken for D.O., Temperature, pH, Fecal Coliform, BOD, TSS, Total Settleable Solids, Total Phosphorous, and Total Nitrogen were compared with existing water quality samples taken before the CSO events. The data from these studies should be considered rather than using literature values for Total Phosphorus and Total Nitrogen. How does EPA's model for TMDL endpoint impacts compare with the approved results of THA's program?

> **Response: On May 28, 2008 EPA received a letter dated May 21, 2008 from the Authority that summarized the data for the 4 overflows. The LTCP was not provided with that letter. As much of the summarized data that could be used was considered in the final TMDL. See General Response #12 and the response to letter #55 for more information. During the development of the TMDL the LTCP was not available. As of May 29, 2008, EPA has not yet received THA's LTCP.**

Comment 3: How does EPA's mean CSO discharge event effluent characteristics cited by Thomann and Mueller compare to THA's 2003 water quality monitoring results from the CSO discharges? How will the percent reduction proposed for CSO discharges be implemented if the measured CSO discharge water quality is better than the estimated effluent characteristics? How will the percent reductions proposed for nonpoint sources be modified?

> **Response: EPA used the best available data to develop the Paxton Creek TMDL. EPA attempted to acquire any relevant data on the CSOs discharges. The assumption used to characterize the CSOs discharges is based on best literature values for mean CSOs nutrient discharges concentrations. As of May 29, 2008, EPA has not received yet THA's LTCP. See our response to Letter #55 and General Response #12 for more information. EPA has accepted the Authority's projected reduction of 14% as stated in the May 21, 2008 letter from the Authority and assigned that reduction to the COS in the TMDL. Based on the May 21, 2008 letter, there should be no additional reductions needed above the LTCP reductions to meet the TMDL allocations.**

Comment 4: THA's improvement alternatives were evaluated using a calibrated SWMM model for five (5) discrete storm events for return periods ranging from 1.2 months to 12 months. The result of this

model, with estimated CSO volumes, is documented in THA's approved LTCP. How do the model results compare with EPA's data used to model TMDLs?

Response: During the development of the TMDL the LTCP was not available. As of May 29, 2008, EPA has not received yet THA's LTCP. Therefore, EPA could not compare or use results from the LTCP SWMM modeling study. The May 21, 2008 letter from the Authority simply summarized the available LTCP data and did not include nor offer the results of any stream or system modeling.

Comment 5: THA's LTCP was prepared and submitted based on impacts to existing water quality to satisfy EPA and DEP requirements for management and control of CSO discharges. The approved alternative (1-A) in the THA's LTCP was to increase the capture volume to 90% of CSO discharges, as well as capture floatables. Proposed construction implementation of LTCP improvements was to start in 2012. Will New TMDL requirements require a new LTCP and subsequent new timelines for improvements?

Response: The WLAs can be used as post construction monitoring goals. We do not anticipate a new LTCP. EPA notes that in 2003 PADEP reminded the City that Paxton Creek —is included on the 303(d) list of impaired waters and one of the causes for listing is the existence of CSOs. Although this stretch of creek through Harrisburg may not be _sensitive', it is important to work on its recovery as a viable aquatic community resource." See General Response #12 for more information. A May 21, 2008 letter from the Authority states that —Hydraulic modeling completed during preparation of the Authority's Long Term Control Plan estimated the annual volume discharged by the CSOs to be approximately 159 MG. However, the Plan recommended optimization of the CSO regulators and enhanced floatable controls to reduce overflow volume to an estimated 137 MG based on hydraulic modeling." That appears to be a 14% reduction in overflow volume. We were not provided data that shows a 90% capture for overflows to Paxton Creek.

Comment 6: Will there be a season (e.g. recreation or growing) where the TMDLs are enforced?

Response: The TMDLs are based on a seasonal endpoint. PADEP will use the state's existing procedures to address off-season permitting requirements

Comment 7: Will all point sources, including storm water and CSO discharges, to the Paxton creek receive an individual NPDES permit? It is our understanding that no new NPDES permits are being issued for new facilities due to the Chesapeake Bay Watershed Initiative.

Response: PADEP is the permitting authority and should be contacted concerning how the permits will be addressed. EPA does not believe that individual permits will be issued for each outfall.

Comment 8: Will the Phase II TMDL implementation require a current MS4 or NPDES Permittee to establish timelines for sampling, monitoring, and implementation actions to satisfy TMDL requirements? If so, what are the typical requirements for sampling, monitoring, and implementation?

Response: PADEP is the permitting authority and should be contacted concerning any issues with permitting of the CSOs.

Comment 9: Through what statutory and regulatory provisions will the TMDLs for the Paxton Creek be

legally binding?

Response: Requirements under Section 303(d) of the CWA and 40 CFR Sections 122.44(d)(1) and 130.7. See General Response #2 for further legal issues discussion.

Comment 10: If PADEP's management goal is to eliminate CSOs, how will the implementation of the TMDLs for CSO reductions affect the current Long-Term Control Plan for the existing CSOs?

Response: If the CSOs are eliminated it must be obvious that the nutrient loading from those CSOs would also be eliminated.

Comment 11: Will PADEP revise the MS4 requirements to meet the recommended endpoint reductions of each MS4 community?

Response: PADEP is the permitting authority and should be contacted concerning any issues with permitting of the MS4s. Please see General Response #8 for EPA's clarifying policy on storm water and permitting.

Comment 12: How will the Nine Minimum Control (NMC) Program be required to be revised if TMDLs are implemented?

Response: PADEP is the permitting authority and should be contacted concerning any issues with permitting of the CSOs.

Comment Letter #18: Concord Township SA Comments on the Chester Creek TMDL

Comment: Our Authority has recently completed construction of a 1.8 MM GPD treatment plant. We used the existing 1.2 MM GPD 10-year old plant to add backup and processing support to the new seven million dollar ($7,000,000.00) facility. We spent many years saving money, investigating various methods and processes, and in the end believed we had built a "state-of-the-art" process that would serve our area for many years. We also thought we had acted responsibly for preservation of the environment and to provide necessary services to the Authority's present and future customers.

We began operating our new plant in October 2007. Almost immediately, we became aware of new TMDL changes being considered by the EPA/DEP. If in fact the new limits for Total Nitrogen (TN) and Total Phosphorous (TP), as rumored, are imposed on the Authority with the enormous attendant costs passed on to the Authority's customers, our new state-of-the-art processing sewage/wastewater treatment facility would not be able to meet the discharge criteria.

Since becoming aware of these potential TMDL changes, we have gathered and analyzed any and all information we can find. We have also faithfully attended all meetings made available to us from a number of sources to educate ourselves.

To summarize all of the above comments, we simply cannot agree with the conclusions shown to us as sound reasoning to justify that these potentially enacted new TMDL TN and TP limits are justified, either from an environmental standpoint or from the financial burden to the recipients of our services.

> **Response: Please see General Response #9. The commenter did not provide any information to which EPA can react to other than the opinion that the TMDLs are not justified. EPA disagrees and believes that the impairment has been confirmed, the endpoint is based on EPA guidance and the allocations are fair and designed to meet existing applicable water quality standards, including stream uses.**

Comment Letter #19: Crafton Borough Comments on Sawmill Run TMDL

Comment: Although we generally support the water quality restoration of Sawmill Run, we feel that this report is not appropriate as it relies on significant generalizations when the report should be based on information representing the actual Sawmill Run Watershed. This is especially pertinent since our region is currently under an EPA Consent Order and we are in the process of collecting data that can be used to report this watershed's characteristics and quality. There will be no need for the generalizations, estimates and assumptions used in the draft report you are proposing to use to generate TMDLs.

As you know, the financial impact to our residents to implement the reductions you are proposing will be substantial. We insist that you reconsider your position and allow time for the current consent order requirements be implemented and a subsequent TMDL report be developed based on actual watershed conditions.

Please see the attached letter from our Municipal engineer, The Gateway Engineers, Inc., providing additional details on this and other subjects. We hope that you concur with our assessment that your Draft Sawmill Run Watershed TMDL Report is premature and you allow time for the results of the Consent Order work to be realized.

Response: Please see response to Comment Letter #10.

Comment Letter #20: John Davis Comments on Chester Creek TMDL

General Comment 1: Goose Creek and the downstream waters of Chester Creek are nutrient enriched. The phosphorus and nitrogen concentrations in the stream are well above background levels, and are probably higher than most streams in PA.

However, the impact of the elevated nutrient concentrations has not been adequately assessed. Biological surveys by PA DEP do not reflect recent conditions and do not cover the entire watershed. The survey methods or evaluation procedures used by PA DEP varied over time and are difficult to interpret. Habitat problems such as excessive sedimentation were identified at many of the sites studied by Pa DEP, and the impacts on the ecosystem due to either nutrient enrichment and/or sedimentation cannot be easily separated. Nutrient enrichment may impact macro-invertebrate communities as were studied by Pa DEP, but nutrient enrichment will more directly impact periphyton species, biomass, and metabolic rates (photosynthesis and respiration). Since none of these aspects were adequately studied in the watershed, I feel that it is difficult or impossible to develop a pollution control strategy that is protective of the environment and cost-effective for the communities located in the watershed.

> **Response: See Chester Creek General Comment #1. In addition, see the chl _a' graph and the TP graph for Chester Creek at the end of the response document. The TP concentrations found in Chester Creek in 2006 greatly exceeded the endpoint established by EPA, indicating a overly enriched system. EPA has produced a Chester Creek Watershed Study that includes an analysis of nutrients throughout the watershed as well as sediment impacts and control recommendations. We believe that implementation of the requirements of the TMDL for Goose Creek and the recommendations for the overall watershed for nutrients and sediment will result in an improved habitat with a healthy, diverse aquatic organisms. A memorandum from Alan Everett, PADEP to Brian Lee, Louis Berger Group dated February 29, 2008 states that 1998 biological data collected by PADEP shows —the macroinvertebrate communities are very much impaired, especially in the headwaters correlating with the highest concentrations of impervious surfaces and treated effluent, and the biologists attributed this impairment to a combination of stormwater and point sources."**

General Comment 2: The TMDL report does not adequately emphasize that nitrate levels in Goose and Chester Creek approach or exceed the 10 mg/L NO_3-N criterion for a public water supply. Chester Creek is used as a public water supply, Watershed Association shows that and data collected by the CRC NO_3-N levels periodically exceed this limit, especially during low flow conditions.

> **Response: Please see General Response #9.**

General Comment 3: The methodology used to develop the target level for total nitrogen concentrations is arbitrary and does not represent a valid approach that clearly identifies impacts caused by excessive nitrogen concentrations.

> **Response: See General Comment #3**

General Comment 4: The sophistication of the water quality model is either not justified or not adequately supported by the limited field data to provide a reasonable level of confidence in its application to develop a TMDL.

> **Response: The need of using a model such as WASP for the Chester Creek nutrient TMDL is justified due to the fact that nutrient loads from point sources and nonpoint sources need to be considered in mass balances as well as chemical and biological kinetic interactions in the water column and benthic. The TMDL development was based on the best available data.**

General Comment 5: I appreciate the legal constraints that EPA is under to complete this TMDL, however, I am afraid that all parties and the environment affected by this TMDL will not be justly served when so little is known of the actual condition of the ecosystem throughout the watershed and the extent of the impacts caused by nutrient enrichment.

> **Response: Since the TMDL has been scaled down to include only the Goose Creek area, there now remains time for PADEP to further explore the watershed as a whole. EPA still believes that nutrients and sediment are a watershed-wide problem with the major sources of nutrients being point sources. The communities need to come to an understanding of the need to better control nutrients in the treatment plants effluent in order to resolve the aquatic life issues in the watershed. Unfortunately, since most of the watershed has been removed from the TMDL, this nutrient control will not happen in the near future.**

Specific Comment 1: The report incorrectly references data collected by the Chester -Ridley-Cram (CRC) Creek Watershed Association and studies conducted by Widener University in support of the CRC Watershed Association. The studies identified on page 2-15 of the TMDL report were conducted by Widener University faculty and students, and some of these data were included in reports prepared by the students. Both the CRC Volunteer Monitoring data and reports on special studies conducted by universities are reported and contained on the CRC Monitor's web page at:

http://muse.widener.edu/HfdOQ01/CRCmonitor/CRCpagel.html

Also, the TMDL report cites water quality samples that were not collected in the Chester Creek Watershed (White Clay Creek, West Branch Brandywine, EBDT, Ridley Creek stations).

> **Response: The name of the location of the first monitoring station from CRC was incorrectly entered in Table 2-8 and was corrected in the revised TMDL report. The references to the stations, White Clay Creek, West Branch Brandywine, EBDT, Ridley Creek, were deleted in the revised TMDL report**

Specific Comment 2: The calibration results shown on pages 4-19 through 4-34 show a consistent and repeating pattern of increasing nitrogen and phosphorus concentrations from the start of the month to the end of each month, followed by a rapid decrease at the end or beginning of each month. This pattern may be explained by rain events occurring exactly at the end of each month, but the actual flow data at the Dutton Mill flow gage do not show this pattern for 2006. I suspect that a component in the model which controls nutrient loads is not set properly.

Response: The simulation results shown in the draft TMDL report are daily concentrations reflecting the response from nonpoint source loads and point sources loads. The figures show time series of daily concentration and not time series of daily load. Therefore a comparison of concentrations to measured flow data at the USGS station 01477000 is not adequate.

Comment Letter #21: John Davis Supplemental Comments on Chester Creek TMDL

Comment: It is not clear whether the graphs of dissolved oxygen concentrations from the calibration study (pages 4-19 thru 4-30) are average daily DO levels or instantaneous values. If they are average values, then the report does not show the variability in DO levels during the course of a day when DO levels could be significantly lower in the evening and early morning hours and much higher during the middle of the day. If they are actually instantaneous values, then I believe there would be an error in the model because a diurnal variation of at least 3- 4 mg/L could be expected. The graphs should be properly labeled to clarify what values they represent.

> **Response: The graphs on page 4-19 through 4-30 show average daily DO and nutrient concentration. EPA corrected the text and captions in the revised TMDL report**

Comment Letter #22: Borough of Dormont Comments on Sawmill Run TMDL

Comment: Although we generally support the water quality restoration of Sawmill Run, we feel that this report is not appropriate as it relies on significant generalizations when the report should be based on information representing the actual Sawmill Run Watershed. This is especially pertinent since our region is currently under an EPA Consent Order and we are in the process of collecting data that can be used to report this watershed‘s characteristics and quality. There will be no need for the generalizations, estimates and assumptions used in the draft report you are proposing to use to generate TMDLs.

As you know, the financial impact to our residents to implement the reductions you are proposing will be substantial. We insist that you reconsider your position and allow time for the current consent order requirements to be implemented and a subsequent TMDL report be developed based on actual watershed conditions.

Please see the attached letter from our Municipal engineer, The Gateway Engineers, Inc, providing additional details on this and other subjects. We hope that you concur with our assessment that your Draft Sawmill Run Watershed TMDL Report is premature and you allow time for the results of the Consent Order work to be realized.

> **Response: Since this is the same letter as Comment Letter #10 please see the response to Comment Letter #10**

Comment Letter #23: East Goshen Municipal Authority Comments on Chester Creek TMDL

General Comment 1: EPA worked from an impairment list provided by PA DEP covering the period 1996-2002. The EPA contractor was unable to answer an audience question of how the impairment was documented. Additionally, the list is 12 years old in some cases and —changes have likely occurred in the meantime - could be either good or bad. The Report should better document the source and rational for the impairment including any measurement data that would support the impairment.

> **Response: See General Response #10. The PADEP collected data in 2006 that showed a very high concentration of phosphorus throughout the watershed. See the graph presented in the attachment to this Response Document. Also the chl _a' graph that is presented at the end of this document shows high biomass in the Goose Creek area. This is fairly recent data showing concentrations at levels that would cause nutrient enrichment issues. Things probably have changed over the last 12 years – development that has reduced the impervious lands which increases sheet flow and sediment into the water course as well as an increase in stream velocities that result in an increase in bank erosion all resulting in impaired habitat, plus an increase in waste flows and impinges on stream corridors.**

General Comment 2: PA DEP has not established standards for nutrients in water bodies. As a result EPA is looking at other state standards (i.e., MD) to make determinations for PA. It appears that DEP is asking to EPA to come up with standards that DEP can then consider for PA. This appears to be the wrong approach in this case. EPA should not be telling the state what standards to adopt.

> **Response: PADEP has not asked that EPA establish nutrient criterion. It appears that the commenter has missed the point and is referred to General Response #1 for further information. The 40 ug/L TP is an endpoint for TMDL development established by EPA and is NOT a water quality criterion. It was not based on a standard from Maryland. PADEP continues to work on the nutrient numeric criterion for the state.**

General Comment 3: One of the significant assumptions made by EPA concerned what flow rate to use in the study. In this case the contractor chose the lowest weekly flow rate that occurred during the 10 year period 1998 - 2007. This was in 2002 when the flow rate was 6.44 cfs. This is the drought of record for Chester County. The average low flow rate during that 10 year period was 28.92 cfs and the only other low flow rate below 20 cfs was in 1999 when 10.86 cfs was observed - another drought year. . *"...the nutrient TMDL allocations were based on flows from the year 2002." (Page 5-1, Section 5.0)* In this case the standard should not be based on the worst case scenario in the last several decades but rather on a more normal condition that would be found in nature. All the low flow rate does is to make the subsequent analysis worst and create more stringent requirements to improve the water quality with a resulting increase in taxpayer dollars to fix.

> **Response: The TMDL allocations for Chester Creek were not developed using the**

lowest weekly flow rate in 2002. The 2002 flow data was identified as the year with the lowest weekly average flow. Therefore, year 2002 was used to develop the allocations and specifically the average flow during the 2002 growing season (April through October). Therefore, reductions for nutrients were based on average flow conditions during the growing season of a dry year and not based on the weekly low flow in 2002. This is consistent with the Code of Federal Regulations (40CFR § 130), stating that a TMDL must consider environmental critical conditions. In an effluent dominated stream like Chester Creek, the environmental critical conditions are during the growing season of a dry weather year.

General Comment 4: The background portion of the report uses a lot of data that is relatively old (1992-2002). Given the changes that DEP has imposed over the years it is very likely the quality of any discharge has improved over time and therefore is not captured by this older data. Even the data used from 2006 is extremely limited and likely not to be representative of the conditions. In particular, in section 3.1.1.5, data from 1991 was used to make the case of impairment. There is no attempt in the report to compare data from 2006 to see any change. It would seem more representative if the 2005-2006 data had been analyzed and those results tabulated in section 3.1.1.2 or at least some comparisons made between the two data sets.

Response: Chapter 3 of the TMDL was expanded with data comparisons between relatively old data and recently collected data.

General Comment 5: Based on questions raised by the audience in the EPA review it appears that some of the science used in the report is at least questionable if not flawed. It is not clear that the real source of impairment has been identified and properly documented. There is no indication that any soil samples were taken from the stream to analyze the content of existing sediment. The focus was totally on nutrients and it is not clear this is the only or even major source of impairment.

Response: Nutrient data and algal biomass data as well as macroinvertebrate information supports the identification of impairment. EPA believes that nutrients are a major source of impairment but not the only source. Sediment, from increasing impervious lands and stream bank erosion due to increased land development resulting in an increase in stream flow and velocity, also plays a significant role in stream quality. Although not part of this TMDL, EPA suggests that the PADEP continue to evaluate the entire watershed for nutrient and sediment impairments and if necessary, develop a sediment TMDL for the basin.

Comment 1: The TMDL methodology used in the Draft Report is not consistent with Total Maximum Daily Load (TMDL) Guidance. Specifically, all seven elements of a TMDL (Figure 1-2, USEPA, 1999) were either inadequately addressed or not addressed at all. The seven elements of a TMDL are: Problem Statement; Numeric Targets; Source Assessment; Linkage Analysis; Allocations; Monitoring/Evaluation Plan; and Implementation Measures.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 2: The report does not provide justification for adding nutrient and organic enrichment to the impairment parameters, neither of which was noted on any of the 303(d) listed segments.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 3: The load allocation element of the nutrient TMDL was inadequate because it unfairly targeted large point source dischargers while dismissing residential point sources. The allocation for non-point sources was too general to be implementable and contained no assurance that it could be achieved.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 4: No monitoring/evaluation plan was presented in the report as required by the TMDL Guidance.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 5: The need to develop a TMDL was expanded to include all stream reaches in the Chester Creek watershed based upon "habitat impairment." The report determined that the reaches were habitat impaired after analyzing the diversity and general classifications (pollution-tolerance or intolerance) of the aquatic organisms observed during biological stream surveys. The Draft Report states that a non-impaired segment of Chester Creek was noted as biologically impaired due to riffle embeddedness "Riffle embeddedness" is a description of the degree to which rocks are embedded in sediment, thereby reducing optimal habitat for sensitive macroinvertebrate (insect) species. Riffle embeddedness is noted in areas throughout the Chester Creek and has nothing to do with nutrient loading. The connection between nutrient and organic enrichment and habitat impairment was therefore not established in the report and does not justify expanding the scope of the nutrient TMDL from the seven listed segments to the entire Chester Creek watershed.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 6: The TMDL exceeds its authority by establishing limits on stream segments that have not appeared on the 303(d) list. The Draft Report states that the Chester Creek watershed consists of seven stream reaches that were listed on the 303(d) list of waterbodies in 1996, 1998, and 2002. Despite this, the TMDL was established for the entire watershed.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 7: There are four segments listed as impaired on the 303(d) list that are isolated unnamed tributaries with no point sources. This contradicts the implication that the point source dischargers are the primary source of impairment despite being required to provide the greatest

reduction in load to the Creek.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 8: The greatest concentration of point source dischargers is on the West Branch of Chester Creek. However, there are no listed segments on the West Branch of Chester Creek. This contradicts the implication that the point source dischargers are the primary source of impairment despite being required to provide the greatest reduction in load to the Creek.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 9: The Draft Report states that the seven impaired reaches were impaired due to "nutrients and organic enrichment." The primary impact of organic enrichment is a lowering of the dissolved oxygen (DO) concentration. The report acknowledges that only one measurement over the last ten years showed a DO concentration below the stream standard. Therefore, the inclusion of organic enrichment as a source of impairment is not justified. The primary impact of nutrient enrichment is the stimulation of aquatic plant growth, which can result in daily variations in the DO concentrations due to plant photosynthesis and respiration. The result is high DO during the day and low DO during the night. In addition, the accumulation of decaying plant materials in the sediments can create a sediment oxygen demand that generally suppresses the DO concentrations at all times. None of these impacts were identified in the report. Therefore, the addition of nutrient enrichment as a parameter that needs to be limited in the Chester Creek watershed is not justified.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 10: Although the problem statement specifies nutrient and organic enrichment as the constituents that need to be limited in the watershed, numeric limits are only established for total nitrogen (TN) and total phosphorus (TP). No explanation for adding, then subsequently dropping, the organic enrichment parameter is given in the report. The critical linkage between nutrient concentration targets and re-establishment of aquatic habitat, the stated basis for including all stream reaches in the Chester Creek watershed, was not established to a reasonable degree of scientific certainty.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 11: There are multiple inconsistencies and over-simplifications used in the water quality modeling that result in establishing overly conservative load allocations.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 12: The WASP 7.2 model was used to model the flow and chemical constituents in the streams in the Chester Creek Watershed. The model was developed without the benefit of a

modeling quality assurance project plan (QAPP) plan. One benefit of a modeling QAPP plan is that it defines the calibration procedures, criteria for calibration, validation procedures, and sensitivity analysis procedures before the modeling task begins. The modeling QAPP applies to hydrologic and chemical constituent calibration.

> **Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14**

Comment 13: The calibration procedure for hydrologic/hydraulics was not described. There was no discussion of which parameters were adjusted to achieve calibration.

> **Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14**

Comment 14: The hydraulic calibration on the model was poor. This was due in part by the fact that the fifteen dams in the watershed were not properly accounted for in the WASP 7.2 computer model. The increased re-aeration caused by the dams was accounted for in the model, however the storage volume and increased detention time caused by the dams was not accounted for in the model.

> **Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14**

Comment 15: Figure 4-3 compares the measured flow at USGS Gage 01477000 with the simulated flow calculated with the WASP 7.2 model. This is presented in the report as a hydrologic calibration. The comparison between the measured and modeled flows is poor. In some periods the modeled flow is two (2) orders of magnitude less than the measured flow (e.g., early April 2006), while at other times the modeled flow is greater than the measured flow by a factor of *60* (early September 2006). In the period September through December 2006 the modeled flow does not match the pattern or structure of the data.

> **Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14**

Comment 16: The calibration procedure for chemical constituents was not described. There was no description of which model parameters were adjusted to achieve calibration.

> **Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14**

Comment 17: The temperature used in the mode] for critical summer low flow conditions was not stated in the report.

> **Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14**

Comment 18: There was no sediment calibration and no sediment or suspended solids measurements were used in model calibrations, although this could have easily been done.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 19: The model was "calibrated" to only two (2) measured data points. This is inadequate.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 20: Global reaction rate data are listed in Table D-3. There were no reach-specific reaction rates listed in the report. Variations in reaction rates would be expected over approximately 132 miles of stream courses in the watershed.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 21: The model was not validated with an independent data set. Model validation is used to test the robustness of the calibrated model.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 22: A sensitivity analysis was not performed. A sensitivity analysis is necessary to evaluate how the uncertainty in the estimation of model parameters will affect the model's result.\

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 23: The Draft Report provides insufficient detail to verify calculations or what was done. Complete input and output files in electronic form should be made available to reviewers to verify model details that are not described in the Draft Report.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 24: The load allocation element of the nutrient TMDL was inadequate because it unfairly targeted large point source dischargers while dismissing residential point sources. Residential point source dischargers were dismissed with a qualitative statement that the loads from these sources are "small" with no backup or analysis. In fact, the per capita loads of P and N are well known and quantifiable.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 25: The methodology used to calculate the $Q_{7\text{-}10}$ flow was incorrect. It assumed that one critical 7-day low flow period occurred in each often years evaluated. The correct $Q_{7\text{-}10}$ flow was cited but it was not clear which low flow value was used in the analysis. The $Q_{7\text{-}10}$ calculated

was one-half that of the actual $Q_{7\text{-}10}$ calculated by USGS. This results in an unnecessary reduction in load allocation.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 26: The parameters most indicative of nutrient enrichment, periphyton and phytoplankton, were not measured and the computer model used to establish nutrient limits was not calibrated to periphyton or phytoplankton, even though periphyton was the major parameter being used to justify the TN and TP limits.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 27: Periphyton is a complex mixture of algae, cyanobacteria, heterotrophic bacteria, and detritus attached to submerged surfaces. Methods for in-stream measurement and assessment of periphyton are available. Phytoplankton are floating plants (algae). Phytoplankton concentrations can be assessed through measurement of chlorophyll-a. This was not done.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 28: The methodology for nutrient reduction is based upon the assumption that the rate of uptake and utilization of TN and TP by plant material in the Creek is controlled by the ration of TN:TP. A recent study by Gelder and LaRoche (2002) reported that the N:P ratio of algae and cyanobacteria is very plastic in nutrient-limited cells. The C:N:P ratio for algae (phytoplankton) is quite different than the ratio for benthic macroalgae (i.e., periphyton). The C:N:P molar ratio for algae is approximately 106:16:1 and is known as the Redfleld Ratio. For macroalgae the C:N:P molar ratio is different and more variable with a median of 550:30:1; known as the Atkinson ratio. This difference was not accounted for in the analysis.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 29: The total phosphorus simulation, as shown in Figures G-1 through G-8 for the post-TMDL simulations, does not appear to be realistic. The dramatic pattern of low constant concentrations of total phosphorus through the summer growing season is highly unusual and is not likely to be achieved in the stream. Due to nutrient cycling, there is a store of phosphorus in the sediments being released into the water column. The Draft Report does not discuss or present information regarding how benthic nutrients were handled in the model.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 30: The assumed failing septic systems were not identified in the Draft Report and a methodology or plan for identifying the failing septic systems was not presented.

Response: Since this is the same comment as in Comment Letter #14, please see the

response to Comment Letter #14

Comment 31: A "weight of evidence" approach was used to establish the nutrient TMDL. This is a qualitative approach that compares TN and TP concentrations with macroinvertebrate diversity indices and species tolerance classifications. There is no guarantee that achievement of target concentrations will improve species diversity or shift populations to more pollution intolerant species.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 32: The "weight of evidence" analysis is questioned for its application to Chester Creek: How representative was the data to Chester Creek? What data was excluded and why? The models used were calibrated to only two data points which may not be representative of actual conditions and are not sufficient to prove a good relationship between the model and actual conditions.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 33: The different species of N and P and their differing bioavailability were not considered. For example, ammonia-nitrogen exerts an oxygen demand as it is transformed into nitrite-nitrogen and nitrate-nitrogen. Nitrate is available for plant uptake but does not exert an oxygen demand on the system. Inorganic and organic forms of phosphorus are utilized differently by plants and aquatic organisms. Dissolved orthophosphate is more readily available than other forms of phosphorus and stimulates the growth of plants and aquatic organisms more readily. Up to 80% of the phosphorous in stormwater runoff is bound (attached to) the sediment contained in the runoff and therefore not available as a nutrient source.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 34: The non-point source BMPs to be employed by each non-point source was vague and not specified. The percent reduction for each BMP was not specified bringing into question the ability to achieve the proposed nutrient reductions

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 35: The time frame for achievement of beneficial uses was not presented.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 36: The cost of treatment plant retrofit to achieve the TMDLs is significant. Even if this investment was to be made, there is no assurance that TMDL will re-establish beneficial uses in all reaches or even impaired reaches.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 37: The non-point source loads from MS4 areas were reduced to pound per day (Ib/d) continuous values. This is not how the non-point source loads occur in reality. In reality the non-point source loads occur less frequently but the loads are larger.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 38: Non-point source loads are estimates. There are no measured bases for the non-point source loads.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 39: The per capita daily total phosphorus loads used in the analysis were too low by 50% compared to literature values (2.5-3.4 g/capita/day versus 1.5 g/capita/day used in the analysis). This puts an unfair burden on the point source dischargers.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 40: The connection, if any, between the habitat impairment and nutrient loads was not demonstrated. No remedies or allocations for habitat impairment were established.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 41: The EPA set the phosphorous TMDL for 7 of the 32 treatment plants at a concentration of 0.05 and 0.04 mg/L which is the current limit of treatment technology. The EPA cited the document "Evaluation of Exemplary WWTPs Practicing High Removal of Phosphorus", prepared for the Spokane River TMDL Collaboration Technical Working Group (November 2005), in its development of the TMDL. This document states that "at this is time, the lowest demonstrated effluent total phosphorus limit for plants of substantial size (>2.5 mgd) is [0.1 mg/L]."

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 42: The EPA set the phosphorous TMDL for 14 of the 32 treatment plants at 0.10 mg/L. The EPA cited the EPA document "Treatment Performance of Various BNR Process Configurations" (June 2007), in its development of the TMDL. This document states that "[Limit of Technology] levels (i.e., [nitrogen] less than 3 mg/L and [phosphorous] less than 0.1 mg/L) have not been demonstrated at treatment plants with capacities of less than 0.1 mgd. BNR for [nitrogen] removal may be feasible and cost effective. However, BNR for [phosphorous] removal is often not cost effective at small treatment plants."

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 43: Canopy cover, in-stream habitat and streambank erosion are not identified, quantified are included in the establishment of the TMDLs despite having significant impact on algae growth in streams. Limiting phosphorous and nitrogen will not address these factors.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 44: The in-stream phosphorous target concentration of 0.04 mg/L is extremely low for a flowing stream. This is recognized in New Jersey where the state-wide in-stream phosphorous target concentration is 0.10 mg/L.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 45: The in-stream nitrogen and phosphorous limits for Chester Creek is half that used in the Chesapeake Bay Watershed. This makes the Creek limits appear overly stringent given the sensitivity of the Chesapeake Bay to nutrient loads.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment 46: The Draft Report states "based on analyses to determine appropriate nutrient endpoints in Southeastern Pennsylvania [emphasis added], a total phosphorus (TP) in-stream target concentration of 0.04 mg/L and a total nitrogen (TN) in-stream target concentration of 3.7 mg/L were used to make reductions of nutrient (TP and TN) loads to major and MS4 point sources (32) and nonpoint sources." This statement implies that any stream PADEP determines is impaired by nutrients, this TMDL is appropriate. For the reasons stated in these comments, the application of these target concentrations is not appropriate and should not be applied universally to southeastern Pennsylvania.

Response: Since this is the same comment as in Comment Letter #14, please see the response to Comment Letter #14

Comment Letter #24: Franconia Sewer Authority Comments on the Indian Creek TMDLs

General Comment 1: It is our belief that most of our users favor a clean environment. But in the real world, unlike the theoretical one that EPA seems to operating in, these users perform a cost-benefit analysis - much like EPA should be doing. Franconia Township officials are well aware of environmental problems - primarily failing On-Lot Disposal Systems (OLDS) and are working to correct them. The current cost per homeowner to connect to public sewer is about 518,000 in our service area AFTER any offsets that might be available, Preliminary estimates show that the average customer's cost for ongoing sewer service will at least QUADRUPLE should limits of 0.04 ppm phosphorus be imposed.

> **Response: The TMDL and its associated data, information and scientific evaluation is beyond theory. It is actually based on fact. The PADEP has numerous biological surveys that point to nutrient impairments due to excessive nutrients. PADEP has identified the Indian Creek as nutrient impaired due to municipal wastewater sources. The commenter is urged to review the pictures of the Indian Creek that are included as attachments to this response document. These are not pictures of a healthy water. The township may be aware of some of the environmental issues but should expand its field of vision. Nutrients together with sediment from land runoff and bank erosion has impaired the aquatic habitat of the watershed. The township needs to address these two issues in order to assure existing state water quality standards, including water uses, are attained and maintained. EPA firmly believes that if the sediment and nutrient allocations are implemented in the watershed, the habitat of the streams will be improved allowing for a healthy water including a diversified aquatic life community that will benefit the residence of the watershed.**

General Comment 2: So what does this potential phenomenal cost buy the average resident in Franconia Township? Surely the benefits will be great - at least great enough 10 justify the great cost. No, sorry to say that all this cost - by EPA's own admission at their March 18, 2008 meeting in Lower Salford - might eliminate something called NUISANCE ALGAE. Might! No, this haphazard taking of money from residents on fixed incomes will not save an endangered species, not even save one fish; but it MIGHT eliminate nuisance algae. It' we arc going to make people spend large sums of money and get nothing in return, why not require every gallon of wastewater effluent to be distilled; then we can waste both money and energy and get nothing in return.

> **Response: It appears the commenter does not fully understand the information provided by EPA or the commenter is getting inaccurate information from other sources. It has been made clear by EPA that the nuisance algae is not the endpoint on which we developed the TMDL endpoint, or in-stream goal, rather it is the aquatic life use adopted by PADEP. The TMDL is based on the goal of achieving a healthy and diverse aquatic life population, including fish and macroinvertebrates. EPA urges the commenter to actually review the information in the endpoint document as well as the General Response #1.**

Comment 1: The Indian Creek has a protected use for warm water fishes (25 Pa Code 93.3). The definition for warm water fishes is "Maintenance and propagation offish species and additional

flora and fauna which are indigenous to a warm water habitat." Since no data has been presented by EPA that indicates the loss of a single fish due to current nutrient levels in the Indian Creek, and the definition is apparently met for a warm water fishery, under what reasoning is a TMDL being developed? 25 Pa Code 93.7, Tables 3 & 4, identifies the environmental parameters for a warm water fishery as Alkalinity, Dissolved Oxygen, Iron, Osmotic Pressure, pH, Residual Chlorine, and Temperature - no Phosphorus.

> **Response: The commenter has incorrectly identified the water use for Indian Creek and warm water fishery. A closer look at the PADEP water quality standards would show the commenter that the actual use as defined by PADEP is trout stocking – PADEP has identified the entire East Branch Perkiomen Creek watershed, which includes Indian Creek, as trout stocking. The state has not identified phosphorus as a statewide criteria for trout stocking waters but the state does have a statewide narrative criteria that applies to all waters - —Water may not contain substances attributable to point or nonpoint source discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life." The commenter needs to think beyond fish. The commenter is wrong in stating that because no fish were lost then the uses are attained. Apparently the commenter is not familiar with the full range of aquatic life protection. The use designation is for aquatic life protection which includes other organisms such as macroinvertebrate. PADEP biological surveys supported impairment of the uses. PADEP regulations at 25 PA Code 96.5 states that —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. (emphasis added)" It seems there is a state consideration for nutrients in free flowing waters**

Comment 2: Assuming that EPA will he using the nuisance algae issue to answer the above question, since nuisance algae is undefined in the Pa Code, by what authority docs EPA (or PADEP) pull this issue from the air and add it to the environmental mix. Furthermore, what keeps EPA from adding other, more ridiculous parameters (if that's possible) to justify an impossible cost local residents?

> **Response: The commenter has made a poor assumption that the reduction of nuisance algae is the final endpoint for which these TMDLs were developed. Please see the response on this issue above. The township should not be surprised that nutrients are an issue since they have been identified as problems by PADEP for some time. The commenter is referred to several site studies completed by PADEP in the early 2000's that focused on point sources and nutrients. In the summer of 2001 a survey found that Indian Creek and several of its tributaries were impaired by nutrients from several municipal treatment facilities. Follow-up surveys were conducted in 2003 to confirm. Some of the in-stream total phosphorus concentrations were as high as 3640ug/l below the facilities (an increase from 150ug/L above the plant). These studies can be obtained from PADEP. PADEP**

continued to believe that nutrients an issue in 2004 when they included Indian Creek and five (5) unnamed tributaries on the 2004 list of impaired waters for nutrient impairment due to municipal point sources (further defining the unknown listing in 1996 as nutrients). These waters remain on the 2008 list of impaired waters. PADEP noticed these lists for public comment. The Township had an opportunity during the public comment process for the various impaired waters lists (6 separate cycles) to comment on these impairment listings, but to EPA's knowledge no comments were submitted by the Township.

Comment 3: What is the science - and not theoreticals from watersheds in Maryland - that drives the TMDL issue? Have the data presented at the March 18, 2008 meeting showed surprising contradictions.

Response: Please see the General Response #1

Comment 4: Why hasn't an exhaustive study been performed on the Indian Creek to determine the actual cause of the so-called impairment? Simply performing a literature search and selecting those documents that support a specific viewpoint is not good science.

Response: The impairments go beyond "so-called". In fact PADEP data has demonstrated the impairment. We also refer the commenter to the pictures of Indian Creek from 2005 and 2006 that illustrate the severity of the problem. The commenter is referred to responses above that describe the PADEP studies that identified the impairments – nutrients and sediment. The commenter is apparently not familiar with the approach used by EPA to establish the endpoints. It was not merely a literature search as implied by the commenter. The commenter is referred to the actual endpoint report, which is on our web site, as well as the General Response #1.

Comment 5: According to the EPA experts at the March 18, 2008 TMDL meeting, not one river mile has improved by implementing stringent phosphorus limits. If increased phosphorus removal could be accomplished by merely flipping a switch, we could certainly try it for a season to see if it actually improved stream flora and fauna. The problem is that we will have to commit huge sums of money for capital upgrades which, if we see what the experts have already pointed out that there is no environmental gain in over-reducing phosphorus - cannot be recovered. Why doesn't EPA fund an actual study in a small area of a watershed to truly determine the effects of hyper-nutrient removal?

Response: We believe the commenter is overstating what was said at the public meeting. Neither EPA nor its representatives said that "not one mile has been improved due to implementation of stringent phosphorus limits". What was said that we did not have any information with us at the time for any situation where impairments have been improved due to phosphorus controls. We also mentioned that there are many situations around the country where stringent phosphorus controls have been required.

Comment 6: Even though we're pretty certain of the answer to this next question, it does have to

be asked -where will the money come from to implement the TMDL? By putting more stringent treatment requirements on residents in Southeastern Pennsylvania, EPA will have unfairly increased the cost of living on a small segment of the population. If super-pristine water has to be paid for in our area, require all municipalities and all public sewer users to bear the same cost.

> **Response: EPA would expect that where nutrient and sediment problems have been identified in other areas, the necessary level of controls will be required. There have been over 100 sediment TMDLs completed in Pennsylvania. EPA is now in the process of establishing nutrient TMDLs for waters in Southcentral Pennsylvania and Southwestern Pennsylvania at basically the same level as the ones in SE PA. Where there is a need then controls will be required.**

Comment Letter #25: Franconia Township Comments on Indian Creek TMDLs

Comment 1: The Township is dismayed by the short response time allowed to comment on what appears to be imminent adoption by the EPA of a significant regulatory and economic burden. The Township Board of Supervisors (BOS) have not been given sufficient time to engage any appropriate professional/consultant assistance to thoroughly examine the report and make meaningful observations as a MS4 permittee on the specific proposals outlined therein. The BOS only have had the opportunity to discuss the report at one regular public meeting since it was posted by the EPA, and having been represented at the March 18, 2008 presentation, have determined that this proposal requires much more discussion and review in order to intelligently dissect the financial obligations as the BOS are required to do in order to properly inform the Township residents of the EPA proposal.

> **Response: EPA has held three public meetings on this TMDL. The first meeting provided the background on what a TMDL is and why EPA is developing a TMDL for the Indian Creek. The second public meeting was held to discuss the technical results of the TMDL and the third meeting was held in April 2008 to present the entire draft TMDL report for public input. EPA feels that three meetings over a one year period to be sufficient for the Township to engage in the process, if they were sufficiently interested from the initial stages of the TMDL development. EPA also requested any data that the stakeholders may have that would be beneficial to the development of the TMDL at each of these meetings. Little if any data was offered or identified until recently.**

Comment 2: It is also especially noted that Pennsylvania Department of Environmental Protection (PA DEP), at various educational seminars for the MS4 program has not referenced this report, On February 27, 2008 PA DEP made a MS4 presentation at the Upper Bucks-Montgomery Community Affairs Association (an organization of 70 local governments), which the Township supports, and denied that nutrient limits were to be made part of the MS4 program when directly asked the question. This fact is contradicted by Appendix F of the document where Phase II of the EPA recommended implementation, beginning June 2008, that requires "All permits issued during Phase II must contain effluent limits consistent with the established TMDL." This document is the first notice that the EPA has provided to the MS4s of the Indian Creek Watershed that it will require PA DEP to regulate toward these limits through its MS4 permits. It indicates that these requirements would be effective five weeks from the June 2008 date.

> **Response: EPA was not involved in the PADEP meetings and cannot respond to the actual intent of the PADEP presentation. However, EPA recommends that the commenter review General Response #8. This will describe EPA's expectations and requirements for the implementation of MS4 allocations. Since EPA has described these requirements at public meetings, they should not be a surprise to the Township at this point.**

Comment 3: In the Executive Summary, page ii, it states "Because the entire Indian Creek watershed is covered by areas within 5 Municipal Separate Storm Sewer Systems (MS4s), all

allocated loads are assigned to the Waste Load Allocation (WLA) category." This assignment, although to be adjusted within the NPDES process when WLA may be reclassified as Load Allocation (LA), suggests a basic contradiction that between 70% and 80% of the watershed area within Franconia and Lower Salford Townships are either in use as agricultural; large lot residential; or are lawn areas that, by design, bypass the MS4s collection systems. These areas are then, by EPA definition, non-point sources and ultimately are not within the jurisdiction of a MS4 permit to manage. The Commonwealth of Pennsylvania does not permit regulatory authority allowable to the MS4s in view of the Pennsylvania Agricultural Security Act in order to implement strategies to control agricultural non-point source nutrient laden runoff to meet reduction goals of the magnitude stated, In short, the EPA proposes the MS4s to manage the waste load reduction goals on areas of the Townships which may constitute only 20% to 30% of the watershed runoff, and suggests a statistical impossibility.

> **Response: Because the Township has not yet defined the actual service area of the MS4, as far as EPA is aware, the entire Township has been defined as the MS4 area. EPA allocated a WLA to that area with the understanding that as the township defines the service area the WLAs can be adjusted with the LAs based on service area, landuse and loading rates provided by the TMDL. EPA does not expect the township to include agricultural or forested areas, for example, in the actual service area, but until the Township finally takes the next step of defining the area, EPA will allocate WLAs to the Township. EPA explained this process at the public meeting. This process has been used in many other TMDLs in the Region, including several in Southeastern Pennsylvania. The commenter is referred to General Response #4 for more discussion.**

Comment 4: The Executive Summary states "This TMDL...as not meeting aquatic life uses...and loading targets established using a reference watershed." At the public presentation on March 18, 2008, a watershed being 80% forested, adjusted to 70%, was noted as being used for purposes of establishment of these criteria for the Endpoints. This is quite unlike the Iron Run watershed listed in the study, which in itself has a 35% forested cover, much beyond the 3-4% coverage of the Indian Creek Watershed. If the goal, i.e. Endpoint, being established is to create a watercourse ecology equivalent to this hypothetical 70% forested watershed, virtually pristine, it is not comprehensible that the Indian Creek Watershed, historically and currently in extensive agricultural use for over a 300 years from settlement by Pennsylvania German immigrants, should be required to meet such nutrient criteria in order to meet the intent of the United States Congress for fishable and swimmable waters. The EPA sets the bar too high with the 70% forested stream ecology goal, and without any rational justification, contradicts the EPA requirement for "reasonable assurance that the TMDLs can be implemented" in Chapter 6 of the report.

> **Response: One of the technical approaches applied in the overall multiple lines of evidence analysis to develop nutrient endpoints protective of aquatic life uses was the frequency distribution based approach. In the frequency distribution based approach, a screening criteria of 70% forested watersheds was used to represent least disturbed sites, or those watersheds with minimal human disturbances and, which therefore can be expected to provide the best empirical estimate of chemical integrity. The 70% forested watershed screening criteria was used to identify sites**

with acceptable water quality conditions, and to evaluate those nutrient levels with respect to the effort to establish target levels for the Indian Creek watershed that can be expected to support the stream's designated uses.

Also, the modeled reference expectation approach was one line of evidence used to derive a candidate nutrient endpoint associated with unimpacted conditions. It was weighed against other factors and the reader will note that the concentration associated with this condition was not the one selected, for many of the reasons suggested in this comment. Again, the goal being to derive protective endpoints.

The goal of establishing the endpoint is not to create ecology similar to a 70% forested watershed; it is to ensure water quality conditions (including chemical and biological characteristics) such that the stream's designated uses are being met. EPA does not feel that the 70% screening criteria was applied without rational justification, nor does EPA believe that the only way to meet the targeted nutrient levels in Indian Creek watershed is to return the area to at least 70% forested. Therefore, it is EPA's position that the identified targets do not contradict the reasonable assurance requirements.

Finally the Ironworks Creek watershed was used to identify reference conditions for the sediment TMDL, not the nutrient TMDL.

Comment 5: It is not clear what "designated aquatic life uses" are tangible targets to be supported in the adoption of the proposed criteria, or expected to be produced, other than water clarity probably not seen before the pre-Columbian native Indian population cleared the land for their fields. The target of a70% forested stream ecology, and the single emphasis on algae growth, is not correlated with the actual historical fish and fauna populations of the watershed, to the extent that such exist and have been viable with historical water levels. The Indian Creek, with its slow moving current, high ambient temperatures, absence of oxygen enriching rapids or forested banks, makes for a difficult environment even for warm water fish. No studies for such local species as bass, perch, minnows and other warm water species appear to have been considered nor were the nutrient limits that such warm water species tolerate presented. The Endpoint standard may well drive the TMDLs to unrealistic and unsustainable high nutrient limits, beyond what is required to support the historical uses of the watershed. The proposed regulation may have impacts on the surrounding land uses such as residential, recreational and agricultural, without any realistic benefit to the stream ecology. In fact, such regulations may very well divert much energy and resources from more attainable goals in addressing the larger non-point problem.

Response: The designated use of streams in the Indian Creek watershed is set forth in PADEP's Water Quality Standards at 25 PA Code, Chapter 93, and is stated on page 5 of the Draft TMDL, —provide habitat and appropriate ecological services as a trout stocking fishery." While evidence of excess algae growth was prevalent during numerous watershed assessments and described on field data sheets collected by PADEP, this was not, as the commenter suggests, the sole focus of the listing. Rather, the listing was based on the lack of intolerant taxa findings in multiple locations during PADEP's assessment of the watershed. Based on the existing

designated use of trout stocking fishery, the PADEP deemed the Indian Creek is not supporting its designated use. The goal of this TMDL was not to evaluate other studies of bass, perch, minnows or other warmwater species (such that may or may not exist) to evaluate the stream's impairment status. As already stated, PADEP has declared the stream impaired. The goal of the modeling exercise in the TMDL was to apply the identified endpoints and to calculate allowable watershed loadings to meet those endpoints, which should, in turn, ensure the stream attains and maintains its use criteria with respect to nutrient levels. As it stands, federal law and regulations require EPA to develop TMDLs sufficient to attain and maintain existing and applicable water quality standards, including numeric criteria, narrative criteria, uses and antidegradation requirements.

Comment 6: The presentation listed as a slide the intent of the model to simulate interactions among nutrients, dissolved oxygen and algae. However, all the sampling areas are on the main spline of the waterway, beneath the outfall(s) for the Telford Borough Authority Waste Water Treatment Plant (primary water source of the watershed) and other treatment plants where treated effluent would have a dilution effect on the base nutrient levels ambient to the watershed. The model does not appear to separately model and calibrate the effects of runoff from the contributing low flow, and intermittent flow, tributaries where significant effects of agricultural and lawn fertilizers can be expected to have different characteristics for different seasons and water levels, contributing to that ambient, or background nutrient levels in surges of their own characteristics rather then the hydrological characteristics of the main stream. It appears the model may undervalue the effects of 70% - 80% of the land area that contributes nutrient runoff as non-point direct flows into the waterways systems, and overvalue the possible results of drastic reductions to the limited point source flows.

Response: The modeling application developed to simulate conditions in the Indian Creek watershed does in fact simulate interactions among nutrients, dissolved oxygen and algae. The location of DEP sampling points, along the mainstem and below point source discharges does not impact the model's ability to simulate background concentrations. Because the dynamic GWLF watershed model was used to develop watershed loads, which were linked to the EFDC receiving water model of the Indian Creek, precipitation driven inputs from low and intermittent flow tributaries were accounted for. While loading effects from agricultural and lawn fertilizers were not explicitly modeled, they are indirectly accounted for by the application of landuse specific parameters for agricultural (row crop and pasture) and residential areas. The effects of these lands is accounted for using precipitation driven events for low and high flow events coming from the tributaries. Since the GWLF model cannot model each and every small tributary the small watershed, the watershed was discretized into 12 small subbasins to better account for the nutrient loadings into the main stem.

Additionally, the model does account explicitly for effects from application of manure fertilizers to agricultural areas. Because a dynamic watershed simulation was performed and linked to the receiving water model, seasonal impacts from the smaller tributaries in the watershed are accounted for. With respect to the comment regarding the individual effects of lawn fertilizer based on —surges of their

own characteristics", EPA feels that the simulation of precipitation driven events should adequately account for such impacts. As a result, EPA does not feel the assumption that the model significantly undervalues the effects of 70-80% of nonpoint source flows into the mainstem is valid

Comment 7: One question was raised at the presentation on the collection of information regarding the modeling of the direct and indirect contribution of failing on-site septic systems in terms of both phosphorous and nitrogen. The answer suggested that a general parameter was applied but that no direct equation, data samples or analysis were included, PA DEP supported and endorsed a Sewer Management Program study within in the Township portion of the watershed and that study found over 40% failing or malfunctioning systems. There where visible observations that indicated through on site inspections that found, often on the surface, discharges into tributary watercourses. It has been said by others that the EPA assumptions in the model is to provide that all on-lot septic systems discharges are to be accepted as being successfully land treated, yet the extensive areas of large lot on-site septic systems would certainly require a separate mathematical formulation to fit these unique challenges to the watershed. In sum, the effect of the failed or mal-functioning on-site septic systems, coupled with the watersheds high shale level, shallow topsoil and underlying clay layers may also mean that the present model undervalues the non-point impacts. Similar characteristics do not appear to exist on the stated 70% forested watershed.

Response: The Township needs to take the necessary steps to ensure that failing septic systems are corrected as required by state law. The modeling assumes that the Township is fulfilling that obligation. The watershed model has been updated with more specific results of the sewer management study and the TMDL has been revised accordingly.

Comment 8: In particular interest is the application of some limits on sediment production. The model appears to address such but does not explicably account for the extensive historical storage of sediments from 300 years of current culture and pre-historic farming, which becomes dislodged during high water events. It would appear that with even perfect controls on point sources that existing banks of sediments, some loosely protected by vegetation during minor rain events, would be cause to distrust main stream sampling results for regulatory confirmation. Such limits would appear to be of questionable value in strict numeric terms rather than the current construction she controls, the only manageable area of sediment control available to MS4s.

Response: EPA acknowledges that in-stream sediment represents a significant source of sediment that may be dislodged during high flow events and carried for some distance to be deposited at another downstream location. The commenter is correct in the observation that the model does not explicitly account for historical in-stream storage of sediment storage from hundreds of years of various landuse activities. The model (GWLF) derived estimates of sediment production are from landbased sources and are presented as loads. The modeling does not predict or estimate stream concentrations of sediment nor does the TMDL specify instream concentration targets which might be compared to monitoring. Modeling applications capable of doing so require significantly more data and

parameterization than was available for this effort. Rather, the sediment model was used to estimate existing landuse-specific sediment loading rates for the watershed, which were compared to target landuse-specific sediment loading rates established for the referenced watershed, Ironworks Creek. This is a process and modeling foundation that has been used by PADEP in a large number of sediment TMDLs throughout the state over the past 5 to 10 years. The target loading rates were applied as the allocated loads for the TMDL. For landuse-based loads (MS4 WLAs), these allocations are specified as annual and daily loads. For municipal wastewater treatment facilities and industrial discharges, WLAs equal to existing facility discharge limits are specified in the TMDL. The majority of sediment loading (exclusive of instream sediment sources and bank erosion sources) to Indian Creek is attributed to landuses in the watershed and is expected to be managed through implementation of BMPs that control loading such as that mentioned in the comment. Implementation issues for MS4s are discussed in the General Response #8.

Comment 9: Also noted during the presentation, the modelers were asked if any demonstration projects had successfully shown that such results are attainable. None were known - leaving us to suspect that this project is intended as an 'experiment', with indeterminate unfunded municipal investment required to implement and no assurance that such projected watershed water quality improvements can indeed be made. Although the EPA disavows any Federal interest in the cost, it must be stated that on the local level this unfunded fiat appears to require significant increased financial resources from the taxpayers without their local representatives being assured of the purported benefits or being provided sufficient time to effectuate remedies.

Response: This has not been an _experiment‘. PADEP has definitively identified that excessive nutrients and sediment are the major factors in the impairment of Indian Creek. The endpoint established for total phosphorus is consistent with EPA guidance and is based in credible science (see General Response #1 as well as other responses). The water quality modeling shows that the endpoint developed to protect aquatic life will also assure that the biomass in the form of chlorophyll _a‘ will be significantly reduced. EPA also firmly believes that since we used a procedure that has been recommended by EPA to develop nutrient numeric criteria, as the PADEP develops their numeric criteria for nutrients, the numbers will be similar to EPA‘s endpoints. Through comments submitted to EPA during the public comment period, PADEP has supported the approach EPA used for the development of the TP endpoint. EPA has suggested an adaptive approach to implementation in order to allow less stringent interim treatment requirements as the state finalizes the numeric standards, giving relief to the municipalities with respect to implementation of the TMDL requirements. PADEP Southeast Region Office has agreed to meet with each individual discharger to discuss the details of this approach, particularly the interim requirements. EPA has allowed for TMDL modifications in the future if the PADEP adopts numeric nutrient criteria much different than the EPA endpoint. EPA policy allows for a BMP approach to TMDL implementation for storm water-related allocations. EPA firmly believes that proper implementation of the sediment and nutrient TMDLs will resolve the habitat issues in the watershed, reduce the obvious algal blooms and allow for a healthy,

viable aquatic community.

Comment 10: A minor point, hopefully not indicative of the care in preparing the information for input into the computer model, is that Upper Salford Township is listed as having a small contribution to the watershed where a careful examination of the USGS Quadrangle Map for the area, and a field inspection, indicates that no portion of Upper Salford Township contributes to the Indian Creek Watershed. It lies entirely in Franconia and Lower Salford Townships with the urbanized area of Telford Borough and its Waste Water Treatment Plant (WWTP) forming the headwaters. Additionally, the report states "approximately 23% of the watershed can be classified as either row crops or pasture" or at another location "36.13%" is stated as Hay/Pasture in a chart. Similar nutrient loading is assumed for both row crops and pasture yet the Soil Cover Complex method applies different runoff characteristics of pasture (or is it meadow, another level of runoff soil cover generation) than to row crops. This ambiguity on what agricultural cover was actually modeled, both in type and a real extent, might also be indicative of the model undervaluing the amount of nutrient non-source loading that high intensity summer thunderstorms may be expected to generate from the high levels of row crops, the exact period of interest for the regulatory agencies.

Response: EPA thanks the commenter for such careful reading of the text of the report. The discrepancy noted is the result of the digital elevation model used in the creating the subbasin delineation and how it overlays with the municipal boundary layer used to identify applicable MS4 areas. The portion of loading attributed to Upper Salford Township (0.01% of total and allocated TP loading: 0.03% of total existing sediment loading and 0.02% of the allocated sediment load) has been removed from the TMDL.

Comment 11: In summary, the establishment of nutrient limits in an attempt to duplicate that one would find in a 70% forested watershed, or even a 35% watershed, ignores the reality of the continuing agricultural basis for land use in the watershed. The EPA ignores the cultural history of the local Pennsylvania German people to believe otherwise. Also, a trout fishery is not historic, nor a practical use of the Indian Creek given the other physical limitations of the watershed. Therefore, the Endpoints are not realistic, and the nutrient limits proposed are for some other, non supportable use.

Response: With regard to the comment concerning the report‘s various estimates of landuse cover percentages, this discrepancy in the report text has been corrected. The text on page 24, —aproximately 23% of the watershed can be classified as either row crops or pasture”, has been corrected to read —aproximately 53% of the watershed can be classified as either row crops or pasture”. The cultural history of the Pennsylvania German people probably did not envision agricultural lands being converted to major housing developments as is happening throughout the area. These growth areas lend themselves to increased impervious areas, resulting in a decrease in groundwater recharge and an increase in storm water runoff. This increased runoff carries with it an increased sediment load and, through the increased flow and velocity of the streams causes stream bank erosion. Riparian areas are being infringed upon by residents using environmentally unfriendly methods such as mowing their lawns to the banks thus increasing the pollutant

problem. The endpoint is based on meeting existing and applicable water quality standards, including stream uses as set by the PADEP. Any questions concerning the appropriateness of the use designations of Indian Creek should be directed to PADEP. Under Section 93.8 of the State's regulations, the PADEP will consider a request for site-specific criteria for protection of aquatic life, human health or wildlife when a person demonstrates that there exists site-specific biological or chemical conditions of receiving waters which differ from conditions upon which the water quality criteria were based.

Comment 12: The EPA further states it seeks input in regard to the Endpoints in regard to nitrogen, while yet admitting that the science does not support the any contribution to the control of algae, therefore proposing the establishment of a high, arbitrary limit is not supportable, but merely an exercise in the expenditure of resources better addressed to the non-point sources - a goal that may be achievable. Sediment should also be eliminated as an Endpoint, at least as to being a measured limit. It is understandable to be concerned with its effect locally and downstream. However, one must question whether it can be successfully regulated on a strict basis of sampling measurements. It is far better that other means be employed, such as the current MS4 practices on construction controls, now in place for over 30 years and again, some measures with non-point sources which remain legally beyond the ability of the MS4s to address, and are not a issue with the watersheds WWTPs

Response: See General Response #3 concerning the Total Nitrogen allocations and General Response on how the MS4s are expected to implement the TMDLs. The sediment allocations remain an important part of the control program necessary in the watershed.

Comment13: We trust that our positions are a direct and thoughtful answer to the request of the EPA for comment on the two salient issues they seek. An honest assessment of these concerns, while abandoning 'pie in the sky' goals of questionable value, should lead the EPA to forgo any haste of action toward a more measured evaluation of reasonable control measures and with regulations that can assure positive and actual progress toward realistic goals.

Response: In summary, EPA believes these sediment and nutrient TMDL requirements are necessary to assure that the Indian Creek and its tributaries attain existing water quality standards, including the trout stocking use. They are not wishful goals but goals necessitated in the fact that the area continues to grow and with this growth comes increases in pollutant loads, larger runoff from an increase in impervious lands, increased stream bank erosion due to the increase in runoff volume and velocity. The treatment volumes for the WWTPs continue to grow making the point source dominated situation even more of an issue. EPA expects the Township, as part of the control program, to fully address the failing septic systems under existing state requirements.

Comment Letter #26: Gateway (representing 7 Municipalities) Comments on Sawmill Run TMDLs

Comment 1: The model used to determine the amount and sources of total phosphorus and total nitrogen assumes the only sources are CSOs, stormwater runoff and groundwater. The model simulation does not account for the SSOs present in the watershed that will be eliminated in their entirety as part of the consent order work that is taking place in the watershed. Currently flow monitoring and modeling is taking place under the consent order to verify the quantity of CSO and SSO discharges to the watershed. Depending on the quantities determined, significant changes in the model for source reduction could occur since SSOs would most likely be the highest concentration of phosphorus and nitrogen in mg/1. Elimination of the SSOs may have a significant impact on the amount of CSO, stormwater, and groundwater reductions to achieve the desired removal.

> **Response: Since this is the same comment received from Brentwood, please see the response to Comment Letter #11**

Comment 2: The model assumes the CSO volume to be 30% of the urban runoff. The CSOs in this watershed are fed from municipal sewers in which some of the municipal sewers are combined and many are separate sewers. The model CSO volume should be adjusted after the flow monitoring and modeling are completed to determine an accurate quantity of CSO discharge volumes as well as accounting for the amount of reduction to be achieved as part of the consent order requirements.

> **Response: Since this is the same comment received from Brentwood, please see the response to Comment Letter #11**

Comment 3: In the CSO discharges, the concentrations of total nitrogen and total phosphorus are assumed to be 9 mg/1 and 3 mg/1 respectively. This is a standard number used for combined sewer discharges. The sewers contributing to these structures are a combination of separate and combined sewers that would most likely lead to higher concentrations at the discharge. This higher concentration would also affect the amount of reduction to achieve the levels required.

> **Response: Since this is the same comment received from Brentwood, please see the response to Comment Letter #11**

Comment 4: The report does not provide a justification for the use of the 0.04 mg/1 standard for total phosphorus. The report also does not provide justification that it this value is achieved, the goal in respect to the aquatic life and water quality will be achieved. There not sufficient data to backup this level of reduction

> **Response: Since this is the same comment received from Brentwood, please see the response to Comment Letter #11**

Comment 5: The total nitrogen TMDL should not be included since the report itself does not provide the justification for establishing a limit. In reality according to the report, the existing total nitrogen concentrations are below the target concentrations. In addition, Pennsylvania

should not be establishing requirements for total nitrogen until scientific proof has been established tying total nitrogen concentrations to periphyton densities.

> **Response: Since this is the same comment received from Brentwood, please see the response to Comment Letter #11**

Comment 6: In the report, it states that all of the fourteen communities in the watershed have MS4 permits. This is not the case, as Crafton is a combined community and does not and is not required to have an MS4 permit.

> **Response: Since this is the same comment received from Brentwood, please see the response to Comment Letter #11**

Comment 7: It is our opinion that setting TMDLs for total phosphorus and total nitrogen is premature due to the extensive work occurring with the sanitary sewers in the region as part of the consent decree issued to all communities in the ALCOSAN sewer system. Data is currently being collected to better refine the model used to determine the target concentrations from the various listed sources. At a minimum, the model should be adjusted once all of the data is in, and should account for the improvements required under the consent decree to determine if and how much of a reduction would be required from each source.

> **Response: Since this is the same comment received from Brentwood, please see the response to Comment Letter #11**

Comment Letter #27: Hall & Associates Comments on Chester Creek TMDL

Section I: Unlawful Changes to 303(d) Listing and Misapplying Court Order

Comment I-1: EPA Unlawfully Modified 303(d) Listing Without Proper Public Notice or Data to Support such a Change.

> **Response: See General Response #2 concerning the legal issues raised in this comment letter.**

Comment I-2: CWA Prohibits Interpreting the Court Order to Address Newly Identified "impairments" not the 1996 Impairments as the Commonwealth of Pennsylvania has the Sole Duty to Address New Impairments.

> **Response: See General Response #2 concerning the legal issues raised in this comment letter.**

Section II. Applicable WQS Not Used in TMDL and Violates Act

Comment II-1: EPA is Required to Follow the State's Published Implementation Method for Nutrients when Interpreting the Narrative Standard.

> **Response: See General Response #2 concerning the legal issues raised in this comment letter.**

Comment II-2: Applicable Federal Regulations Preclude EPA's New Interpretation of the state‘s narrative

> **Response: See General Response #2 concerning the legal issues raised in this comment letter.**

Comment II-3: DEP Guidance has Excluded Total Nitrogen Regulation on Streams

> **Response: Please see General Response #3**

Comment II-4: EPA Historically Implemented Narrative Criteria consistent with DEP Guidance and must follow that Interpretation.

> **Response: There is no reason to cling to past procedures when improved approaches are available. The approach used by EPA is consistent with state regulations and has been accepted by PADEP**

Comment II-5: EPA's Court Filings Confirmed Proper Narrative Criteria Interpretation

> **Response: See General Response #2 concerning the legal issues raised in this comment letter.**

Comment II-6: EPA's Own Guidance Confirms the New Interpretation is Incorrect.

Response: See General Response #2 concerning the legal issues raised in this comment letter.

Comment II-7: EPA cannot Reinterpret a Water Quality Standard without following Proper Rule-Making Process.

Response: See General Response #2 concerning the legal issues raised in this comment letter.

Section III. EPA's TMDL is Substantively and Technically Flawed

Comment III-1: EPA's TMDL Neither Ensures Use Attainment nor is Necessary to Achieve Designated Uses.

Response: The development of the TP endpoint was based on the protection of aquatic life. If this endpoint is attained in the stream, then it is expected that the designed uses will be properly protected. EPA acknowledges that control of excessive sediment from the increasing overland flow from increasing impervious lands is also needed to assure designated uses are attained and maintained.

Comment III-2: Conditional Probability Analysis Demonstrates that Phosphorus Control will not Mitigate Alleged Impairments

Response: EPA believes that the commenter does not fully understand the approach used by EPA to establish the nutrient endpoint. Please see General Response #1 and General Response #7 for further discussion of the endpoint approach.

Comment III-3: EPA did not Consider Site-Specific Information Confirming the TMDL was Inappropriate and Ineffective

Response: The endpoint was based on ecoregion information and data and was consistent with EPA guidance. EPA believes that the approach was properly applied and fully describes the impairment and controls necessary to attain and maintain applicable water quality standards. EPA believes that he commenter does not fully understand the methods used by EPA. PADEP collected site data in 2006. Please see General response #1 for more information. Please see the Tt memo of general responses to TMDL comments, subject line: General response to common concerns with the endpoint approach developed for TP TMDLS in Pennsylvania. In addition, Tt used the data made available and data we were able to acquire readily for the analysis to derive the TP endpoints. Lastly, one would have to make sure that the methods used in the collection of these invertebrates were comparable to those used in derivation of these endpoints. MBSS uses, for example, a multihabitat sample and a 100 individual subsample for identification. Looking at the data and based on experience with USGS sampling methods, the methods used to derive these data were different and therefore the comparison is invalid.

Comment III-4: Available EPT Taxa Data Confirm EPA Approach is Misapplied

Response: EPA believes that the commenter does not fully understand the approach used by EPA to establish the nutrient endpoint. Please see General Response #1 and General Response #7 for further discussion of the endpoint approach.

Comment III-5: EPA Presented no Demonstration of Excessive Plant Growth in the TMDL.

Response: The commenter is reminded that the endpoint was not based on the control of biomass or plant growth. However, water quality modeling confirms that the endpoint established for the protection of aquatic life is also sufficient to maintain the algal biomass below the generally accepted value of 150 to 200 mg/m2. The growth rate has little or no impact on the allocations due to the approach EPA used for the development of the nutrient endpoint. A sensitivity analysis was completed on Chester and Indian Creeks which verified this. EPA believes that the commenter does not fully understand this approach and refers him to General Response #1 and General Response #7. Further there is biomass data for the watershed. The commenter is referred to the attachment to this Response Document for that data.

Comment III-6: EPA Presented no Relationship between Algal Growth and Nutrients and Admitted Plant Growth will Not be Limited

Response: The commenter is reminded that the endpoint was not based on the control of biomass or plant growth. The commenter misrepresents EPA position on the impacts to algal biomass. However, water quality modeling confirms that the endpoint established for the protection of aquatic life is also sufficient to maintain the algal biomass below the generally accepted value of 150 to 200 mg/m2. The growth rate has little or no impact on the allocations due to the approach EPA used for the development of the nutrient endpoint. A sensitivity analysis was completed on Chester and Indian Creeks which verified this. EPA believes that the commenter does not fully understand this approach and refers him to General Response #1 and General Response #11. The commenter misrepresents what Dr. Paul has said. Dr. Paul did not state that algal growth would not increase above 3.7 mg/L TN, but that the data indicate that the streams are not limited by nitrogen. Further, nowhere in the Paul and Zheng (2007) report does it state that algal growth would not be limited at a concentration of 40 mg/L. The author of this comment refers to discussion of algal growth saturation, conducted in ideal laboratory settings, which do not mimic natural conditions and are not the same as biomass accrual. Cells may grow at a maximum rate and still not achieve maximum biomass.

Section IV. Modeling Parameters Were Arbitrarily Selected To Project Greatly Reduced Periphyton Levels With TN/TP Control Contrary to Available Data:

Response: The commenter is reminded that the endpoint was not based on the control of biomass or plant growth. However, water quality modeling confirms that the endpoint established for the protection of aquatic life is also sufficient to maintain the algal biomass below the generally accepted value of 150 to 200 mg/m2.

The growth rate has little or no impact on the allocations due to the approach EPA used for the development of the nutrient endpoint. A sensitivity analysis was completed on Chester and Indian Creeks which verified this. EPA believes that the commenter does not fully understand this approach and refers him to General Response #1.

Comment IV-2: Plant growth rate was not calculated or verified

Response: The commenter is reminded that the endpoint was not based on the control of biomass or plant growth. However, water quality modeling confirms that the endpoint established for the protection of aquatic life is also sufficient to maintain the algal biomass below the generally accepted value of 150 to 200 mg/m2. The growth rate has little or no impact on the allocations due to the approach EPA used for the development of the nutrient endpoint. A sensitivity analysis was completed on Chester and Indian Creeks which verified this. EPA believes that the commenter does not fully understand this approach and refers him to General Response #1.

Comment IV-3: Selected Plant Growth Rate Confirmed Incorrect by Available Data

Response: The commenter is reminded that the endpoint was not based on the control of biomass or plant growth. However, water quality modeling confirms that the endpoint established for the protection of aquatic life is also sufficient to maintain the algal biomass below the generally accepted value of 150 to 200 mg/m2. The growth rate has little or no impact on the allocations due to the approach EPA used for the development of the nutrient endpoint. A sensitivity analysis was completed on Chester and Indian Creeks which verified this. EPA believes that the commenter does not fully understand this approach and refers him to General Response #1.

Comment IV-4: EPA admitted the selected algal growth rate was incorrect for projecting periphyton growth in two other EPA PA TMDLs

Response: EPA made no such admissions. Previous TMDLs and assumptions should not be sued as a baseline or comparison to these TMDLs. To do so would be simply a smokescreen in order to obscure the important facts and data applicable to the Chester Creek TMDL. Please see the response to comment number 17 above. See General Response #11.

Comment IV-5: EPA's Expert Report Contradicts the Selected Growth Rate

Response: Please see the response to comment number 18 above.

Comment IV-6: Claim That TMDL Will Remedy All Use Impairments Clearly Incorrect Regulating Pollutants without Need Violates TMDL Rules & Statutes

Response: PADEP has collected and analyzed chemical and biological data for the watershed and determined that Goose Creek is impaired due to excessive nutrients

and several waters for sediment. These impairments have been included on the PADEP section 303(d) list of impaired waters for many years. The commenter has had an opportunity to comment on these listed impairments each year the PADEP has proposed a new list, which according to federal regulations is every even numbered year, starting in 1992. To EPA's knowledge the commenter did not proved comment on these identified impairments at any time during the listing process. EPA fully expects that the reduction of sediment, following PADEP's development of a sediment TMDL and the control of nutrients throughout the watershed following EPA's recommendations in the Chester Creek Watershed report will provide the watershed an opportunity to attain a healthy and viable aquatic community.

Comment IV-7: The TMDL Documents Confirm TN Reduction is Not Needed to Address Impairment

Response: Please see General Response #3.

Comment IV-8: Claims Reduction in TN Needed for Possible Issues in other water (Delaware Bay) though No Impairment Listing Exists in such waters

Response: EPA has deleted TN from the final TMDL. See General Response #3

Section V. No Substantial Evidence for EPA's Technical Conclusion

Comment V-1: TMDL Claims Nutrients are the Cause of Impairment based on Assertion of DEP Biologist.

Response: EPA agrees with this comment.

Comment V-2: EPA Admits No Plant Growth Data were Collected

Response: The commenter is reminded that the endpoint was not based on the control of biomass or plant growth. However, water quality modeling confirms that the endpoint established for the protection of aquatic life is also sufficient to maintain the algal biomass below the generally accepted value of 150 to 200 mg/m2. The growth rate has little or no impact on the allocations due to the approach EPA used for the development of the nutrient endpoint. A sensitivity analysis was completed on several streams which verified this. EPA believes that the commenter does not fully understand this approach and refers him to General Response #1. Also see General Response #11 and modeling results presented in the attachment to this Response Document.

Comment V-3: TMDL Claim that Regulating Nutrients will Solve all Impairment Problems is Unsupported

Response: EPA does not make this claim. The commenter is once again using misdirection to further his cause. EPA has recognized on several occasions that not only nutrients but sediment must also be controlled in order to assure a healthy,

diverse aquatic community. Unfortunately sediment TMDLs were not completed for this watershed. However, EPA has completed a watershed report that provides suggested reductions watershed-wide for both nutrients and sediment. The commenter is referred to the watershed report for more information. Also see General Response #9 for more information on the scope of this TMDL.

Comment V-4: TMDL has Extensive Analyses Showing Habitat Causes Impairment

Response: See response to comment #25

Comment V-5: No Analyses of Chester Creek Nutrient Data versus Impairment Presented to Support EPA Conclusion

Response: EPA presented the data analysis and the results of the stream modeling.

Comment V-6: Historical Impairment Data show No Significant Difference in Impairment above or below Treatment Plant The limited data available on biological impairments above and below point sources in the drainage basin show that the impairments exist above and below point source discharges (see Table 3-5, TMDL at 3-9). In this case, Station A on East Branch Chester Creek (the only upstream station) is identified as biologically impaired. Water quality data in this area, collected by the USGS and National Parks Service, indicate that phosphorus and nitrogen levels are below the endpoints used in this TMDL.

Response: Based on PADEP's permit information, there are three point sources located upstream from sample site A. Of the three point sources, one is a sewage publicly owned plant (Westtown Twp STP, PA0031771) and two are sewage non-publicly owned plants (Malvern School of Glen Mills, PA0056821, and Cheyney University of PA, PA003070). Therefore, the statement that —impairments exist above and below point source discharges" is incorrect. As far as the water quality measurements conducted by USGS and National Parks Service are concerned, the majority of the nutrient data collected from these entities are between 10 and 17 years old. Therefore, this data set cannot be used to reflect existing conditions in the East Branch Chester Creek. It should be noted that the Chester Creek Nutrient TMDL was revised to include only the Gosse Creek watershed.

Comment V-7: Historical Data Show Impairment Trends Exist Regardless of Nutrient Level Present or Location of Discharges. The limited data available on biological impairments above and below point sources in the drainage basin show that the impairments have gotten progressively worse over time, regardless of the nutrient concentrations in those locations (suggesting that some area-wide change, such as habitat degradation associated with regional development is to blame). These observations, reported in the TMDL (see Section 3.2.1), confirm that nutrients are not the cause of the observed impairments. Consequently, this TMDL will not restore designated uses because it does not address the real cause of use impairment.

Response: Biological data generally provide an overall health rating of a stream and reflect disturbances of the stream system over a long-term period. In contrast, chemical monitoring provides only a snapshot over the period monitoring was

conducted. This is in particular true when nutrients measurements were conducted only once a year as it occurred for the Chester Creek during the biologic data collection. It should be noted that the Chester Creek Nutrient TMDL was revised to include only the Goose Creek watershed.

Comment Letter #28: Hall & Associates Comments on Indian Creek TMDL

Comment 1: The 1996 TMDL listing only addressed the uppermost 1.5 mile segment of Indian Creek. Impairments were only designated due to Salinity/TDS/Chlorides from Municipal Point Sources and Causes Unknown due to Source Unknown. The 1996 listing did not determine that Indian Creek was broadly impaired by nutrients from multiple sources.

Response: See General Response #2

Comment 2: Under Pennsylvania law, nutrients are only regulated as necessary to control excessive plant growth and excessive dissolved oxygen swings associated with such excessive plant growth (see, Implementation Guidance for Section 95.9 Phosphorus discharges to Free Flowing Streams (Document ID 391-2000-018, October 27, 1997), and Assessment and Listing Methodology for Integrated Water Quality Monitoring and Assessment Reporting - Clean Water Act Sections 305(b)/303(d), May 8, 2006).

Response: See General Response #11

Comment 3: This TMDL sets a new nutrient standard for streams, unrelated to plant growth and DO impacts, and claims such water quality must be achieved to protect invertebrate populations in Indian Creek. Moreover, this report fails to show that Indian Creek invertebrate populations are actually impaired and provides no confirmation that the assumed impairment is, in fact, caused by instream phosphorus or nitrogen levels.

Response: The commenter is referred to the many PADEP stream survey reports for the watershed. These reports, based on biological and chemical data, connect the biological impairment with the nutrient issues. PADEP has also identified sediment as a considerable problem in the watershed.

Comment 4: EPA's consultants admitted the new technical analyses relied upon by EPA do not confirm that nutrient impairment exists in any particular stream. The entire TMDL is based on addressing assumed invertebrate impairments using a new standard that has never been adopted by the Commonwealth of Pennsylvania or subject to the public review process applicable to all state water quality standards.

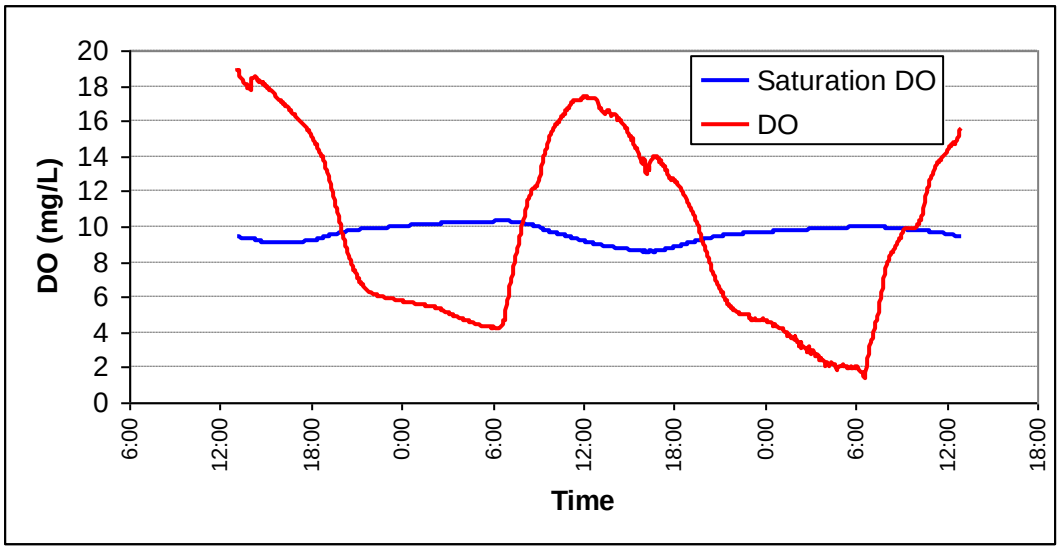
Response: See General Response #1 and General Response #2

Comment 5: Beyond these critical legal and procedural flaws, it is apparent that basic information for a proper nutrient standard and TMDL development are missing from the TMDL report and the modeling approach employed by the TMDL is inapplicable to nutrient impact evaluation. EPA's document states that the reason for controlling nutrients is to control excessive plant growth (TMDL at 9; "The selected TP endpoint would be applied as an average concentration during the growing season from April to October, which in streams is typically the time during which the greatest risk of deleterious algal growth exists".). However, there are no specific data on plant growth for Indian Creek, only anecdotal reports from 2006 (TMDL at 13). The TMDL claims that modeling was done to show that nutrient reductions will adequately address necessary DO criteria and nuisance algal levels (TMDL at 66). In fact, the model was not

calibrated to calculate periphyton levels (no plant data) and the modeling results indicate that DO levels following TMDL implementation will be far above those necessary to achieve state standards (TMDL at 95) (i.e., overly protective). The modeling was actually done to address hypothetical invertebrate impairments and EPA's rationale for this TMDL is highly misleading.

Response: The TMDL language will be modified. The TMDL, as has been explained on many occasions, was based on the need to attain and maintain the aquatic life uses. PADEP data proves that the invertebrate impairment rises above theoretical. The commenter's suggestion that invertebrate impairments in Indian Creek are hypothetical is in direct contradiction to PADEP's listing documentation upon which the impairment status of the watershed is based. EPA hereby provides a summary of the results of one such investigation conducted on the Unnamed Tributary to Indian Creek, Stream Code 01182, on August 14, 2003. During this investigation, PADEP conducted chemical and biological sampling at two stations upstream and downstream of the Lower Salford Township Authority Harleysville STP (PA0024422) outfall. Based on the results of this investigation, the invertebrate community at station one was found to be "fair to poor" and the invertebrate community at Station two was found to be "poor". Recommendations of the field staff conducting the investigation included the recommendation "that the unnamed tributary to Indian Creek be listed as impaired from the Lower Salford Township Authority, Harlyesville STP outfall to the mouth for municipal point source nutrients." It was upon this recommendation and specific findings in the field as well as others similar to it throughout the Indian Creek watershed, that the stream was included on PADEP's 303(d) list as impaired. For example, a second field form on which the results of the stream assessment of Indian Creek at Indian Creek Road found: "Indian Creek is impaired based on the taxa collected. This station lacked pollution sensitive taxa and was dominated by facultative taxa. The cause of impairment is likely from storm water runoff from Harleysville and Telford and from sewage effluent as the stream is effluent dominated." EPA's modeling and analysis was been performed in direct response to these specific findings. EPA therefore feels the rationale for the TMDL to be perfectly straightforward and justifiable.

The Indian Creek model does, in fact, simulate periphyton and its link to nutrients and DO. Because DO levels are reflective of and impacted by periphyton, they were essentially used as a surrogate for calibration. Changes of water temperature can change the DO in water. As shown in the figure below for monitoring data recorded at the Bergey Road location, the change of saturation DO follows the change of temperature in the reverse. When water temperature increases in the day time, saturation DO decreases. In the night time, saturation DO increases when temperature decreases.



DO at Bergey

Aquatic plant life, especially algae, is the most significant factor that causes DO fluctuation. In the day time when there is light reaching the bottom, algae's photosynthesis dominates and DO increases dramatically. When reaeration is not fast enough to release oxygen into the air, DO becomes supersaturated. At night, algae's respiration dominates and DO decreases. When reaeration is not fast enough to bring oxygen into the water from air, DO depletion occurs in water. The figure above of monitored DO at the Bergey Road station, shows a typical DO diurnal fluctuation caused by high levels of algae. The DO concentration corresponds to light intensity and reaches a peak at early afternoon due to the highest level of algae growth, and becomes very low before dawn due to the respiration of algae. No other factors can cause such a strong DO swing.

For these reasons, DO is an excellent indicator of the presence of periphyton, perhaps an even better one than periphyton itself. Periphyton is fixed algae and is spatially variable. Direct sampling of periphyton at select locations will not necessarily represent periphyton levels at a large scale. DO is mixed in the water column and is therefore suitable for evaluating average periphyton levels on a larger scale. As a result, using DO data and calibrating the model to DO is a solid approach to representing the nutrient and periphyton dynamics in Indian Creek.

Based on model results, under TMDL conditions, DO levels are predicted to be above the state specified minimum criteria of 5 mg/L in contrast to current conditions, under which DO levels have been shown to fall below state specified criteria. The table below shows predicted minimum DO levels at the six sampling locations, none of which are deemed by EPA to be —overly protective".

Site Location	Minimum DO (mg/L) after TMDL
Bergey	6.70
Godshall	6.85
PilgrimTrib	6.50
SalfordTrib	7.22
RT63	6.99
ICMouth	6.95

Comment 6: The underlying Expert Report, prepared by Tetra Tech as the basis for the water quality standard, acknowledges that the selected standard will not materially change whatever plant growth is presently occurring in the stream, rendering the regulation of phosphorus a meaningless exercise. The Expert Report also shows that the phosphorus and nitrogen standards alleged to be needed to protect invertebrate populations are actually not expected to achieve EPA's chosen impairment levels for invertebrates, even if the suggested standards are achieved.[4] The Expert Report admitted nitrogen was not causing excessive plant growth or invertebrate impairments. Thus, the procedures used to generate this standard are both legally and technically flawed since the standard neither ensures use protection nor is necessary to ensure use protection contrary to applicable federal regulations.

Response: As is described in the Expert Report, the TP endpoint was derived such that aquatic life use would be protected. In the examination of a relationship between algal metrics and nutrient levels, the Export Report found that four nutrient based metrics were significantly related to TP concentrations, the TSI index, the PANS TP model, the MSU TSI index, and the MSU-MAIA TSI index (pp. 16-17).

The commenter's use of the term —standard" in relation to the water quality endpoint targets is misleading and erroneous. In the Report submitted by Tetra Tech, outlining the procedures and analyses applied in determining appropriate nutrient endpoints for this and other TMDLs in the region, it was clearly stated that the case for nitrogen endpoints is weak. EPA's decision to include draft nitrogen allocations in the DRAFT TMDLs does not as a result, indicate that the procedures used to identify the proposed TP endpoint are legally or technically flawed.

It is not clear what the commenter means by the statement: —The Expert Report also shows that the phosphorus and nitrogen standards alleged to be needed to protect invertebrate populations are actually not expected to achieve EPA's chosen impairment levels for invertebrates, even if the suggested standards are achieved."

Comment 7: Finally, it is clear that the modeling was never calibrated to any existing instream periphyton data and bears no reasonable relationship to reality. While the model predicts algal growth to estimate dissolved oxygen variability, it has no information to determine whether the algal predictions are correct. The modeling approach used to predict dramatic DO impairments was confirmed by EPA and Tetra Tech to be unsubstantiated and unrealistic in a prior EPA TMDL action for Wissahickon Creek.

The model was "calibrated" using actual flows "because facilities typically discharge at volumes lower than design flow volumes and at concentrations lower than permitted concentration limits" (TMDL at 51). The TMDL run, however, is based on permitted flows and uses daily average loads from the MS4 dischargers. The use of permitted flows through the summer low-flow period grossly overestimates the load from point sources and the use of daily average loads from MS4s cannot properly characterize storm flows (short-duration, high intensity).

The report states that the nutrients endpoints are to be applied as growing season averages (April - October), however, the TMDL is specified as an annual load and includes mass and concentration limits during the non-algal growing season. Thus, the flawed EPA standard is misapplied to the wrong stream conditions and misapplied to the wrong time period.

Response: As has been stated in previous responses, the Indian Creek modeling application was calibrated to instream chemical and dissolved oxygen levels among other parameters. The statement that the model bears no resemblance to reality is at best wishful thinking on the commenter‘s part and at worst an inability to interpret graphical representations of model output and monitoring results. The DO impairments referred to in the text of the TMDL were based on actual monitoring data; although the model does simulate those actual conditions (see Appendix B).

The approach used in this Indian Creek TMDL is not the same as that used in Wissahickon Creek. Permitted flows and concentrations are used to represent TMDL baseline loading scenarios because they represent the largest possible amount of pollutant that can legally be discharged into the stream as a function of the discharger‘s NPDES permitted maximum potential. This is a standard and normal practice for TMDL development. It is also standard and normal practice to calibrate models using actual flow and discharge conditions. The fact that TMDL reductions are specified in relation to baseline loading conditions actually means that actual facility reductions are not as dramatic since reductions will realistically be based on current discharge levels, which are already below permitted levels. Daily average loads are specified for MS4s as well as loads based on longer-term averaging periods. Interpretation of these WLAs for purposes of including in MS4 permits and how any resulting limits will be structured will be up to the permit writer and, pursuant to NPDES regulations at § 122.44(d)(1)(vii)(B) are required to be consistent with the assumptions and requirements of the wasteload allocation. Finally, the various averaging periods for which the WLAs are specified were included in the report, in addition to the growing season loads, in an effort to provide potentially helpful information for permit writers in developing appropriate NPDES permit effluent limitations pursuant to these TMDLs upon approval.

Comment 8 - Section I. Impairment Listing Unlawfully Amended and Consent Decree Requirements Violated

Response: See General Response #2

Comment 9 – Section II: EPA Has Illegally Modified the State's Approach to Nutrient Regulation

Sub 1: EPA is required to adhere to the state's published guidance on nutrient regulation for streams and is not free to interpret the narrative standard as it wishes.

Response: See General Response #2 and General Response #11

Sub 2: In May 2007, EPA filed documents requesting a time extension in the American Littoral Society case. The filing confirms that EPA clearly understood that to impose a nutrient limit EPA must prove (1) excessive plant growth exists and (2) that plant growth is causing D.O. related impairment.

Response: See General Response #2 AND General Response #11

Sub 3: EPA amended the state's published guidance on assessing aquatic life impairments by arbitrarily selecting impairment thresholds for macroinvertebrate metrics that conflict with the state's published protocol for evaluating aquatic life impairment.

Response: See General Response #11

Sub 4: EPA has violated federal rules regarding WQS adoption by failing to provide public notice that it was amending the state's existing narrative criteria interpretation procedure.

Response: See General Response #2

Sub 5: The basis of EPA's standard is data from the piedmont area of Maryland. There is no demonstration contained anywhere in the TMDL or its supporting studies showing that such information is properly applied to Pennsylvania.

Response: It is apparent that the commenter does not fully understand the approach used by EPA. See General Response #1

Comment 10 – Section III: Proposed Standard Admitted to Be Ineffective in Ensuring Use Protection

Response: Please see General Response #1. Further note that it is our opinion that the EPA Guidance also allows indirect response measures to be used in deriving nutrient criteria. We suggest the authors of this comment read pages 45 and look at the case study from Tennessee in Appendix A for the descriptive use of macroinvertebrate indicators for developing nutrient endpoints.

Sub 1: The TMDL did not consider plant growth in this system and did not confirm that invertebrate impacts exist due to excessive nutrient levels in this system.

Response: See General Response #11. EPA modeled plant biomass. See the attachment to this Response Document. PADEP data confirms macroinvertebrate impairment.

Sub 2: The approach used by EPA to impose very restrictive TP reductions is based on a weak correlation between TP and invertebrate levels.

Response: See General Response #1.

Sub 3: It is well recognized legal and scientific principle that correlation does not prove causation. The Expert Report acknowledges that the correlation analyses do not prove that phosphorus is the cause of the possible reduction in invertebrate levels.

Response: See General Response #1

Sub 4: EPA consultant's admitted that the approach used to derive the standard (conditional probability) has not been approved as an acceptable approach by DEP, and has never been used to derive a standard by EPA.

Response: EPA believes that the commenter does not fully understand the approach used by EPA to establish the nutrient endpoint. Please see General Response #1 for further discussion of the endpoint approach. PADEP provided comments during the comment period. One comment supported the approach used by EPA.

Sub 5: The Expert Report apparently relies on the conclusion that TP levels are a direct cause of invertebrate impairment since it acknowledges no obvious relationship between plant growth and nutrient levels.

Response: EPA believes that the commenter does not fully understand the approach used by EPA to establish the nutrient endpoint. Please see General Response #1 for further discussion of the endpoint approach

Sub 6: The phosphorus endpoint analysis described in the Expert Report is premised on the assumption that TP is responsible for impairments to the number of EPT taxa, the percent of clinger macroinvertebrates, and the shift in trophic state index.

Response: EPA believes that the commenter does not fully understand the approach used by EPA to establish the nutrient endpoint. Please see General Response #1 for further discussion of the endpoint approach

Sub 7: The Expert Report claims it is using conditional probability and several other approaches as a "scientifically defensible" procedure. EPA guidance on standards development, as well as the rules applicable to criteria development (Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their

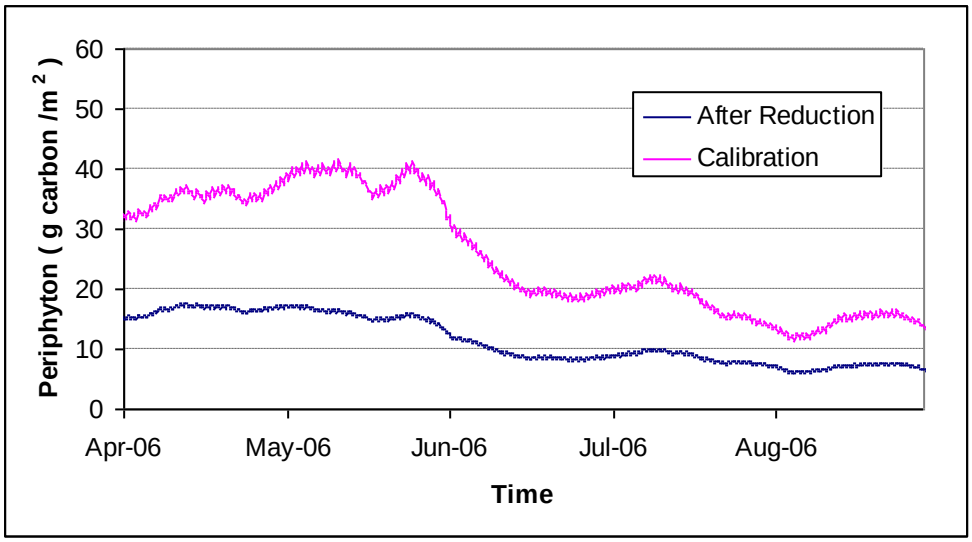
Uses, 1984, "National Guidelines") is clear that the same level of protection afforded by EPA Section 304(a) Criteria (full use protection) is required when using an alternative method of criteria derivation.

Response: EPA believes that the commenter does not fully understand the approach used by EPA to establish the nutrient endpoint. Please see General Response #1 for further discussion of the endpoint approach

Comment 11 – Section IV. TMDL Calculations Are Flawed and Unsupported

Sub 1: EPA's analysis presumes, but does not confirm, that a nutrient-related impairment exists in Indian Creek. This is not allowable under state law, the Clean Water Act, or it's implementing regulations. For a violation of a narrative standard to exist, one must have site-specific information showing that a particular constituent, not regulated by a numeric standard, is causing an impact on beneficial uses (fishing, swimming, aquatic life, etc.). EPA never even attempts to make this demonstration in the TMDL. Rather, EPA applies the Expert Report conditional probability-derived instream objective for phosphorus as if exceedance of that value confirms impairment. That approach unlawfully and improperly applies the narrative standard as if it were an adopted numeric value for which site-specific impairment information is unnecessary. EPA's approach plainly misapplies the Expert Report. The Expert Report is perfectly clear that the proposed phosphorus value is based on generic information, indicating only a possibility that phosphorus may be causing an impact. The report nowhere concludes that an exceedance of the 0.040 mg/L value confirms an impairment exists for an individual stream. It is also clear that TN levels do not control plant growth or invertebrate diversity. Therefore, EPA's TMDL lacks the basic information necessary to conclude that a narrative criteria violation exists and to confirm that phosphorus or total nitrogen is the pollutant causing the impairment.

Response: See General Response #1 and See General Response #2. The commenter apparently does not understand the approach used by EPA. PADEP has agreed with the approach and EPA Headquarters standards program has confirmed that it is appropriate. The determination of impairment of the watershed was made by PADEP. Data collected prior to TMDL development also confirmed exceedences of PA DO criteria. The purpose of the TMDL exercise was to develop appropriate nutrient endpoints in response to PADEPs listing and to develop TMDL allocations based on those endpoints. Results of the calibrated model developed to support this TMDL show that under the TMDL conditions (i.e., when the seasonal average TP concentration is met) periphyton levels are predicted to be reduced. The Figure below shows predicted periphyton levels for existing conditions and TMDL conditions at the Bergy Road location. These are directly resulting from reduced TP inputs.



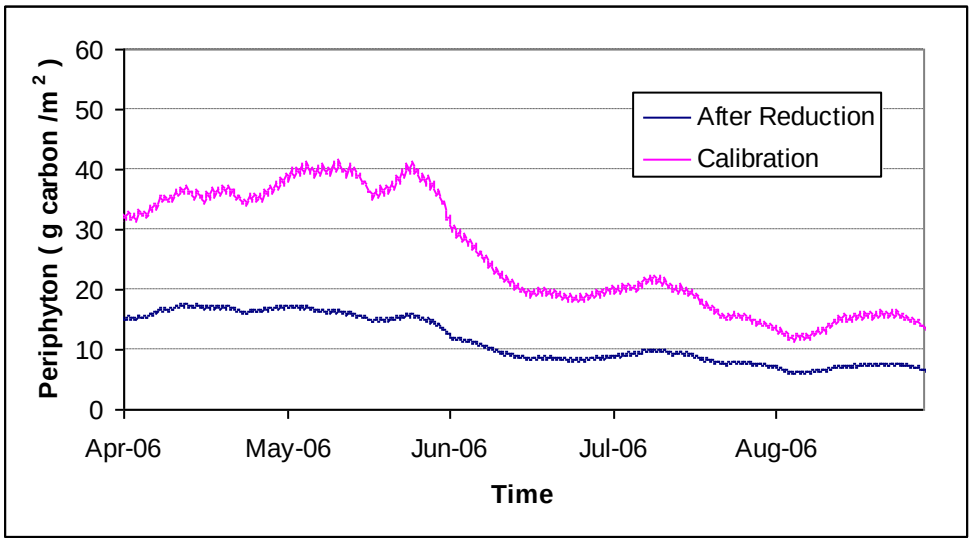
The lawfulness and properness of how EPA has interpreted the existing narrative standard has already been addressed in multiple comment responses including General Response #2. EPA also believes, that by reference to the 2007 report by Paul and Zhen —Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application" the TMDL document provides sufficient information related to the nutrient endpoint development effort and rationale. Nevertheless, EPA has updated the language in Section 1.2 related to impaired waterbodies in the watershed, with text from PADEP field sheets to provide additional details on the listing.

Sub 2: EPA states that the purpose of the phosphorus and nitrogen effluent limitations was to control plant growth in the growing season.

> "*The nutrient endpoints for this TMDL consist of the average seasonal total phosphorus (TP) and total nitrogen (TN) concentrations associated with acceptable levels of periphyton densities." [TMDL at 6]*
>
> "*To ensure that the reductions made to comply with the seasonal nutrient endpoints will also adequately address necessary DO criteria and nuisance algal levels" [TMDL at 66]*

EPA did not calibrate the model for plant growth. There is no evidence, whatsoever, supporting the position that the required loads are needed to reduce plant growth to acceptable levels. The complete absence of such analysis renders EPA's derivation of TP loadings arbitrary and capricious. Moreover, in the various TMDL public workshops, EPA admitted that plant growth and DO impacts were not used to derive the TMDL requirements. The Expert Report's acknowledgement that TN does not affect plant growth proves EPA's proposal is arbitrary and capricious

Response: EPA does not accept the argument that the proposal is arbitrary and capricious. EPA used existing science, including existing EPA guidance for the development of nutrient criteria, to establish the instream goals for the TMDLs. As the commenter acknowledges, EPA has consistently stated that those goals are based on the need to attain and maintain the aquatic life uses of the waters as defined by PADEP. As discussed in the General Response #11, we did model the projected biomass and found that the control of the nutrients at a level that will protect the aquatic life will also reduce the biomass to acceptable levels. We will review the TMDL report to see if language changes are needed to better represent the approach. Please see General Response #3 for more on TN. It is scientific fact that nutrients support the growth of algae, and high levels of algae are caused by high concentrations of nutrients. The point of developing a numerical model of the system is to quantify the relationships between nutrients and algae in Indian Creek. The fact that there was no direct comparison between modeled periphyton and instream periphyton does not mean that the model was not calibrated or was inadequately calibrated. Again, the strong DO swing is caused by high levels of algae; and DO is a strong indicator for periphyton levels. After simulated TP reductions, the algae are predicted to dramatically reduce as shown in the Figure below for the sampling site at Bergey.



While the TMDL does not include analysis of TMDL TP levels and resulting algal growth, the analysis provided herein supports the assumption that both DO and algal levels under TMDL conditions are expected to be acceptable. That is, DO levels above state specified minimum criteria and predicted periphyton densities less than 100 mg/m^2. Again, neither plant growth nor DO were used to derive the TMDL requirements; the TMDL requirements were based on a loading scenario that achieves identified average nutrient concentration levels for the period from April 1

– October 1. The predicted levels of DO and periphyton under TMDL conditions were assessed to ensure that designated uses in the stream would be beneficially impacted by the TMDL reductions. Furthermore, EPA has decided not to include allocations for total nitrogen in this TMDL.

Sub 3: The TMDL claims that "Data analysis and modeling runs have established a clear linkage between phosphorus loading and periphyton densities in the watershed". (TMDL at 66). This statement is unsupportable as no data or analyses show that this TMDL will improve periphyton densities in Indian Creek. With regard to phosphorus, EPA has data from nearby watersheds that conclusively refute this "linkage". That data is even discussed in the Expert Report:

> Not surprisingly, a strong algal biomass - nutrient relationship was not present in our examination of the datasets. (Expert Report at 15)
>
> The samples with the highest algal biomass were collected by the PADEP -Pennsylvania State University periphyton study, which focused on the targeted watersheds. Surprisingly, the highest algal biomass occurred at sites where TP concentrations were relatively low (14—35 ug/L). (Expert Report at 16)

These statements from the expert report confirm that (1) data analyses have not established a clear linkage between phosphorus loading and periphyton densities, and (2) a growing season average TP concentration of 40 ug/L (i.e., 0.040 mg/L) will not limit periphyton densities. Therefore, this TMDL will not have any material impact on periphyton densities in Indian Creek or DO swings attributed to periphyton.

The suggestion that modeling runs have established a clear linkage between phosphorus loading and periphyton densities is contingent upon believing that the model is properly calibrated for periphyton growth. However, this model was only calibrated for nutrients and DO (see TMDL at 59). With regard to periphylon, lhe TMDL stales:

> The original calibration conducted in 2006 used only May 2006 data. The August 2006 data were also used in the updated calibration to obtain more reliable values of the benthic macroalgae parameters. The major change is the phosphorus half-saturation constant for macroalgae, which was changed from the original estimation of 0.005 mg/L to 0.05 mg/L after using two sets of data for the updated calibration. (TMDL at *59)*

The effect of this change is to reduce macroalgae (i.e., periphyton) growth at TP concentrations below 0.10 mg/L. At the selected endpoint of 0.040 mg/L, the revised phosphorus half-saturation constant results in a model-predicted reduction in maximum periphyton growth of 56%. This reduction in growth rate is opposite the evaluation presented in the Expert Report:

> Algal growth potential has been evaluated using artificial stream channels that are fully exposed to nutrient and light gradients. Previous studies (Homer et al. 1983, Bothwell 1989) demonstrated that in artificial streams, algal growth could be

> saturated (i.e., achieved maximum growth rate) at 25-50 ug/l phosphorus. (Expert Report at 23)

In response to a question at the Chester Creek TMDL public meeting (March 5, 2008), Dr. Paul (author of the Expert Report) replied that maximum growth, at 25 - 50 ug/L phosphorus, is not consistent with a half-saturation constant of 0.05 mg/L.

Since no periphyton data were collected in Indian Creek, it is obvious that the model was not calibrated for periphyton growth. Furthermore, the observations reported in the Expert Report (quoted above) confirm that the supposed linkage does not exist at these concentrations. Therefore, the model must be disqualified as an appropriate tool for establishing the TMDL because it produces results that are diametrically opposed to the conclusions of EPA's expert.

Response: The commenter continues to be concerned with algal biomass when EPA continues to make it clear that the endpoint is driven by the aquatic life use protection. This comment is not consistent with the approach used by EPA. The significant observed DO swings in the Indian Creek are indicative of the relationship between phosphorus loading and periphyton densities. This relationship was confirmed by modeling. The half-saturation constant can vary within a large range and is site-specific. The value was adjusted during calibration based on values supported by the literature together with other parameters such as maximum growth rate, respiration rate, and death rate. It is a routine procedure to adjust parameter values during calibration and validation to result in a good match with data. Borchardt (1996) summarizes representative studies on nutrient limitation of benthic algae. Saturated growth rates range from 8 µg/L to 60 µg/L TP and 55 to 700 µg/L TN. The individual vales are as follows: saturated growth rate occurred at 8 µg/L P and 500-700 µg/L N (Wuhrmann and Eichenberger 1975); 60 µg/L P (Wong and Clark 1976); 40-50 µg/L P (Horner and Welch 1981); 25 µg/L P (Horner et al. 1983); and 55 µg/L N (Grimm and Fisher 1986). Borchardt's (1996) summary also indicates that maximum biomass occurs at 25-50 µg/L P (Bothwell 1989) and less than 100 µg/L N is growth limiting (Lohman et al. 1991). Therefore, 50 ug/L is an acceptable value.

Dr. Paul did not make the statement as claimed by the commenter.

Sub 4: The TMDL claims that "the linkage between nitrogen and periphyton in this system is somewhat less well-established". (TMDL at 66). This statement is misleading as there is no data or analyses showing that nitrogen control, at 3.7 mg/L, will control periphyton densities in Indian Creek. The Expert Report notes the following:

> High N:P ratios indicate P is limiting growth, and low N:P ratios suggest that N is limiting growth. In addition to the strong evidence of P limitation from nutrient ratios, our examination of all the metrics with TN and other nitrogen parameters did not find strong correlations with biological variables. As a result, we considered Northern Piedmont streams as principally P-limited systems and focus on relationships with TP concentrations. (Expert Report at 15)

In response to a question at the Chester Creek TMDL public meeting (March 5, 2008), Dr. Paul (author of the Expert Report) replied that TN concentrations would not affect periphyton growth, whether the instream concentration was 3.7 mg/L or 8 mg/L because, at either concentration,

nitrogen is present in excess of algal requirements. Since TN has no effect on algal growth or DO at the proposed endpoint used in this TMDL, the TMDL should not regulate TN.

Response: Please see the General Response #3

Sub 5: The TMDL wasteload allocations are based on endpoints specifically identified as growing season averages. However, the wasteload allocations presented in Table 5-6 and Table 5-7 (TMDL at 67) specify annual WLAs as well as winter limits. These tables also present "Growing Seasonal Loads", but the values presented are a simple ratio of the growing season months (April - October) to the entire year. Rather than assess instream conditions from April through October, the analysis appears to be based on annual conditions. The EPA-derived standard does not apply to annual conditions. Therefore, the entire TDML analysis is suspect.

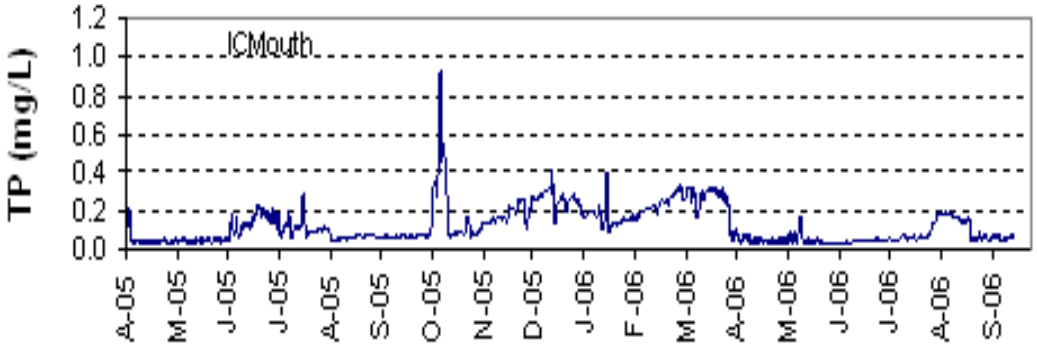
Response: The WLAs listed for the facilities in Section 5 of the Draft TMDL were provided in various time steps (annual, seasonal and daily) to assist PADEP in interpreting and deriving NPDES permit limitations to comply with assumptions and requirements of the TMDL. Under the TMDL condition, point sources were represented in the model using a constant flow and concentration. As a result, the values presented for the seasonal load are proportional to the values presented for the annual load. Successive model runs were performed to evaluate the level of instream nutrient concentrations during the target growing season period. Source loads were reduced (in this case the average concentration used to represent discharges) until the average instream nutrient concentration for the period from April 1 to October 31 was met. This text has been added to the document to clarify the modeling process. This text has been added to the document to clarify the modeling process. Daily load expressions are required to be included in the TMDL and will not be deleted (See EPA policy memorandum, November 15, 2006).

Sub 6: The model, used to predict instream TP levels under varied flow conditions, was not calibrated or verified, particularly for wet weather conditions. The TMDL sets the total load from permitted point sources at 278 Lbs/yr and MS4s at 1,320 Lbs/yr. However, storm flows and loads would be carried out of this small drainage basin very quickly, having virtually no impact on conditions in the stream. This approach to wet weather flows was used in the Southampton Creek TMDL for circumstances virtually identical to Indian Creek.

> Although nonpoint sources likely contribute more nutrient loadings during high flow periods, given significant increase of the flow volume, the high flow condition does not become a critical condition under which this nutrient TMDL is established. Based on literature research and evaluation of the relative nitrogen and phosphorus loads from wet weather, it is determined that much of the nitrogen and phosphorus entering the system from the land runoff during wet weather events will be transported out of the receiving water system along with the higher flows. (Southampton Creek TMDL Report at 44)

Response: Commenters seem to want EPA to fully consider the contributions of stormwater to the nutrient loadings in the watersheds as well as ignore the contributions of this source. EPA knows of no way of doing both. EPA has considered the input from stormwater and has appropriately allocated loads to that

source. The commenter provided no basis of his own that would support his statement that stormwater will have "virtually no impact on conditions in the stream." The small tributary to Southampton Creek for which nutrient allocations were developed bears little resemblance to the entire Indian Creek Watershed. There were no data collected during wet weather conditions. Therefore, no comparison was made between modeled TP and observed TP. As the commenter mentioned, TP during storm events leaves the stream quickly and as a result, wet weather TP was not critical for the algae simulation. The model development focused on the critical periods when point sources are dominating. However, results of the calibrated model do show elevated levels of TP in the stream following precipitation events as shown in the graph below, where peaks of TP are predicted as a direct result of precipitation.



It is unclear in the context of this comment what relevance the Southampton Creek analysis has to that performed for the Indian Creek watershed as the two watersheds are different in size (Indian Creek is larger), landuses (Southampton is more heavily developed) and sources (there is only one point source in the Southampton Creek). Assumptions made in the Southampton Creek report are not necessarily valid for application in the Indian Creek watershed and EPA will not presume to do so here. Moreover, nonpoint source loading does occur in the watershed and while the impact of nonpoint source loads during the critical low flow condition is demonstrably less than those from permitted point sources, EPA does not assume that all nonpoint source nutrient loads are swept out of the system simply because they are delivered during high flow events.

Comment 12 – Section V: Regulating Pollutants Without Need Violates TMDL Rules & Statutes

Section 303(d) and its implementing regulations only authorized TMDL development where impairment listing has occurred. To demonstrate that a nitrogen or phosphorous regulation is necessary, at a minimum EPA must demonstrate that controlling that nutrient will control plant growth. EPA's Expert Report admits this will not occur for phosphorus and cannot occur for nitrogen. EPA's actions are therefore plainly arbitrary and capricious since it fails the basic purpose of CWA Section 303(d).

The stressor-response analysis showed no relationship to TN concentration whatsoever. Consequently, EPA has no basis for regulating TN in this TMDL. EPA's proposal to control nitrogen exceeds its statutory authority, is arbitrary.

Response: Please see General Response #3

Note: The response to the following _critical evaluation" can be found at the General Response #1. This —critical evaluation —was included with several comment letters and is not repeated, in this response document, with the other letters.

Attachment 1

Critical Evaluation of Total Phosphorus Endpoint Determination using Conditional Probability and Change Point Analysis

William T. Hall
Hall & Associates
April 18, 2008

The USEPA, Region 3, released five nutrient TMDLs in late February, 2008. Each of these five TMDLs used a total phosphorus endpoint of 0.040 mg/L as the instream threshold for designated use impairment to aquatic life. The basis for the development of this endpoint was presented in a report by Paul and Zheng (2007), titled "Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application" (the "Expert Report"). Biological data from the Maryland piedmont area, with paired total phosphorus data, was evaluated using a "suite of analytical techniques that derive candidate endpoints by exploring the relationships between response variables and nutrient concentrations" (Expert Report at 8). The specific response variables used to develop the final endpoint value included the number of EPT taxa, the percentage of Clinger macroinvertebrates, and the trophic diatom index (TDI). These response variables yielded endpoints ranging from 36 – 39 µg/L. Another response variable, percent urban intolerant taxa, yielded an endpoint of 64 µg/L and did not factor into the final selection of 40 µg/L as the final endpoint. The endpoints were calculated using a two-step procedure wherein the stressor-response data were evaluated using conditional probability analysis. The threshold associated with the change point of the conditional probability evaluation was used to calculate the endpoint. The procedures used to make these calculations are presented below.

The basic assumption inherent in the analysis is that increasing nutrient levels cause a decrease in sensitive taxa (i.e., EPT taxa, Clinger macroinvertebrates) and an increase in pollution-tolerant taxa (i.e., increasing TSI value). Thus, the change point analysis should show that higher TP concentrations are expected to produce poorer invertebrate and diatom populations. However, a more detailed assessment shows that the endpoints are not affected by nutrient levels – the same change point occurs regardless of the biological target. Such a result confirms that nutrients are not controlling the ecological condition of concern.

Conditional Probability Analysis

Conditional probability analysis involves sorting the stressor-response data by increasing stressor concentration, then calculating the conditional probability of a response proceeding from the lowest stressor concentration to the maximum concentration. The conditional responses selected by Paul and Zheng (2007) include: (1) EPT taxa <8, (2) Clinger macroinvertebrates < 52.5%, and (3) TSI > 4.5.

These response conditions are presumed to represent impairment thresholds, but a reasonable justification for such a designation was lacking in the report. The Expert Report merely noted that the selected impairment thresholds were the midpoints of the scoring criteria used by State of Maryland.

Using the conditional response, all of the response data at or above the selected stressor concentration are evaluated to calculate a probability that the response condition will occur. This may be represented mathematically as follows:

$$RP_{Ci} = \frac{\sum_{Ci}^{C\max} CR}{\sum_{Ci}^{C\max} Observations} \qquad [1]$$

where:

RP_{Ci} = response probability for concentration Ci

CR = conditional response for concentrations ranging from Ci to the maximum concentration (Cmax) in the data set (if the metric meets the conditional response, it is counted. If it does not meet the conditional response, it is not counted)

Observations = all of the observations of the response metric from Ci to Cmax.

This analysis results in the conditional probability curves presented in the Expert Report (see Figure 5 b,d; Figure 6b and Figure 7b).

Change Point Analysis

The change point analysis is described in the Expert Report as a nonparametric deviance reduction technique to identify thresholds in biological responses to nutrients after Qian et al. 2003). Qian et al (2003) describes this technique.

> The deviance (Venables and Ripley, 1994), a measure of homogeneity, is defined for a continuous variable, as:
>
> $$D = \sum_{k=1}^{n} (y_k - \mu)^2 \qquad [1]$$
>
> where D is the deviance, n is the sample size, and μ is the mean of the n observations y_k.
>
> When the response data are divided into two groups, the sum of the deviance for the two subgroup is always less than or equal to the deviance of the entire data. Each possible change point is associated with a deviance reduction:

$$\Delta_i = D - (D_{\leq i} + D_{>i})$$

where D is the deviance of the entire data set y1, . . . , yn, D≤i is the deviance of the sequence y1, . . . , yi, and D>i is the deviance of the sequence yi+1, . . . , yn, where i = 1, . . . , n. The change point r is the i value that maximizes Δi :

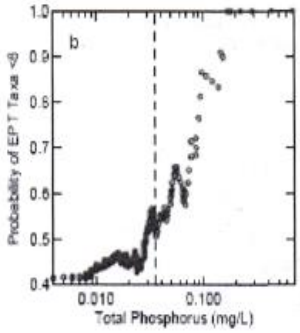
$$r = \max_i \Delta_i.$$

Qian, S., R. King, and C. Richardson. 2003. Two statistical methods for the detection of environmental thresholds. Ecological Modelling 166 (2003) at 88 – 89.

Evaluation of Stressor-Response Data

The stressor-response data that Paul and Zheng (2007) relied upon to derive the TP endpoint used in the various TMDLs was provided to Mr. William T. Hall by Ms. Mary Kuo (EPA Region 3 TMDL Coordinator) via email. These data were evaluated to assess the applicability of this method for endpoint derivation. The first part of this analysis was to demonstrate that the assessments presented in the Expert Report could be duplicated.

The conditional probability evaluation for EPT taxa < 8 was the only assessment of this metric provided in the Expert Report (Figure 6b), illustrated below. The Expert Report notes that the change point analysis for this conditional probability curve is 38 µg/L.



Paul and Zheng (2007) – Figure 6b

Figure 1: Conditional Probability Chart - EPT < 8

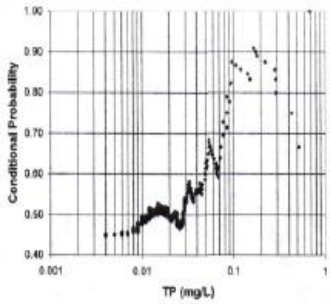


Figure 1 – Evaluation of data provided by Ms. Mary Kuo for EPT < 8

We attempted to duplicate this graph using the data provided by Ms. Kuo. However, the analysis for the condition, EPT taxa < 8, did not yield the same graph. Our analysis is presented in Figure 1. Our analysis could not yield the same graph as that presented in the Expert Report because the data set includes an observation of 8 EPT taxa at a TP concentration of 0.52 mg/L. This data point cannot be in the Expert Report database and yield the conditional probability curve presented in Figure 6b. An analysis for the condition, EPT taxa < 9, did yield a graph that looks nearly identical to the chart presented in the Expert Report, as illustrated in Figure 2.

Figure 2: Conditional Probability Chart - EPT < 9

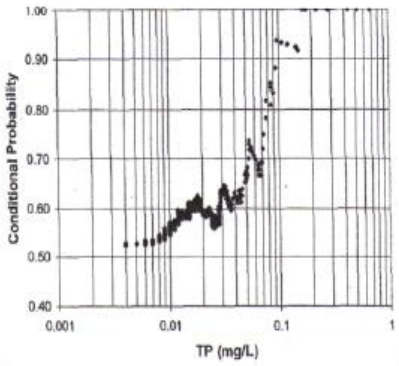
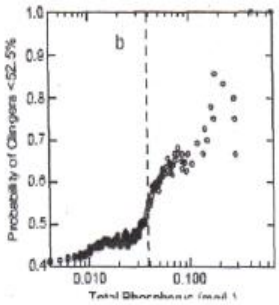


Figure 2 - Evaluation of data provided by Ms. Mary Kuo for EPT < 9

Similar comparisons were made for the conditional probability charts for the percentage of clinger macroinvertebrates (Expert Report Figure 7b) and TDI (Expert Report Figure 5c,d). These comparisons are illustrated below along with the conditional probability chart prepared from the data provided for Clinger macroinvertebrates (Figure 3) and TDI (Figure 4 – TDI vs TP; Figure 5 – TDI Conditional Probability Chart).



Paul and Zheng (2007) – Figure 7b

Figure 3: Conditional Probability Chart
Clingers < 52.5%

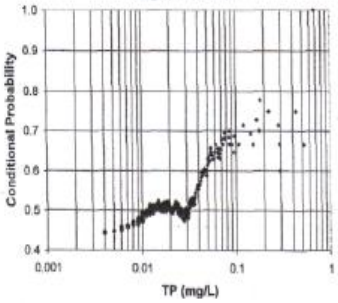
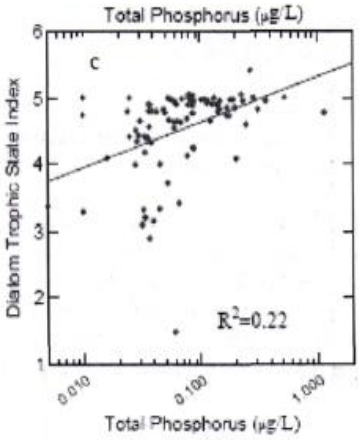


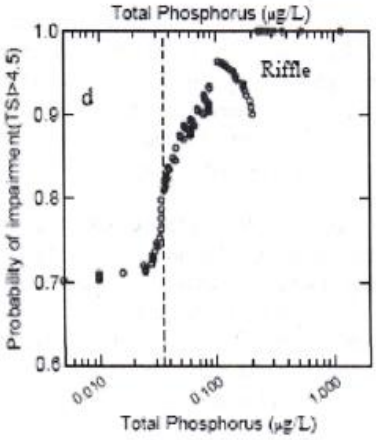
Figure 3 – Evaluation of data provided by Ms. Mary Kuo for Clingers < 52.5%

A comparison of the conditional probability graphs for the Clinger percentage indicates that the charts are not identical. This may be due to a difference in the data sets used or in the methodology applied to develop the charts.

4



Paul and Zheng (2007) – Figure 7c



Paul and Zheng (2007) – Figure 5d

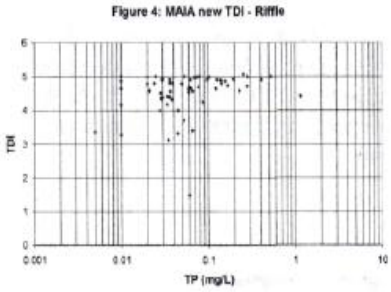


Figure 4 – TSI vs TP for riffles

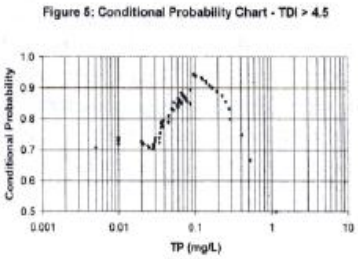


Figure 5 - Evaluation of data provided by Ms. Mary Kuo for TSI > 4.5

A comparison of the graphs for the TDI data indicates that the charts are not identical. When Figure 4 is compared with Figure 5c from the Expert Report, it is apparent that the data sets used to prepare the figures is not identical. More specifically, the point corresponding to the highest TP concentration is Figure 5c is greater than 4.5 while the same point in Figure 4 is less than 4.5. This difference accounts for the dissimilarity seen in the two conditional probability charts at the upper end of the concentration data. While the comparative analyses are not identical for each of the stressor-response data sets, the results are close enough to continue with this critical evaluation.

Critical Evaluation of Stressor-Response Approach to Nutrient Endpoint Development

The stressor-response evaluations are predicated on the assumption that the stressor (i.e., TP) causes an adverse response to the metric being evaluated (e.g., number of EPT taxa

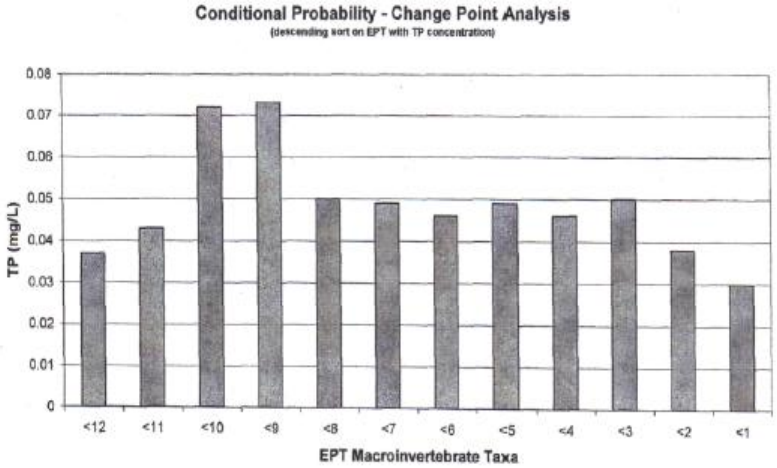
present; percent of Clinger macroinvertebrates present; or, TDI). The Expert Report observes that higher numbers of EPT taxa and percent Clinger macroinvertebrates represent higher quality waters (e.g., lower TP concentration). Conversely, as the concentration of TP increases, these response variables are expected to decrease. With regard to TDI, the higher the index, the worse the stream condition. Thus, the stressor-response approach presumes that the TDI will increase as the TP increases.

Given the assumption that elevated concentrations of TP are the root cause of decreasing macroinvertebrate and diatom metrics, it should be possible to use the conditional probability analysis and change point evaluation to show that the TP endpoint (as determined by change point analysis) increases as the response metric shifts toward a more impaired condition. This analysis was conducted for each of the identified metrics by evaluating multiple metric conditions, proceeding from a less impaired condition to a more impaired condition.

EPT Taxa

In the case of EPT taxa, we evaluated conditional probabilities ranging from < 12 taxa (an excellent biological condition) to < 1 taxa (a very poor condition). The results of this analysis are illustrated in Figure 6. The figure shows that at the highest conditional probability (<12 EPT taxa), the change point occurs at 37 µg/L. The threshold concentration of TP corresponding to the <11 and <10 EPT show an increasing change point concentration up to 72 µg/L, but then the TP change point levels off and decreases such that the calculated change point remains constant from EPT < 8 to EPT <3. As the number of EPT taxa decreases below <3, the change point concentration decreases and is at a minimum for EPT <1 (e.g., no EPT taxa present).

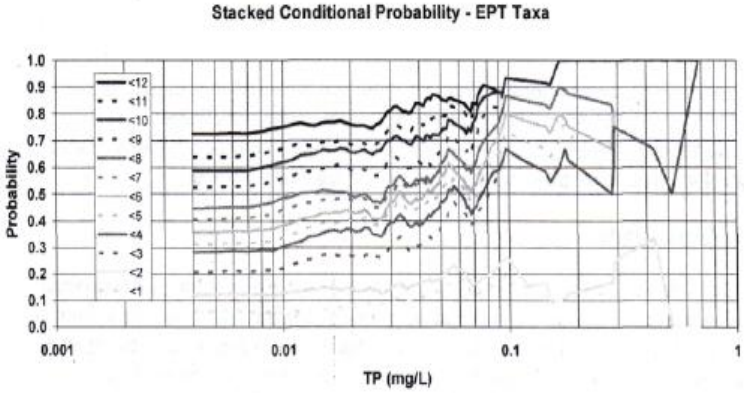
Figure 6



The change point concentrations in Figure 6 show that the number of EPT taxa is insensitive to the TP concentration. Therefore, TP control will not affect the number of EPT taxa present.

The reason for this insensitivity is apparent if the individual conditional probability data are illustrated on one chart (Figure 7). The chart shows that the different response thresholds (i.e., number of EPT taxa) are stacked one on top of the other, and the individual lines generally follow the same pattern, regardless of threshold. The change point analysis looks for relative deviations in each line, and the maximum deviance reduction responds to the shape of the line. In order for the conditional probability evaluation to show that increasing TP is responsible for decreasing EPT taxa (and a candidate for TMDL control), the lines for the lower response conditions (decreasing number of EPT taxa) should shift to the right as fewer taxa are present. If this were the case, the typical regression analysis would show a significantly higher R^2 value than reported by Paul and Zheng (2007).

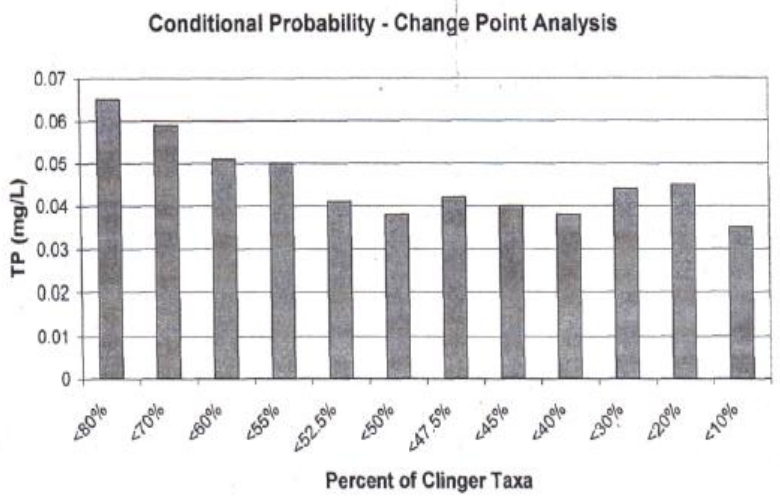
Figure 7



Percent Clingers

The Expert Report characterizes clinger macroinvertebrates as indicators of stream quality, with an increasing percentage of clingers representing improving water quality. In the case of percent clinger taxa, we evaluated conditional probabilities ranging from <80% clingers (high quality) to <10% clingers (poor quality). The results of this analysis are illustrated in Figure 8. The figure shows that at the highest conditional probability (<80% clingers), the change point occurs at 65 µg/L. The threshold concentration of TP corresponding to percent clingers ranging from <70% to <52.5% shows a gradual decrease in concentration, but then the TP change point levels off from that point to <20% clingers. The lowest change point concentration occurs at <10% clingers (35 µg/L). .

Figure 8

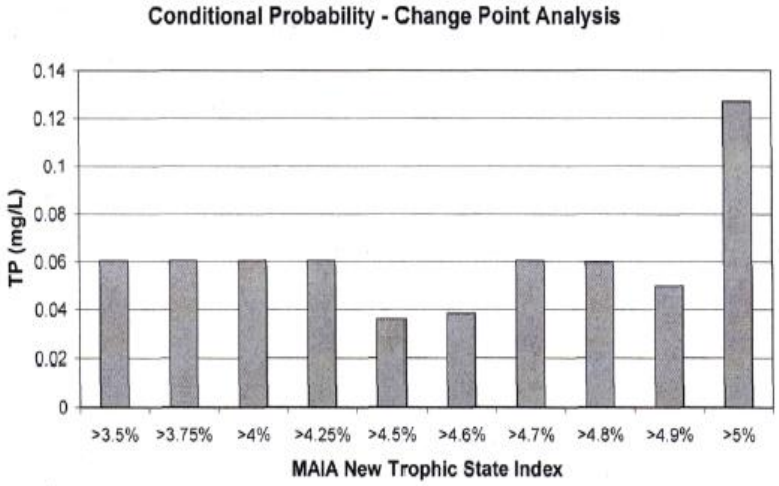


The change point concentrations in Figure 8 show that the number of clinger organisms is insensitive to the TP concentration; decreasing concentrations of clinger macroinvertebrates (poorer condition) coincide with lower TP concentrations. Therefore, TP control will not affect the percentage of clinger organisms present.

Trophic Diatom Index

The Expert Report characterizes trophic state index (TSI) as one of the most important nutrient enrichment indicies. As the concentration of nutrients increases due to human disturbance, the TSI will also increase. A TSI value of 4 indicates a meso-eutraphentic condition and 5 indicates a eutraphentic condition. The Expert Report used an impairment threshold of TSI = 4.5, which represents the transition from meso-eutraphentic to eutraphentic. We evaluated conditional probabilities for the TSI metric ranging from >3.5 (oligotrophic) to >5 (eutrophic) using the data provided by EPA. The results of this analysis are illustrated in Figure 9. The figure shows that at the highest diatom quality index (TSI>3.5), the change point occurs at 61 µg/L. The threshold concentration of TP corresponding to TSI values ranging from >3.5 to >4.9 is flat or slightly decreasing (e.g., TSI improves as TP concentration increases). The TP change point concentration for TSI > 5.0 increases to 0.13 mg/L, but this may be an artifact of the small data set (N = 64). There are only four observations for TSI > 5.0, with associated TP concentrations ranging from 0.01 mg/L to 0.53 mg/L, and these observations are evenly distributed across this range of TP concentrations. This analysis indicates that TSI is not responding to TP concentration.

Figure 9



Summary

Each of the stream quality metrics (EPT taxa, percent Clinger macroinvertebrates, and TSI) were evaluated, using the conditional probability/change point analysis methods described in the Expert Report, to determine whether the change point increased as the water quality metric decreased. In each case, the relationship was flat or was positively correlated (i.e., the water quality metric improved as TP increased). These results confirm that TP concentration is not linked to decreasing ecological quality as measured by the three biological metrics.

Comment Letter #29: Hall & Associates Comments on Paxton Creek TMDL

Comment 1: The consent decree only required EPA to address impairment listings associated with the 1996 CWA Section 303(d) listing for Pennsylvania, should PADEP not publish a TMDL or subsequently determine that such listing was not supported. The 1996 TMDL listing only addressed the segment of Paxton Creek from Wildwood Lake to its confluence with the Susquehanna River. Nutrient impairments were only designated for agricultural source-related impacts. CSO impacts on the 1996 listing were only associated with organic enrichment and low DO concerns, not nutrients. The 1996 listing did not determine that Paxton Creek was broadly impaired by nutrients from multiple sources.

> **Response: EPA cannot ignore sources of the pollutant subject to the TMDL under development. To do so would be inconsistent with federal law and regulations. PADEP added the CSO nutrient listing in 2004 and which must be addressed here. See General Response #2.**

Comment 2: Under Pennsylvania law, nutrients are only regulated as necessary to control excessive plant growth and excessive dissolved oxygen swings caused by excessive plant growth (see, Implementation Guidance for Section 95.9 Phosphorus discharges to Free Flowing Streams (Document ID 391-2000-018, October 27, 1997), and Assessment and Listing Methodology for Integrated Water Quality Monitoring and Assessment Reporting -Clean Water Act Sections 305(b)/303(d), May 8, 2006). This TMDL, however, does not address issues associated with the 1996 TMDL listing as required by the consent decree, nor does it address excessive plant growth and related DO impairments, assuming that a nutrient impairment actually existed. Rather, this TMDL sets a new nutrient standard for streams, unrelated to plant growth and DO impacts, and claims such water quality must be achieved to protect invertebrate populations in Paxton Creek. However, this report fails to show that Paxton Creek invertebrate populations are actually impaired (see. TMDL and Expert Report[2]) and provides no confirmation that the assumed impairment is, in fact, caused by instream phosphorus levels.

> **Response: See General Response #2, General Response #11 and General response #13**

Comment 3: EPA's experts admitted the new technical analyses do not confirm that nutrient impairment exists in any particular stream. The entire TMDL is based on addressing assumed invertebrate impairments using a new standard that has never been adopted by the Commonwealth of Pennsylvania or subject to the public review process applicable to all state water quality standards. Moreover, the alleged violation of the new phosphorus standard is based on theoretical loading conditions, not actual conditions. Thus, EPA's proposed TMDL approach illegally modifies the 303(d) listing for this creek, unlawfully sets a new WQS without DEP approval or proper public notice procedures, imposes requirements not demonstrated necessary to protect stream uses, modifies the terms of the consent decree, and usurps DEP's authority to develop a TMDL for impairment concerns first identified in 2004 that are not covered by the decree.

> **Response: See General Response #2**

Comment 4: The modeling approach employed by the TMDL is inapplicable to nutrient impact evaluation and uses flawed nutrient load assumptions. EPA's document states that the reason for controlling nutrients is to control excessive plant growth (TMDL at 4-2; "The selected TP endpoint would be applied as an average concentration during the growing season from April to October, which in streams is typically the time during which the greatest risk of deleterious algal growth exists".). However, there are no data on plant growth for Paxton Creek, and no modeling was done to show why the phosphorus limitations are necessary to control plant growth or DO levels as required by state law.

> **Response: The language will be modified. As noted so frequently, EPA established the TP endpoint based on the need to address the aquatic life use for Paxton Creek, therefore no modeling was necessary to consider algal biomass.**

Comment 5: The underlying Expert Report, prepared by Tetra Tech as the basis for the water quality standard, acknowledges that the selected standard will <u>not</u> materially change whatever plant growth that is presently occurring in the stream, rendering the regulation of phosphorus a meaningless exercise. The Expert Report also shows that the phosphorus standard alleged to be needed to protect invertebrate populations is actually not expected to achieve EPA's chosen impairment levels for invertebrates, even if the suggested standards are achieved.

> **Response: EPA believes that the commenter does not fully understand the endpoint approach used by EPA. The commenter is urged to read the endpoint report along with its appendix that addresses the Pittsburgh and Harrisburg ecoregions. Also see General Response #2 that hopefully clarifies the issue for you.**

Comment 6: It is clear that the model prepared for this TMDL was never calibrated to any existing instream data and bears no reasonable relationship to reality. The report states that nutrients are only regulated in the growing season, however, modeling was conducted on year-round conditions and this TMDL proposes to adopt annual limits. The available data confirm that the majority of the non-point and CSO loadings occur outside the growing season. Thus, the flawed EPA standard is misapplied to the wrong stream conditions and wrong period of discharge. The limited data collected within the growing season show that EPA's instream phosphorus standard is, in fact, attained throughout the "impaired segments". The only area where attainment is a close call is in a concrete lined section of the creek near its mouth. Excessive plant growth could not be a concern in this environmental setting nor would significant invertebrate populations exist here due to the altered habitat.

> **Response: Please see the SRBC data. This data shows excessive TP concentrations throughout the watershed.**

Comment 7 – Section I: Impairment Listing Unlawfully Amended and Consent Decree Requirements Violated

Sub 1: The consent decree that covers this TMDL only authorizes EPA to issue a TMDL to address impairment concerns identified in the 1996 303(d) listing, nothing more. The 1996 303(d) listing was quite precise that nutrient issues, to the degree they existed, were associated with agricultural sources. The CSO components were only identified as a DO

concern. The procedures applicable to nutrient related impairment listings are found in Chapter 96.5, DEP's Guidance implementing that rule ("Implementation guidance for Section 95.9 Phosphorus discharges to Free Flowing Streams", Department of Environmental Protection Bureau of Watershed Conservation, October 27, 1997), and DEP's Section 303(d) listing guidance. The rules and state implementing guidance specify that a nutrient-related impairment is defined as excessive plant growth, with attendant violations of the DO standard.

Response: See General Response #2 and General Response #11

Sub 2: Rather than evaluate the specific concerns of the listing, EPA created a new nutrient-related impairment based on invertebrate impacts? That concern is not specified in state law and is not part of the 1996 impairment listing or any subsequent publically noticed or adopted impairment listing.[5] No data have been presented to the public to justify such an impairment listing or concern, rather, EPA simply presumed that invertebrate impairments existed throughout the lower segments of Paxton Creek and the cause of such impairment was nutrients. Neither federal nor state law allows EPA to make such assumptions—impairment requires site-specific proof and subjects that proof to a public review process.

Response: EPA did not assume the nutrient impairment. PADEP included the nutrient impairment on the 1996 list of impaired waters and added the CSOs as sources in 2004. Therefore EPA did not make assumptions as implied by the commenter. The public had significant opportunity to comment on the listing of Paxton Creek as impaired for nutrients from agricultural activities as well as CSOs during the PADEP's establishment of the 1996, 1998, 2002, 2004, 2006 and 2008 list of impaired waters. In fact, PADEP gave another opportunity to the City to address the impairment issue in 2003 when PADEP sent a letter to the City's LTCP consultant reminding them of the Paxton Creek listing and the need to address the listing issues.

Sub 3: In a TMDL public meeting, EPA acknowledged that the Pennsylvania DEP did not approve of this new narrative standard approach. Federal TMDLs may only be developed for specific concerns identified in the 303(d) listing process. CWA Section 303(d)(2). Sierra Club, Inc. v. Leavitt,4M F.3d 904, 908 (11th Cir. 2007).

Response: The commenter is misleading with this comment. As written the comment makes it seem as though PADEP actually made a decision to not approve the approach. This is not an accurate summation of EPA's statement. What was said was that PADEP had not yet commented on the approach. PADEP provided comments to EPA during the comment period. These comments supported EPA's approach to establishing the TP endpoints.

Sub 4: If EPA believes that an invertebrate impairment exists in Paxton Creek and that DEP should have identified such impairment as part of the 1996 or 2004 303(d) listings, the proper procedure, as discussed in the Consent Decree, would be to inform DEP of the listing deficiency and require a new impairment designation.

Response: The PADEP listings were based on their standard field evaluations that

include macroinvertebrate collection and evaluation. See General Response #11. There is no need to inform PADEP of something they have developed.

Sub 5: EPA violates the terms of the consent decree by preparing a TMDL that does not address the listing impairments identified in the 1996 303(d) list. That listing was intended to address DO impairments thought to exist due to excessive plant growth and CSO loadings

Response: Nutrients were also listed in 1996. See General Response #2

Sub 6: Regarding CSO-related impacts on DO attributed to "biochemical oxygen demand and organic enrichment," EPA has failed to determine the amount of CSO reduction needed to address these concerns. Regulating phosphorus, an inorganic chemical, does not specifically regulate BOD or organic (carbon-based) enrichment Consequently, the wrong pollutant has been proposed for regulation in this TMDL, and this TMDL violates the terms of the consent decree by failing to assess and, if necessary, address the impairments found in 1996. Moreover, the CSO discharges are already subject to an approved long term control plan that addresses water quality standards compliance. Thus, EPA should have concluded that CSO impacts did not require the development of a TMDL since Pennsylvania DEP approved the Long Term Control Plan to ensure such discharges do not cause a standard exceedance, 40.CFR § 130.7(b).

Response: The LTCP does address the DO–related issues. However, the City explicitly excluded the nutrient issue in that evaluation simply because the PADEP did not have a numeric criterion for TP. The City failed to address the narrative criterion that would apply to TP and therefore did not include the TP listing issue in the LTCP.

Comment 8 – Section II: EPA Has Illegally Modified the State's Approach to Nutrient Regulation

Sub 1: EPA is required to adhere to the state's published guidance on nutrient regulation for streams and is not free to interpret the narrative standard as it wishes. Friends of the Earth v. EPA, 346 F. Supp. 2d 182, 201-202 (D.D.C. 2004

Response: See General Response #2. State regulations actually allow for a nutrient limit based on available TMDLs. See General Response #11

Sub 2: In May 2007, EPA filed documents requesting a time extension in the American Littoral Society case. The filing confirms that EPA clearly understood that to impose a nutrient limit EPA must prove (1) excessive plant growth exists and (2) that plant growth is causing D.O. related impairment.

Response: EPA also addressed the use impairment in the TMDL. That required the need to address the macroinvertebrate issue to assure that there is a healthy diverse aquatic community. See General Response #11

Sub 3: EPA amended the state's published guidance on assessing aquatic life impairments by arbitrarily selecting impairment thresholds for macroinvertebrate metrics that conflict with the

state's published protocol for evaluating aquatic life impairment.

Response: See General Response #2 and General response #11

Sub 4: EPA has violated federal rules regarding WQS adoption by failing to provide public notice that it was amending the existing narrative criteria interpretation procedure in violation of public notice rules and the procedures described in Section 303 (c) of the Act. (CWA §§ 101(e); 303(c); 40 CFR § 131.5)

Response: See General Response #2

Sub 5: The basis of EPA's standard is data from the piedmont area of Maryland. There is no demonstration contained anywhere in the TMDL or its supporting studies showing that such information is properly applied to Pennsylvania in a non-piedmont area. Moreover, the section of Paxton Creek being regulated is primarily concrete lined. Such a habitat is radically different from the Maryland piedmont streams that served as the basis for the macroinvertebrate data used to derive the TP endpoint.

Response: EPA heard the commenters concern and conducted an evaluation specifically for the Harrisburg and Pittsburgh ecoregions. This evaluation can be found as an appendix to the original endpoint report. It is also repeated at General Response #7. The result for Harrisburg was an endpoint for TP of 25ug/l. This new endpoint, based on the concerns of the commenter, was used in the final TMDL.

Sub 6: There are no site-specific data to show that the assumed impairment condition (>8 sensitive invertebrate taxa) is related to plant growth in Paxton Creek in any manner. State law requires a site-specific demonstration that impairment exists due to excessive nutrients.

Response: PADEP through the 303(d) listing process has shown an impairment caused by nutrients. Also the SRBC data presented to EPA during the comment period shows high TP concentrations as well as nutrient-tolerant macroinvertebrates in the watershed.

Comment 9 – Section III: Proposed Standard Admitted to be Ineffective in Ensuring Use Protection

Sub 1: All applicable EPA nutrient criteria guidance specifies that the link between the nutrient level, excessive plant growth and the identified use impairment must be demonstrated to ensure that use protection will occur by nutrient regulation. (Nutrient Criteria Technical Guidance Manual - Rivers and Streams (USEPA, July 2000)) The new approach employed in the Expert Report to set the 0.040 mg/L total phosphorus (TP) growing season average standard fails this basic requirement. In addition, the Expert Report and EPA's technical staff make a number of critical admissions verifying that even if the 0.04 mg/L standard is achieved, invertebrate populations are not likely to reach the level EPA now claims is required for use protection, as follows:

Response: EPA believes that the commenter does not fully understand the

approach used to determine the endpoint. See General Response #1. The endpoint for Paxton Creek is now set at 25ug/L. See General Response #7. Further note that it is our opinion that the EPA Guidance also allows indirect response measures to be used in deriving nutrient criteria. We suggest the authors of this comment read pages 45 and look at the case study from Tennessee in Appendix A for the descriptive use of macroinvertebrate indicators for developing nutrient endpoints.

Sub 2: The TMDL did not consider plant growth in this system, did not confirm that invertebrate impacts exist due to excessive nutrient levels in this system, and did not show any other nutrient-related impairment (i.e., excessive DO swings) exist in this stream due to excessive nutrient levels.

Response: Please see the SRBC data. EPA did not need to consider plant growth since the endpoint was based on aquatic life protection.

Sub 3: The approach used by EPA to impose very restrictive TP reductions is based on a weak correlation between TP and invertebrate levels. The assumption behind this correlation is that TP is causing excessive plant growth. The criteria derivation document, however, clearly shows there is no significant correlation between TP level and algal (periphyton) growth in streams.

Response: See General Response #1. The commenter is fixated on algal biomass. The endpoint was based on aquatic life protection.

Sub 4: It is a well recognized legal and scientific principle that correlation does not prove causation. The Expert Report acknowledges that the correlation analysis does not prove that phosphorus is the cause of the possible reduction in invertebrate levels.

Response: See General Response #1

Sub 5: EPA consultant's admitted that the approach used to derive the standard (conditional probability) has not been approved as an acceptable approach by DEP, and has never been used to derive a standard by EPA. The results of the unauthorized procedure, in fact, confirm that even if the "protective" TP standard is attained, there is a 60% probability that use attainment WILL NOT occur.

Response: See General Response #1. PADEP through comments submitted during the comment period agreed with the approach used by EPA.

Sub 6: The Expert Report apparently relies on the conclusion that TP levels are a direct cause of invertebrate impairment. This treats TP like a toxic that directly impairs animal life. EPA has repeatedly informed the public that nutrients are not toxics and cannot be assessed like a toxic.

Response: See General Response #1

Sub 7: The phosphorus endpoint analysis described in the Expert Report is premised on the assumption that TP is responsible for impairments to the number of EPT taxa, the percent of

clinger macroinvertebrates, and the shift in trophic state index. If this assumption is correct, the conditional probability analysis would show that the endpoint determination would increase as the response variable shifted to a more degraded condition.

Response: See General Response #1

Sub 8: The Expert Report claims it is using conditional probability and several other approaches as a "scientifically defensible" procedure. EPA guidance on standards development, as well as the rules applicable to criteria development (Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses, 1984, ("National Guidelines")), is clear that the same level of protection afforded by EPA Section 304(a) Criteria (full use protection) is required when using an alternative method of criteria derivation.

Response: See General Response #1

Sub 9: The Paxton Creek watershed has been fully assessed by DEP. EPA's experts admitted that the available site-specific data were not considered in determining whether or not nutrients were likely causing invertebrate impairment. Available phosphorus data for this watershed confirms that TP is not causing invertebrate impairment. Unimpaired sections of the creek have higher TP levels than the allegedly TP impaired segments. Long term average TP levels in unimpaired segments range 0.049-0.222 mg/1. (TMDL Tables 3-4). This demonstrates that EPA's conditional probability approach does not reasonably predict impairment in Paxton Creek.

Response: See General Response #1

Comment 10 – Section III: TMDL Calculations Are Flawed and Unsupported

Sub 1: EPA's analysis presumes, but does not confirm, that phosphorus causes nutrient-related impairment in Paxton Creek.

Response: PADEP has established that nutrients from CSOs and agricultural lands are causing an impairment in Paxton Creek.

Sub 2: Although EPA states that the purpose of the phosphorus effluent limitations was to control plant growth in the growing season, EPA did not model plant growth or any related impact of plant growth (diurnal DO swings). There is no evidence, whatsoever, supporting the position that the required loads are needed to reduce plant growth to acceptable levels. The complete absence of such analysis renders EPA's derivation of TP loadings arbitrary and capricious.

Response: EPA will modify this language. The endpoint was established to protect aquatic life.

Sub 3: The model, used to predict instream TP levels under varied flow conditions, was not calibrated or verified and has no rational relationship to the available instream data.

Response: The modeling approach uses the AVGWLF model especially tailored for Pennsylvania. The approach focuses on developing a target and existing nutrient loads for Paxton Creek. The target nutrient load was calculated using the long-term average flow in Paxton Creek and the nutrient endpoint concentration. Therefore, it was necessary to insure that the model reproduces adequately the observed flow in Paxton Creek. The existing nutrient load is the annual average nutrient load output from AVGWLF. The same approach is used for the revised TMDL. However, it focuses only on the upper portion of the Paxton Creek watershed (above Asylum Rum). In addition, the revised TMDL uses a target load and existing load for the growing season.

Sub 4: The modeling results predicted that phosphorus loadings needed to be reduced from 5,910 Lbs/year to 978 Lbs/year - an 83.4% reduction. This is clearly an incorrect conclusion based on erroneous modeling. Paxton Creek first flows into Wildwood Lake which greatly reduces TP levels in the lower segment of Paxton Creek. Data presented in Appendix A of the TMDL show that TP levels in Paxton Creek, upstream of the lake are significantly higher than the levels exiting the lake to the lower reaches of Paxton Creek that are the subject of this TMDL. Wildwood Lake has been acting as a settling basin and filling in for decades, confirming particulate phosphorus (the primary form of TP from MS4 discharges) is removed from the water column by this water body. The model completely ignored this physical reality and incorrectly assumed MS4 loads all contribute to the TP condition in the lower portions of the creek.

Response: EPA estimated the 83.4 percent reduction using the results of a 10-year AVGWLF simulation to compute annual average nutrient target loads and annual average nutrient existing loads. The 83.4% reduction applies to the entire watershed, considers dry- and wet-weather conditions, and is not specific to the lower portion of the watershed, rather applies to the entire Paxton Creek watershed. Recent field observations in Wildwood Lake do not support the claim that Wildwood Lake acts as a —settling basin" removing nutrients and sediments. This might have been true 20-30 years ago, however, considerable sediment deposits have changed Wildwood Lake into a flow-through system with insignificant pollutant reduction.

Sub 5: The available stream data presented by EPA indicate that conditions below Asylum Run in Paxton Creek only marginally exceed EPA's 0.04 mg/L target. The exceedance is at most 20% with an average instream concentration of 0.05 mg/1. These data show that an 83.4% reduction in phosphorus is not necessary and therefore EPA has exceeded statutory authority in this TMDL proposal. The data would need to show long term average conditions 6 times higher than the standard (or 0.24 mg/1 TP growing season average) for an 83.4% reduction to be necessary. There are no data indicating such high TP levels are present as a growing season average.[14] The model bears no rational relationship to instream conditions and, therefore, produces an arbitrary and capricious result.

Response: Most the instream nutrient observations in Paxton Creek were collected during dry-weather low-flow conditions. Therefore, using these dry-weather low-flow observations to estimate the anticipated nutrient removal using is erroneous.

EPA estimated the 83.4 percent reduction average using the results of a 10-year AVGWLF simulation to compute annual nutrient target loads and annual average nutrient existing loads. The 83.4% reduction applies not only to dry-weather conditions but also to wet-weather conditions.

Sub 6: The DO swing data presented in the report show that minimal DO variation is present and that variation does not cause any DO standard violations. (Figures 3-6, 3-7 and Appendix A) In fact, the DO levels presented in the TMDL report for 2006 are generally excellent. These data confirm that the state's narrative standard for nutrients is not violated. DO swings are caused by two events: changes in temperature and changes in plant respiration. The data show that DO variations are highest in May and lowest during the period when peak aquatic plant growth would be expected - August and September. (Table 3-1) The highest DO swings occurred in Paxton Creek when the lowest TP levels were present.[16] Thus, elevated TP readings identified in EPA's July- September 2006 monitoring have no relationship to plant growth. EPA has simply regulated the wrong pollutant with no apparent connection to the instream conditions of concern.

Response: DO diurnal fluctuation of 6.1 mg/L was recorded on May 2006 at PC15 and a DO diurnal fluctuation of 4.9 mg/L was recorded on May 2006 at PC03. EPA considers that these dissolved oxygen fluctuations are significant indicating a relatively highly productive stream. In addition, such a range diurnal DO variation might cause the oxygen level to fall below the PA DO standard of 4 mg/L. EPA is aware of the relatively higher TP concentrations in the small streams in the basin above Wildwood Lake. The Paxton Creek nutrient TMDL was developed for the entire watershed including the basin draining to the lake. Therefore, this TMDL addressed implicitly the loads from the upper portion of watershed

Sub 7: Data in Table 3-4 (TMDL at 3-17) prove EPA's approach to TP regulation is flawed. Virtually the entire basin above the lake exhibits TP>0.04 mg/L. These segments of the Paxton Creek watershed are <u>not</u> identified as nutrient impaired although average TP levels range from 0.049 to 0.222 mg/L. As higher TP levels are plainly <u>not</u> associated with nutrient impairment in this basin, it is not possible that protecting uses hinges on achieving a 0.04 mg/L TP level in the lower segment of Paxton Creek.

Response: See response to Sub 6 above

Sub 8: The TMDL modeling entirely misapplied the growing season average standard. Rather than assess instream conditions from April through October, the analysis focused on annual conditions instream. However, the EPA-derived standard does not apply to annual conditions. Therefore, the entire TDML analysis is misplaced. Data on the CSO discharges confirms that most of the CSO events occur in the non-growing season. Therefore, EPA has improperly included those loadings in the analysis though the standard does not apply to those loading events. The same situation applies to the MS4 communities. The data used to run the model (Figure 2-7, TMDL at 2-20) show that flows are higher from November through March (the non-growing season) than April through October. About 70% of the nutrient loading from non-point sources would be expected during this period based on the documented long term flow regime. Including the loadings from the non- growing season improperly regulates

the MS4 communities and the CSO discharges.

Response: The revised TMDL focuses solely on developing allocation during the growing season from April through October.

Sub 9: EPA's annual average approach also resulted in a mistaken evaluation of the data. The growing season data presented in Table A-2, Appendix A show that in 2006, EPA's standard was basically achieved throughout the segments originally listed as nutrient impaired from agricultural sources by DEP, as follows:

PCI .5 (Dry weather) - 0.035 mg/L average (0.032 - 0.042 mg/L)

PC03 (Dry Weather) - 0.045 mg/L average (0.005 - 0.061 mg/L)

Given the available data it is apparent that phosphorus levels are not in a range that is materially different from the suggested EPA standard or that reducing instream levels to 0.04 mg/L could possibly have a material change on aquatic communities in this watershed. As noted previously, vast areas of the basin exceed the 0.04 mg/L level and are not considered by DEP to be impaired. Conditions associated with wet weather flows would not change this conclusion as reduced plant growth and scour would be associated with those flows due to increased stream velocity and higher TSS levels. Elevated TSS, as exemplified by data presented in Table A-3 (TMDL at A-6) would prevent photosynthesis and plant growth during wet weather conditions.

Response: EPA believes that the commenter‘s assessment of compliance based on dry-weather low-flow observations is incorrect. EPA is aware of the relatively higher TP concentrations in small streams in the basin above Wildwood Lake. The Paxton Creek nutrient TMDL was developed for the entire watershed including the basin draining to the lake. Wildwood Lake is not currently providing any significant pollutant trapping efficiency; therefore, the existing TMDL addressed implicitly the loads from the upper portion of watershed. It should be noted that EPA revised the Paxton Creek TMDL to include only the loads from the upper of the watershed above Asylum Run. This modification stemmed from an analysis of the time of travel in the channelized section of the creek; below Asylum Run; indicating that there is a relatively short time of travel for nutrients to have significant impact on the water quality in the creek. Therefore, the revised TMDL focuses on the segment below Wildwood Lake to the confluence with Asylum Run.

Sub 10: There is no analysis showing that wet weather related loadings of phosphorus could possibly contribute to increased plant growth in Paxton Creek. EPA's action is based purely on assumption, not demonstrated scientific facts. Moreover, the assumption that loadings occurring under higher flow must be regulated to control growing season average plant growth has no scientific basis and is contrary to the accepted approaches for analyzing stream plant growth. Modeling of plant growth in streams must account for detention time, available light, the form of phosphorus present, and scour due to elevated flows. (*Technical Guidance Manual for Developing Total Maximum Daily Loads Book 2: Streams and Rivers Part 1: Biochemical Oxygen Demand/Dissolved Oxygen and Nutrients/Eutrophication*, USEPA.

March 1997). *Protocol for Developing Nutrient TMDLs,* USEPA 1999 at 2-5. The modeling analysis completely failed to assess any these well documented critical factors controlling plant growth during elevated runoff events. The proper consideration of these factors makes it impossible for the wet weather contributions to materially change plant growth or contribute to increases in plant growth in the Creek.

First, it is only the last three miles of Paxton Creek (where the CSOs are located) that show a potential for phosphorus levels above EPA's growing season average target levels. Under wet weather conditions that are short term events, elevated flows would cause the detention time in this part of the system to be no more than a few hours at most. In fact, the largest CSO (No. 48, which contributes the greatest flow to the creek) discharges within a half mile from the mouth. The detention time for this flow and its associated load is less than 30 minutes. The short detention time of this system is confirmed by Figure 3-8 (TMDL at 3-12). Considering these loads as a significant contributor to plant growth was a significant technical error. The exposure period is not sufficient for any significant change in plant growth or phosphorus uptake to occur in response to the loadings.

Second, the flows associated with elevated rainfall events would produce stream velocities that would likely scour the plants and flush wet-weather phosphorus loads out of the system. As much of the lower portion of Paxton Creek is concrete lined and does not provide a suitable substrate for maintaining fixed plant growth, scour is a major physical factor impacting plant growth in this area. This physical reality that controls plant growth under wet weather conditions must be addressed.

Third, high TSS levels accompany the high flows and would prevent light penetration in the stream, preventing photosynthesis. Thus, the TP levels occurring during wet weather events could not stimulate plant growth in any event, if scour were not already preventing such growth.

Finally, if is clear that the form of phosphorus occurring during runoff events is not available to promote plant growth. EPA guidance states that for streams, soluble reactive phosphorus (SRP) or PC>4 (not total or particulate phosphorus), is the relevant fraction of phosphorus that may stimulate plant growth. Protocol for Developing Nutrient TMDLs, First Edition, EPA 841-B-99-007 (November 1999) at 2-4. ("In streams with relatively short residence times, it is less likely that the transformation from unavailable to available forms will have time to occur and SRP is the most accurate estimate of biologically available nutrients."). The data contained in the TMDL (Table 3-4 and A-3) confirm that the vast majority of phosphorus associated with high TP readings is particulate phosphorus (well over 90%). For example, the USGC data show that the maximum PC>4 reading at USGS Station 15700890 was 0.01 mg/1 while the TP maximum reading was 0.267 mg/1 or 96% particulate phosphorus and on average 94% particulate. The downstream station averaged 88% particulate phosphorus. EPA's 2006 single day wet weather sample showed similar results. Consequently, EPA has mis-regulated this situation by focusing its efforts of the regulation of wet weather total phosphorus loadings that do not affect plant growth and, in any event, are rapidly transported out of this system,

Response: The TMDL was developed based on the best available data. It should be

noted that EPA revised the Paxton Creek TMDL to allocate the loads projected by the Harrisburg Authority after implementation of the LTCP. This modification stemmed from an analysis of the time of travel in the channelized section of the creek; below Asylum Run; indicating that there is a relatively short time of travel for nutrients to have significant impact on the water quality in the creek but also considering the possibility that an overflow event could have some impact on the aquatic life. Therefore, the revised TMDL focuses on the segment below Wildwood Lake to the confluence with Asylum Run with the TPO load from the CSOs set to equal the Authority's own estimate of the TP load after implementation of the LTCP. Therefore, the revised TMDL includes the CSOs loads consistent with the City's own LTCP projections. Refer to the General response for more information.

Sub 11: The proposed TMDL failed to consider the extensive data and information regarding CSO loadings presented in the approved 2006 Long Term Control Plan (LTCP). The LTCP constitutes an existing permit requirement that should have been reflected in the TMDL assumptions. For example, EPA's CSO phosphorus load assumptions are incorrect. EPA presumed that TP levels were 3 mg/1 in CSO events based on "literature values" from a 1987 publication. (TMDL @ 4-5). However, actual CSO data are available. The actual average TP concentration is 0.6 mg/L, a small fraction (20%) of EPA's estimated amount. Thus, EPA has greatly overestimated (by at least 80%) the phosphorus loading from the CSO discharge to Paxton Creek and all of the instream concentration estimates and projected load reductions are overestimated. Moreover, the LTCP has required the reduction of CSO discharges which will primarily reduce the frequency of overflows and first flush discharges, further reducing the expected TP concentration when overflow events occur. The TMDL must be amended to properly reflect the approved LTCP.

Response: At an April 17, 2008 public meeting, the City of Harrisburg indicated that LTCP information was available at their offices. EPA agreed to consider additional information from the City even though the comment period ended on April 18, 2008. The Authority's comments dated April 18, 2008 indicated that a clarifying letter would be submitted to EPA by April 28, 2008. That information was not provided until May 28, 2008. EPA agreed to meet with the City if the City wished to review the data since the City indicted the information filled many file drawers. At that time the City indicated that they would be in touch with EPA to schedule a meeting to review the data. On May 15, 2008 EPA attempted to contact the City of Harrisburg to inquire about obtaining LTCP data. On May 28, 2008 EPA received a letter from the City dated May 21, 2008 that included a summary of the LTCP findings but did not include the needed supporting documentation. EPA cannot consider amending any report if we are not provided with the appropriate data available from the Authority. EPA reviewed the agency files on the Harrisburg LTCP and did not find any effluent data that would support the commenters position. Please see the response to Letter #55 for more discussion.

Sub 12: Rather than model daily instream TP concentrations over the growing season in response to rainfall, EPA applied annual average phosphorus loads predicted using the AVGWLF model. (TMDL @4-5) The model is described as "a planning tool for estimating nutrient and sediment loadings on a watershed basis. Designers of the model intended for it to

be implemented without calibration". (TMDL at 4-9) Such a "planning tool" cannot be used as the basis for a site-specific water quality model for TMDL purposes since there is no information showing the model reflects reality. Furthermore, it is incorrect to use long-term average loads to simulate storm runoff/CSO loads. These are not equivalent analyses and there is no demonstration showing that the loading analysis would be comparable to an instream concentration analysis required for a compliance assessment with the 0.04 mg/L target. That assumption would only be possible if the flows associated with the peak loads were fixed or constant - and EPA's data show that they most assuredly are not. Stream flows vary by a factor of 200 as demonstrated by the 1994 flow data in Table A-l. Thus, loadings from high flow and runoff events could easily increase by a factor of 50-100 times the dry weather conditions and still not exceed EPA's selected instream standard. This is commonly understood by EPA in its assessment of wet weather related impacts. 53 Fed Reg. 49416. It is wholly improper to take a peak loading associated with a high flow and "average" that load with other loadings occurring on much lower flow conditions. That approach will predict standard exceedences where none actually exist. As noted previously, this error was compounded by assessing loads during the non-growing season that were not relevant to the proper application of the standard.

Response: EPA used AVGWLF estimated the daily nutrients loads. These loads were than average on a monthly and annual basis. The AVGWLF is a watershed model to estimate nutrient NPs load model and is specifically tailored for Pennsylvania. The approach focuses on developing a target and existing nutrient loads for Paxton Creek. Since all the nutrient sources in Paxton Creek are wet-weather driven, EPA believes that using the results of 10-year AVGWLF simulation if appropriate to estimate the required nutrient reduction. EPA did calibrate the flow in Paxton Creek and the statement –*designers of the model intended for it to be implemented without calibration*" was erroneously inserted in the report

Comment Letter #30: Hall & Associates Request to Withdraw Chester, Paxton and Indian Creek TMDLs

Comment 1: EPA's Technical Experts Admit the Need and Benefit of The Proposed Nutrient Limitations Not Demonstrated. The TMDL will force the unnecessary expenditure of well over $500 million dollars to implement point source and MS4 limitations, but is expected to produce NO DEMONSTRABLE ENVIRONMENTAL BENEFIT. EPA is basing its entire regulatory approach on a single graph (using data from other piedmont streams), which purports to show a direct relationship between nutrient levels and sensitive invertebrate populations. However, EPA's technical expert present at the public hearings admitted this analysis does not prove that nutrients are causing impacts on sensitive invertebrates! Thus, EPA's reliance on this analysis as proof of nutrient impairment is misplaced. Site Specific Data Confirm Invertebrate Impacts Are Not Related to Nutrients

> **Response: The commenter states that it _is expected to produce no demonstratable environmental benefit.‘ The commenter provided no data or information to support that claim. See General Response #1.**

Comment 2: EPA's experts acknowledged that they never checked to see if the available site-specific watershed data supported the existence of the claimed nutrient/invertebrate impairment relationship. EPA admitted It Lacked Basic Data and Analyses

> **Response: The Susquehanna River Basin Commission submitted macro-invertebrate data to EPA during the public comment period. This data was from 2006 and 2007. PADEP has conducted many aquatic surveys for the streams and concluded that the aquatic community was impaired and that impairment was due to nutrients. This resulted in the listing of these waters and impairments on the state‘s section 303(d) list of impaired waters.**

Comment 3: EPA's TMDL actions are supposed to be supported by credible scientific analyses and site-specific data. On March 5, 2008, we submitted an information request to obtain documents addressing various TMDL report claims and findings. (Attachment) EPA provided some data reports but no information or analyses showing TMDL claims were supported by record information. Incredibly, EPA's email response to the data request admitted certain TMDL claims were false (i.e., that DEP biologists had declared Chester Creek nutrient impaired) and that other obvious errors contained in the DO and periphyton modeling were irrelevant because EPA did not use the questionable model results in its decision making. Thus, it is apparent that the TMDL nutrient requirements are not supported by credible scientific information.

> **Response: The Chester Creek TMDL has been modified to include only Goose Creek. We stand by the fact that certain periphyton information is not relevant because we used aquatic life protection and an established TP endpoint for the TMDL. The commenter needs to understand the concepts applied by EPA.**

Comment 4: This TMDL Action Is Not Authorized by Consent Decree or Federal Law. Although EPA's TMDL documents assert that the actions being taken are required by the American Littoral Society consent decree, that assertion is simply not true. The proposed TMDL

actions go far beyond those required by the American Littoral Society consent decree that was limited to addressing concerns specifically identified on the 1996 impaired waters list. Rather, EPA's TMDL actions seek to (a) regulate unimpaired stream segments as well as recently listed segments, (b) revise the established impairment designations and definitions adopted by DEP, (c) presume the existence of these new impairments rather than verify impairments with site specific data under the CWA Section 303(d) process, (U) utilize unprecedented procedures for nutrient criteria development that conflict with published EPA and DEP approaches, (e) impose new nutrient water quality standards without notice or due process as required by CWA Section 303(c), and finally, (f) impose TMDL requirements admitted in the Expert Reports to be both unnecessary and insufficient to attain applicable narrative standards or remedy the use impairments identified on the 1996 listing. These actions violate a host of mandatory duties specified in The Clean Water Act, federal-regulations and WQS and TMDL development, as well as the terms of the consent decree.

Response: See General Response #2

Comment 5: Conclusion - The municipal entities do not understand why EPA Region III has sought to broadly impose nutrient requirements that were acknowledged by EPA staff as either unnecessary to protect uses (total nitrogen) or ineffective in addressing the state-identified impairments (total phosphorus). Nor do we understand why EPA would declare the creeks invertebrate impaired without any site-specific evidence that the claim is true. EPA is certainly not under a legal mandate or judicial constraint to take these actions. It is clear that the scientific basis for these actions is lacking and that additional time is needed to collect appropriate data and to determine what, if any, nutrient reduction measures are needed in these watersheds. Consequently, we are formally requesting that EPA withdraw these TMDL proposals and limit its TMDL actions to those required by the American Littoral Society consent decree.

Response: PADEP used their standard field evaluations which included macroinvertebrate analysis to declare the waters impaired by nutrients. It is clear that data exists and procedures were followed that supports the TMDLs. EPA has no plans to withdraw these TMDLs. Modifications have been made to the draft TMDLs that considers some of the comments and concerns EPA received during the comment period, including determining the TP endpoints for Sawmill Run and Paxton Creek using data from the appropriate ecoregions, elimination of the TN TMDLs, restructuring the Chester Creek TMDL to include Goose Creek only and basing the allocations for the Harrisburg CSOs on the LTCP expectations presented by the City.

Comment Letter #31: Lower Salford Authority Comments on Indian Creek

Comment 1: The Indian Creek Watershed TMDL ("TMDL") does not establish any clear linkage between use impairment and nutrient concentration, algal growth, or point source contribution.

Sub-Comment a: The TMDL does not establish any clear linkage between use impairment and nutrient concentration or algal growth. The TMDL states that the "designated use for streams" is "trout stocking fishery" and that "excessive nutrient concentrations in streams and rivers contribute to algal blooms." (p, 5-6.) The TMDL fails to provide (1) support for any correlation between "excessive nutrient concentrations" and "algal blooms" in the Indian Creek, and (2) any data or scientific evidence on the effect of setting nutrient endpoints at the limits proposed in the TMDL. In other words, no assurance is provided that achieving the target of 0.04 mg/1 TP (or 3.7 mg/1 TN) will restore a use, or that some other target would not restore the use equally well. Similarly, the TMDL fails to provide any scientific support of a linkage between nutrient loading and periphyton densities.

Response: This portion of the response relates to the scientifically established linkage between use impairment, phosphorus loading and periphyton densities. Algal blooms are caused by excessive nutrients. Chetelat et al. (1999) found periphyton biomass to be strongly correlated with TP concentration and conductivity. Algal patterns were observed along a TP gradient and there was a high diversity of periphyton communities among sites with TP concentrations <20 mg/L. Moreover, —nutrient-rich sites were associated with high periphyton standing crop and were dominated by particular filamentous taxa (p. 568)." *Cladophora*, *Audouinella*, and (or) *Melosira* were dominant taxa at sites >20 mg/L TP. Riskin et al. (2003) did not find any relationship between chlorophyll *a* in phytoplankton and TN and TP; however, chlorophyll *a* in periphyton increased significantly with TN and TP concentrations in both open and shaded stream sites. —This suggests that periphyton may be a better indicator of eutrophication than phytoplankton in wadeable [New England] streams, regardless of canopy conditions (Riskin et al. 2003, p. 12)."

In turn, eutrophic conditions in waterbodies lead to impacts on aquatic life habitat. As is stated by Paul and Zheng, 2007, which is referenced by the TMDL, —Nutrients cause enrichment of primary producer and decomposer biomass and productivity, the increase of which leads to changes in the physical and chemical stream environment (e.g., reduced oxygen, loss of reproductive habitat, alteration on the availability of palatable algal taxa, etc.). It is these effects which directly result in changes to the biological stream community (e.g., loss of disturbance sensitive taxa), and ultimately impair the use of a stream for aquatic life."

Sub-comment b: Although the TMDL states that its "data analysis and modeling runs have established a clear linkage between phosphorus loading and periphyton densities in the water shed," there is no data or information in the TMDL document itself to support this statement, (p. 10) To the extent not specifically requested above, the US EPA should also provide any watershed-specific information to show that both TP and TN control is necessary to control

algal/plant growth in the Indian Creek Watershed and the nexus between nutrients and the degree of algal/plant growth causing impairment of the Indian Creek Watershed.

Response: The TMDL language will be changed. The endpoint was based on aquatic life protection and not a biomass limit. The PADEP surveys have established the link between aquatic life and nutrients. We have dropped the TN TMDL. See General Response #3. See General Response #1 and General Response #11. The following portion of the response relates to the modeling analysis of phosphorus loading and periphyton densities

It is a scientific fact that excessive nutrients cause algal bloom. The duty of the model is to establish the linkage quantitatively, and to identify the dominating sources of nutrients to the system. Calibration of the model is a process to establish the quantitative linkage between nutrients and other system dynamics, for example, phosphorus loading and periphyton densities. The calibration plots showing the comparisons between model results and monitoring data in space (e.g., longitudinal profiles of phosphorus, nitrogen, and DO results), and in time (e.g., continuous DO time series) are the best available information currently supporting the linkage in Indian Creek. TN is no longer considered in this TMDL.

Sub-Comment c: The TMDL refers to periphyton densities in the Indian Creek as an indicator of impaired use, but does not provide or support a linkage between periphyton density and use impairment. The TMDL states that "the nutrient endpoints ... consist of...concentrations associated with acceptable levels of periphyton densities" (p.6), but fails to define and substantiate the "acceptable" level of periphyton densities in the Indian Creek. Therefore, the United States Environmental Protection Agency ("USEPA") should provide the acceptable level of periphyton densities in the Indian Creek and any evidence of (1) a link between this "acceptable" level and the designated or projected water use or (2) that the proposed nutrient endpoints will achieve this "acceptable" level.

Response: Algal biomass in streams may be linked to nutrient enrichment and, therefore, nuisance thresholds may be associated with nutrient values that can be used as indicators of water quality impairment or excessive algal growth. Nutrient and algal biomass concentrations indicating eutrophic conditions in streams have not been as strongly established as compared to lakes, but there have been some investigators that studied the response of algal biomass in streams to nutrient enrichment and suggested threshold values for what may be considered acceptable or unacceptable.

Dodds et al. (1998) analyzed published data for a large number of temperate stream sites for mean benthic chlorophyll *a*, maximum benthic chlorophyll *a*, sestonic chlorophyll *a*, TN, and TP as an effort to establish criteria for trophic boundaries in streams. The boundary between oligotrophic and mesotrophic categories is defined by the lower third of the cumulative distribution of the values and the mesotrophic-eutrophic boundary is defined by the upper third of the distribution (Table 1).

Table 1. Suggested boundaries for trophic classification of streams from Dodd et al. (1998)

Variable (units)	Oligotrophic-mesotrophic boundary	Mesotrophic-eutrophic boundary
Mean benthic chlorophyll (mg/m^2)	20	70
Maximum benthic chlorophyll (mg/m^2)	60	200
Sestonic chlorophyll (µg/L)	10	30
TN (µg/L)	700	1500
TP (µg/L)	25	75

Studies suggest a range for values considered to be nuisance benthic algal biomass. Horner et al. (1983) and Welch et al. (1988) suggest a range from 100 to 150 mg/m^2. Nordin (1985) provides a range of 50 to 100 mg/m^2. A study by Biggs (2000) provides a range from 50 to 200 mg/m^2. Biggs (1996) summarizes several studies that identified what constitutes nuisance algal growth, including Horner et al (2003) and Nordin (1985) discussed above. Chlorophyll *a* greater than 100-150 mg/m^2 or a cover greater than 20 percent by filamentous algae is unacceptable (Horner et al. 1983). Filamentous algae becomes conspicuous from the bank at greater than 40 percent and if cover is greater than 50 percent (50 g/m^2 ash-free dry mass) it usually results in smothering of the bed sediments (Biggs and Price 1987). Nordin (1985) recommended criteria for benthic algal biomass in streams of less than 50 mg/m^2 chlorophyll *a* for recreational use and less than 100 mg/m^2 for aquatic life. Zuur (1992) recommended a seasonal maximum cover by filamentous algae of 40 percent and biomass should not exceed 100 mg/m^2 chlorophyll *a*.

For purposes of comparing modeled nutrient levels and periphyton densities in Indian Creek, a level of 100 mg/m^2 was used to define —aceptable".

Evidence that the proposed TP endpoint will achieve this "acceptable" level is provided in multiple studies conducted in the Northern Piedmont ecoregion, which have shown consistent low values for TP required for the control of benthic chlorophyll *a*. In New Jersey, a trophic diatom index (TDI) was developed by Belton et al. (undated paper). The index included a TP concentration below 25 µg/L for a low TDI and a range from 75µg/L to 100 µg/L for a high TDI.

EPA's nutrient threshold recommended for the Northern Piedmont Ecoregion is

2,225 µg/L for TN and 40 µg/L for TP (USEPA 2000b). Charles and Ponader (2004) applied EPA's reference approach to the Northern Piedmont Ecoregion in New Jersey and found close agreement with the EPA recommended numbers. The Charles and Ponader (2004) numbers were 1,300 µg/L TN and 40 µg/L TP.

The United States Geological Survey (USGS) conducted a study in 2001 that included the New River and Big Sandy River in Virginia (Robertson et al. 2001). Using the reference approach, USGS found that a TP concentration of 20 µg/L was appropriate for what is defined as Environmental Nutrient Zone 2. In a study of over 35 streams in Virginia, Ponader et al. (2005) observed changes in the diatom assemblages and suggested threshold limits of 500 µg/L TN and 50 µg/L TP to protect against nutrient impaired conditions.

Delaware uses TP in assessing the state's waters for reporting under Section 305(b) of the Clean Water Act. Delaware lists segments as impaired when one or more water quality stations have a Lower Confidence Limit at or above the moderate value of 1,000 to 3,000 µg/L TN and 50 to 100 µg/L TP.

USEPA (2000a) and USEPA (2000b) present EPA's recommended criteria for TP, TN, chlorophyll *a*, and turbidity for rivers and streams in Nutrient Ecoregions XI (Central and Eastern Forested Uplands) and Nutrient Ecoregion IX (Southeastern Temperate Forested Plains and Hills), respectively. Nutrient Ecoregion XI includes parts of Pennsylvania and Nutrient Ecoregion IX includes southeastern Pennsylvania.

The recommended values of TN and TP for Nutrient Ecoregion XI are 0.31 mg/L and 10 µg/L, respectively (based on reference condition 25th percentiles). The range of subecoregion reference conditions (based on 25th percentiles) for TP is 5.63 – 10.47 µg/L and the range for TN is 0.21 – 0.58 mg/L. The recommended chlorophyll *a* (spectrophotometric method) value based on 25th percentiles for the ecoregion is 1.61 µg/L, while the range of subecoregion reference conditions (based on 25th percentiles) is 0.25-3.36 µg/L.

The recommended values of TN and TP for Nutrient Ecoregion IX are 0.69 mg/L and 36.56 µg/L, respectively (based on reference condition 25th percentiles). The range of subecoregion reference conditions (based on 25th percentiles) for TP is 22.5 – 100.0 µg/L and the range for TN is 0.07 – 1.0 mg/L. The recommended chlorophyll *a* (spectrophotometric method) value based on 25th percentiles for the ecoregion is 0.93 µg/L and 20.35 mg/m^2 for periphyton chlorophyll *a*. The range of subecoregion reference conditions (based on 25th percentiles) for chlorophyll *a* is 0.05-5.74 µg/L and 3.13 – 20.35 mg/m^2 for periphyton chlorophyll *a*. As mentioned earlier, EPA's nutrient threshold recommended for the Northern Piedmont Ecoregion, which is part of Nutrient Ecoregion IX, is 2,225 µg/L for TN and 40 µg/L for TP (USEPA 2000b). The chosen TP TMDL target of 40 µg/L (Paul and Zheng 2007) is very similar to the recommended aggregate ecoregion value of 36.56 µg/L (USEPA 2000b) and the same as the recommended Northern Piedmont Ecoregion value of 40 µg/L (USEPA 2000b).

Comment 2: The TMDL target for Total Phosphorus (TP) lacks an adequate technical basis and is not related to the restoration of aquatic life uses. A study' was performed in order to establish "appropriate TMDL endpoints for nutrients that are both protective of aquatic life uses in this region and defensible." However, we believe the TP endpoint of 0.04 mg/1 is not directly related to aquatic life uses and is not defensible.

The segment of the Indian Creek tributary downstream of the Lower Salford Township Authority's ("LSTA") treatment plant was designated as impaired based apparently on macroinvertebrate sampling. Nutrients and sediments were listed as the causes of impairment. Sedimentation impacts are obvious and substantial throughout the watershed, and are likely the cause of the biological impairment, which was observed throughout the watershed including a tributary with no point source contribution. There are places in the watershed where plant and algae produce "scummy" conditions, indicating productivity is high. Also, diurnal dissolved oxygen (DO) and pH measurements performed for model calibration confirm that productivity is high, leading to substantial diurnal swings. However, the TP endpoint of 0.04 mg/1 is not directly related to the attainment of aquatic life uses, as shown below.

A "multiple lines of evidence" approach was used to determine an appropriate endpoint for TP. The first problem is that the original assumption, namely that an appropriate endpoint for this system should be based on a TP concentration, is flawed. Plants and algae uptake only available forms of nutrients; orthophosphorus (OrthoP) is the only form of phosphorus that is available for uptake. There are no major impoundments in the watershed where particulate organic phosphorus could be expected to be stored and recycled. Therefore, TP is not relevant to biological impacts and should not be the basis for an endpoint to mitigate biological impacts.

The "multiple lines of evidence" approach consists of three broad types of approaches, each of which is substantially flawed:

- The "Reference Approach" category identifies the range of TP concentration that might be expected under "reference" (i.e., undeveloped) conditions. This entire approach ignores the attainment of uses. The TP conditions that existed in a nearly undeveloped condition is not relevant. The question instead should be: what TP level (if any) causes use impairment? The frequency distribution approaches select levels that correspond to the 75th percentile of reference sites and the 25th percentile of all sites. By definition, these levels ensure that 25% of all reference sites and 75% of all sites would be designated as impaired! The modeled reference approach, which is a simulation of "reference" conditions using land cover that is completely different than what is actually in the Indian Creek watershed, is equally irrelevant.

- The "Stressor-Response" category explores the relationships between the "stressors" (TP and TN) and biological response indicators. This in theory should be the only means of determining an appropriate endpoint to support narrative criteria, and USEPA does list it as the most important. The problem is that some of the metrics used had nothing to do with biological impairment, and the overall results demonstrated that it is not possible to select a TP level associated with use impacts.

o The Trophic State Index (TSI) is an example of a completely irrelevant metric in terms of biological impairment. TSI evaluates overall nutrient conditions according to the composition of

diatom communities present. The diatoms exhibit different nutrient preferences and therefore exhibit a gradient along nutrient concentrations. However, the fact that some diatoms prefer higher nutrient concentrations and are therefore more prevalent in nutrient-rich environments has nothing to do with use impairment. These diatoms are not "tolerant" of higher nutrient concentrations; rather, they prefer and grow more with higher nutrient concentrations. It is circular reasoning to apply TSI to use impairment, since higher nutrient concentrations obviously favor diatoms that prefer these conditions.

o Furthermore, the Endpoint Study (Paul and Zheng, 2007) states: "the highest algal biomass occurred at sites where TP concentrations were relatively low (0.014 to 0.035 mg/1). It is possible that algal growth has been saturated even at this low level." In explaining the poor relationship between TP and any of the biological metrics (see graph below from the Endpoint Study, Paul and Zheng, 2007), the study notes that "at some of the high nutrient concentration sites there was a light and flow limited accumulation of algal biomass." If indeed nutrient saturation occurs at 0.035 mg/1, achieving 0.04 mg/1 would not have any impact in terms of reducing productivity. Furthermore, why would we assume that Indian Creek is not flow or light-limited, especially the very small tributary into which LSTA discharges? The stream is 3-4 feet wide and shallow at the point of discharge. Even at the confluence with Indian Creek it is still very shallow and only about twice as wide. The stressor-response evaluation essentially demonstrated that it is not possible to select a P level associated with use impairment.

• The third "line of evidence" is simply literature values, many of which contain the same failings of the first two lines of evidence. For instance, the TSI index studies in New Jersey are referenced. These establish a clear gradient of diatom communities with varying nutrient levels, but it is nutrient preference that drives the gradient rather than pollution tolerance (which would be indicative of use impairment). Most of the other literature values use frequency distributions, which again have no relationship to use impairment. Instead, they establish levels that ensure that 25% of reference streams would be considered impaired.

An evaluation of the "multiple lines of evidence" reveals a stool with three broken legs that cannot stand scrutiny. USEPA offers nothing to ensure that achieving the target of 0.04 mg/1 TP will result in attainment of aquatic life uses.

> **Response: Please see General Response #1. Also note that the comment that orthophosphorus is the only form of P available for uptake is patently untrue. Authors are referred to any introductory limnology textbook for discussion on algal P acquiring enzymes. In addition, readers should see documents by Dodds in the report related to the preferential use of TP versus dissolved P forms for endpoint development in streams.**

> **Multiple studies have indicated the appropriateness of total nutrient parameters to indicate water quality attainment rather than dissolved or soluble. The Clark Fork River study, in which nutrient targets were developed to control benthic chlorophyll levels in streams, states that —…practical regulations for general external nutrient loading for stream eutrophication control should not be based upon in-stream**

Soluble Reactive Phosphorus [SRP] or Dissolved Inorganic Nitrogen [DIN] levels, because the prediction uncertainty inherent in such an approach may preclude the satisfactory management of benthic chlorophyll *a* (Dodds et al. 1997, p. 1740)." The study further states: —Our analyses revealed that both total N and total P are related more strongly with benthic algal biomass than are dissolved inorganic N or P (Dodds et al. 1997, p. 1740)." In-stream TN and TP concentrations are more indicative of the nutrients that are ultimately available for the growth of algae.

Dodds (2003) suggests that control based on measured levels of dissolved inorganic nitrogen and phosphorus may not be effective because these pools are replenished rapidly by remineralization in surface waters. Dodds (2003) indicated that at high TN (i.e., 0.5 mg/L) and TP (i.e., 0.2 mg/L) concentrations, more than 60 percent of the nutrient is usually made up of dissolved inorganic forms, but at low levels the ratio of dissolved inorganic to total nutrients is highly variable. Therefore, DIN:SRP is a weak surrogate for TN:TP and should be used with caution to indicate nutrient limitation. Calculating TMDLs based on TN and TP criteria is also more practical than using dissolved forms of phosphorus and nitrogen because more total nitrogen and phosphorus water quality data are available than dissolved. Therefore, TP is the preferred endpoint.

We also disagree that the reference approach is flawed. This is a well established and recommended approach for nutrient endpoint development. In addition, the goal is to derive protective endpoints. Author should read the biocriteria literature for discussions on use of 25th percentiles of reference. The use of these is a function of uncertainty in the definition of reference condition and is an attempt to balance Type I and Type II errors. EPA believes that Paul and Zheng 2007 as well as multiple responses to comments submitted regarding this and other TMDLs (see specifically the General Response section of this document) more than adequately describe the technical basis for development of the TP endpoint applied in this TMDL. The assertion that the TP endpoint must be directly related to aquatic life use to be defensible is incorrect. As is stated by Paul and Zheng, 2007, which is referenced by the TMDL, —Nutrients cause enrichment of primary producer and decomposer biomass and productivity, the increase of which leads to changes in the physical and chemical stream environment (e.g., reduced oxygen, loss of reproductive habitat, alteration on the availability of palatable algal taxa, etc.). It is these effects which directly result in changes to the biological stream community (e.g., loss of disturbance sensitive taxa), and ultimately impair the use of a stream for aquatic life." Moreover, the Indian Creek TMDL also includes allocations for the control of sediment, which is both directly and indirectly related to aquatic life uses.

Stressor-response analyses are only one line in the recommended multiple lines of evidence and are actually not the only means of determining endpoints. In addition, the use of TSI values is appropriate because trophic condition is a concept that applies to ecosystem condition, seeing as eutraphentic conditions are not natural nor desired conditions and are an appropriate condition to protect against. The TSI used here was developed with independent data and applied to data from these

streams, therefore the circularity argument is inappropriate. That high nutrient algae increase with nutrients is expected, it is not always observed. That we observed it is further evidence that nutrients are affecting aquatic life (since algae are, after all, aquatic life) in these streams and moving them away from natural trophic conditions.

The authors seem to confuse the concepts of biomass, growth, and productivity and it is unclear exactly which facet they are addressing. Maximum growth does not assure maximum biomass since many factors constrain biomass accrual. Likewise, maximum growth is not always achieved for a variety of reasons. Lastly, it is difficult to characterize algal biomass at the spatial and temporal scale necessary to define impacts. Light levels vary by season and location, as does flow. This is why algal and invertebrate composition are more appropriate response indicators since they integrate over longer and wider temporal and spatial scales.

Lastly, the literature values are based on methods approved by USEPA guidance for endpoint development. So, the same statements made above apply to this statement. The criticism of TSI's in New Jersey are also specious. That certain algae prefer nutrients is akin to saying certain chironomids prefer sewage (which some do). That certain invertebrate increase under organic pollution does not invalidate their utility. Nutrients are pollutants. That some diatoms are tolerant of them (and others not) means that diatoms are excellent response indicators for when nutrients have increased to eutrophic conditions. Especially when built into TSIs that are anchored to reference conditions and can be used to identify deviations from background.

<u>TSI and Diatoms</u>

The comment states –TSI evaluates overall nutrient conditions according to the composition of diatom communities present." Pan et al. (1996) found that there is a strong relationship between diatoms and important environmental variables in the Appalachian Mountain portion of Pennsylvania, Maryland, West Virginia, and Virginia. Diatom species were highly correlated with a pH gradient and variables that were commonly associated with agricultural runoff (e.g., turbidity and TP). Pan et al. (1996) concluded that diatoms can be used as quantitative indicators of environmental conditions in streams.

Flow limitation usually applies to phytoplankton, and that's the reason why periphyton dominates in streams. Light limitation is considered in the model. The EFDC model reads in light intensity and adjusts the intensity based on the water depth and water column light extinction coefficient. As the commenter mentioned, Indian Creek is shallow. Therefore, in general, the light intensity is sufficiently high for periphyton growth during the day time of the growing season.

Comment 3. The methodology used in the Endpoint Study by Paul and Zheng to determine the nutrient endpoints in the Indian Creek are not scientifically supported.

Sub-comment a: The proposed TN endpoint by the Model Reference Approach is not scientifically supported. The model of TN vs. Non-Forested Land Cover has a Fit Coefficient of only 0.43, meaning that it can only explain less than one half of the. data, far from a "significant" correlation as claimed in the Endpoint Study (p.32) .

Response: Please see General Response #1 and General Response #3 and responses to previous comments.

Sub-comment b: The study does not establish any correlation between TP and algal growth. Regarding the Stressor-Response approach on TP, there is no algal response observed, such as Chl _a‘ or periphyton biomass, in any of the data sets. This is inconsistent with the claim in the TMDL that "[d]ata analysis and modeling runs have established a clear linkage between phosphorus loading and periphyton densities in the watershed" (p. 10).

Response: Please see General Response #1. The TMDL language will be changed to make it clear that algal biomass was not the basis of the endpoint. Because the endpoint was based on aquatic life protection and the allocations were calculated using an instream TP concentration, it was not necessary to relate back to algal biomass. The modeling did however calculate the projected reductions in biomass after the TP allocations are met. These results are shown in the attachment to this Response Document.

Sub-comment c: The Reference Site is based on "minimal human disturbances", the majority of which do not come from point sources. Specifically, the Reference Sites with >70% forest covers are neither appropriate nor achievable for the Indian Creek, (pp.5-6).

Response: See General Response #1

Sub-comment d: The Stressor-Response approach did not include indicators such as DO, pH, or algae (no response) which are more closely related to nutrient loading.

Response: See General Response #1

Sub-comment e: The Stressor-Response approach: DIN and SRP should also be studied in addition to TN and TP because they produce more direct response and are more closely related to point source loading and algal growth.

Response: EPA notes (Nutrient Criteria Technical Guidance Manual, Rivers and Streams, page 100) that although much of the total nutrient concentrations in the water column of streams are not immediately available total concentrations probably have more general applicability than soluble fractions. While soluble fractions are more readily available, they may also be held at low levels during high-biomass periods due to uptake. EPA recommended ecoregion criteria are in totals. Ortho versus TP in the permitting process can be discussed with PADEP.

Sub-comment f: With respect to the Stressor-Response approach - the Spearman Correlation showed no correlation for majority of the parameters, with the "strongest correlation with TP" being only slightly above 0.5. Furthermore, the small variance explained by the regression

model between TSI and TP indicated the possibilities of "other stressors coexisting in the streams" (p. 17). The USEPA should explain how ecoregion-wide TMDLs can be applied effectively to individual watersheds. Specifically, as shown in Appendix A and B, the Spearman Correlation analyses produced no or very few significant correlations between TN and TP and macroinvertebrate metrics in two major databases used in the TMDL, with the highest correlation being slightly higher than 0.5. The N:P ratio in all database used ranged from 5 to 2,298 (p. 15), using an average of 208 to set a TN endpoint based on a TP endpoint is inappropriate for all watersheds.

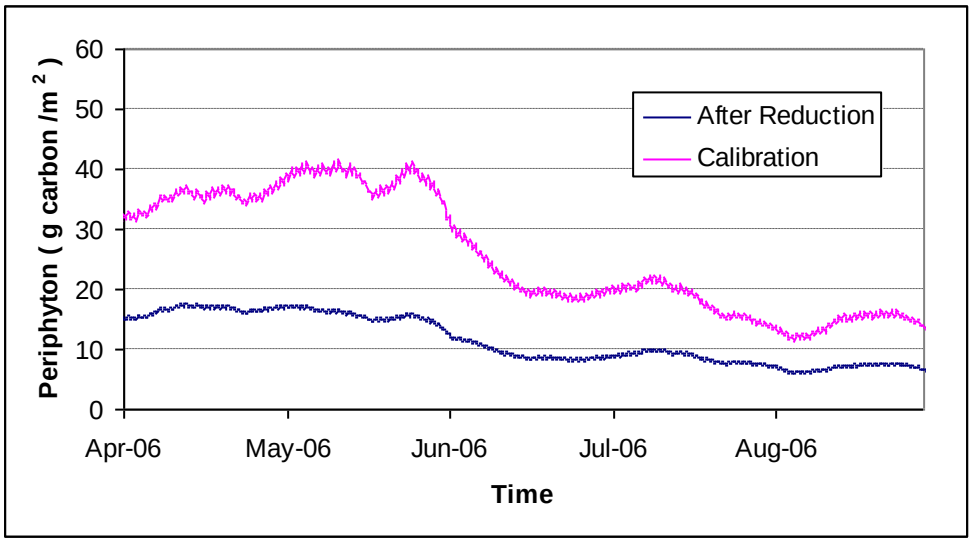
Response: See General Response #1. With respect to the TN Endpoint, the TMDL for Indian Creek will no longer include nitrogen allocations.

<u>Modeling analysis:</u>

The fact that no TP chlorophyll a response was seen in the Stressor-response analysis is not inconsistent with the modeling results showing changes in periphyton density with changes in TP loads. See also the response to Comment 1.

The Stressor-response analysis was based on average nutrient values at reference sites and corresponding average response variable values. The timeframes are not sufficient for evaluating immediate response of variables to nutrient levels. For such an evaluation, a dynamic continuous simulation model that assesses the interactions between the various factors that affect algal growth can be much more informative.

The results of the calibrated model support the average TP concentration targets derived by the multiple lines of evidence approach. After simulated TP reductions, algae are predicted to dramatically reduce as shown in the Figure below for the sampling site at Bergey.



While the TMDL does not include analysis of TMDL TP levels and resulting algal

growth, the analysis provided herein supports the assumption that both DO and algal levels under TMDL conditions (i.e., meeting the average seasonal target of 40 µg/L) are expected to be acceptable. That is, DO levels above state specified minimum criteria and predicted periphyton densities that are dramatically reduced. Again, neither plant growth nor DO were used to derive the TMDL requirements; the TMDL requirements were based on a scenario that achieves identified average nutrient concentration levels for the period from April 1 – October 1. Furthermore, EPA has decided not to include allocations for total nitrogen in this TMDL.

<u>DIN and SRP:</u>

Multiple studies have indicated the appropriateness of total nutrient parameters to indicate water quality attainment rather than dissolved or soluble. The Clark Fork River study, in which nutrient targets were developed to control benthic chlorophyll levels in streams, states that —…practical regulations for general external nutrient loading for stream eutrophication control should not be based upon in-stream Soluble Reactive Phosphorus [SRP] or Dissolved Inorganic Nitrogen [DIN] levels, because the prediction uncertainty inherent in such an approach may preclude the satisfactory management of benthic chlorophyll *a* (Dodds et al. 1997, p. 1740)." The study further states: —Our analyses revealed that both total N and total P are related more strongly with benthic algal biomass than are dissolved inorganic N or P (Dodds et al. 1997, p. 1740)." In-stream TN and TP concentrations are more indicative of the nutrients that are ultimately available for the growth of algae.

Dodds (2003) suggests that control based on measured levels of dissolved inorganic nitrogen and phosphorus may not be effective because these pools are replenished rapidly by remineralization in surface waters. Dodds (2003) indicated that at high TN (i.e., .5 mg/L) and TP (i.e., .2 mg/L) concentrations, more than 60 percent of the nutrient is usually made up of dissolved inorganic forms, but at low levels the ratio of dissolved inorganic to total nutrients is highly variable. Therefore, DIN:SRP is a weak surrogate for TN:TP and should be used with caution to indicate nutrient limitation. Calculating TMDLs based on TN and TP criteria is also more practical than using dissolved forms of phosphorus and nitrogen because more total nitrogen and phosphorus water quality data are available than dissolved. Therefore, TP is the preferred endpoint.

Comment 4: No justification was given for replacing LSTA's orthophosphate effluent limit with a TP effluent limit. LSTA has a seasonal effluent limit of 0.5 mg/1 orthophosphorus (OrthoP), which the proposed TMDL would change to 0.0475 mg/1 TP. Given that there are no impoundments in Indian Creek downstream of the LSTA discharge, the impact on algae and dissolved oxygen would be expected to be entirely driven by OrthoP. In other words, the concentration of organic phosphorus discharged from LSTA has no relevance to biological productivity or aquatic life uses. Therefore, any effluent limit for LSTA should be expressed as OrthoP rather than TP, and should be determined based on impact to biological activity rather than compliance with an essentially arbitrary level of TP in the stream.

Response: Literature shows that TP is more appropriate. The commenter is

referred to the literature review conducted as part of this TMDL.

Comment 5: The 0.04 mg/1 TP target and 3.7 mg/1 TN target are not water quality criteria and cannot be used as endpoints because they do not relate directly to the impairment of uses or the narrative criteria. As stated in the TMDL report, "Pennsylvania does not currently have specific numeric water quality criteria for nutrients." The target TP and TN concentrations were identified in order to satisfy the narrative water quality criteria at 25 PA Code Chapter 93.6 (a and b).

However, in order to satisfy the narrative criteria, the targets would have to be related to use impairment. In other words, attaining the targets would result in attainment of the uses. For the reasons provided in our Comment #2, the TP and TN targets are not directly related to use impairment. There is no assurance whatsoever that attaining the targets will result in restoration of aquatic life uses, or even any improvement in aquatic life use.

Response: See General Response #2

Comment 6: Monitoring data from PADEP does not demonstrate any relationship between point source discharges and observed DO swings. From the graphics provided in the TMDL, it appears that Dissolved Oxygen ("DO") concentrations did not become progressively lower along the stream when subjected to more point source discharges during the minimum DO period of 11 p.m. to 7 a.m. (P. 17) As shown in Figure 2-5, longitudinal DO concentrations from the headwater down to the mouth of the Indian Creek did not decrease as more point source discharges entered the creek; therefore, the data provided in the TMDL demonstrates that the Indian Creek did not become more impaired as it was subjected to more point source discharges. Moreover, the baseline condition simulation indicates that DO swings will increase, with concurrent decreases in DO minimums, with the addition of phosphorus from point sources discharging at their design flows. However, the higher phosphorus levels in more downstream locations in Indian Creek do not cause larger DO swings or lower DO minimums. In fact, the mouth of Indian Creek, which received phosphorus from all point sources combined, exhibits one of the lowest DO swings and highest DO minimums. The USEPA should explain how these data correlate with the suggested relationship between stream impairment and point source discharges and the contribution of nonpoint sources.

Response: The TMDL is not suggesting that the addition of TP leads directly to large diurnal swings in DO, rather, the indirect effects of TP loading promotes this occurrence. The commenter‘s assumption that dissolved oxygen levels will be lower along the stream when subjected to more point source discharges is not correct. The DO problem in Indian Creek is caused by high levels of periphyton which are fueled by nutrients from the point sources. In fact, the nutrients concentrations will decrease along the stream after periphyton uptake. The two small STPs on the tributaries do not impact the main stream significantly since the nutrients from both are used by the tributary periphyton before reaching the main stream.

Phosphorus may largely be taken up prior to its reaching the mouth of Indian Creek, which receives water from all the point sources combined. It is incorrect to presume that phosphorus should become higher in the more downstream locations.

In addition, periphyton levels depend not only on nutrients, but also other physical factors such as light intensity. The downstream portion of Indian Creek is deeper than upstream portions, resulting in more blockage of light to the bottom, it experiences more canopy cover (shade) than other portions of Indian Creek, and it also has a higher gradient and a rockier substrate. At the same time, the water volume is higher in downstream locations. On a per unit water volume basis, the same densities of periphyton will generate/consume less DO as water volume increases.

Comment 7: Dissolved oxygen dynamics are not adequately simulated in the TMDL. What is the explanation for the larger dissolved oxygen swing observed in May than August of 2006, and how was it simulated? The model simulates larger diurnal DO swings in April and May than in July and August. Even so, the model underestimates the swing actually observed at the mouth of Indian Creek during both events and overestimates the observed swing in August in the Lower Salford tributary. Given the small shallow nature of the tributary, reaeration and sediment oxygen demand are likely to exert a major influence on the water column. DO simulations at both these locations are poorly calibrated, being off by 2-3 mg/1 compared to observed values. Additional diurnal DO data are necessary to properly calibrate the model at the two locations downstream of LSTA discharge and throughout the watershed. Without a properly calibrated model, it is not possible to predict the impact of phosphorus reductions on DO in the future.

There is no evidence at either of the two diurnal DO monitoring locations downstream of LSTA discharge that DO currently violates the 5 mg/1 minimum DO criterion. While DO at upstream locations in Indian Creek was observed below 5 mg/1 during the diurnal minimum periods of the May and August events in 2006, this was not the case at the two monitoring locations downstream of LSTA discharge. DO at those two locations (Lower Salford tributary and Indian Creek mouth) did not go below 5 mg/1 during either monitoring event.

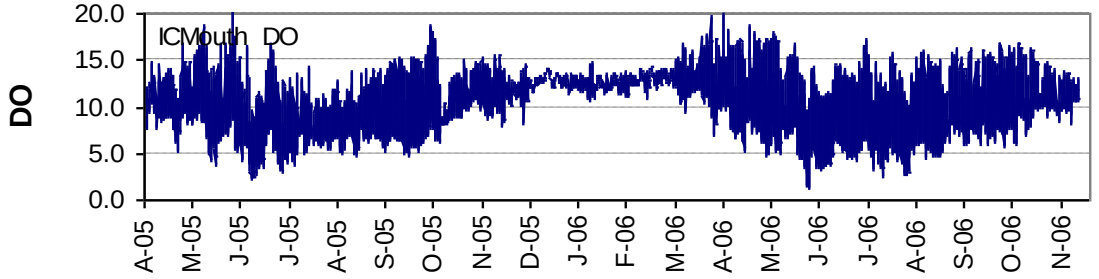
It appears that the baseline condition, which simulates point sources discharging at their design flows, simulates a larger DO swing in the Lower Salford tributary than was simulated for the existing condition. This may also be true at the mouth of Indian Creek, although the baseline condition simulation for that location was inadvertently left out of the graphs in Appendix D. The phosphorus levels are already much higher than needed to support plant and algal growth; orthophosphorus concentrations are over 0.2 mg/1 at the mouth of Indian Creek and higher in the Lower Salford tributary. These orthophosphorus concentrations are 5-10 times higher than the level needed to support the maximum growth rate of plants and algae. Given that the baseline condition adds more flow and more phosphorus, there is no reason to expect productivity, and therefore diurnal DO swings, to increase. In fact, the increased flow from the point sources, if anything, would be expected to dampen DO swings. The fact that the baseline condition simulates increased DO swings is a counterintuitive result that needs to be explained before it can be accepted. It is very likely that this relates to the high Phsat value selected for the model, which needs to be justified.

Response: The larger DO swing in May than in August 2006 is caused by the periphyton. Periphyton growth depends on nutrients, temperature, and light intensity. The model used a temperature dependent function to consider the temperature impacts on periphyton growth. We do not agree the commenter's

statement that the DO dynamics are not adequately simulated. The model is calibrated against both spatial and temporal data to simulate the periphyton-nutrient-DO interactions in Indian Creek. We agree that the modeled DO did not match across all the data points after calibration. However, it is never the expectation to do so for any model development. Also consider that models are developed with currently available resources, as was the case with the Indian Creek model. Additionally, model development is often focused on known critical areas and or issues, (i.e. the locations with highest DO swing in Indian Creek). The model is well-calibrated and can accurately simulate the spatial and temporal changes of nutrients, periphyton, and DO.

Modeling results show that orthophosphorus levels are not always higher than 0.2 mg/L at the mouth of Indian Creek. The periphyton levels and the resultant DO swings depend on the nutrient concentrations not only in a specific day, but also in previous days during the growing season. The baseline condition provides higher phosphorus than the calibration condition for the entire modeling period, and there is no question that the periphyton grows higher during the baseline condition. It is true that higher flow can dampen DO swing. However, judging whether DO swings will be higher or lower from high or low flow conditions is not a straightforward process. While intuition might suggest that the larger DO swings in April/May are improbable if not impossible, with the help of the calibrated model, the complex interactions can be more fully accounted for. The Phsat value is addressed in the response to comment #8.

The baseline condition simulation for the mouth of Indian Creek is provided here; it was not included in the Appendix D; it will be added to the Final version of the TMDL report.



Comment 8: Justification must be provided for the unusually high phosphorus half-saturation value for periphyton. The half saturation constant, or half velocity coefficient, is the nutrient concentration, such as TP, at one-half of the maximum algal growth rate. The phosphorus half-saturation ("Phsat") value for periphyton was increased from 0.005 mg/1 to 0.05 mg/1 during the validation process. Such a high Phsat causes the model to simulate phosphorus limitation at concentrations that are normally considered too high to limit productivity. Furthermore, no justification was given as to why the Phsat would be increased during validation. Presumably this was done in order to better simulate the August 2006 event. However, depending on the nature of the initial calibration simulation, there may be a dozen easy ways of changing the model to better capture the validation data. Changing the Phsat to such a high level requires a

better explanation and justification as to why an unusually high Phsat is warranted for this system. Furthermore, having adjusted model parameters to fit "validation" data, additional validation data are now required in order to test the new model coefficients. The USEPA should explain the significance of such change in relation to setting the TP endpoint at 0.04 mg/L on significantly reducing algal growth.

> **Response: The Phsat value was adjusted during calibration within an appropriate range based on literature values together with other parameters such as maximum growth rate, respiration rate, and death rate. As a calibration parameter, the Phsat value should be looked at together with all other parameters. The single reason for adjusting this value is for calibration purposes—there is no one value that is recommended for use in the system. The value that ultimately was used is the result of calibration. Changing only the Phsat value while leaving all the other parameters unchanged after calibration would have a significant impact on simulated algal growth, but as it is not the sole value determining periphyton growth, this single focus parameterization approach should not be applied. Borchardt (1996) summarizes representative studies on nutrient limitation of benthic algae. Saturated growth rates range from 8 µg/L to 60 µg/L TP and 55ug/L to 700 µg/L TN. The individual vales are as follows: saturated growth rate occurred at 8 µg/L P and 500-700 µg/L N (Wuhrmann and Eichenberger 1975); 60 µg/L P (Wong and Clark 1976); 40-50 µg/L P (Horner and Welch 1981); 25 µg/L P (Horner et al. 1983); and 55 µg/L N (Grimm and Fisher 1986). Borchardt's (1996) summary also indicates that maximum biomass occurs at 25-50 µg/L P (Bothwell 1989) and less than 100 µg/L N is growth limiting (Lohman et al. 1991). Therefore, 50 ug/L is an acceptable value.**
>
> **It is a routine modeling procedure to adjust parameter values during calibration and validation as well if more data become available since the model was first developed (as was the case here). Again, the value 50 ug/L is within the range presented in the literature, and the model works well with this value together with other parameters of periphyton dynamics.**

Comment 9: The Models in the TMDL do not use site specific parameters and are not properly calibrated or validated. The Nutrient sub model in the TMDL does not use site-specific parameters. The literature default values used in the model (p.46) for nutrient concentrations in runoff over manured areas and from septic system contributions need to be verified with local conditions.

The Hydrologic sub model in the TMDL is not properly calibrated. For GWLF model calibration on hydrologic parameters, the East Branch of the Perkiomen Creek Watershed is used as a surrogate for the Indian Creek Watershed. As shown in the calibration result (Figure 4-4, p. 48), the model predicted monthly average streamflow from 1997-2004 is approximately 34% higher than the observed streamflow during the same time period. The USEPA should explain the impact of this discrepancy on modeled nonpoint and point source nutrient contributions to the Indian Creek Watershed. In addition, since the Indian Creek Watershed only represents a small fraction of the East Branch of the Perkiomen Creek Watershed, the USEPA should explain how the model is believed to be calibrated "reasonably well" (p. 47) to represent the Indian Creek

Watershed hydrologic parameters, particularly given the discrepancy in model calibration on the East Branch Perkiomen Creek Watershed (p.48).

The EFDC model was based on very limited data obtained from the Indian Creek. For example, the DO and nutrient data was only obtained over a 3-day period in May, 2006 and again over an unknown duration of time in August, 2006 (p.54). There is simply insufficient data to calibrate and validate this model. The USEPA should explain how reliable and accurate the EFDC model actually is given the limited local data available, and explain why more complete and comprehensive data collection was not performed.

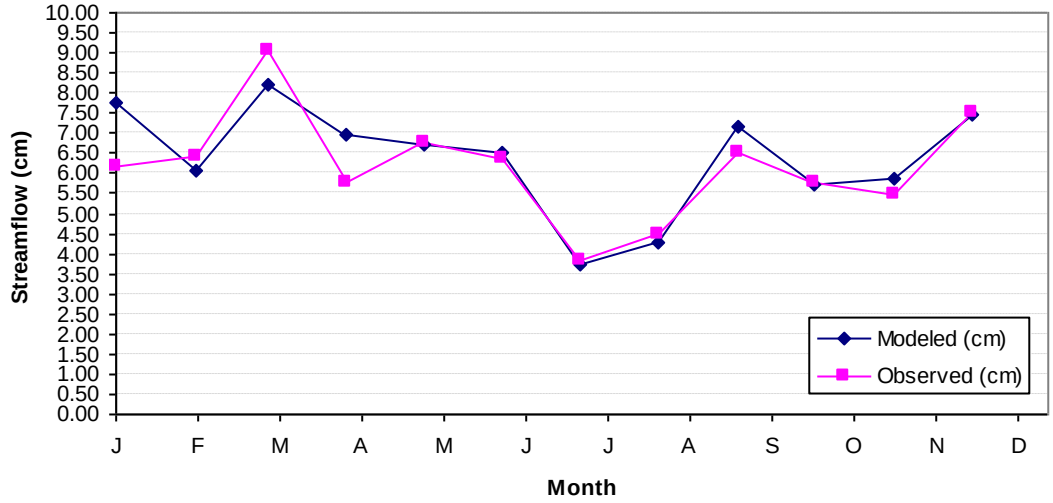
As shown in Table 4-15 (p. 59-60), Key Water Quality Parameters for Indian Creek EFDC model, optimal depth for macroalgae growth is set at 0.3 m (1.0 ft). However, as shown in Table 4-11 (p. 55), survey data from seven cross sections for the modeled segments of Indian Creek indicate the average depth of the creek ranged from 0.25-0.78 ft. The USEPA should explain (1) when (month and year) was the survey data obtained, (2) did the width and depth of each segment vary with streamflow in the model, (3) did the depth ever reach the optimal depth for macroalgae growth set in the model during the modeled duration, and if it did, were point sources or nonpoint sources the major nutrient loading contributor during the period.

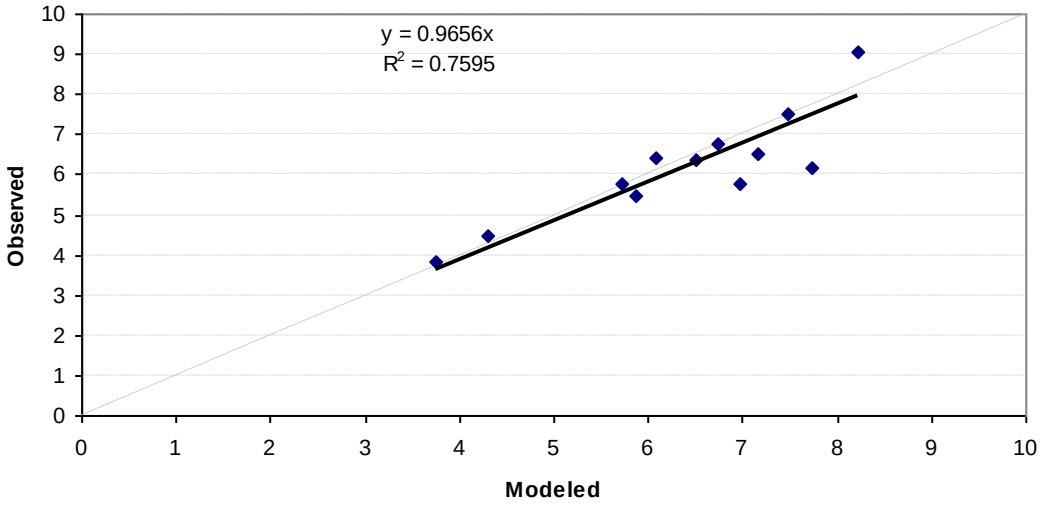
Response: All modeling performed to support development of this TMDL utilized the data available at the time of model development.

It is true that the GWLF nutrient loading simulation does not use site specific parameters to represent nutrient concentrations in runoff from manured areas. An attempt was made to develop more locally specific parameter data. An agricultural practices survey was sent to the Montgomery County Pennsylvania Conservation District. General information was included in their response, such as manure is definitely applied to agricultural lands in the watershed; however no specific information on times of application or rates of application were available. Nor were there any studies available to characterize locally specific runoff concentrations. Therefore, literature derived values provided in the GWLF users manual were applied.

With respect to septic system representation, based on comments received from Franconia Township, EPAs contractors were informed of a sewer management study for the township. The model's septic representation has been updated to reflect more accurately these local conditions.

GWLF hydrologic calibration:





The hydrologic calibration was based on the best available data. There were no long-term USGS flow gages (or weather) data within the Indian Creek watershed. The nearest available USGS gage was at the outlet of the East Branch of the Perkiomen Creek watershed of which Indian Creek is a sub-basin. Hence, it was necessary to use this calibration approach. In addition there were no rain gages in the East Branch of the Perkioment Creek watershed. Since GWLF is precipitation driven, the lack of any precipitation gages within the watershed makes it difficult to have a —prfect" calibration. Based on the calibration result the model predicted monthly average streamflow from 1997-2004 showed an r^2 value of 0.76 (see Figure). It should be noted that the calibration during the critical summer period showed good agreement.

The optimal depth for macroalgae growth is set at 0.3 m in the Indian Creek EFDC model. This does not mean that the water body itself has to be deeper than 0.3 m. The number is used for adjusting the impact of light intensity. It is equivalent to

setting an optimal light intensity for algal growth. The optimal depth for growing algae is around 0.3 m, while anything deeper or shallower would tend to restrict algae growth relative to this depth.

The stream channel survey, which was conducted in May 2006, measured the channel geometry up to the water surface, and the survey results were used as the basis for configuration of the channel geometry in the EFDC model. The simulation period covers both wet and dry periods, and the depth varies related to the flow, which is from both point and non-point sources. The depth can be deeper or shallower than 0.3 m based on different flow conditions. When the depth is around 0.3 m, it can be either non-point sources dominated or point-sources dominated; however, in general, lower flow depths provide optimal conditions for algae growth.

Comment 10: Data are woefully insufficient to calibrate and validate a water quality model. Model calibration for chemical constituents was performed based on data at 7 locations collected during a single sampling event on May 11, 2006. Simultaneous diurnal dissolved oxygen data were collected from May 10 to 12 at the same locations. A single additional sampling event was performed on August 2006 and used for model validation. While the spatial distribution of sampling locations appears adequate for the size and hydrology of the watershed, calibrating and validating a watershed-wide water quality model based on two sampling events is completely inadequate and not in keeping with standard engineering practice. As a comparison, the State of New Jersey performed over 20 sampling events during a variety of flow conditions to provide a basis for calibration and validation of its nutrient TMDL models. Two diurnal DO events totaling four days is similarly inadequate to calibrate and validate diurnal variations in DO. Three diurnal events are generally considered a minimum, and more can be necessary if the data are questionable, as is the case here because larger DO swings were observed in May than August. Differences between the events might be due to equipment or differences in meter deployment. Additional diurnal monitoring is necessary to better understand the system and to properly calibrate and validate the model. Without a properly calibrated model, it is not possible to predict the impact of phosphorus reductions in DO and water quality constituents.

Response: It is not clear how the commenter defines one diurnal event. The commenter did not state the durations of the minimum three diurnal events. If one day's continuous monitoring of DO is considered as one diurnal event, there are 6 diurnal events totally for Indian Creek. The two monitoring periods cover May and August, which are within the critical algal growing season. The water temperature and light intensities are different for these two periods and potentially impact the growth of algae together with different nutrient inputs. Therefore, these two data sets are sufficiently good to calibrate the algal growth under different environmental factors. The commenter asserts that the data are questionable because larger DO swings were observed in May than in August. However, it is not unusual for algae levels to be higher in May than in August, resulting in larger DO swings in May than August.

The EFDC model development went through a strict calibration processes. The modeled depths agree well with the observed depth during the low flow period. The modeled water temperature matches the observed continuous water temperature

data. After the physical representation of the model was calibrated, the water quality part was examined. The data used for calibration were collected in 2006. The model was run from April, 2005 dynamically through the end of 2006 to eliminate any initial impacts. The water quality calibration focuses on the most critical locations where the DO swing is the highest. At the same time, other locations were checked to ensure the model captures the trend of DO swings.

While only two sampling events (or 6 diurnal events) were conducted to support the pre-TMDL data collection effort, the time period represented by the monitoring data were selected to better understand waterbody conditions during the critical warm weather, low-flow period. When modeling, more data are always useful; however, time-variable data such as those collected for this effort (i.e., 48-hour diurnal sampling) is very informative with respect to the influence of algae on relevant stream water quality parameters.

Comment 11: It appears that the water quality model assumes all productivity is due to periphyton (attached algae) rather than phytoplankton (water column algae). No basis for this assumption is provided. The role of phytoplankton versus periphyton is not explored. The water quality model appears to be able to simulate phytoplankton; however, parameters for phytoplankton kinetics are not provided. While there is certainly periphyton in Indian Creek and its tributaries, phytoplankton also appears to be playing an important role during the events depicted in the pictures provided at a public presentation on November 30, 2006[3]. While it is difficult to assess based only on pictures, some of the green biomass appears to be Duckweed. While Duckweed is a floating plant, it is not rooted and therefore behaves more like phytoplankton than periphyton. The simulation of dissolved oxygen and the response of the system to nutrient reductions may be completely speculative if the role of phytoplankton and periphyton during critical events is not first understood.

Response: Attached algae usually dominates in shallow and flowing stream; and this is the case for Indian Creek. Pictures taken at different times and locations support this statement for Indian Creek. It is possible that other aquatic plants such as Duckweed exist in Indian Creek. However, model development was focused on the dominating factor, the attached algae in this TMDL

Comment 12: The sediment module appears to be completely speculative, with little to no information available to calibrate the sediment dynamics. Sediment dynamics may very well be an important driver in the Indian Creek watershed. In fact, a visual inspection reveals that the tributary into which LSTA discharges and the Indian Creek itself are heavily impacted by sedimentation. The sediment TMDL assumes that sedimentation is largely driven by inputs of Total Suspended Solids (TSS), but instream erosion clearly plays a major role as well. The model includes a sediment model that purports to simulate the impacts of sediments on dissolved oxygen and nutrients, but no information on parameterization of the sediment module is provided. How the sediment module was calibrated, and the importance of the sediment module to dissolved oxygen and nutrient dynamics, are not explained. Nutrients that are mobilized by streambank erosion may be very important, and may be substantial enough to provide enough nutrients to sustain the level of productivity observed in Indian Creek. If so, reductions in phosphorus from LSTA would not result in any instream benefit.

Furthermore, sedimentation in Indian Creek has clearly impacted the hydraulics of the stream, resulting in many pools of relatively stagnant water due to the many deposition areas in the stream. These pools may be important environments for phytoplankton growth, and may in fact be the main cause of the large diurnal dissolved oxygen and pH swings. This was not explored.

> **Response: The sediment module was not activated for Indian Creek since the attached algae is the focus. References to the EFDC sediment flux module will be removed from the report.**
>
> **The monitoring sites for continuous DO measurements were not located in any pools. These sites are located on the two tributaries and on the main stem of Indian Creek. The site at Bergey Rd is above a pool; Others are far away from pools. All of them showed strong DO swings, indicating high levels of periphyton. We do not exclude the possibility that phytoplankton exist in some pools. However, when we look at the entire stream, periphyton is the dominating algal species**.

Comment 13: It is believed that the Model used in the TMDL is capable of simulating algal growth, however, no algal growth modeling is presented in the TMDL. The USEPA should explain why no algal growth (phytoplankton and periphyton) was modeled in the Indian Creek Watershed.

> **Response: Quantitative periphyton data were not available; however, periphyton was observed and thus modeled using EFDC. As DO is a strong indicator for periphyton levels, and the signficant DO swings in the waterbody implies high levels of periphyton, EPA feels that the DO and nutrient predictions of the model are sufficient evidence to demonstrate its ability to simulate periphyton growth. It was not presented in the TMDL because this was not the focus of the TMDL modeling exercise. The TMDL modeling exercise was focused on simulating the point and nonpoint source loading necessary to meet the average instream phosphorus concentration target.**

Comment 14: The Ecoregion approach used to determine the nutrient endpoint in the Endpoint Study is inappropriate. Among the four datasets shown in Figure 4, only the USGS dataset exhibited a "reasonable wedge shaped relationship" which "is often found in large scale investigations when multiple stressor/constraints are present" and that "elevated levels of algal biomass can exist at relatively low nutrient concentrations (< 100 ug/L)" (p. 15). No relationship was found in other datasets.

Samples that were actually collected in the targeted local watersheds by PADEP indicate "the highest algal biomass occurred at sites where TP concentrations were relatively low (14-35 (ug/L). It is possible that algal growth has been saturated even at this low level. (Endpoint Study, p. 16)". Explain how setting TP endpoint at 40ug/L will reduce algal growth and improve water quality in Indian Creek Watershed, (p. 16). Moreover, given the diverse response cited in the Report, explain why an Ecoregion-wide endpoint approach is adopted in setting the nutrient endpoints, as opposed to watershed specific approach to address local conditions of each watershed.

Response: See General Response #1. The endpoint was established to protect aquatic life and not to reduce algal biomass to a certain level.

Comment 15: Site specific data was not used in the development of the Nutrient Endpoints. The Conditional Probability study regarding the Stressor-Response approach on TP is based primarily on Maryland database. Maryland Biological Stream Survey (MBSS) was the largest dataset used in the report's analysis on macroinvertebrate responses to nutrient concentration. MBSS includes 6 metrics: total taxa, EPT taxa, Ephemeroptera taxa, % clingers, % intolerant urban, and % chironomidae (Endpoint Study, p. 18, Table 5 on p. 20). Of the 6 metrics, 3 didn't yield correlations because they were "either not sensitive to nutrient enrichment or more sensitive to other stressors (Endpoint Study, p. 18)"; 1 suggested a TP endpoint of 0.064 mg/L with 50% probability, and 2 suggested endpoint of about 0.04 mg/L with 70-88% probability. The USEPA should explain how using the weight of evidence approach the authors arrived at a TP endpoint of 0.04 mg/L based on these 6 metrics; and what is the percent probability of the Indian Creek Watershed meeting the non-impairment goal if this endpoint is achieved. The USEPA should explain how effective ecoregion-wide TMDLs based on Maryland data can be applied effectively at individual watersheds in Pennsylvania.

There was no correlation established for the TN endpoint, and the Endpoint Study suggests that TN "likely contributes less to use impairment from eutrophication in this region" (p.30); therefore, setting TN endpoint using an average ecoregional ratio is inappropriate.

The Endpoint Study does not discuss the effects of implementing the proposed nutrient endpoints, then there is no basis to expect that the stream quality will improve after TMDL is implemented, even at the endpoints proposed in the TMDL.

Response: See General Response #1

Comment 16: The USEPA has not adequately investigated background and nonpoint source contributions to the Indian Creek. It appears that the proposed nutrient endpoint for TP in the TMDL is less than the background level. No evaluation of background levels in the Indian Creek Watershed was performed. In Appendix A, "Ambient Sampling Data at STPs," it appears that the background level of TP detected at both sampling sites in the stream are above 40 ug/L. These samples were taken during dry weather when the impact of nonpoint sources would be minimized. Given that background TP concentrations may well exceed 0.4 mg/1, the USEPA should explain how setting the TP endpoint at 40 ug/L will reduce algal growth and improve water quality.

In the discussion of PADEP Monitoring on pages 12-22, it is noted that neither "DO" nor nutrient concentrations were measured upstream of any point sources for background comparison purposes. Therefore, it is impossible to ascertain how much impact nonpoint source contribution has on the Indian Creek Watershed and what effect, if any, reduced loading by point sources will have on the Indian Creek Watershed.

Response: Prior to listing the stream, PADEP collected data upstream of the Telford and Lower Salford discharges during —ambient sampling events"; the background here just means that it‘s not impacted by the point sources. These

upstream locations are impacted by nonpoint sources and non-point sources need to be reduced for the TMDL too.

Nevertheless, from the ambient sampling, the measured nutrients downstream of point sources showed a clear influx of nutrients at the discharge followed by a decreasing trend of nutrients along the stream, which implies no significant non-point source impact at the time of the sampling. Otherwise, the nutrients will not decrease along the stream (assuming that algal uptake is similar).

In addition, the target is seasonally averaged TP, not individually sampled TP. The GWLF watershed simulation was conducted in order to ascertain the impacts of nonpoint source contributions to the watershed.

Comment 17: The proposed loading reduction by point sources is unjustified because the TMDL does not adequately address loading from nonpoint sources. The TMDL explicitly recognizes that nonpoint sources are a significant source of loading into the Indian Creek, yet the percent reduction for point sources far outweigh that expected from nonpoint sources. Specifically, the TMDL states that "The Indian Creek watershed appears subject to significant nutrient loading from both point and nonpoint sources." (P. 34), "Land use activities ... play an important role," and "an approach to develop TMDLs ... account for sources ... during both low flow and high flow conditions.") (P.35). The information on page 51 also reveals that nonpoint source TP loading is 51% of the total TP loading. Given the above statements in the TMDL, the USEPA should explain why the point source reduction proposed in the TMDL is significantly higher than that of nonpoint source (96% vs. 70%).

Response: Reductions to point sources outweigh those called for nonpoint sources due to the time period during which the most critical watershed conditions occur: warm weather, low flow conditions. This is when the stream is largely overwhelmed by effluent from the point sources in the watershed. This is not to say that the nonpoint loading of nutrients do not contribute to the impairment. However, the timing and conditions under which the majority of the two types of loads are delivered are different. For the period modeled, the majority of the nonpoint source load is delivered during storm events and is episodic in nature; whereas the point source load is delivered in a steady, more continuous fashion throughout the period modeled. Because of the nature of the watershed, a large portion (although not all) of the annual nonpoint load may be moved entirely out of the drainage basin during the same events that the nonpoint source load is delivered. In contrast, the continuous nature of the point source discharges means that these sources contribute a lower proportion of nutrients to the stream during high flows and a higher proportion of nutrients to the stream during low flows. It is because the point sources represent the largest source of nutrients to the stream during summer low flow periods, when the identified target applies, that they require a higher overall reduction than nonpoint sources.

Comment 18: It is unnecessary and counterproductive to impose a TMDL for Total Nitrogen (TN) for the Indian Creek watershed. A TN target of 3.7 mg/1 was selected because it corresponds to the TP target of 0.04 mg/1 based on the average TN:TP molar ratio for reference

streams in the piedmont region. As stated in the TMDL report, the "underlying basis of this approach is that it is protective to reduce nitrogen in proportion to phosphorus based on ambient molar ratios." This is a meaningless basis for many reasons:

- The ratio of the total forms of nitrogen and phosphorus means nothing regarding nutrient limitation, since it is the available forms (orthophosphorus, ammonia, and nitrate) that drive plant and algal growth.

- Reducing nitrogen such that the N to P ratio is the same as that in a reference stream would have no impact whatsoever on productivity levels, since reference streams are strongly phosphorus-limited. In other words, plants and algal growth would slow due to lack of phosphorus long before nitrogen. Since nitrogen concentration is in excess of algal growth needs, it does not matter how much in excess.

- Although current levels of both phosphorus and nitrogen are much too high to limit plant and algal growth, high N:P ratios suggest that phosphorus would become limiting before nitrogen. Reducing nitrogen would have no impact whatsoever on productivity until it were reduced low enough to induce nitrogen limitation. However, inducing nitrogen limitation in freshwater streams tends to favor less desirable types of algae and is not a preferable means of limiting productivity.

The TMDL document contains this gross understatement: "the linkage between nitrogen and periphyton in this system is somewhat less well-established." In fact, there is no possible linkage between nitrogen and periphyton in this system because the system is not anywhere close to being nitrogen-limited. USEPA proposes to impose a TN target and TMDL nonetheless because of potential downstream impacts of excessive nitrogen loading to estuarine waters, namely the Delaware Bay. Furthermore, USEPA points out that PADEP is developing nutrient criteria that may include nitrogen. The fact that nitrogen limits may be imposed in the future, either to protect/restore the Delaware Bay or in response to new criteria, is a reason NOT to impose nitrogen limits now based on an essentially arbitrary threshold. Plants could upgrade to satisfy the target TN concentration, only to find that they have to upgrade again to satisfy a regulatory action for the Delaware Bay or new instream criteria. The initial upgrade to satisfy the instream target of 3.7 mg/1 would have been a complete waste of resources with no environmental benefit whatsoever. Therefore, the USEPA is urged not to implement the proposed TMDL for TN.

Response: See General Response #3

Comment 19: Information from the Endpoint Study conclusively establishes that TN should not be regulated. "Because these systems are not N limited, relationships between TN and response measures are less well established." (p.30) "The fact that N is not limiting also means that TN likely contributes less to use impairment from eutrophication in this region. Endpoints are best derived when clear connections to use impairment can be made." (p.30) "It is most likely that N contributes to use issues in the tidal and estuarine waterbodies downstream of rivers and streams in this region (e.g., Delaware Bay). Those systems are where data and analyses will be able to suggest an appropriate N target for upstream systems. That being the case, there is some risk in setting stream TN endpoints in this region that may ultimately be inconsistent with those needed to protect uses from TN enrichment in the Bay." (p.30-31) "[w]e cannot recommend an N

target." (p.31) "[t]here appears to be little reason to think that TN is limiting uses in these northern piedmont freshwater stream systems." (p.32)

Response: Please see General Response #3

Comment 20: Additional technical evaluation is required in order to properly establish a TMDL for the segments downstream of LSTA. Very little information is provided about the details of the model and the exploration of alternative future scenarios. The USEPA is urged to postpone adoption of the TMDL, and to provide LSTA the opportunity to explore the model in more detail. Additional data collection may be necessary as well. The TMDL, as currently expressed, imposes drastic requirements on LSTA and other point sources in the Indian Creek watershed, without any assurance that the actual use impairment will be addressed in any way by these actions.

Response: The LSTA is certainly welcome to collect additional data below its facility. If sufficient information is collected that would warrant a request to re-evaluate the TMDL, EPA would consider the request. However, at this time EPA believes that sufficient data exists to confirm the LSTAs impacts on the quality and health of the stream below its outfall. LSTA has presented opinion and no supporting data and evaluation that would change this opinion. EPA would be interested in any LSTA's views on future alternative scenarios.

Comment 21: While the TP endpoint lacks justification, the USEPA's decision to apply the endpoint as a seasonal average is technically justified. Given the fact that nutrients impact biological systems over the growing season, it makes technical sense to apply any nutrient thresholds as a seasonal average rather than a not-to-exceed value.

Response: EPA agrees with this comment

Comment 22: The TMDL does not provide the data or information on which the Indian Creek Watershed was assessed as impaired due to nutrients. The USEPA should provide all such data or information.

Response: PADEP conducted the data collection and analysis as part of the development of various Clean Water Act Section 303(d) lists of impaired waters. PADEP public noticed each required list for comment by the public. During this time PADEP would make available any basis for listing a specific water if requested. EPA is not aware of the commenter requesting such data and information during the listing comment period. EPA used the PADEP listing decisions as the basis for the TMDL. Although much of the data is summarized in the TMDL, EPA suggests that, because the listing was a state action, the commenter request and obtain the listing decision data from the PADEP.

Comment 23: The USEPA should identify other TMDLs in USEPA Region III or elsewhere that have utilized the weight-of-evidence approach for selecting nutrient endpoints.

Response: Chester Creek, Sawmill Run, Southampton Creek all in PA

Comment 24: Under the Clean Water Act, states are responsible for establishing TMDLs Please explain why the USEPA and not PADEP is publishing the TMDL

Response: Please see General Response #2 concerning legal issues. The TMDL Consent Decree (modified) required TMDLs to be completed by June 30, 2008. Under this CD EPA must complete the TMDLs if the state fails to do so. Due to a number of concerns, PADEP could not complete this particular TMDL under the time frame allowed by the CD. PADEP notified EPA of this failure and EPA assumed responsibility to complete the TMDL.

Comment 25: In developing the TMDL, did the USEPA or anyone else consider any economic issues, particularly the cost to meet the proposed TMDL nutrient endpoints?

Response: EPA did not base the TMDL and allocations on cost issues. Federal law and TMDL regulations do not require the TMDL to consider costs associated with meeting applicable water quality standards. The TMDL program charge is to identify the loads and loading reductions necessary to attain and maintain applicable water quality standards, including numeric, narrative, uses and antidegradation.

Comment 26: Did EPA consider the requirements imposed on local governments, including municipal authorities, (e.g., bidding, procurement, design, construction, financing) in structuring its proposed Adaptive Implementation Strategy in Appendix F to the TMDL?

Response: EPA did not consider the cost of meeting the required allocations necessary to attain and maintain applicable water quality standards. The adaptive management approach was suggested by EPA as a way to avoid costly treatment upgrades before the PADEP develops its numeric criteria for nutrients. Actual implementation of the wasteload allocations is the responsibility of the permitting authority.

Comment 27: In developing the TMDL, did the USEPA or anyone else consider the secondary environmental impacts associated with phosphorus removal?

Response: No

Comment Letter #32: Hann for Lower Salford Comments on Indian Creek TMDLs

Comment 1: In developing the TMDL, did the USEPA evaluate or consider the cost of any treatment plant upgrades or expansion that may be necessary to meet the proposed TMDL nutrient endpoints, including, for example, the need to add/install denitrification filters or disk filters.

> **Response: EPA presented a Treatability analysis. This analysis was not point source specific and was envisioned to act as a resource for determining the appropriate implementation approach for meeting the wasteload allocations. The report did include treatment type information. The commenter may not have reviewed this report.**

Comment Letter #33: City of Harrisburg Comments on Paxton Creek TMDLs

Comment 1: Diurnal dissolved oxygen variation in the Harrisburg section of Paxton Creek is not the result of considerable biological activity indicating nutrient impairment. We request to review the data used to make this determination, as well as flow and ambient condition information in order to evaluate its validity.

> **Response: EPA reassessed the analyses presented in the existing TMDL report. In fact, EPA is revising the existing TMDL to consider the Authority's own TP projections after implementation of the LTCP. See our response to letter #55 and the General Response section for more information. This revision stemmed from an analysis of the time of travel in the lower section of Paxton Creek. The analysis showed that, in the lower channelized portion of the creek, there is a relatively short time of travel for nutrients to have significant impact on the water quality in the creek. All the data used for the development of the TMDL is in the public domain and will be available as part of the final TMDL deliverables.**

Comment 2: There is no data available to support that there is an increase in algal growth in the City section of Paxton Creek.

> **Response: EPA did revise the study area for the Paxton Creek TMDL to include loads from the upper portion of the watershed above Asylum Run plus the Authority's own projected TP loads after the implementation of the LTCP. See our response to letter #55 and the General Response section for more information.**

Comment 3: Benthic invertebrate study information is not available and was not used for the model; however, we do not believe such information is relevant, as the Harrisburg position of this waterway is not a creek, but a concrete-lined channel.

> **Response: The Susquehanna River Basin Commissions provided biological and chemical data for the watershed during the comment period. See the General Response section for our review of that data. EPA agrees with PADEP that the creek in the Harrisburg area needs to be protected for aquatic life. The LTCP considered the PADEP water quality standards, so there is no reason why the TMDL should not do the same.**

Comment 4: More research is necessary to verify that the results of extensive efforts made by the City of Harrisburg to reduce discharges to Paxton Creek will result in decreased impairment.

> **Response: Because the TMDL has been revised to allocate the TP load to the City based on their own expectations from implementing the LTCP, additional efforts are not expected.**

Comment 5: It may be in the best interest, from a cost-benefit perspective, to focus on Wildwood Lake's nutrient sink capabilities to sequester phosphorus and control flow to the

channelized section of Paxton Creek.

Response: Recent field observations and instream data do not support the claim that Wildwood Lake has capabilities to sequester phosphorus and control flow. This might have been true 20-30 years ago, however, considerable sediment deposits have changed Wildwood Lake into a flow-through system with insignificant pollutant trapping. The recent phosphorus instream data supports this fact indicting that concentrations before and after lake show no trapping efficiency.

Comment 6: The channelized section has been addressed by the Harrisburg Authority's Long Term Control Plan (LTCP) which was approved by PADEP in 2006. The LTCP addresses the 303(d) listed segment of Paxton Creek and satisfies EPA and DEP requirements for management and control of CSO discharges.

Response: However, the LTCP, although it identified TP as a water quality standard that needed to be addressed, it failed to consider TP simply because there were no numeric criteria. The LTCP failed to consider the narrative criteria and other nutrient considerations required by the PADEP. Therefore the LTCP failed to fully consider the listed segment for the pollutants for which it was listed.

Comment 7: There is no reasonable way to capture all of the water that periodically flows from the CSOs and MS4s without a huge investment of capital. This would be to meet loading levels that we believe are unattainable with available technology

Response: EPA notes that the May 21, 2008 letter projects a 14% reduction in CSO volume to Paxton Creek. Neither the TMDL nor apparently the LTCP expects a 100% capture as suggested by the comment.

Comment Letter #34: Harrisburg Authority Comments on Paxton Creek TMDLs

Comment 1: EPA has provided no data or other scientific support for the proposition that the Paxton Creek is in any way impaired by Total Nitrogen (TN) or Total Phosphorous (TP), nor has EPA provided any data or scientific support for the proposition that implementation of the TMDLs, and meeting the new load limits, would in any way improve the water quality of the Paxton Creek, reduce plant growth, or affect the invertebrate communities within the Paxton Creek. There is no evidence to support that the Authority's Combined Sewer Overflow ("CSO") events are contributing to increased periphyton growth and invertebrate population impairment in Paxton Creek. Proper modeling of plant growth in creeks must account for detention time, available light, the specific form of phosphorus present in the creek and the affect of scour at the elevated flows within the creek associated with CSO events. To this end, the flow from CSO events is conveyed to the Susquehanna River in a very short time period (approximately 1 hour) in a concrete-lined channel at scour velocities. Therefore, we question that phosphorus uptake is facilitated by CSO events.

> **Response: The main stem of Paxton Creek was reported on PADEP 303(d) list in 1996 and 2004 as impaired due to excessive nutrients caused by agricultural (1996) and urban runoff/storm sewers (2004). Additionally, Paxton Creek was also reported in 1998 as impaired due organic enrichment/low DO caused by urban runoff/storm sewers. After reevaluation and analysis of the time of travel in the concrete-lined channel, EPA decided to consider the Authority‘s projected TP loads following implementation of the LTCP and the loads form the upper portion of the creek between Wildwood Lake and the confluence with Asylum Run.**

Comment 2: EPA failed to consider or account for the data contained in, and the proposed TMDLs bear no relationship to, the Authority's Long Term Control Plan, approved by the Pennsylvania Department of Environmental Protection ("DEP") on February 1, 2006. The LTCP was prepared for the Authority's CSO facilities for compliance with the CSO Control Policy. The Authority's CSO Capture efficiencies are already in compliance with the DEP and EPA CSO Control Policies. However, the Plan recommended optimization of the CSO regulators and enhanced floatables control at each CSO location. These improvements will reduce overflow volumes even further and are estimated to cost the Authority $12,150,000.

> **Response: At the time EPA initiated the TMDL development for Paxton Creek, the Long Term Control Plan has not been published. On May 28, 2008 EPA received a letter dated May 21, 2008 from the Authority that summarized the data from the LTCP. This letter did not include sufficient for a full evaluation by EPA. See the response to Letter #55 and the General Response section for more information.**

Comment 3: The assigned literature value for the total phosphorus (TP) concentration of the Authority's combined sewer overflow (CSO) facilities used in the US EPA model appears to be erroneous. The model assumed a TP concentration of 3 mg/1. The Authority has analytical data from our CSO Management and Control Program which shows average TP concentrations during CSO events of approximately 0.6 mg/1.

Response: See the response to letter #55 and the General Response section. The May 21, 2008 letter from the Authority shows a CSO EMC of 440ug/L for overflows to Paxton Creek and not the 660ug/L suggested in the comment. EPA wonders which is correct.

Comment 4: The Authority will submit, as supplemental comments by April 30, 2008, as discussed in an EPA workshop on April 17, 2008, portions of the LTCP which will show, among other things, that the actual existing TP loading to the Paxton Creek is significantly less than the assumptions made in the Berger Group Report, leading to EPA's grossly overestimating the current TP load.

Response: It would have been helpful for EPA to receive the comments as promised. However, additional comments were not received until 28 days later. See the letter #55

Comment 5: To the extent that the Paxton Creek TMDLs are created to comply with the Consent Decree which resolved the litigation in American Littoral Society v. EPA, that Consent Decree required EPA to address impairment listings associated with the 1996 Clean Water Act §303(d) listing for Pennsylvania, in the event DEP does not publish a TMDL or determines that such listing was not supported. The 1996 listing did not determine that Paxton Creek was impaired by nutrients, rather that determination was only made in 2004. As set forth above, the 2004 determination of impairment is not supported by any data or scientific information.

Response: Please see the General Response #2.

Comment 6: The US EPA model is based on ten year average conditions and does not distinguish between growing season (April to October) and non growing season. Each of the Authority's 31 CSO facilities is observed and maintained daily and the Authority keeps record of the CSO occurrences for submission to DEP each year as part of our Annual Wasteload Management (Chapter 94) Report. It is apparent from the data collected over the years that the majority of CSO events occur during the non-growing season (November to March) which is not reflected in the TMDL.

Response: During the development of Paxton Creel TMDL, EPA constantly requested information on CSOs occurrences. It appears that PADEP did not have this information. Therefore, EPA could not include and use data on CSOs occurrences in the Paxton Creek TMDL. It should be noted that in the revised TMDL, EPA considers only the growing season for the development of the allocations. In addition, EPA considered in the revised TMDL the Authority‘s projected TP loads after the implementation of the LTCP and the upper portion of the creek between Wildwood Lake and the confluence with Asylum Run.

Comment 7: The TMDLs do not comply with current Pennsylvania law. Nutrients are only regulated by DEP to control excessive plant growth or excessive dissolved oxygen ("DO") caused by excessive plant growth. There is no evidence of any excessive plant growth in the Paxton Creek, and EPA has acknowledged that the DO does not exceed applicable limits, therefore the proposed TMDLs, even if the Authority were able to comply, would not result in

any changes to the creek.

Response: See General Response #2, the response to letter #55 and the EPA evaluation of the SRBC biological and chemical data in the General Response section.

Comment 8: The portion of Paxton Creek affected by our CSO facilities is in a urban land use setting and is essentially an urban stormwater drainage way. The vast majority of Paxton Creek affected by the Authority's CSO facilities is within a concrete lined channel with only the extreme upstream and downstream portions consisting of natural channels. We would not consider this a habitat for invertebrate populations.

Response: PADEP's letter of August 26, 2003 reminds the City that this section of the creek should be protected to achieve a viable aquatic life. This was done for the LTCP, there is no reason to do otherwise for the TMDL.

Comment 9: Enforcement of the TMDL is unclear and is a cause for concern. It is unclear whether the TMDL will be enforced based on an annual loading, growing season loading, daily loading or concentration basis. The Authority requested clarification on this issue at the April 17, 2008 meeting held at the Lower Paxton Township Municipal Building and EPA noted that this question could not be answered at this time as it will need to be clarified by the DEP permit writer. The answer to this question will have a huge impact on the Authority with regards to alternatives and cost. Furthermore, there may not be available technology to consistently meet the proposed limits.

Response: All implementation issues should be directed to the permitting authority

Comment 10: The Authority is extremely concerned with the cost to implement the TMDL. It is estimated that compliance with the TMDL as currently written will require a capital investment between 40 and 120 million dollars. These are very preliminary estimates based on information to date but in any case are excessive for improvements that the Authority sees as producing no demonstrable environmental benefit. These costs in addition to the costs associated with Chesapeake Bay Tributary Strategy compliance place an unprecedented financial burden on the Authority. The Authority would also incur significant operation and maintenance costs associated with chemical addition, sludge and screenings removal, power and operations of any new facilities required for TMDL compliance. These facilities would be dormant during the non CSO events, which is the majority of the time. This huge financial burden would need to be borne by rate payers, despite the fact that, as set forth above, no improvements to the creek would take place by implementing the TMDLs.

Response: Please see the General Response section. EPA has set the TP allocations to the CSOs in Paxton Creek equal to the Authority's own projected TP loadings after the implementation of the LTCP. See letter #55 and the General Response section. Therefore at this time there should be no additional cost to the City.

Comment Letter #35: Lower Paxton Township Comments on Paxton Creek TMDLs

Comment 1: The Paxton Creek TMDL is certain to impose high costs for compliance upon the Township and severely restrict growth within our community. Yet, with these high costs the TMDL, in the opinion of the Township, will not improvement water quality or the habitat for aquatic life within the stream.

> **Response: This appears to be an opinion without supporting documentation. Based on EPA's extensive analysis we believe that implementation of the sediment and nutrient TMDLs for Paxton Creek will be sufficient to restore the waters to a healthy and diverse aquatic community. The TP endpoint was determined based on that goal and the sediment TMDL was based on a watershed that is already unimpaired.**

Comment 2: EPA has failed to provide all relevant data to the Township to ensure that the proposed action was necessary to achieve standards compliance. As part of a meeting held with the affected municipalities on April 17, 2008, it was noted by EPA's consultant that certain relevant information had just been received. Also, it was stated at this same meeting that certain relevant information possessed by the City of Harrisburg was not even in the possession of EPA for use in developing the TMDL. The Township and all affected parties should be provided with all relevant data so a complete review of EPA's action is possible. Moreover, all relevant data should be included in the development of the TMDL.

> **Response: EPA, at the April 17, 2008 public meeting had recommended that the City provide any information they thought would be helpful from the City's stormwater Long Term Control Plan. On May 28, 2008 EPA received a letter dated May 21, 2008 from the Authority that included a brief summary of what was described as an extensive stormwater study. EPA was able to use some of the summarized information in the final TMDL. If the Township or City believes there is additional information in their possession that would help support their opinions, then that information and/or data should have been provided to EPA in sufficient time for EPA to evaluate it and include it, if appropriate, in the final TMDL report.**

Comment 3: From the information provided by EPA to date, it is apparent to the Township that the Paxton Creek TMDL has not adequately linked wet weather loadings in the stream to adverse plant growth in Paxton Creek, while the control of plant growth appears to be the overriding objective of the TMDL. In fact, the Township is unaware of any data showing that excessive plant growth exists in Paxton Creek

> **Response: The Susquehanna River Basin Commission provided data for Paxton Creek during the comment period. Please see EPA's evaluation of that data in the General Response section. The TP data shows a remarkable correlation with flow. Also see our response to letter #55 and the General Response section.**

Comment 4: The ambient data presented in the TMDL report shows that EPA's chosen nutrient standards are basically met throughout the watershed. Therefore, it does not seem possible that

80-90% reductions in phosphorus are needed for our MS4 communities.

> **Response: Percent reductions are based on total loading allowed and the existing loading from each source. One should understand that the higher the present loading the greater the percent reduction necessary to reach the goal. Most the instream nutrient observations in Paxton Creek were collected during dry-weather low-flow conditions. Therefore, using these dry-weather low-flow observations to estimate the anticipated nutrient removal is erroneous. EPA estimated the nutrient percent reduction using the results of a 10-year AVGWLF simulation that account for dry-weather and wet-wet loads. In addition, EPA is using in the revised TDML more recent land use distribution in the Paxton Creek watershed.**

Comment 5: Lower Paxton Township believes that the Paxton Creek TMDL may be seriously flawed and based on unsupported assumptions, rather than documented facts or demonstrated environmental need: As such, the Township requests that "the Paxton Creek TMDL be withdrawn in its entirety by EPA.

> **Response: EPA appreciates the Township‘s comment, but is not prepared to withdraw the TMDL. We have made some modifications to the proposed draft based on comments received higher we believe that the data and information available to EPA and the evaluation of that data is sufficient to support the TMDL results and requirements. Paxton Township has not presented any supporting data and/or evaluation that convince EPA that the TMDL is in error.**

Comment Letter #36: Lower Salford Township Comments on Indian Creek

Comment 1: The Township is dismayed by the short response time allowed to comment on what appears to be imminent adoption by the Agency of a severe regulatory burden. The Board of Supervisors has been given insufficient time to engage appropriate professional assistance to thoroughly examine the proposal and make meaningful observations as a MS4 permittee on the specific proposals outlined therein. Only one workshop meeting of the Board has occurred in this time frame where the elected local representatives have had an opportunity to discuss the proposal on behalf of their citizens.

> **Response: Since this is the same comment as Comment Letter #25, please see EPA's response to Comment Letter #25**

Comment 2: It is also especially noted that PA DEP, at various educational seminars for the MS4 program, and as late as a presentation at a recent meeting of the Upper Bucks-Montgomery Community Affairs Association (an organization of 70 local governments) has denied that nutrient limits were to be made part of the MS4 program. This fact is contradicted by Appendix F of the document where Phase II of the Agencies recommended implementation, beginning June 2008, requires that "All permits issued during Phase II must contain effluent limits consistent with the established TMDL." This document is the first notice that the EPA has provided to the MS4s of the Indian Creek that it will require DEP to regulate MS4's toward these limits, effectively in five weeks from this date.

> **Response: Since this is the same comment as Comment Letter #25, please see EPA's response to Comment Letter #25**

Comment 3: In the Executive Summary, page ii, it states, "Because the entire Indian Creek watershed is covered by areas within 5 Municipal Separate Storm Sewer Systems (MS4s), all allocated loads are assigned to the Waste Load Allocation (WLA) category." This assignment, although to be adjusted within the NPDES process when WLA may be reclassified as Load Allocation (LA), suggests a basic contradiction in that between 70% & 80% of the watershed areas within Franconia and Lower Salford Townships are either in use as agricultural, large lot residential, or are lawn areas that, by design, bypass the MS4's collection systems. These areas are then, by EPA's own definition, non-point sources and ultimately are not within the MS4 permit's jurisdiction to manage, nor is there any regulatory authority allowable to the MS4's in view of the PA Agricultural Security Act to implement strategies to control agricultural non-point source nutrient laden runoff to meet reduction goals of the magnitude stated. In short, the EPA proposes the MS4s to manage the waste load reduction goals on areas of the Townships, which may constitute only 20% to 30% of the watershed runoff, a statistical impossibility.

> **Response: Since this is the same comment as Comment Letter #25, please see EPA's response to Comment Letter #25**

Comment 4: The Executive Summary further states, "This TMDL.. .as not meeting aquatic life uses.. .and loading targets established using a reference watershed." At the public presentation a watershed being 80% forested, adjusted to 70%, was noted as used for purposes of establishment of these criteria for the Endpoints. This is quite unlike the Iron Run watershed listed in the study,

which in itself has a 35% forested cover, much beyond the 3-4% coverage of the Indian Creek. If the goal, i.e. Endpoint, being established is to create a watercourse ecology equivalent to this hypothetical 70% forested watershed, virtually pristine, it is not comprehensible that the Indian Creek watershed, historically and currently in extensive agricultural use for over a 300 years from settlement by Pennsylvania German immigrants, should be required to meet such nutrient criteria in order to meet Congress's intent for fishable, swimable waters. The EPA sets the bar much too high with the 70% forested stream ecology goal, and without any rational justification, contradicts the EPA requirement for "reasonable assurance that the TMDLs can be implemented" in Chapter 6 of the report.

Response: Since this is the same comment as Comment Letter #25, please see EPA's response to Comment Letter #25

Comment 5: To that end it is not clear what "designated aquatic life uses" are tangible targets to be supported in the adoption of these criteria, or expected to be produced, other then water clarity not seen since before the pre-Columbian native Indian population cleared the land for their fields. The target of a 70% forested stream ecology, and the single emphasis on algae growth, is not correlated with the actual historical fish and fauna populations of the watershed, to the extent that such exist and have been viable with historical water levels. The public presentation included a slide in which the designated use was to "Provide habitat and ecological services as a trout stocking fishery." The Indian Creek has historically never had a trout population, nor with its slow moving current, high ambient temperatures, absence of oxygen enriching rapids or forested banks, is it conceivable. Yet the realistic, and in historical terms, only possible fishery of warm water species such as bass, perch, minnows and other warm water species, are more indicative of what is endemic and supportable in the Indian Creek. No studies for such local species appear to have been considered nor were the nutrient limits that such warm water species tolerate presented. The Endpoint standard for a cold water fishery for trout populations may well drive the TMDLs to unrealistically and unsustainable high nutrient limits, beyond that required to support the historical uses of the watershed. The resulting over-regulation may have impacts on the surrounding land uses, residential, recreational and agricultural, without realistic benefit to the stream ecology. In fact, such overreaching may very well divert much energy and resources from more attainable goals in addressing the larger non-point problem.

Response: Since this is the same comment as Comment Letter #25, please see EPA's response to Comment Letter #25

Comment 6: The presentation listed as a slide the model's intent to simulate interactions among nutrients, dissolved oxygen and algae. Yet all the sampling areas are on the main spine of the waterway, beneath the outfall(s) for the Telford and other Treatment Plants where treated effluent would have a dilution effect on the base nutrient levels ambient to the watershed. The model does not appear to separately model and calibrate the effects of runoff from the contributing low flow, and intermittent flow, tributaries where significant effects of agricultural and lawn fertilizers can be expected to have different characteristics for different seasons and water levels, contributing to that ambient, or background nutrient levels in surges of their own characteristics rather then the hydrological characteristics of the main stream. In short, the model may undervalue the effects of the 70-80% of land area that contributes nutrient runoff as non-

point direct flows into the waterways systems, and overvalue the possible results of drastic reductions to the limited point source flows.

Response: Since this is the same comment as Comment Letter #25, please see EPA's response to Comment Letter #25

Comment 7: Also at the presentation a question was raised on the collection of information regarding the modeling of the direct and indirect contribution of failing on-site septic systems in terms of both Phosphorous and Nitrogen. A rather cavalier answer suggested that a general parameter was applied but that no direct equation, data samples or analysis was included. Yet, a DEP supported study within Franconia's portion of the watershed found over 40% failing or malfunctioning systems where visible observations provide testimony to direct, often on the surface, discharges into tributary watercourses. It has been said by others that the EPA assumptions in the model is to provide that all on-lot discharges are to be accepted as being successfully land treated, yet the extensive areas of large lot on-site septic systems would certainly require a separate mathematical formulation to fit these unique challenges to the watershed. In sum, the effect of the failed or mal-functioning septic systems, coupled with the watersheds high shale level, shallow topsoil and underlying clay layers may also mean that the present model undervalues the non-point impacts thereof. Similar characteristics do not appear to exist on the stated 70% forested watershed.

Response: Since this is the same comment as Comment Letter #25, please see EPA's response to Comment Letter #25

Comment 8: In particular interest is the application of some limits on sediment production. The model appears to address such but does not explicably account for the extensive historical storage of sediments from 300 years of current culture and pre-historic farming, which become dislodged during high water events. It would appear that with even perfect controls on point sources that existing banks of sediments, some loosely protected by vegetation during minor rain events, would be cause to distrust main stream sampling results for regulatory confirmation. Such limits would appear to be of questionable value in strict numeric terms rather then the current construction site controls, the only manageable area of sediment control available to MS4s.

Response: Since this is the same comment as Comment Letter #25, please see EPA's response to Comment Letter #25

Comment 9: It needs to be also noted that during the presentation the modelers were asked if any demonstration projects had successfully shown that such results are attainable. None were known, leaving us to suspect that this project is intended as an 'experiment', with indeterminate unfunded municipal investment required to implement, with no assurance that such projected watershed water quality improvements can indeed be made. Although the Agency disavows any Federal interest in the cost, it must be stated that on the local level this unfunded fiat appears to require significant increased financial resources from the taxpayers without their local representatives being assured of the purported benefits or being provided sufficient time to effectuate remedies.

Response: Since this is the same comment as Comment Letter #25, please see EPA's response to Comment Letter #25

Comment 10: A minor point, hopefully not indicative of the care in preparing the information for input into the computer model, is that Upper Salford Township is listed as having a small contribution to the watershed where a careful examination of the USGS Quadrangle Map for the area, and a field inspection, indicates that no portion of Upper Salford contributes to the Indian Creek Watershed. It lies entirely in Franconia and Lower Salford Townships with the urbanized area of Telford and its STP forming the headwaters. Additionally, the report states "approximately 23% of the watershed can be classified as either row crops or pasture" or at another location "36.13%" is stated as Hay/Pasture in a chart. Similar nutrient loading is assumed for both row crops and pasture yet the Soil Cover Complex method applies different runoff characteristics of pasture (or is it meadow, another level of runoff soil cover generation) than to row crops. This ambiguity on what agriculturally cover was actually modeled, both in type and extent, might also be indicative of the model undervaluing the amount of nutrient non-source loading that high intensity summer thunderstorms may be expected to generate from the high levels of row crops, the exact period of interest for the regulatory agencies.

Response: Since this is the same comment as Comment Letter #25, please see EPA's response to Comment Letter #25

Comment 11: In summary, the establishment of nutrient limits in an attempt to duplicate that one would find in a 70% forested watershed, or even a 35% watershed, ignores the reality of the continuing agricultural basis for land use in the watershed. The EPA ignores the cultural history of the local Pennsylvania German people to believe otherwise. Also, a trout fishery is not historic, nor a practical use of the Indian Creek given the other physical limitations of the watershed. Therefore, the Endpoints are not realistic, and the nutrient limits proposed are for some other, non-supportable use.

Response: Since this is the same comment as Comment Letter #25, please see EPA's response to Comment Letter #25

Comment 12: The EPA further states is seeks input in regard to the Endpoints in regard to Nitrogen, while yet admitting that the science does not support its contribution to the control of algae, therefore again the establishment of a high, arbitrary limit is not supportable, but merely an exercise in the expenditure of resources better addressed to the non-point sources, a goal we can all agree on. Sediment should also be eliminated as an Endpoint, at least as to being a measured limit. It is understandable to be concerned with its effect locally and downstream. However, one must question whether it can be successfully regulated on a strict basis of sampling measurements. It is far better that other means be employed, such as the current MS4 practices on construction controls, now in place for over 30 years and again, some measures with non-point sources which remain legally beyond the ability of the MS4s to address, and are not a issue with the watersheds STPs.

Response: Since this is the same comment as Comment Letter #25, please see EPA's

response to Comment Letter #25

Comment Letter #37: Gateway (Mt. Oliver) Comments on Sawmill Creek TMDLs

Comment 1: The model used to determine the amount and sources of total phosphorus and total nitrogen assumes the only sources are CSOs, stormwater runoff and groundwater. The model simulation does not account for the SSOs present in the watershed that will be eliminated in their entirety as part of the consent order work that is taking place in the watershed. Currently flow monitoring and modeling is taking place under the consent order to verify the quantity of CSO and SSO discharges to the watershed. Depending on the quantities determined, significant changes in the model for source reduction could occur since SSOs would most likely be the highest concentration of phosphorus and nitrogen in mg/1. Elimination of the SSOs may have a significant impact on the amount of CSO, stormwater, and groundwater reductions to achieve the desired removal.

Response: Since this is the same comment, please see our response to Letter #11

Comment 2: The model assumes the CSO volume to be 30% of the urban runoff. The CSOs in this watershed are fed from municipal sewers in which some of the municipal sewers are combined and many are separate sewers. The model CSO volume should be adjusted after the flow monitoring and modeling are completed to determine an accurate quantity of CSO discharge volumes as well as accounting for the amount of reduction to be achieved as part of the consent order requirements.

Response: Since this is the same comment, please see our response to Letter #11

Comment 3; In the CSO discharges, the concentrations of total nitrogen and total phosphorus are assumed to be 9 mg/1 and 3 mg/1 respectively. This is a standard number used for combined sewer discharges. The sewers contributing to these structures are a combination of separate and combined sewers that would most likely lead to higher concentrations at the discharge. This higher concentration would also affect by the amount of reduction to achieve the levels required.

Response: Since this is the same comment, please see our response to Letter #11

Comment 4: The report does not provide a justification for the use of the 0.04 mg/1 standard for total phosphorus. The report also does not provide justification that if this value is achieved, the goal in respect to the aquatic life and water quality will be achieved. There is not sufficient data to backup this level of reduction.

Response: Since this is the same comment, please see our response to Letter #11

Comment 5: The total nitrogen TMDL should not be included since the report itself does not provide the justification for establishing a limit. In reality according to the report, the existing total nitrogen concentrations are below the target concentrations. In addition, Pennsylvania should not be establishing requirements for total nitrogen until scientific proof has been established tying total nitrogen concentrations to periphyton densities.

Response: Since this is the same comment, please see our response to Letter #11

Comment 6: In the report, it states that all of the 14 communities in the watershed have MS4 permits. This is not the case, Crafton is a combined community and does not and is not required to have an MS4 permit.

Response: Since this is the same comment, please see our response to Letter #11

Comment 7: It is our opinion that setting TMDLs for total phosphorus and total nitrogen is premature due to the extensive work occurring with the sanitary sewers in the region as part of the consent decree issues to all communities in the ALCOSAN sewer system. Data is currently being collected to better refine the model used to determine the target concentrations from the various listed sources. At a minimum, the model should be adjusted once all of the data is in, and should account for the improvements required under the consent decree to determine if and how much of a reduction would be required from each source.

Response: Since this is the same comment, please see our response to Letter #11

Comment Letter #38: Mt. Oliver Comments on Sawmill Run TMDLs

Comment 1: Although we generally support the water quality restoration of Sawmill Run, we feel that this report is not appropriate as it relies on significant generalizations when the report should be based on information representing the actual Sawmill Run Watershed. This is especially pertinent since our region is currently under an EPA Consent Order and we are in the process of collecting data that can be used to report this watershed's characteristics and quality. There will be no need for the generalizations, estimates and assumptions used in the draft report you are proposing to use to generate TMDLs.

Response: Since this is the same comment, please see our response to Letter #10

Comment 2: As you know, the financial impact to our residents, to implement the reductions you are proposing will be substantial. We insist that you reconsider your position and allow time for the current consent order requirements be implemented and a subsequent TMDL report be developed based on actual watershed conditions.

Response: Since this is the same comment, please see our response to Letter #10

Comment Letter #39: Pennsylvania Department of Environmental Protection Comments on Chester Creek, Southampton Creek and Indian Creek TMDLs

Comment 1: With respect to phosphorus, the Department supports the approach that EPA used as an interpretation of the Commonwealth's narrative criteria.

> **Response: Thank you for your support on the approach used to establish the TP endpoints**

Comment 2: EPA has requested comment on whether total nitrogen endpoints are appropriate in these TMDLs. The Department does not have sufficient evidence at this time to support the inclusion of TMDLs for total nitrogen in these watersheds.

> **Response: See General Response #3**

Comment 3: Based on the Department's review of the draft Chester Creek TMDL, the Department is submitting additional data to ensure your records are complete.

> **Response: See General Response #9**

Comment 4: EPA has allocated a total of 1% of the TP load, or 0.12 lbs per day, to small flow facilities, which equates to 1.86 mg/1 TP. The Department believes that these small flow facilities likely discharge between 4-5 mg/1 TP, so it may be more appropriate to allocate them 2-3% of the TP load for a true representation of their allocation.

> **Response: Since this applies to the Chester Creek TMDL and that TMDL has been modified to include Goose Creek only, this comment has been addressed.**

Comment 5: The Department requests that the interim nutrient control limitations, found in the Appendices of the TMDLS referring to suggested adaptive implementation strategies, be incorporated into the body of the TMDLs. This recommendation is consistent with EPA's Memorandum of August 2, 2006, titled "Clarification Regarding "Phased" Total Maximum Daily Loads. This Memorandum states that Phased TMDLs may occur when a revision of the applicable standard is underway and will necessitate development of a second phase, revised TMDL to comply with the new standard. Given the three phases identified in the implementation strategies, these TMDLs fit within the intent of the memorandum and the phased TMDL approach should be a fundamental part of the TMDLs.

> **Response: EPA believes that the implementation approach suggested by EPA is an implementation issue and therefore more reasonably resides in an Appendix to the TMDL and not the main body of the report. Note that the Appendix is a full part of the TMDL.**

Comment 6: In addition, the Department recommends that EPA more fully develop a phased approach on how to attain compliance with the phosphorous wasteload allocations for MS4s.

> **Response: We will pass this comment on to the permitting program. The TMDL is**

not required to include specific implementation issues. This should be addressed by the appropriate program.

Comment Letter #40: Paxton Creek Watershed and Education Association Comments on Paxton Creek TMDLs

Comment 1: We are pleased that TMDLs for this stream now exist, even in draft form. They are measurable water quality targets. They place the weight of the Federal government, hopefully as future partners, for local water quality improvement. Adjustments still may occur as to TMDL scope (considerations of other pollutants), magnitudes (amounts of pollutants), modeling capabilities (strengths and weaknesses of calculation techniques, and procedures), and data used, but the final TMDLs will be goals for comprehensive actions to remedy some of the watershed's ills. We thank you, indeed, for the TMDLs!

Response: Thank you for your statement of support

Comment 2: We feel a little chagrined to criticize something basic to the watershed's improvement, but if you thoughtfully consider what we say, and use some of our information together with data from our Targeted Watershed Grant partner, the Susquehanna River Basin Commission, it will allow better reports and final TMDLs to be produced.

Response: EPA fully considers all comments. SRBC did not provide any data to EPA until the TMDL comment period. We have considered that data in the final TMDLs.

Comment 3: Get real. It is unrealistic to receive meaningful input from watershed stakeholders: when information solicitation overlooks major resources, and/or the information dispersal is poor (e.g., an announcement was made to the public only halfway through the month following the TMDLs release); even the municipality where the public meeting was held did not know about the TMDLs until just before the gathering; crucial watershed management organizations (municipal governments, county agencies, and others) were not notified until then, or not at all; no contacts apparently were made to these parties during the data collection phase and TMDLs formulation. Past communication and information exchange in the TMDL process would be a joke, if it were not so sad.

Response: EPA followed the established procedures for notifying stakeholders of the TMDL availability. EPA did extend the comment period and held a second public meeting to assure everyone had sufficient opportunity to comment.

Comment 4: Some numbers are screwy, and need to be reworked**.** Numbers are what drive TMDLs, but they have to be accurate and representative. Errors can cause watershed stakeholders to pay a lot more to fix the problems. Just to illustrate the situation: the watershed has three separate agricultural security areas (and the participating farmers were hard-pressed put together the 306 acres to qualify). Yet, the report says that this small portion of agricultural land contributes 37% of the erosion in the 27+ sq. mi. watershed. (The report says the sediment is mainly from croplands, but most of these are livestock farms!).

Response: In the revised TMDL, EPA incorporated the recent land use data found in the Act 167 Plan for Paxton Creek. This new data will reflect more accurately the existing farmland areas.

Comment 5: The same report says that 16% of the sediment from Swatara Township needs to be removed, but Swatara Township occupies only 0.45% (less than half of 1 percent) of the watershed). This municipality has so minor a land area in the watershed, that it is not even listed in many statistical tables for the watershed.

> **Response: The report mentions that 16 percent sediment reduction is needed for Swatara Township. The report never implied that the Swatara Township sediment contribution is 16 percent of the total load in the watershed. In fact, Table 5-4 clearly indicates that the sediment contribution from Swatara Township is just 0.15% of the total sediment load from the watershed (5 tons/year from Swatara Township out of a total of 3,441 tons/year form the entire watershed – Table 5-4).**

Comment 6: Several years ago the watershed measured an average 30% impervious coverage (over 59% in Harrisburg and Penbrook Borough). It is erosion by stormwater from impervious surfaces that is causing many of the present problems, not erosion from farms. For new residential developments municipalities permit up to 35% of the lands to be impervious, and up to 75% for commercial developments. With this amount of expanding impervious surface, it will be almost impossible for municipalities to meet their nonpoint source MS4 goals, and the TMDLs without major changes in ordinances and ways of handling stormwaters.

> **Response: EPA is aware of the challenges facing MS4s municipalities to meet the proposed nonpoint sources goals. Recommendations for modification in stormwater ordinances can be made during the TMDL implementation. It should be also noted that in the revised TMDL, EPA incorporated more recent land use data found in the Act 167 Plan for Paxton Creek that will reflect more accurately the urban areas in Paxton Creek. The townships need to consider smart growth.**

Comment 7: The best available data were not used. The TMDLs appear to be based upon limited water samples collected over a decade or more in small parts of the watershed. Maybe, the TMDL efforts did include part of the Macros Blitz study conducted in March, 2004 when PCWEA got five professional organizations together to conduct simultaneous sampling for chemistry analyses (30 parameters) using the same procedures, with an aquatic macroinvertebrates (water bugs) survey under Rapid Bioassessment Protocol Level III (a very high assessment) at 24 sampling sites throughout the watershed. The TMDL reports did not mention water bug data, however, an important omission. Most water sampling gives results limited to moments in time when the samples are collected; the bugs assessment constitutes a "faunal memory," where the abundance and diversity of the critters can indicate past stresses (such as a poison flowing through the creek), and give an overall perspective on how well biota (various life forms) in the stream are doing. More recently, during the last 18 months, our partner, the Susquehanna River Basin Commission (SRBC) monitored the watershed 8-9 cycles for 11 physico-chemical parameters (including suspended solids, nutrients), the water bugs (2 cycles), water levels, and flows. Pollutant loads can be easily determined from these data - actual, empirical, real world data. To your credit, the USEPA requested data from SRBC, extended the TMDL comments period, and apparently scheduled another public meeting.

> **Response: In the existing TMDL report, EPA did include and analyze PCWEA chemistry data in Chapter 3 Section 3.1.1 where all the dry-weather data were lumped**

and assessed together. Since EPA received these data from PADEP it was erroneously labeled as PADEP-2004 data in Figure 3-1. EPA will correct this in the revised TMDL and acknowledge PCWEA efforts in restoration of Paxton Creek watershed. EPA did receive and analyze PCWEA data from the aquatic macroinvertebrates survey. The analysis of PCWEA macroinvertebrates data was not conclusive and showed some discrepancy. Therefore EPA did not include it in the existing TMDL report. In the revised TMDL report EPA will include PCWEA macroinvertebrates data. EPA requested and received, during this comment period, the biological data from the Susquehanna River Basin Commission (SRBC). SRBC conducted biologic monitoring on two occasions at eleven stations in fall 2006 and twelve stations in spring 2007. These new data are included in the revised TMDL report. The results of the SRBC data analysis clearly show that the impaired segment of Paxton Creek provides a poor habitat for macroinvertebrates and does not support its aquatic life use goals. See the General Response section that evaluates this data.

Comment 8: Agriculture is not the main source of nutrients or sediment. Agriculture was a principal source of pollutants for 2 1/2 centuries in Paxton Creek. Today, agriculture is almost gone from urban-suburban Paxton Creek watershed. Land development in the past half century has changed most remaining farmlands into buildings, parking lots, roads, and other developments with impervious surfaces. These surfaces cause precipitation (stormwater, snowmelt) to run off the landscape into Paxton Creek, where the waters erode surface lands, swell the creek, cut its bottom and banks, and create further misery downstream (clogged waterways, less lake depth, smothered habitat, floods). The nutrients are mainly coming from yard fertilizers, animal waste, and leaks from cracked or open (combined) sewers. Again, impervious surface is the bane of Paxton Creek!

Response: In the revised TMDL EPA incorporated the recent land use data found in the Act 167 Plan for Paxton Creek to reflect the existing conditions. This new data will reflect more accurately the existing urban areas. It is hoped that in order to meet the sediment TMDL requirements, not only land runoff of sediment but bank erosion will be controlled. This can be done by the reduction of runoff flow volume and velocity, thereby reducing stream bank erosion.

Comment 9: The reports recognize remediation projects from only one source, and they are not the majority. The Paxton Creek Targeted Watershed (TWO) grant for $1.5 millions (matching) administered by SRBC is a grand effort, but it will result hi only 5-6 projects with associated monitoring, education, and other actions. PCWEA, the community college, Boy Scouts, municipalities, and other partners have built more than another dozen stormwater management facilities in the last 4 years. These projects are of a wide variety: stream naturalization (channel rehabilitation), bioretention areas, rain gardens, riparian buffers, swales, retrofitted detention basins, a soak-a-way (infiltration terrace), and other best management practices (BMPs). In the watershed another 4-6 projects are to be built during the next two years, besides those of the TWO.

Response: Thank you for identifying on-going activities. The TMDL briefly discusses implementation activities but is not required to do so in detail.

Comment 10: The recommended best management practices are overly general, and need direction concerning watershed needs. The BMPs suggested hi the TMDL reports are neither complete, nor show the complete scope suited to the watershed. Paxton Creek has undergone several great transformations: partial forest clearance, farms and small industries, residences and major industries, transport, commercial, and governmental centers, but the changes are not consistent throughout the watershed. These differences prompted PCWEA to develop a plan that addresses watershed management in the context of 11 subwatersheds, each with its unique requirements for remediation and enhancement (emphasis upon creek buffers where channel degradation has been minimal, as hi headwater areas; rain gardens, bioretention areas, and other BMPs where impervious surface area is moderate; retrofitted detention basins, Low Impact Development (LID)-based infill, and other BMPs hi areas with extensive impervious surface). Over 10 different best management practices hi various combinations, employed in a two-prong strategy (LID implementation, and impervious surface/other retrofits) together with appropriate educational programs, are being used in specific areas of the subwatersheds. For more insight see the Rivers Conservation Plan on the website www.paxtoncreek.org

Response: Thank you for this additional information.

Comment 11: Some report narratives at times are what consultants call "boilerplate" with limited usefulness. Some sections of the TMDL reports for nutrients and sediment have essentially the same words. The sections are the same from the beginning to the end, except for where the word "sediment" needs to read "nutrients," and vice versa. It is fine for the consultants (report authors) to do this to save time, money, and effort, but there is a danger that insufficient attention will be paid to unique aspects that warrant additional attention. This happened in the Paxton Creek reports on TMDLs, where the words are exactly the same in Section 6.2.2 concerning Existing Projects, and elsewhere such as in the reference lists, Section 8.0. The nutrient TMDL report lists 3 more in-house (USEPA) publications than does the sediment report, but neither contains several important documents for Paxton Creek watershed itself such as: the *Act 167 Stormwater Management Plan for Paxton Creek* which includes stormwater management modeling, and BMP considerations; the *Paxton Creek Rivers Conservation Plan* of 2006, which has lots of information on watershed characteristics, an educational chapter, discussions on problems, impervious surfaces, projects, and over 100 strategies and tactics for dealing with the TMDL-related conditions in the watershed; the Paxton Creek Roundtable (Builders for the Bay) document of 23 LID-type principles or guidelines that resulted from months of discussions among local developers, municipal officials, and environmental groups; the many reports of surveys and analyses of the 52+ linear miles of the creek corridors for erosion, and riparian landscapes for pollutant sources with opportunities for correcting the creek's problems; the educational brochure *Are You Loving Paxton Creek To Death?* fact sheets, and slide shows that various stakeholders can use to improve the creek around them. Most are available online, again, at www.paxtoncreek.org, and the website for the Center for Watershed Protection at hhtp://wwwxwp.org/Comrnunity_Watersheds/Paxton/paxtoncreek.htm One has to ask, did a "boilerplate" approach and mentality get in the way of the best considerations and analyses for Paxton Creek? Paxton Creek, this watershed upon which the capital of the great state of Pennsylvania was built (see its history, briefly covered in the Rivers Conservation Plan with appendices) d-e-s-e-r-v-e-s better.

Response: The TMDL must meet the requirements of the CWA Section 303(d) and 40

CFR Section 130.2. One of the requirements is to provide a complete inventory of all pertinent information and data related to the waterbody. This might cause some redundancy in the information presented for separate TMDLs for the same waterbody. In the revised report EPA included and referenced all the information mentioned in this comment including the Act 167 Stormwater Management Plan for Paxton Creek.

Comment Letter #41: Pittsburgh Water and Sewer Authority Comments on Sawmill Run TMDLs

Comment 1: The Pittsburgh Water and Sewer (not Sanitation) Authority (PWSA) is offering the following comments on the proposed Saw Mill Run TMDL. In general, we are disappointed with the lack of data used in generating the proposed limits and the number of assumptions made. As part of its CSO project, the PWSA developed a detailed hydraulic INFOWORKS model of its collection system. This model was calibrated using approximately 420 ADS flow monitors. The results of this model provide a great deal of information regarding discharges from PWSA and ALCOSAN CSOs in the Saw Mill Run watershed.

> **Response: On April 19, 2006 EPA met with representatives of ALCOSAN and the City of Pittsburgh to discuss the TMDLs. We took that opportunity to describe the TMDL process, the goals of the TMDL and the need to coordinate with the LTCP process. At that time we asked the City and ALCOSAN to provide any information that would help with the coordination, including any source identification or location, stream data, effluent data, storm data, modeling information or any other pertinent information. We did not receive any input from ALCOSAN. The TMDL results can be evaluated in the LTCP process going forward and individual allocations adjusted by the state as new information becomes available and as necessary.**

Comment 2: On Page 2-25 of the TMDL report it is stated that there is no information characterizing the volume or concentrations from these outfalls (CSOs). This statement is incorrect. The PWSA has generated modeled overflow statistics for 2004, 2005 and 2006 and is currently developing statistics for 2007 as part of its CSO Annual Report. The 2004, 2005 and 2006 data has been submitted to the Pennsylvania Department of Environmental Protection under the requirements of our NPDES permit. PWSA has determined that the amount and characteristics of precipitation events during 2005 represent typical annual conditions.

> **Response: The TMDL was developed based on the best available data. In the revised TMDL, the CSOs volumes were revised using monitoring data found in Appendix B of 2006 Statistics for Permitted CSOs**

Comment 3: Table 5-1 in the TMDL report states that the Existing Load from CSOs is 18,722 Ibs/year. Assuming the 3.0 mg/L Total Phosphorus concentration in CSO discharges used in the report, this number equates to a yearly CSO volume of 684 million gallons. Based upon model simulations, PWSA's typical "rainfall" year estimates annual CSO discharges to Saw Mill Run equivalent to about 57% of this volume. Hence, we contend that the estimated Total Phosphorus load from all CSOs in Saw Mill Run is significantly overstated.

> **Response**: **In the revised TMDL, the CSOs volumes were revised using monitoring data found in *Appendix B of 2006 Statistics for Permitted CSOs*. These data indicate that the annual CSO volume in Sawmill Run is approximately 422 million gallons.**

Comment 4: A reduction to an allocated Total Phosphorus Load of 1.77 lbs per day from CSOs as presented in Table 5-6 of the TMDL is equivalent to a 94% reduction in CSO volumes basin wide. A 94% reduction in CSOs will have a significant impact on the costs associated with any CSO Long Term Control Plan. Based on the above paragraph, the PWSA asserts that the computation of existing loads and load allocation should be re-evaluated based upon CSO volumes that are more representative of the Saw Mill Run situation. We feel that a much better understanding of the load allocation needs to occur.

> **Response: EPA revised the CSO annual volume in Sawmill Run using more representative information found in *Appendix B of 2006 Statistics for Permitted CSOs***

Comment 5: Given the extremely limited nature of the effluent and in-stream sampling, we are concerned that the data collected may not be reflective of typical conditions or years and may not be sufficient to verify the accuracy of the assumptions made in the analysis.

> **Response: EPA believes that the existing instream data and the use of a 10-year simulation to develop the allocations, is sufficient to capture the existing loading conditions in Sawmill Run.**

Comment 6: Table 2-10 lists Permitted Discharge Facilities. There is no data provided for these dischargers and there is no indication that these discharges have been factored into the analysis.

> **Response: These dischargers are not permitted for nutrients. Therefore they were not considered in the analysis.**

Comment 7: In Section 6.2, the document states that "Implementation of best management practices (BMPs) should eventually achieve the loading reduction goals established in these TMDLs." The PWSA disagrees with the above statement and requests information that supports this assertion.

> **Response: PWSA is currently working on developing its long term control plan (LTCP). The LTCP is a good example of BMPs that can be implemented to reduce the nutrient loads towards the projected nutrient TMDL developed during this project. EPA would be interested in knowing specifically why the commenter disagrees. Since the commenter did not provide data or any evaluation that supported his opinion EPA cannot directly respond.**

Comment Letter #42: Pennsylvania Municipal Authorities Association Comments on Chester Creek, Indian Creek, Paxton Creek, Sawmill Run and Southampton Creek TMDLs

General Comment 1: We are particularly troubled by EPA's intervention in PA's water quality standards development process, by virtue of EPA's unilateral interpretation of the narrative criteria in 25 PA Code, Ch. 93 in the form of numerical instream criteria for nitrogen and phosphorus. This new interpretation differs dramatically from adopted DEP procedures, historically applied by EPA, in developing other nutrient TMDLs. This type of radical change must undergo rulemaking before it is used in the regulatory program. Further, the array of methodologies used by EPA to derive such criteria (characterized as a "weight of evidence" approach) seems to represent an attempt to make the means justify a predetermined endpoint that has little relevance in the case of these five streams.

> **Response: EPA objects to the implication that we were more than forth coming in the development of the endpoints. We do not believe such accusations deserve a response.**

General Comment 2: The inclusion of Nitrogen as a parameter of interest for nutrient-related TMDLs essentially represents a "guilt by association" approach, which has little scientific merit. It will result in huge expenditures of public funds for no valid purpose and we believe it should be dropped entirely from these and any future TMDL efforts.

> **Response: See General Response #3**

General Comment 3: We are also very concerned over the lack of supporting data and analysis presented in these TMDL reports pertaining to the actual impact of nutrients in the "impaired" segments. If nutrients are having major impacts on the aquatic ecosystem, why is there so little information presented about the actual impacts (e.g. nuisance algae, diminished species diversity, etc.) or the areal extent of those impacts, particularly upstream vs. downstream from point source discharges? It would appear that there is little meaningful scientific documentation available.

> **Response: PADEP conducted standard stream surveys of all waters as a basis for identifying impairments and the pollutants and sources causing those impairments. That data can be obtained from PADEP. Much of it is summarized in the TMDL reports. Did the commenter comment on the state‘s section 303(d) lists when they were proposed in 1996, 1998, 2002, 2004, 2006 and 2008 and requested that data at that time?**

General Comment 4: DEP's integrated water quality monitoring and assessment report (2006) List 4.c indicates that significant impairments have occurred within some of these watersheds due to hydrologic impacts from various land use activities. It seems quite likely that such impacts will continue to occur, even though not subject to a TMDL, and that any TMDL-related improvements will be rendered meaningless.

> **Response: So we are to ignore what we can do now because no one is expected to control impacts in the future? That seems to be a _hide-your-head-in-the-sand‘**

approach. Impacts from land use activities need to be controlled. We hope that the sediment TMDLs will be a way to address the issues of hydraulic impacts, such as increased runoff flow and velocity and decreased infiltration. These increases in impermeable lands increase runoff to streams which include increased sediment loads. It also increases stream velocities during storm events which increases stream bank erosion, increasing stream sediment loads.

General Comment 5: If these proposed TMDLs are adopted in their present form, and if the PA Department of Environmental Protection attempts to enforce the related wasteload and load allocations, we believe that this will result in prolonged litigation and expenditure of huge amounts of public monies which could otherwise be put to more productive uses.

Response: EPA is sure that sources realize their obligation to assure a clean, healthy environment for everyone (including aquatic life) and put their resources into addressing the remaining environmental issues in each of these watersheds. It is discouraging to be threathened with lawsuits before anyone has even a chance to explore implementation options. EPA, however, stands ready to answer any challenges brought through the legal system.

General Comment 6: We suggest that the stream segments in question be "de-listed" as being nutrient impaired.

Response: They have been identified as impaired by PADEP with supporting data. The public had an opportunity to comment on those listings in each of the listing years – 1996, 1998, 2002, 2004, 2006 and 2008 – and request that they not be included on the list at that time. Since they remain on the list as impaired, EPA assumes there was insufficient cause to remove them then as there is now.

General Comment 7: We urge EPA to either:

- Withdraw these TMDLs and cease working on any other TMDLs pertaining to nutrient impairment

- Revise these TMDLs in manner that eliminates specific allocations for nutrients and defers to DEP's ongoing effort to develop nutrient water quality criteria.

    - **Response: These TMDLs are based on data and science and will not be withdrawn. They have been modified somewhat based on comments received. The suggested adaptive implementation does consider PADEP‘s efforts in establishing nutrient numeric criteria.**

General Comment 8: We also suggest that PA DEP and EPA should focus their efforts on a hierarchical watershed management approach to protect and preserve the streams within these watersheds, focusing on:

- First reducing hydrologic impacts due to "urbanization" of the watershed;

- Then reducing impacts from sediment-laden runoff from land development activities;

- Then reducing impacts from MS4 stormwater and CSO discharges within the watershed (without imposing nutrient effluent limits);

- Then achieving reductions from point source wastewater discharges.

Response: EPA disagrees with the proposed ‗series' approach. EPA believes that all of the actions suggested in this comment need to be addressed as a package in order to achieve the goals of the TMDLs which are to restore the aquatic life community to a healthy and diverse one.

Paxton Creek Comments

Section 2 Watershed Characterization

Comment 1: The contractor's reliance on 1992 National Land Cover Data from the USGS to describe the various types and percentages of land use in the watershed is inaccurate and misleading. For instance, large portions of the watershed have been converted to medium density suburban development in the last 16 years.

Response: In the revised TMDL, EPA incorporated the 2001 land use data updated with the 2005 land use data found in the Act 167 Plan for Paxton Creek. This new data will reflect more accurately the existing urban areas.

Comment 2: Most of the 5-mile segment of "impaired" waters, flows through urban land used for commercial, industrial and transportation-related purposes, making this segment essentially an urban stormwater drainage way.

Response: Paxton Creek through Harrisburg is still considered a water of the state. It has a use designation of warmwater fishery. The August 26, 2003 letter from PADEP to the City's LTCP contractor makes it clear that it is important to work on its recovery as a viable aquatic community/resource.

Comment 3: Within the 5 miles of "impaired" stream segment, the final 3 miles consist of a concrete-lined artificial channel in various states of repair. Much of the upper 2 miles, although not concrete-lined, has been reconfigured to accommodate the various commercial land uses and roadway construction. Very little in the way of a "natural" stream channel exists.

Response: See above

Comment 4: The report neglects to mention that Wildwood Lake, which discharges significant flow to at the start of the impaired segment of Paxton Creek, is a significant waterfowl refuge (which is a very likely source of much of the nutrients entering this segment).

Response: Existing data does not support the fact that Wildwood Lake contributes significant nutrient load to Paxton Creek. The commenter did not provide any data to justify his contention that the lake is a major contributor, only his opinion that it is likely to.

Comment 5: PMAA staff have recently observed and obtained photographic evidence of the physical characteristics of the creek and surrounding land use at several locations along the "impaired" segment. We have prepared the attached photo-essay to illustrate the above points.

Response: Thank you for the photos.

Section 3 Environmental Monitoring

Comment 1: This section presents a fairly limited amount of chemical water quality data but presents no biological data on aquatic life (insects, fishes, plants) that are supposedly being negatively impacted. It is not reasonable to conclude that the area is impaired by nutrients without site-specific data confirming such impairment exists.

Response: EPA presented and analyzed all data available at the time of the TMDL development. In addition, there were no biological data that can be analyzed to prove or disprove the negative impact on aquatic life. Please see the SRBC biological and chemical data from 2006 and 2007 which was submitted during the comment period.

Comment 2: No data on chemical characteristics of various stormwater discharges and combined sewer overflows is presented, except for indirect indications of instream water quality changes during wet weather events.

Response: The TMDL was developed based on the best available data. EPA used the best acceptable literature information to perform the characterization of the combined sewer overflow in Paxton Creek. EPA received by letter dated May 21, 2008 a summary of the City's CSO data. However the City did not provide any of the detailed analysis and modeling they say they conducted. EPA reviewed that information. See our response to Comment Letter #55, General Response #12 and General Response #13

Comment 3: Interestingly, a 2006 chronic toxicity study conducted at the lower segment of the creek showed no significant effect on fathead minnows or ceriodaphnia.

Response: This only shows that something other than toxic pollutants are causing the water quality impairment.

Comment 4: Most importantly, there is no discussion, data or even speculation that nutrients from any source are having any demonstrable impact on the "impaired" section of the creek.

Response: EPA presented and discussed dry-weather and wet-weather nutrient data in the existing TMDL report. The analysis of nutrient wet-weather data clearly shows the drastic increase in nutrient concentrations before and after storm events (Table 3-2). The SRBC data also shows many nutrient tolerant macroinvertebartes in Paxton Creek.

Comment 5: During our March 2008 photo survey, there was no visual evidence of algae or any other type of aquatic plant life present (even in a dormant state). In the non-concreted section, the stream substrate consists mainly of mud and sand with little value as a habitat for a variety of

plant, insect or fish species (unless one considers abandoned tires as habitat!

Response: This photo survey is just a snapshot in time which might have not captured evidence of productivity which usually occur during the growing season from April to October. However, this is valuable information that has been included in the revised TMDL report.

Section 4 Nutrient TMDL Development

Comment 1: Having done nothing to establish any cause/effect relationship or demonstrable impact from nutrients on aquatic life in the creek, the contractor simply falls back on the weight-of-evidence approach that has been invented by EPA as a surrogate for how to determine the proper amount of nutrients to protect **aquatic life.**

Response: The approach has not been invented by EPA but is an acceptable approach for establishing TP endpoints. It is consistent with EPA guidance and accepted by PADEP as an appropriate approach for interpreting the state's narrative. The language related to the weight of evidence approach as —invented by EPA" is only partially correct. See the USEPA National Stream and River Nutrient Guidance to see that this approach was actually –invented" and published by EPA and a panel of nationally recognized nutrient experts. Both PADEP and EPA Headquarters has endorsed the approach.

Comment 2: We believe that this approach is scientifically invalid and somewhat naive, particularly considering the urban drainageway nature of Paxton Creek.

Response: An August 26, 2003 letter from PADEP to the City's LTCP contractor has indicated that work is needed on its recovery as a viable aquatic community/resource.

Comment 3: The one thing we would agree on with the contractor is that Total N is not of concern for this TMDL.

Response: See General response #3

Section 5 Nutrient TMDL Allocation

Comment 1: The contractor concludes that reducing 88% of the phosphorus in 31 CSO discharges and an average of 84% in MS4 storm water discharges, plus 75% in non-point source contribution will restore the "impaired" segment of Paxton Creek (i.e. the 5-mile urban storm drainageway) to an appropriate condition. The logic behind these recommendations defies common sense, since the contributions of nutrients and other pollutants during wet weather events flushes through the "impaired" segment of the creek in a few hours.

Response: EPA reassessed the existing data and decided to include in the revised Paxton Creek TMDL to include the loads for the CSOs as projected by the Authority after the LTCP implementation and the loads from the portion of the watershed above Wildwood Lake. This modification stemmed from the fact that the

channelized concrete channel in Paxton Creek may not provide sufficient time of travel for nutrients to have significant impact on the water quality in the creek. The revised TMDL focuses on the LTCP projected loads and the segment below Wildwood Lake to the confluence with Asylum Run. Therefore, the revised TMDL does take into account the CSOs loads that are projected to occur after the LTCP is implemented.

Comment 2: No analysis of the cost of doing the above has been prepared or presented. PMAA understands that the DEP-approved Long Term Control Plan (LTCP) for addressing 31 CSO discharges to Paxton Creek would cost around $12 million simply to eliminate "floatables" present in those discharges. Furthermore, to actually capture and/or treat CSO discharges for the normal parameters of BOD and TSS, it could cost 10 times the above. Further reductions in phosphorus could cost an even larger amount.

Response: The TMDL is not required to consider costs, only the loading reductions and allocations necessary to attain and maintain applicable water quality standards. Accepting the Authority's projected TP reduction through implementation of the LTCP does not require any additional costs.

PMAA Conclusions and Recommendations

Comment 1: This proposed TMDL report represents the results of a "desktop" analysis by persons who have never personally visited or observed the watershed or stream segment of concern, using out-dated land use information and water quality data that are incomplete and inconclusive.

Response: The commenter needs to verify facts before commenting. This type of comment reflects the commenters overall misunderstanding of the approach used by EPA and quite possibly the data and goals of the TMDL. It leans a level of suspect on the other comments provided. The EPA and its contractors visited the watershed and performed a watershed evaluation. Land use data has been updated and the water quality data supports the development and conclusions of the TMDLs.

Comment 2: There is no obvious data presented to support an actual nutrient-related impact, either in terms of stimulating nuisance algal growth or any other kind of indirect effect on aquatic life.

Response: EPA presented and analyzed all data available at the time of the TMDL development. EPA recently received biological data from the Susquehanna River Basin Commission (SRBC). SRBC conducted biologic monitoring on two occasions at eleven stations in fall 2006 and twelve stations in spring 2007. This biological data was not available during the period of TMDL development for Paxton Creek. These new data are included in the revised TMDL report and the results of the analysis clearly show that the impaired segment of Paxton Creek provides a poor habitat for macroinvertebrates and does not support its aquatic life use goals.

Comment 3: Based on visual observation by PMAA staff, this stream segment has been (and will forever) continue to be impaired primarily due to irreversible hydrologic changes that have

occurred to accommodate various commercial, industrial and transportation land uses in this segment of the watershed.

Response: PADEP apparently disagrees. Although EPA is not speaking for PADEP, the letter of August 26, 2003 presents PADEP's position on Paxton Creek. In that letter from PADEP to the City's LTCP consultant PADEP recognizes that it is important to work on restoring Paxton Creek as a viable aquatic community/resource. The letter is included in this Response Document.

Comment 4: Any attempt to seriously implement the recommendations of this TMDL would have a devastating financial impact on the City of Harrisburg and the Harrisburg Authority (which is already in an untenable situation just to address its obligations under PA DEP's Chesapeake Bay Tributary Strategy)

Response: EPA based the allocations for the City's CSOs in the final TMDL on loading projections after implementation of the LTCP provided by the City itself. Therefore, we see no additional cost beyond the LTCP costs to the City for meeting the allocated loads.

Comment 5: PMAA strongly recommends that:

A. The stream segment in question be "de-listed" as being nutrient impaired.

B. EPA should withdraw this proposed TMDL.

C. EPA and DEP should focus efforts on a hierarchical watershed management approach to protect and preserve the smaller tributary streams within the Paxton Creek watershed, focusing on:

- First reducing hydrologic impacts due to "urbanization" of the watershed;
- Then reducing impacts from sediment-laden runoff from land development activities
- Then reducing impacts from MS4 stormwater and CSO discharges within the watershed (without imposing nutrient effluent limits).

Response: See our responses to the general comments #8 and #9 in this comment letter. EPA will not be recommending the delisting of the Paxton Creek. It may be possible that additional segments may be listed in the future.

Southampton Creek Comments

Section 1 Introduction and Watershed Characterization

Comment 1: Section 1.2 notes that a PA DEP assessment in 1999 determined that over 95% of the sub-basin 03 J that includes 114 miles of stream was impaired. It is unclear as to whether Southampton Creek constitutes sub-basin 03 J or is simply part of that sub-basin.

Response: It is part of the sub-basin

Comment 2: However, a review of the 2006 WQ Monitoring and Assessment Report shows only 1.4 miles of one unnamed tributary to Southampton Creek as being impaired by one municipal point source sewage discharge (requiring a TMDL) and only 8.7 miles of stream impaired by hydrologic modifications related to residential development (not requiring a TMDL). This appears to be inconsistent with the 1999 assessment.

Response: See the listings in the General Response #6

Comment 3: Figure 2, and the accompanying narrative in Section 1.2 very clearly shows that the Southampton Creek watershed is almost completely covered by low-density and high-density development, and that the creek and its tributaries are severely stressed by such development. Since impairments due to hydrologic modification can have an equal or greater impact on the aquatic ecosystem than actual pollutant loadings, this suggests that developing and attempting to implement this TMDL will have little or no positive benefit to the watershed.

Response: EPA believes that the control of sediment loading to the stream includes not only overland flow but also stream bank erosion. Both are the products of increased flows from impervious lands due to development. The control of the stream bank erosion must consider the decrease in flow to the stream and its associated decrease in stream velocity.

Comment 4: The most interesting discussion in Section 1.2 refers to the lack of historical data directly linking specific water quality data for nitrogen or phosphorus with the excessive algal growth observed within the watershed. Even though reference is made to additional water quality monitoring that was done in August-September 2006 timeframe (discussed in Section 4) there apparently was no data collected or evaluated on the actual levels of algal growth, nor was any data collected relative to impacts on the benthic community or other aquatic life. We have no way of knowing, for example, the comparative severity of the algal growth upsteam or downstream of the municipal point source discharge, or in comparison with algal growth in other sections of the creek or its tributaries

Response: The TP endpoint was based on the aquatic life use and not directly related to algal biomass. Therefore, algal growth was not as important as the TP concentrations found in the stream. Algal biomass measurements reflect short term conditions were the aquatic life is longer term, providing a better overall measurement of the stream‘s quality. Since the endpoint for TP was the goal of this TMDL, the instream concentration of TP is important. The data collected in 2006 shows a TP concentration immediately below the municipal facility ranging from 556 to 1347ug/L, considerably higher than the endpoint of 40ug/L. Upstream TP concentrations were measured as 28 to 54ug/L.

Comment 5: Finally, having done nothing to establish any cause/effect relationship or demonstrable impact from nutrients on aquatic life in the creek, the contractor simply falls back on the weight-of-evidence approach that has been invented by EPA as a surrogate for how to determine the proper amount of nutrients to protect aquatic life. We believe that this approach is

scientifically invalid and somewhat naive, particularly considering the highly urbanized nature of this watershed.

Response: See our response to the same comment under the Paxton Creek comments. Also see the General Response #1.

Section 2 Source Inventory and Assessment

Comment 1: The information presented shows that the one municipal point source was generally in compliance with permit limits. It is incorrect, however to state that maximum daily discharge flows cannot exceed the permitted limit of 0.22 mgd.

Response: The TMDL report will reflect the correct compliance issues.

Comment 2: Interestingly, while this TMDL focuses on nutrient impacts, there is very limited data presented in Appendix B on the levels of N or P in this point source discharge.

Response: This is interesting. Data was collected on two separate occasions in 2006 for TP from the municipal facility. Each sample showed a very high TP concentration of 3350ug/L. This is interesting in that this value is considerably higher than the endpoint of 40ug/L. The instream TP concentrations measured, along with the effluent data show the significant impact of the municipal point source on the TP concentration instream. It is obvious that the effluent TP concentration from this source is significant without additional monitoring information. Data for the facility for the period from January 2001 to January 2005 are presented in the body of the report and shown graphically in Figures 3 through 19.

Comment 3: No data is presented on nutrients associated with MS4 stormwater or CSO discharges.

Response: As the commenter must know, there are no CSOs in the sub-watershed. Data was not collected for the MS4 areas, however, modeling projections were used to establish land-based TP loads to the stream.

Section 4 Nutrient TMDL Development

Comment 1: We are very skeptical as to the validity of the modeling effort and the resulting TMDL. Without having established the nature and extent of excessive algae and related aquatic impacts, and without having anything more than 2 sampling events for the municipal point source and for instream water quality, the contractor carried out a modeling exercise using a very sophisticated stream water quality model (QUAL2K). The draft modeling report lists over 75 variables (and associated rate constants) that are used in this model. These rate constants are all based on assumed "default" values and, depending on the values assigned, can have a tremendous impact on model results (for instance the nitrogen and phosphorus half-saturation constants, which supposedly relate to algal growth, can vary from 1-1,200 and 0.5 - 500, e.g. up to 3 orders of magnitude). In plain English, this model can be structured to produce any desired result just by selecting rate constant values. We fail to see the validity of this approach.

Response: The endpoint was TP concentration and not algal biomass so the selection of variables such as the half-saturation constant is not as significant. The model was used in order to include nonpoint source-type loads, here the MS4 loads. Since there is only one municipal facility and the endpoint is an instream concentration for TP, if we were not to consider other loads such as nonpoint source-type loads, then a simple mass balance would have been possible.

EPA disagrees with the assertion that "default" values were used for the various modeling variables. Section 2.3.3.2 of the accompanying modeling report outlines calibration procedures:

"Calibration data for ambient water quality were based on the PADEP field sampling effort. Appendix C lists ambient water quality data collected by PADEP for August 2 and September 13, 2006.

Input parameters from permitted point source (Chapel Hill WWTP) were based on the available discharge monitoring data from the facilities. The corresponding discharger monitoring summary sheet for August 2 and September 13, 2006 is in Appendix D.

Air temperature, dew point temperature, and wind speed were based on direct measurement of meteorological data from weather station in Willow Grove, Pennsylvania.

The QUAL2K model was calibrated based on water quality data collected by PADEP on August 2 and September 13, 2006. Model output results were compared with observed data in order to determine the appropriate parameter adjustment. Adjustment of model parameters was based on EPA guidance documents entitled "Rates Constants, and Kinetics Formulations in Surface Water Quality Modeling (Second Edition)" and "Technical Guidance Manual for Developing Total Maximum Daily Loads, Book 2: Streams and Rivers, Part I: Biochemical Oxygen Demand / Dissolved Oxygen and Nutrients / Eutrophication". Table 14, 15 and 16 provide calibration values for stoichiometry, rate parameters, light and heat parameters in QUAL2K model."

Comment 2: The model was supposedly calibrated for several water quality parameters, but not for algal growth, further calling into question the validity of this approach.

Response: If one understood the approach EPA took to develop the TP endpoint for this TMDL then it should be no surprise that algal growth was not calibrated. The goal was an instream TP concentration not an algal biomass limit. Please refer to the General Response #1 and the endpoint report.

Appendix F: Suggested Adaptive Implementation Strategy

Comment 1: This strategy focuses almost entirely on gradual lowering of effluent loads for N and P for point source sewage discharges and only dwells briefly on BMPs for other sources. We seriously doubt that such an approach will achieve any noticeable improvement of the type

visualized by this TMDL (i.e. reductions in excessive algal growth). The cost of achieving even the suggested interim limit of 8 mg/1 Total N, along with Total P reduction, will be significant and an unwarranted expense of public funds in the absence of any demonstrable cause/effect relationship between nutrients and algal growth.

Response: It is the sources responsibility to develop a control program. EPA made one suggestion. If the commenter does not believe it would be effective then we suggest the commenter recommend an alternative.

Comment 2: Considering the nature of the impacts to stream segments in this watershed (i.e. largely due to hydrologic modification - see our comments under Section 1 above) EPA and DEP should instead focus on a hierarchical approach at watershed restoration, focusing on:

- First reducing hydrologic impacts due to "urbanization" of the watershed;
- Then reducing impacts from sediment-laden runoff from land development activities;
- Then reducing impacts from MS4 stormwater and CSO discharges within the watershed (without imposing nutrient effluent limits);
- Then, if necessary, adjusting effluent requirements for point source sewage discharges (but only after establishing a clear, scientifically-valid cause/effect relationship for such discharges).

Response: See the response to the general comments #8 and #9 of this letter

PMAA Conclusions and Recommendations

Comment 1: This proposed TMDL report is primarily the result of a "desktop" modeling analysis using information and water quality data that are incomplete and inconclusive.

Response: EPA disagrees. The commenter provided no documentation for this opinion

Comment 2: There is no obvious data presented to support an actual nutrient-related impact, either in terms of stimulating nuisance algal growth or any other kind of indirect effect on aquatic life.

Response: PADEP has established the impairment using state survey information. We suggest that the commenter review that information. EPA wonders if the commenter provided comments on the original listing of this water under section 303(d) of the CWA by PADEP.

Comment 3: PMAA strongly recommends that:

A. The stream segment in question be "de-listed" as being nutrient impaired.

B. EPA should withdraw this proposed TMDL.

C. EPA and DEP should focus efforts on a hierarchical watershed management approach described above.

Response: See responses to the general comments #8 and #9 of this letter

Indian Creek Comments

Section 1 Introduction and Background

Comment 1: Irrespective of whether or not there is any documented evidence of excessive algal growth and related impacts, the contractor simply falls back on the weight-of-evidence approach that has been invented by EPA as a surrogate for how to determine the proper amount of nutrients to protect aquatic life. We believe that this approach is scientifically invalid and somewhat naive.

Response: We question why the commenter did not provide any scientific justification, data and analysis to support his opinion. The approach was accepted by PADEP, EPA Headquarters standards program and is consistent with EPA guidance. Also note that the language related to the weight of evidence approach as —invented by EPA" is only partially correct. See the USEPA National Stream and River Nutrient Guidance to see that this approach was actually –invented" and published by EPA and a panel of nationally recognized nutrient experts.

Section 2 Data Inventory and Analysis

Comment 1: There is a very limited amount of discussion on aquatic life impacts and cause/effect relationships between nutrients and algal growth in various portions of the watershed. In fact, there is no data presented on algal occurrence. There is no data presented here or in Section 3 on the actual levels of algal growth or relative impacts on the benthic community or other aquatic life. We have no way of knowing, for example, the comparative severity of the algal growth upsteam or downstream of the municipal point source discharge, or in comparison with algal growth in other sections of the creek or its tributaries

Response: We will note again that the algal biomass was not of as much concern since the TP endpoint was based on the protection of aquatic life and the TMDL was established based on the need to meet a specific instream TP concentration. PADEP surveys show a comparison of the macroinvertebrates above and below the point sources. See General Response #1. Especially note the language related to what the role of EPA's contractor was in this process – namely identifying nutrient endpoints to protect aquatic life uses not on making the original impairment listing decision. PADEP made the impairment and listing decision in 1996. Please see also, Response #1 to Comment Letter #31.

With respect to data related to levels of algal growth, EPA acknowledges that no such quantitative data were available for analysis in this watershed. The presence of periphyton was, however, observed at multiple locations in the watershed.

It should be noted that DO is a strong indicator of periphyton level. DO exhibits

significant temporal variability in the presence of periphyton and other forms of aquatic plant life. Other physical factors such as water temperature and reaeration tend to dampen the fluctuation toward the saturation level. DO was measured at four sites on the main stem of Indian Creek and two DO sites on its tributaries. We believe that these locations are sufficient to show the spatial variation of DO in Indian Creek.

Comment 3: The contractor simply relies on the noted diurnal fluctuations of dissolved oxygen (DO) at a few locations in the watershed as indirect indications that algal photosynthesis and respiration are taking place.

Response: As you provided a picture tour of Paxton Creek emphasizing how important pictures are, we have also provided a picture tour of Indian Creek to show the severe growths of periphyton. We urge the commenter to take a look at those.

Section 3 Source Assessment

Comment 1: There is data presented on the levels of N or P in the 3 point source discharges. No data is presented on nutrients associated with MS4 stormwater or other discharges.

Response: Please carefully review the data that is presented in the report. Nutrient endpoints were developed to protect aquatic life, not on algal response per se. Pages 26 through 33 of the Draft Report discuss levels of N and P in the three point source discharges. Table 3-1 lists the permitted nutrient limitations for each facility and a brief paragraph summarizes available DMR results for the facilities, listing dates when DMR data exceeded limits. Additionally, Figures 3-2, 3-3, and 3-4 present graphic results of DMR data, illustrating permit limits and monitoring results, with exceedences shown. Finally, on page 56, Table 4-12, DMR data used in establishing representative existing conditions for each facility are presented. No data for MS4 or other discharges are presented because there were none available. Modeling was used to predict these loads.

Section 4 TMDL Technical Approach

Comment 1: We are very skeptical as to the validity of the modeling effort and the resulting TMDL. Without having established the nature and extent of excessive algae and related aquatic impacts, the contractor carried out a modeling exercise using a combination of sophisticated stream water quality models (GWLF and EFDC) to simulate the response of the stream water quality to various point and non-point source inputs. This modeling relies upon numerous variables (and associated rate constants which are based on assumed ~~"d~~efault" values and, depending on me values assigned, can nave a tremendous impact on model results (for instance the nitrogen and phosphorus half-saturation constants, which supposedly relate to algal growth, can vary significantly). In plain English, the model can be structured to produce any desired result just by selecting rate constant values. The model was then calibrated for several water quality parameters, including DO, but not for algal growth, further calling into question the validity of this approach.

Response: Nutrient endpoints were developed to protect aquatic life, not on algal response per se.

The goal of the analysis was not to revisit the impairment determination made by the PADEP. The TMDL was based on meeting average instream nutrient concentrations during the period from April 1 through October 31. As a result, simulated loads from the watershed, from both point and nonpoint sources were reduced until instream nutrient concentrations were met. Because this was the focus of the modeling analysis, and not DO levels or plant growth it was not necessary to demonstrate that particular levels of algae or DO were present in the stream prior to the TMDL. Again, neither plant growth nor DO was used to derive the TMDL requirements; the TMDL requirements were based on a loading scenario that achieves identified average nutrient concentration levels for the period from April 1 – October 1. The predicted levels of DO and periphyton under TMDL conditions were assessed to ensure that designated uses in the stream would be beneficially impacted by the TMDL reductions. See response to Letter 28, comment IV-2 for discussion of modeling results related to TP reductions and algal levels.

It is true that the modeling application used to simulate the Indian Creek is a sophisticated model which incorporates many variables rate constants. The values selected do in fact have a tremendous impact on model results. This is the reason that such values are adjusted during the calibration process—to achieve the closest fit possible to actual monitoring data. However, model parameter values must always be within the range of physical possibility and those used in the Indian Creek modeling application are within such ranges.

Section 5 TMDL Allocation Analysis

Comment 1: The contractor states, in Section 5.2, that *"Data analysis and modeling runs have established a clear linkage between phosphorus, shading and periphyton densities in the watershed.."*. We do not believe this to be true, at least not based on the information and discussion presented in other sections of this TMDL report. The contractor goes on to say that *"...however, the linkage between nitrogen and periphyton in this system is somewhat less well established. "* We do not believe it is possible to establish any such linkage. We further believe that there should be no further attempt to include N in such TMDL efforts. Tables 5-8 and 5-9 summarize the existing annual loads, TMDL annual wasteload allocation, % reduction and daily maximum loads for the 3 point source dischargers and MS4 areas. The % reduction: called for will impose huge financial burdens on these dischargers. It is unclear as to whether these are year-round limits. We fail to see the need for imposing a "daily maximum" loading on any discharge.

Response: Nutrient endpoints were developed to protect aquatic life, not on algal response per se. Effluent limitations pursuant to these TMDLs will be determined by PADEP and are required to be consistent with the assumptions of the TMDL. The critical period for attaining the identified target is during the growing season from April 1 through October 31. The WLAs listed for the facilities in Section 5 of the Draft TMDL were provided in various time steps (annual, seasonal and daily) to

assist PADEP in interpreting and deriving NPDES permit limitations to comply with assumptions and requirements of the TMDL. Under the TMDL condition, point sources were represented in the model using a constant flow and concentration. As a result, the values presented for the seasonal load are proportional to the values presented for the annual load. Successive model runs were performed to evaluate the level of instream nutrient concentrations during the target growing season period. Source loads were reduced (including the average concentration used to represent discharges) until the average instream nutrient concentration for the period from April 1 to October 31 was met. The Nitrogen allocations proposed in the Draft TMDL will not be included in the Final TMDL. See General Response #3. Based on the ruling of a TMDL in the District of Columbia, EPA Headquarters has directed the regions to include daily loads in all TMDLs. The permitting authority will interpret the wasteload allocations when issuing permits.

Appendix F: Suggested Adaptive Implementation Strategy

Comment 1: This strategy focuses almost entirely on gradual lowering of effluent loads for N and P for point source sewage discharges and only dwells briefly on BMPs for other sources. We seriously doubt that such an approach will achieve any noticeable improvement of the type visualized by this TMDL (i.e. reductions in excessive algal growth). The cost of achieving even the suggested interim limit of 8 mg/1 Total N, along with Total P reduction, will be significant and an unwarranted expense of public funds in the absence of any demonstrable cause/effect relationship between nutrients and algal growth.

Response: See Southampton Appendix F response

Comment2: Considering the nature of the impacts to stream segments in this watershed (i.e. largely due to hydrologic modification - see our comments under Section 1 above) EPA and DEP should instead focus on a hierarchical approach at watershed restoration, focusing on:

- First reducing hydrologic impacts due to "urbanization" and other significant land use activities within the watershed;
- Then reducing impacts from sediment-laden runoff from agricultural and residential/commercial land development activities;
- Then reducing impacts from MS4 stormwater and CSO discharges within the watershed (without imposing nutrient effluent limits);
- Then, if necessary, adjusting effluent requirements for point source sewage discharges (but only after establishing a clear, scientifically-valid cause/effect relationship for such discharges).

Response: See our response to general comments #8 and #9 of this letter.

PMAA Conclusions and Recommendations

Comment 1: This proposed TMDL report is primarily the result of a "desktop" modeling analysis using information and water quality data that are incomplete and inconclusive.

Response: We disagree and suggest that the commenter more fully review the data and analysis. The commenter provided only opinion with no data to support that opinion

Comment 2: There is no obvious data presented to support an actual nutrient-related impact, either in terms of stimulating nuisance algal growth or any other kind of indirect effect on aquatic life.

Response: The data PADEP used to list the waters for nutrient impairment is sufficient to document a nutrient impairment and the impacts on aquatic life.

PMAA strongly recommends that:

A. The stream segment in question be "de-listed" as being nutrient impaired.

B. EPA should withdraw this proposed TMDL**.**

C. EPA and DEP should focus efforts on a hierarchical watershed management approach described above.

Response: See our response to the general comments #8 and #9 of this letter.

Chester Creek Comments

Section 1 Introduction

Comment 1: The original "impaired" status listings for this creek and various tributaries have been published at different times going back to 1996. Apparently, these listings generally were based on impacts of unknown origin, however, the report states that: *"PA DEP biologists have since interpreted the unknown causes for all these listings to organic enrichment and nutrient impairments based on available data and information."* We find it unsettling that DEP staff, who were previously unable to figure out what was wrong, have suddenly recognized the nature and extent of the impairments.

Response: EPA is concerned with the implications contained in this comment. We do not believe it deserves a response.

Section 2 Watershed Characterization

Comment 1: Section 2.1.2 indicates that the TMDL only addresses impairments in the 17 miles of stream identified by DEP in its WQ Monitoring and Assessment reports, and that future TMDLs will be performed as more impairments are identified. It is difficult to envision how such a segmented approach will occur and how it may affect dischargers subject to this current TMDL.

Response: As water quality issues are identified, then TMDLs must be developed. It is not appropriate to wait until all issues are identified. That approach would delay any implementation indefinitely.

Comment 2: In any event, no information is presented in this TMDL report to support an actual nutrient-related impact, either in terms of stimulating nuisance algal growth or any other kind of indirect effect on aquatic life.

Response: See the attachment to this Response Document. Very high TP concentrations have been recorded for the entire watershed. Algal biomass data for Goose Creek also indicate excessive amounts of algal biomass. A memorandum from Alan Everett, PADEP to Brian Lee, Louis Berger Group dated February 29, 2008 states that 1998 biological data collected by PADEP shows —the macroinvertebrate communities are very much impaired, especially in the headwaters correlating with the highest concentrations of impervious surfaces and treated effluent, and the biologists attributed this impairment to a combination of stormwater and point sources."

Section 3 Environmental Monitoring

Comment 1: Apparently there has been a wealth of data collected on point source discharge quality, streamflow, aquatic life and water quality by PA DEP, USGS and other entities for many years within the watershed. However, it would appear that data on nutrients in the creek and in the discharges was only collected in 2006 in order to facilitate TMDL development. This might explain the above-quoted statement attributed to PA DEP biologists about the sources of impairment

Response: It is only logical to collect more recent data to develop the TMDL. If EPA failed to do that, then we would assume the commenter would question the use of old data. The data collected in 2006 supported the nutrient impairment and the TMDL.

Comment 2: It would appear that information on stream biota and habitat condition is limited, with little conclusive analysis or documentation as to nutrients being a major factor contributing to observed conditions. More specifically, there have been few notations of filamentous algae by DEP biologists. Apparently there are many examples of stream physical habitat degradation, which would not be surprising in heavily developed areas or in agricultural settings.

Response: There is TP data for the Goose Creek watershed as well as algal biomass for the stream. This data shows high levels of both. PADEP has identified this stream as impaired by nutrients from municipal facilities. A memorandum from Alan Everett, PADEP to Brian Lee, Louis Berger Group dated February 29, 2008 states that 1998 biological data collected by PADEP shows —the macroinvertebrate communities are very much impaired, especially in the headwaters correlating with the highest concentrations of impervious surfaces and treated effluent, and the biologists attributed this impairment to a combination of stormwater and point sources."

Comment 3: In spite of all the monitoring efforts that have taken place for many years, there is essentially no information presented in this TMDL report concerning the occurrence of algae (excessive or otherwise)

Response: Please see the attachment to this Response Document

Section 4 Nutrient TMDL Development

Comment 1: Having done nothing to establish any cause/effect relationship or demonstrable impact from nutrients on aquatic life in the creek, the contractor simply falls back on the weight-of-evidence approach that has been invented by EPA as a surrogate for how to determine the proper amount of nutrients to protect aquatic life. We believe that this approach is scientifically invalid and somewhat naive, particularly considering the urbanized nature of the Chester Creek watershed:

Response: The commenter presented an opinion with no support for that opinion. The commenter is referred to other responses concerning this same issue. The commenter is directed to the wealth of information contained in General Response #1, General Response #7, responses to previous comments, the endpoint report and the literature review. EPA Headquarters standards program has reviewed the approach and indicated that it was an —xcellent example of following EPA guidance on the derivation of numeric values…" The commenter is also referred to the USEPA National Stream and River Nutrient Guidance to see that this approach was actually invented and published by EPA and a panel of nationally recognized nutrient experts.

Comment 2: We are very skeptical as to the validity of the modeling effort and the resulting TMDL. Without having established the nature and extent of excessive algae and related aquatic impacts, the contractor carried out a modeling exercise using a combination of sophisticated stream water quality models (GWLF, WASP and WASP7) to simulate the response of the stream water quality to various point and non-point source inputs. The WASP7 module is specific to predicting algal response. This modeling relies upon numerous variables (and associated rate constants which are based on assumed "default" values and, depending on the values assigned, can have a tremendous impact on model results (for instance the nitrogen and phosphorus half-saturation constants, which supposedly relate to algal growth, can vary significantly). In plain English, the model can be structured to produce any desired result just by selecting rate constant values.

Response: The model was run to meet a specific instream TP concentration. The Chester Creek nutrient TMDL was not developed based on a periphyton endpoint. Rather, this TMDL was developed using endpoints for nitrogen and phosphorus. There was no intention in this TMDL to produce evidence of a direct linkage between nutrients and algae growth.

Comment 3: Section 4.3.5 discusses model input for WASP7 and notes that: "*... the majority of point sources in Chester Creek had no available DMR data* " and that nutrient discharge info was limited to that obtained in the two sampling events of 2006. Non-point source inputs were

simulated using BasinSim.

Response: That is correct. Only few permitted major dischargers had an adequate DMR data set and the nonpoint sources were estimated using BasinSim.

Comment 4: The model was then calibrated for several water quality parameters, including DO, but not for algal growth (because *"No absented measurements were available for periphyton andphytoplankton* "), further calling into question the validity of this approach.

Response: Once again we were concerned with aquatic life and not an endpoint for biomass. Please review all of the other responses to all of the other comments on this topic.

Section 5 Nutrient TMDL Allocation

Comment 1: Tables 5-3 and 5-4 summarize the permitted and allocated nutrient loads and % reductions for the 32 point source dischargers. N reductions range from 0% to 83% (with effluent concentrations of between 4 and 65 mg/1) and P reductions range from 0% to 99% (with effluent concentrations of between 0.04 and 2.56 mg/1). For many of these dischargers, achieving such reductions will require huge expense.

Response: That may be the cost of assuring that the water quality and aquatic life is protected.

Comment 2: Tables 5-5 and 5-6 summarize the reductions for MS4 stormwater dischargers, recommending that each achieve 5.7% reduction of N and 84.8% reduction of P, which will likewise involve significant expense

Response: Again there may be costs associated with achieving the allocations, however, the commenter did not provide any cost information for EPA's consideration.

PMAA Conclusions and Recommendations

Comment 1: This proposed TMDL report represents the results of a "desktop" analysis, using out-dated land use information and water quality data that are incomplete and inconclusive.

Response: EPA disagrees. See our response in other sections of this comment letter.

Comment 2: There is no obvious data presented to support an actual nutrient-related impact, either in terms of stimulating nuisance algal growth or any other kind of indirect effect on aquatic life.

Response: Please see the PADEP listing data and the attachment to this Response Document

Comment 3: PMAA strongly recommends that:

A. The stream segment in question be "de-listed" as being nutrient impaired.

B. EPA should withdraw this proposed TMDL.

C. EPA and DEP should focus efforts on a hierarchical watershed management approach to proted and preserve the streams within the watershed, focusing on:

- First reducing hydrologic impacts due to "urbanization" of the watershed;
- Then reducing impacts from sediment-laden runoff from land development activities;
- Then reducing impacts from MS4 stormwater and CSO discharges within the watershed
(without imposing nutrient effluent limits).
- Then, if necessary, adjusting effluent requirements for point source sewage discharges (but only after establishing a clear, scientifically-valid cause/effect relationship for such discharges).

Response: See our response to general comments #8 and #9 of this letter.

Sawmill Run Comments

Section 2 Watershed Characterization

Comment 1: The contractor's reliance on 1992 National Land Cover Data from the USGS to describe the various types and percentages of land use in the watershed is likely to be inaccurate and misleading. For instance, some portions of the forested lands in the watershed may have been converted to residential or commercial development in the last 16 years.

Response: The final TMDL is based on the National Land Cover Data from 2001.

Comment 2: Reliance on other "remote" sources of geographic and hydrologic data is further indication of the "desktop" nature of this TMDL effort.

Response: Using _remote‘ online data is a common approach in environmental projects and EPA believes that these data are sufficient to develop the nutrient TMDL for Sawmill Run.

Comment 3: It should be noted that PA's 2006 Integrated WQ Monitoring and Assessment Report shows some 14.4 miles of main stem and tributary streams being significantly impacted by hydrologic modification (which can have an equal or greater impact on the aquatic ecosystem than actual pollutant loadings), although such impacts are not addressed by this TMDL.

Response: This TMDL addresses nutrients. Previous TMDLs addressed mining-related impairments.

Comment 4: It should also be noted that the contractor identified no municipal sewage treatment plant dischargers, but did note the existence of some 47 CSO outfalls (28 belonging to

ALCOSAN), 14 MS4 stormwater entities and 6 stormwater GP dischargers.

Response: EPA fails to see the significance of this statement. All sources of the pollutant of concern must be addressed.

Section 3 Environmental Monitoring

Comment 1: This section presents a fairly limited amount of chemical water quality data, resulting from 3 DEP sampling events in 2006 at different locations, and 5 sampling events by the 3Rivers 2nd Nature organization near the mouth of Sawmill Run.

Response: That data presented was sufficient to identify the problems and develop the TMDL.

Comment 2: Other than referencing a biological survey conducted by the 3 Rivers 2nd Nature Program in May 2000, no actual biological data is presented on aquatic life (insects, fishes, plants) that are supposedly being negatively impacted nor is there any data on existence of "nuisance levels" of periphyton.

Response: We did not establish a nuisance level for algal biomass. The endpoint was to protect aquatic life. The evaluation provided by the 3 Rivers 2ND Nature Program showed that there was a low percentage of sensitive organisms in the Sawmill Run, ranking 25 out of the 35 streams evaluated. The FBI score calculated by the 3 Rivers program was representative of a water impaired by sewage pollution.

Comment 3: Data on Total N show levels far below the recommended instream level of 3.7 mg/1 during dry weather flow, and Total P at or below the recommended instream level of 0.04 mg/1. Dissolved oxygen levels, a key water quality parameter for aquatic life, did not violate the PA instream criteria.

Response: We eliminated the TN from the TMDL. We are not sure which data the commenter is reviewing. Of the 10 samples collected for TP by PADEP in the Sawmill Run mainstem, six (6) were above the endpoint of 40ug/L. Note at the new TP endpoint of 35ug/L, seven (7) of the samples were above that value. In addition, the TP concentrations during the wet weather sampling were as high as 253ug/L, nearly 9 times the dry weather concentrations measured. Although the DO concentrations did not fall below the minimum PADEP standard of 4mg/L, there was a pronounced diurnal fluctuation in the stream. In some areas the daily fluctuation was as much as 13.52 mg/L. Biological impairment can occur even when the minimum DO standard is being met. PADEP recognizes this in their ICS.

Comment 4: During wet weather, Total N levels were still below the recommended instream level, while Total P was about 6 times higher than recommended (with most of the P being of "organic" form). It is difficult to imagine these short-term spikes in nutrient loading as posing a major threat to this aquatic ecosystem.

Response: Though difficult to imagine, the commenter did not provide any

supporting information or calculations to support his imagination.

Comment 5: No data on chemical characteristics of various stormwater discharges and combined sewer overflows is presented, except for indirect indications of instream water quality changes during wet weather events.

Response: For the revised TMDL, EPA acquired CSOs and SSOs flow discharge monitoring data from the Allegheny County Health Department. These data were used in characterizing the overflow volumes and to develop the revised Sawmiull nutrient TMDL.

Comment 6: There is no discussion, data or even speculation that nutrients from any source are having any demonstrable impact on the "impaired" sections of the stream.

Response: The endpoint was based on the protection of aquatic life. If this endpoint is exceeded in the stream then the aquatic life community would be impaired. The TMDL shows that the combination of all of the sources exceeds this critical endpoint. 3 Rivers data shows biological impairment. Chemical data shows TP concentrations exceeding the endpoint for both dry and wet weather conditions.

Section 4 Nutrient TMDL Development

Comment 1: Having done nothing to establish any cause/effect relationship or demonstrable impact from nutrients or aquatic life in the creek, the contractor simply falls back on the weight-of-evidence approach that has been invented by EPA as a surrogate for how to determine the proper amount of nutrients to protect aquatic life. We believe that this approach is scientifically invalid and somewhat naive.

Response: see previous responses to the same opinion

Comment 2: In the absence of municipal point source sewage discharges, the contractor then estimates the nutrient loadings from CSOs and MS4 sources and, along with a wide variety of other AVGWLF model inputs (assumed), computes both target and existing loads for Total N and Total P.

Response: The sources of the pollutant were identified. There were no _traditional' point sources.

Section 5 Nutrient TMDL Allocation

Comment 1: The contractor concludes that reducing 96.6 % of the phosphorus in 47 CSO discharges and an average of 84.7 % in MS4 stormwater discharges, plus 55% in non-point source groundwater contribution will eliminate the impairment of concern (whatever that is). The logic behind these recommendations defies common sense, since the contributions of nutrients and other pollutants during wet weather events flushes through the "impaired" segments of the watershed in a relatively short time.

Response: It should be obvious to the commenter, if he read the report, that the

pollutant of concern is TP. The commenter did not provide any supporting data for the time of travel of any storm events. Therefore EPA cannot respond to this comment.

Comment 2: No analysis of the cost of doing the above has been prepared or presented.

Response: The TMDL regulations do not require cost analysis. It requires the identification of the load reductions necessary to attain and maintain applicable water quality standards.

Comment 3: PMAA understands that the DEP and EPA have been working with ALCOSAN, the City and other communities to implement Long Term Control Plans (LTCPs) for addressing CSO discharges to Sawmill Run, and that consent orders and agreements have been signed.

Response: That is correct

Comment 4: We do not know what these LTCPs call for in terms of impact reduction, nor do we know what that cost would be for this particular watershed. However we suspect that none of these regulatory activities have actually focused on reduction of nutrients in CSOs as part of these LTCPs, and we further suspect that such reduction would be significantly more costly.

Response: The commenter admits to not being familiar with the LTCP. The commenter presents suspicions. EPA cannot respond to suspicions. It is suggested that the commenter obtain information before commenting.

PMAA Conclusions and Recommendations

Comment 1: This proposed TMDL report represents the results of a "desktop" analysis by persons who have never personally visited or observed the watershed or stream segment of concern, using out-dated land use information and water quality data that are incomplete and inconclusive.

Response: The commenter once again shows that he is commenting on issues and situations of which he has no knowledge. See our response to this question in earlier portions of this letter response.

Comment 2: There is no obvious data presented to support an actual nutrient-related impact, either in terms of stimulating nuisance algal growth or any other kind of indirect effect on aquatic life.

Response: See previous discussions

Comment 3: PMAA strongly recommends that:

A. The stream segment in question be "de-listed" as being nutrient impaired.

B. EPA should withdraw this proposed TMDL.

C. EPA and DEP should focus efforts on a hierarchical watershed management approach to protect and preserve the smaller tributary streams within the Sawmill Run watershed, focusing on:

- First reducing hydrologic impacts due to "urbanization" of the watershed;
- Then reducing impacts from sediment-laden runoff from land development activities
- Then reducing impacts from MS4 stormwater and CSO discharges within the watershed (without imposing nutrient effluent limits).

Response: See previous responses.

Comment Letter #43: Souderton Borough (Miano) Comments on Indian Creek

Section I. Background

General Comment: The Borough is located in northern Montgomery County. The Borough comprises an area of about 1.2 square miles and has a population of approximately 6,700. A small portion of the Borough, approximately 65 acres, is located in subbasin 12 of the Indian Creek watershed; roughly 12% of the area represented by the subbasin. Of these 65 acres, all but 3 acres are developed and most of the developed areas contain impervious surfaces. Therefore, the stormwater that discharges from the Borough to this subbasin contains only minor quantities of sediment. Based on this information, the actual land areas and resulting discharges associated with the Borough appear to be significantly different than assumed by the Environmental Protection Agency (EPA) in its calculations for this draft TMDL

Moreover, the Borough has a permitted MS4 program (permit #PAG 130132), and a written Operation, Maintenance and Inspection Program for stormwater facilities, pursuant to which it maintains all stormwater collection and conveyance facilities throughout the Borough, including those that drain into subbasin 12. The Borough's plan specifically addresses annual inspection and periodic cleaning of sediment catch basins and inlets. In addition, in February 2005, Borough Council adopted PADEP's model stormwater management ordinance. Finally, the Borough is a member of the Perkiomen watershed Conservancy and participates in the Perkiomen M$4 Partnership. This partnership provides a variety of public educational services to promote awareness of stormwater impacts on streams.

Given the above facts, the Borough believes that its contribution of sediment to this watershed is minimal.

Response: Good. All of this will help in meeting the allocated sediment loads.

Comment A1: Section A, EPA Has No Authority To Establish The Indian Creek TMDL. The Borough believes that EPA has no authority under the federal Clean Water Act (CWA) to establish the Indian Creek TMDL. Pursuant to applicable law, the Commonwealth of Pennsylvania, through PADEP, has the duty to establish the TMDL, not EPA. EPA may establish the TMDL only if PADEP first establishes the TMDL and EPA disapproves of it. In fact, EPA states repeatedly in the draft TMDL that it is the duty of the states to establish TMDLs. (Draft TMDL pp. i, i.) While the Borough understands that EPA believes it derives its authority from the Consent Decree it entered into with several environmental groups, the Borough does not believe that the Consent Decree can supplant the statutory requirement that the Commonwealth first develop a TMDL for this watershed. PADEP has been extremely active in developing and establishing TMDLs throughout the Commonwealth and in the area, and therefore has not evidenced the requisite legal intent to sustain a finding that it will not establish this TMDL. Moreover, based on information and belief, the Borough understands that as a practical matter, the Commonwealth was not provided with its statutory opportunity to develop a TMDL for this watershed because of EPA's agreement/decision to develop the TMDL on its own. The Borough therefore believes that EPA's establishment of the Indian Creek TMDL is contrary to law.

In addition, even assuming that the Consent Decree provides any authority for EPA to establish a TMDL for the Indian Creek watershed, it clearly limits EPA's authority to the specific water quality listed segments (WQLS) set out in PADEP's 1996 federal CWA 303(d) listing. EPA appears to have unilaterally modified the listing to add additional WQLS and to change impairment listings. The Borough believes these changes are contrary to requirements under the CWA and therefore not allowed under applicable law. Therefore, EPA is without authority to establish the current draft TMDL.

EPA must follow state-established implementation methods for interpreting narrative standards. PADEP has published an implementation method for establishing numerical WQS for its narrative nutrient WQS. EPA's methods set out in the draft TMDL, however, are inconsistent with PADEP's established methodology and therefore are not authorized by law. Thus, even if this were one of the limited instances where EPA could establish a TMDL, EPA has not followed the required implementation method for doing so and, as a result, EPA's actions are contrary to law. Therefore, EPA is without authority to establish the current draft TMDL.

> **Response: See General Response #2 for responses to Clean Water Act, federal regulation and the TMDL Consent Decree in Pennsylvania.**

Comment A2: The TMDL Should Incorporate Adaptive Implementation Provisions. The draft TMDL contains, as Appendix C, a "Suggested Adaptive Implementation Strategy for NPDES Point Source Dischargers." This document is intended to provide guidance to PADEP in considering various strategies for incorporating the TMDL in permits for point source dischargers in the Indian Creek watershed. The Borough supports the concept of utilizing adaptive implementation strategies that will be applicable to both POTWs <u>and</u> MS4 dischargers. However, the Borough believes that such strategies should be specifically incorporated into the TMDL itself, rather than merely attached as an unincorporated appendix.

Moreover, the TMDL must be structured to allow for various adaptive implementation strategies recognized in EPA guidance, such as a phased TMDL, (see August 2, 2006 EPA Memorandum from Benita Best-Wong - Clarification Regarding "Phased" Total Maximum Daily Loads), and water quality trading, (see discussion in Section A(3) Below). The Borough believes that establishing a phased TMDL in this instance makes good sense and is in keeping with EPA guidance. "The phased TMDL approach would be used in situations where limited existing data are used to develop a TMDL... and the use of additional data-would likely increase the accuracy of the TMDL... Such significant uncertainty may arise, for example, because the State is using a surrogate to interpret a narrative standard..." (Excerpted from above-referenced EPA guidance.) The development of a phased TMDL in this watershed would appear to squarely fit the example given in EPA's own guidance.

> **Response: EPA believes that the TMDL allows for the adaptive management approach to implementation. This includes suggested interim treatment goals for the point sources. PADEP, the permitting authority, must decide how the suggested adaptive approach will be factored into the permitting process. The adaptive implementation approach allows for a reasonable time for the state to complete the standards setting process. It also allows for the revision to the TMDL if/when the state adopts nutrient numeric criteria. As noted in the TMDL, if the state adopted**

numeric criterion is different from the TMDL developed endpoints, the state has the option of submitting a revised TMDL to EPA for approval.

Comment A3: The TMDL Should Allow For Water Quality Trading

The Indian Creek TMDL should clearly and specifically allow for the possibility of water quality trading among the various point and nonpoint dischargers, where appropriate. Water quality trading is encouraged by both EPA and PADEP and can serve as a powerful tool in implementing any final TMDL. The Borough believes this approach is consistent with EPA guidance. One possible mechanism to foster such trading would be the issuance of a watershed permitting mechanism for the Indian Creek Watershed, applicable to all sources.

Response: The TMDL sets the water quality goals for pollutant trading. The TMDL becomes the driver for sources to consider trading. Any trading proposed in the watershed must show that the resulting pollutant loads are consistent with the TMDL, i.e., that the combination of the traded pollutant loads will continue to attain and maintain applicable water quality standards. The trading becomes an implementation option for the TMDL. The TMDL report 1) is not required to include implementation options, and 2) even if EPA included implementation in this TMDL, it would be impossible to foresee all possible trading options. The sources in the watershed must take the TMDL results and goals and determine through any implementation activities, what trading, if any, would be beneficial to them while maintaining the water quality goals. EPA's policy supports trading of nutrients (e.g., total phosphorus, total nitrogen) and sediment load reductions. Trading may be used to reduce the cost of achieving reductions established by a TMDL. EPA does not support trading that delays implementation of an approved TMDL or a TMDL established by EPA that would cause the combined point source and nonpoint source loadings to exceed the cap established by a TMDL. All water quality trading should occur within a watershed or a defined area for which a TMDL has been approved. Establishing defined trading areas that coincide with a watershed or TMDL boundary results in trades that affect the same water body or stream segment and helps ensure that water quality standards are maintained or achieved throughout the trading area and contiguous waters. Where a TMDL has been approved or established by EPA, the applicable point source waste load allocation or nonpoint source load allocation would establish the baselines for generating credits. Trades and trading programs in impaired waters for which a TMDL has been approved or established by EPA should be consistent with the assumptions and requirements upon which the TMDL is established. Provisions for trading may be established through various mechanisms, including: legislation, rule making, incorporating provisions for trading into NPDES permits and establishing provisions for trading in TMDLs or watershed plans. These provisions may incorporate or be supplemented by private contracts between sources or third-party contracts where the third party provides an indemnification or enforcement function

Comment A4: The TMDL For Nitrogen Is Unnecessary. The establishment of a TMDL for nitrogen is completely unsupported in the draft TMDL both from a technical and a legal

standpoint. In fact, EPA's draft TMDL states there is no technical basis for establishing nitrogen loads but states that establishing such loads may make sense now because there is a potential future need for nitrogen limits. (Draft TMDL p. 10.) Without a current legal or technical basis for establishing TMDL loads for nitrogen, however, EPA is unnecessarily burdening taxpayers by requiring costly and time-consuming modifications to existing structures. As such, the inclusion of nitrogen loads in the draft Indian Creek TMDL is arbitrary, capricious and contrary to law.

Response: See General Response #3

Comment A5: EPA's Reference Watershed Approach Is Inappropriate. EPA's use of a reference watershed (Ironworks) on which to base the draft TMDL is inappropriate because the reference watershed is very different from the Indian Creek watershed. In fact, the two watersheds are not at all comparable - the Indian Creek watershed contains at least 30% more agricultural land and 18% more high density development. The Ironworks watershed contains 25% more forested areas. The different composition of the two watersheds makes the use of the Ironworks watershed as a surrogate for loading development inappropriate, arbitrary and capricious.

Response: **The Ironworks Creek watershed was selected as the Reference watershed for the sediment portion of the TMDL in consultation with the PADEP. Efforts were made to select a watershed located in the same geographic region and having a reasonably close match in landuse characteristics. The reference watershed approach for developing sediment/siltation TMDLs is an established approach and has been used by PADEP and EPA for multiple TMDLs which have been approved in the state (e.g., Conodoguinet Creek (2001), Bens Creek (2005), etc).**

Comment A6: Nonpoint Source Impacts Have Not Been Determined. The draft TMDL fails to address nonpoint sources, which the Borough believes are a significant contributor to any impairments. As described by EPA, "the TMDL lumps nonpoint source loadings into the WLA portion of the TMDL." (Draft TMDL p. 68.) EPA makes the assumption that all land is within MS4S (including forested, agricultural and pastoral land). EPA also concedes, however, that it "cannot determine what portions of the municipalities are designated/used for collection or conveying stormwater, as opposed to portions that are truly nonpoint sources." (Draft TMDL p. 67.) The assumption that all land is within areas is entirely unsupported. Clearly, EPA's statement that it cannot determine what portions of the municipalities are composed of truly nonpoint sources undermines any basis EPA might give for the assumption that all land is within MS4 areas. This false assumption leads to additional false assumptions with respect to the legal authority and physical ability of the municipalities to control such sources. This assumption is clearly arbitrary and capricious. As such, EPA's position that the draft TMDL will cure the impairments is without any basis and renders the TMDL arbitrary and capricious.

The draft TMDL also ignores the contribution to the system from nonpoint sources during low flow conditions. The TMDL states that the critical time is in the summer when flow is low. It also states that the point sources are the overwhelming contributors during this time frame. However, rainstorms certainly occur in the summer, during which time the ground is so dry that much of the water runs off, carrying nutrients. (See also, the discussions of the golf course at

section 6(5) of these comments.) As the contribution to the system from these nonpoint sources is not factored into the TMDL, EPA's above-described assumptions are not supported.

Response: The commenter should review the TMDL report for Indian Creek more closely. Nonpoint source loads were specifically identified. The tables that summarize the nutrient and sediment allocations specifically include an allocation for each of the MS4 areas, which are the permitted areas that contribute nonpoint source-type loads. Nonpoint source-type loads were included for the critical periods. EPA believes that if the commenter were to fully review the TMDL report, he would understand that the nonpoint loads were actually considered in the development of the TMDL and included allocations. Please note that the MS4 areas are non-point source-type sources but receive NPDES permits. Since the entire area is covered under one or more MS4 permit, all non-point source-type loads were assigned to the MS4s. The fact that all loading in the TMDL is considered under the WLA category does not indicate that nonpoint loads were not addressed. The dynamic GWLF watershed model was used to develop estimates of nonpoint source watershed loads, which were linked to the EFDC receiving water model of the Indian Creek. Nonpoint source loads are addressed in the TMDL. All land-based nonpoint source loading was considered under the WLA portion for MS4 townships because of the lack of information available to parse out at this phase of the TMDL specific areas within the MS4. EPA acknowledges there are areas currently considered under the MS4 WLA that may not be within the control and jurisdiction of the MS4 authority to control such loading. However the permittee has not specifically identified these areas, which must be done under the MS4 permit. Please see EPA's additional responses related to impacts on MS4s in the General Response portion of this document.

In addition, the draft TMDL does not ignore low flow contributions from nonpoint sources. Reductions to point sources outweigh those called for from nonpoint sources due to the time period during which the most critical watershed conditions occur: warm weather, low flow conditions. This is not to say that the nonpoint loading of nutrients do not contribute to the impairment or that they have not been factored into modeling analysis. The timing and conditions under which the majority of the two types of loads are delivered are different. For the period modeled, the majority of the nonpoint source load was delivered during storm events and is episodic in nature; whereas the point source load is delivered in a steady, more continuous fashion throughout the period modeled. Because of the nature of the watershed, a large portion (although not all) of the annual nonpoint load may be moved entirely out of the drainage basin during the same events that the nonpoint source load is delivered. In contrast, the continuous nature of the point source discharges means that these sources contribute a lower proportion of nutrients to the stream during high flows and a higher proportion of nutrients to the stream during low flows. It is because the point sources represent the largest source of nutrients to the stream during summer low flow periods, when the identified target applies, that they require a higher overall reduction than nonpoint sources.

Comment A7: The Draft TMDL Does Not Address Assumed Impairments. The draft TMDL

fails to demonstrate that it will address listed impaired uses of Indian Creek. EPA does not clearly articulate what the impaired uses of the various Indian Creek WQLS are and does not explain how the proposed loading reductions in the TMDL are meant to address each of them. A review of the impairment listings shows that there are multiple segment listings for Indian Creek, for multiple uses, and containing multiple listing dates. Since EPA's draft TMDL fails to address how the proposed loadings will cure the various listed impairments in each segment, it is arbitrary and capricious.

> **Response: It should be obvious that the TMDL was based on the analysis of the Indian Creek watershed, which included the impaired segments. The TMDL addresses the listed impairments – nutrients and sediment – and allocated those pollutant loads at a level that would attain and maintain applicable water quality standards including water uses. EPA fails to understand the commenters concerns. The impaired use is to provide habitat and appropriate ecological services as a trout stocking fishery. This is specified on page 5 of the DRAFT TMDL. The proposed load reductions are expected to address the use impairment by resulting in improved stream water quality by reducing periphyton densities and eliminating large swings in DO. Additionally, the sediment TMDL will result in reduced loading of sediment to the stream, thus improving stream bottom habitat among other things**

Comment A8: The Draft TMDL Is Based On Insufficient Data. The draft TMDL is based on very little actual data. For example, it appears that only two rounds of stream sampling were used in the Environmental Fluid Dynamics Code (EFDC) model. Significantly, the results from the second round of sampling are materially different than the results from the first round. Rather than collecting additional data to determine the cause of the disparate results, EPA averaged the two rounds. The Borough believes that the "average" data used in preparing the modeling cannot be relied upon as representative. Such a disparity between the two rounds of sampling indicates that additional sampling is necessary before the TMDL can be established. EPA's use of such limited, conflicting data is arbitrary and capricious.

> **Response: These two sets of data were not averaged. One set was used for calibration, and the other was used for validation. The disparity in the sampling results and the model‘s ability to simulate them supports the periphyton dynamics simulation in the EFDC model.**

Comment A9: There Is No Link Between Phosphorus and Periphyton Growth. The draft TMDL assumes that there is a link between phosphorus and periphyton growth but fails to establish any such link. EPA historically has not been able to establish any correlation, and this TMDL does nothing to advance EPA's argument for a correlation. Therefore, a basic assumption underlying the TMDL is wholly unsupported and the resulting TMDL is arbitrary and capricious.

> **Response: EPA has stated on many occasions that the nutrient endpoint was based on the need to protect aquatic life and not based on the reduction of periphyton growth. EPA;‘s review of the literature however shows that many researchers have related nutrients to algal growth and have recommended various levels of instream nutrient levels to address algal growth. The commenter is referred to EPA‘s**

literature review report. EPA‘s own nutrient criteria development document recommends chlorophyl _a‘ as a parameter to be considered as a criterion for the control of nutrients, indicating to us that EPA believes there is a link between nutrients and algal biomass. EPA believes that the commenter is ignoring well known facts and the comment is arbitrary and capricious. Please see the response to comment #1, Letter #31

Comment A10: EPA Assumptions Regarding Algae Are Unsupported. EPA's assumption that there are detrimental quantities of algae in Indian Creek is wholly unsupported by any data. Rather, the assumption regarding the presence of algae is based only on anecdotal reports by PADEP sampling staff. (Draft TMDL p. 13.) Such anecdotal evidence cannot form the basis for a significant underlying premise in the TMDL. As such, both the assumption and the TMDL are arbitrary and capricious.

Response: EPA does not believe that the PADEP data and analysis is anecdotal. It was based on proven PADEP data collection and analysis methods. Therefore the comment is inappropriate. The commenter is referred to the attachment to this Response Document and specifically the pictures of Indian Creek that show actual algal blooms in the watershed. A picture is worth a thousand words. While evidence of excess algae growth was prevalent on numerous watershed assessments and on field data sheets collected by PADEP, this was not, as the comment suggests, the sole focus of the listing nor of the analysis that supported the TMDL. Rather, the listing was based on the lack of intolerant taxa findings in multiple locations during DEP‘s assessment of the watershed. Based on the existing designated use of trout stocking fishery, the PADEP deemed the Indian Creek is not supporting its designated use. The PADEP declared the stream to be impaired due to nonsupport of aquatic life uses. The goal of the TMDL and the modeling exercise in the TMDL was to apply the identified nutrient endpoints and to calculate allowable watershed loadings to meet those endpoints, which are expected, in turn, to ensure the stream meets its use criteria with respect to nutrient levels.

However, we disagree with the comment that EPA‘s assertion of detrimental quantities of algae in Indian Creek is unsupported. First, DO (particularly significant variability) is an indicator for algae. Second, pictures taken in Indian Creek visually show high levels of algae.

Comment A11: Essential Definitions Are Not Sufficient. The TMDL fails to adequately define "critical conditions" and "seasonal variations." These terms are critically important to EPA's establishment of seasonal loadings. (Draft TMDL pp. 71-72.) These terms must be better defined, based on better data collection.

Response: EPA regulations at 40 CFR 130.7(c)(1) requires TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. For purposes of this TMDL, the term _critical condition‘ refers to the general setting under which problematic waterbody characteristics occur. It is also the condition that, if criteria are met under it, will be protective of all other conditions that would occur. In the case of Indian Creek, problematic conditions tend to occur during

periods of warm weather following periods of little to no precipitation when flow volumes in the creek and its tributaries are in general, lower than mean flow volumes. During these times, the stream commonly experiences conditions which lead directly or indirectly to impairment of aquatic life uses (e.g., low levels of dissolved oxygen, excessive algae growth, etc.) This general time frame was important to identify in setting the appropriate time period in which instream nutrient targets are to apply. For the TMDL analysis, loading reductions were considered adequate for meeting the TMDL targets once the average TP concentration in the stream did not exceed 40 ug/L for the period April 1 to October 31, which was considered representative of the critical period in this watershed.

Similarly, _seasonal variation‘ refers to the general variability in water quality parameters and waterbody conditions which occur from season to season and year to year due to differences in loading from precipitation driven and other source loading events. The TMDL considers seasonal variability by using a continuous flow simulation, inherently considering seasonal hydrologic phenomena and source loading. The longer the continuous simulation period is, the more accurate the representation of seasonal variability.

Comment A12: Assumed POTW Flows Are Flawed. EPA's use of maximum (100%) flows by dischargers, even during low flow periods, is flawed. In fact, EPA states in the draft TMDL that normal flows are, at present, only approximately 40% of that figure. (Draft TMDL p. 72.) It is unrealistic to assume that the POTWs discharge at full permitted capacity during low flow periods as such an assumption would mean that those plants would vastly exceed permitted flow capacities during high flow periods. Therefore, the use of this assumption is unrealistic, overly conservative, arbitrary and capricious.

Response: The commenter fails to recognize that PADEP‘s procedures for developing permit requirements are based on design flow conditions. When the state calculates the BOD requirements, for example, the design conditions include the 7 day 10 year low flow as defined by the state regulations and the permitted flow conditions. There is no reduction of effluent flow in the calculations because the conditions evaluated are low flow conditions. The TMDL is using the same approach that the state has used for many years. Since the approach is based on state procedures that have been in place for years, the TMDL is neither arbitrary nor capricious.

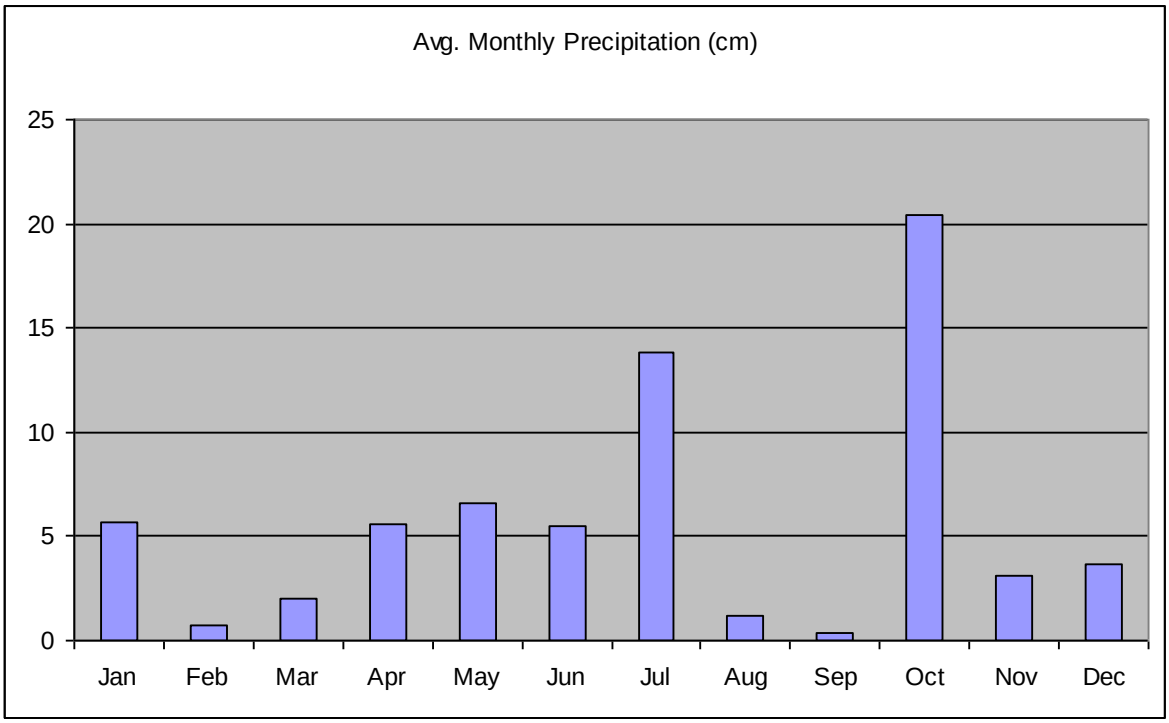
Comment A13: EPA's Assumption Regarding Ammonia and Nitrate Is Unrealistic. In calculating "representative point source effluent flows," EPA makes an unsubstantiated assumption that "the total amount of ammonia and nitrate was identical among the three point sources since only one point source (Pilgrims Pride) had N03 measurements." (Draft TMDL p. 56.) This assumption applies the TMDL to all plants based on data from only one plant (Pilgrims Pride). Significantly, the Pilgrims Pride plant is a very different kind of plant than the others. This assumption is arbitrary and capricious.

Response: The total amounts of ammonia and nitrate of the two point sources that do not have N measurement were calculated based on data from the Pilgrims Pride

facility. Ammonia and nitrate may vary significantly for different facilities. For the five point sources in Wissahickon Creek, for example, ammonia varies from 0.03 mg/L to 0.33 mg/L, nitrate varies from 12.6 mg/L to 21.6 mg/L. The nitrogen from the Pilgrims Pride facility are within the same magnitudes as the Wissahickon point sources. In addition, the nitrogen in Indian Creek is sufficiently high that nitrogen is not a limiting factor on the growth of algae. Therefore, we deem it acceptable to use the Pilgrims Pride data to assign nitrogen to the other two point sources.

Comment A14: Data Are Unsupported. In Table 4-9, there is no apparent correlation between predicted loads and traditional low flow/high flow periods of the year, as might be expected. In addition, the data for October appear to be a complete aberration. (Draft TMDL p. 50.) These data must be further explained or revised.

Response: The loads presented in Table 4-9 are the average monthly loads predicted for the period simulated. They are a function of the precipitation data used to drive the watershed model simulation; the process used to develop the weather time series is described in the Draft Report on page 44. Average monthly precipitation for the modeled period is shown in the following graph.



As can be seen by the precipitation data, the modeled loads correlate to periods of low and high precipitation. The predicted load results for October are explained by the high amount of recorded precipitation at the weather stations used in developing the precipitation data for the model.

Comment A15: Assumed Growth Rates Are Unsupported. The TMDL assumes 1% residential growth, which may or may not be reasonable. EPA provides no factual basis for this assumption.

Response: The commenter in turn does not provide any support for any other growth rate, simply it may or may not be reasonable. The commenter provides no factual basis for suggesting the 1% growth is wrong.

Comment A16: Designated Uses Do Not Reflect Current Actual Conditions. The designated uses of the Indian Creek stream segments listed in the 303(d) impairments list are outdated and not reflective of current conditions. These stream segments are located in areas that have undergone significant development (including urban, suburban, industrial and agricultural development). Any impairments that may be noted in the watershed would appear to result from significant habitat changes. EPA's attempts to cure these assumed impairments through modifications of POTW and MS4 discharges will not reverse these long term habitat changes. Therefore, before any TMDL is established for this watershed, the agencies must perform an analysis of the actual current uses (referred to in EPA guidance as a Use Attainability Analysis) and adjust them appropriately.

Response: The Clean Water Act, Section 303(d) and implementing regulations at 40 CFR Section 130.7 requires EPA to establish TMDLs at a level that will attain and maintain the applicable narrative and numeric water quality standards. Therefore TMDLs are to be based on the existing standards as adopted and implemented by the state. PADEP has adopted trout stocking uses for the entire East Branch Perkiomen Creek watershed which includes Indian Creek. If the commenter believes that the uses as adopted by PADEP are incorrect, then the commenter should petition the state under the state‘s water quality standards procedures.

Comment B1: EPA's Comparison of the Indian Creek and Ironworks Watersheds Is inappropriate. In addition to the arguments articulated in Section A(s) above, EPA's use of the Ironworks watershed to develop sediment loading reductions for Indian Creek is inappropriate. Based on the description in the draft TMDL, it seems that EPA only performed a calculation based on physical comparison of the two watersheds. EPA then used this overly-simplified calculation to determine presumed appropriate loading reductions for sediment. The Ironworks watershed, however, has fewer nonpoint source areas prone to erosion than does the Indian Creek watershed. (Draft TMDL p. 63.) As a result, the physical calculation (in addition to being insufficient as a process) yields a result that cannot be representative of conditions in the Indian Creek watershed. As such, EPA's use of this methodology is arbitrary and capricious.

Response: The Ironworks Creek watershed was selected as the Reference watershed for the sediment portion of the TMDL in consultation with the PADEP. Efforts were made to select a watershed located in the same geographic region and having a reasonable close match in landuse characteristics. EPA recognizes that finding a perfect match for such analysis is unlikely; however this watershed was deemed acceptable for the analysis by PADEP. The reference watershed approach for developing sediment/siltation TMDLs is an established approach and has been used by PADEP and EPA for multiple TMDLs which have been approved in the state (e.g., Conodoguinet Creek (2001), Bens Creek (2005), etc).

In the loading analysis done to develop the sediment TMDL, landuse specific loading RATES were used to derive the allowable loading values for landuses in the

Indian Creek watershed, not total areas and total loading from those same areas in Ironworks Creek. Basing the allocation on landuse specific loading rates reduces the risk of assigning too stringent loading allocations to a watershed t based on comparison to a reference watershed that is smaller or has less —erosion prone" land areas and thus would always have a smaller total load.

Comment B2: Assumed Current MS4 Loadings Are Unsupported. The draft TMDL contains assumed current loadings for the various MS4 dischargers, both for sediment and nutrients. However, the draft TMDL does not explain how those loadings were derived. Actual current MS4 loadings may be materially different than those assumed in the draft TMDL, and should have been based on adequate, representative sampling. As a result, the baseline against which the MS4S' future compliance will be judged may be wholly inadequate. This is the case even for nutrients, for which no reductions are required, but which have assumed current loadings listed in the TMDL that presumably must be maintained. These assumptions are unsupported, arbitrary and capricious.

Response: Page 64 of the Draft TMDL describes how the estimated MS4 loadings were derived. Additional language has been added in an effort to clarify the process that was used. The MS4 loadings were derived based on the modeled GWLF results after the EMPR reduction analysis. First the GWLF model was used to estimate landuse specific unit area loadings for each subbasin. The municipality total areas were then overlaid with the subbasins within GIS to estimate the MS4 area falling within each subbasin. Next this unit area loading for each landuse within a particular subbasin was multiplied by the area of the municipality that it falls into to estimate the MS4 loads.

Comment B3: MS4 Methods Of Compliance Must Be Explained. The draft TMDL fails to provide any explanation or guidance regarding how an MS4 is expected to comply with the reduced loadings. Moreover, the draft TMDL fails to explain how an MSA must demonstrate compliance with the reduced loadings. Depending on the approach, the costs to an MS4 can range dramatically. For example, will actual monitoring and treatment be required or will Best Management Practices (BMPs) suffice? Even if only BMPs are required, are there any proven BMP technologies that will reduce loadings over 90%? What are the costs of such BMPs if they exist? These area particularly important questions for the Borough, whose property that drains to the Indian Creek watershed is almost entirely covered by impervious surfaces. This property is not expected to contribute significant quantities of sediment. Without consideration of and answers to these and similar questions, the draft TMDL puts MS4S in an untenable position.

Response: The large amount of impervious surface is a major concern. These surfaces increase the overland flow of pollutants to the receiving waters. Even if the area does not contribute pollutants to the stream, which is difficult to accept without supporting data, the area will increase flow volume and velocity in the stream, which in turn increases the stream bank erosion and instream sediment loads. These increased loads have a serious detrimental impact on aquatic habitat. The Township needs to evaluate flow controls for these areas. Please see General Response #4 and General Response #8 for more on MS4 allocations and implementation. Federal law and regulations do not require TMDLs to include

detailed implementation issues. We suggest that the Township coordinate with the PADEP on how the allocations will be implemented consistent with EPA permitting regulations and policy.

Comment B4: EPA's Assumption That MS4S Encompass The Entire Subbasin Is Incorrect. As discussed in comment A(6) above, the draft "lumps nonpoint source loadings into the WLA portion of the TMDL" (Draft TMDL p. 68.) EPA wrote the TMDL this way because it incorrectly assumes that all land in a subbasin is contained within and incorporated into the MS4 drainage areas (including, for example, forested, agricultural and pastoral land). EPA concedes, however, that it "cannot determine what portions of the municipalities are designated/used for collection or conveying stormwater, as opposed to portions that are truly nonpoint sources." (Draft TMDL p. 67.) The assumption that all land is within MS4 areas, therefore, is entirely unsupported. In addition, the related assumption that MS4S have the ability to control these discharges js incorrect. EPA's assumptions lead to significant overregulation of M$4S in a manner that is contrary to law. As such, the resulting loads are arbitrary and capricious.

Response: EPA has made several attempts to describe the approach to the MS4 areas, including a discussion at various public meetings. It appears that the commenter is having difficulty in understanding the approach. Please see General Response #4 for an explanation as to how the allocations were made to the MS4 areas. The Townships need to definitively identify each MS4 service area so that the TMDL WLAs and Las can be adjusted based on actual service area.

Comment B5: EPA's Assumptions Regarding the Golf Course Are Incorrect. The draft TMDL fails to adequately incorporate the effects of the golf course. On the one hand, EPA appears to assume that the drainage from the golf course is collected through the M$4. For the reasons stated in comment 6(4) above, that is incorrect. On the other hand, EPA's claim that it does not have enough information to determine the effects of the golf course is disingenuous. It is well known that golf courses utilize significant quantities of nutrient rich fertilizers and other chemicals and that they contain large grassed areas that are relatively impervious. Moreover, golf courses must be irrigated, particularly during the summer ("low flow") months. The Borough believes that this combination leads to significant discharges of nutrients from the golf course. In fact, the data in the draft TMDL bears this out in the following respects. First, according to the data, the highest levels of nutrients are detected near the golf course. Second, the Dissolved Oxygen saturation levels in the TMDL clearly indicate that the golf course is a large part of the problem. (Draft TMDL pp. 12-13.) EPA's failure to address the contributions from the golf course results in an inequitable allocation of loads to the MS4S and other point source dischargers. As such, the resultant loadings are unsupported, arbitrary and capricious.

Response: With respect to the comment related to collection of the golf course drainage, please refer to the response to comment A6 above. Based on implementation of the MS4 permit program, it is EPA‘s intention that as specific areas subject to actual MS4 collection are better delineated and quantified, loadings from non-MS4 areas will be reassigned to the LA portion of the TMDL and addressed by implementation of NPS BMPs. Loadings from the golf course are indeed part of this portion. In addition, EPA fully agrees that the golf course represents a significant potential source of nutrient loading to the Indian Creek

watershed . As such, it is expected that significant measures will be taken by the golf course and other responsible entities to implement practices that will result in significant reductions in nutrient loading from the golf course

Comment Letter #44: Susquehanna Township Comments on Paxton Creek TMDLs

General Comment 1: According to EPA (2003), "the process to change environmental values should involve the preparation of a regional or locally based environmental management plan that has included extensive community based consultation". We in Susquehanna Township feel that such consultation was inadequate (e.g., an announcement was made to the public only half-way through the month following the TMDLs release).

> **Response: EPA followed proper procedures in noticing the TMDLs for comment. However, based on comments received by the stakeholders, EPA did agree to a second public meeting which was held on April 18, 2008.**

General Comment 2: Municipalities typically permit up to 35% of the lands to be impervious for new residential developments, and up to 75% for commercial developments. With this amount of expanding impervious surface, it will be almost impossible for municipalities to meet their nonpoint source MS4 goals and the TMDLs without major changes in land use, ordinances and methods of handling stormwater.

> **Response: EPA expects that changes will need to be made in how the townships require the control of runoff from large developments that include a high percentage of impervious lands. Changes in ordinances may be one way of addressing the issue. The goals should be, no matter the approach used, to reduce the flow volume from these land areas. Reducing volume will reduce the amount of pollutants being discharged to the receiving waters and will also reduce the velocity within the stream, resulting in less stream bank erosion which will reduce the sediment load to the waters resulting in habitat improvement.**

General Comment 3: The reports lack an attainability analysis. Attainability analysis is a structured, technically objective process for determining whether a designated use can be met. We in Susquehanna Township propose the initiation of an attainability study for the TMDLs which are suggested. How can such analysis be conducted when the State has not approved yet a defendable water quality standard for TN/TP and sediments.

> **Response: The TMDL is based on existing and applicable water uses. The state has established those uses for Paxton Creek, which include warmwater fisheries. If the 2commenter believes that the existing uses are not appropriate and wish a use attainability analysis (UAA) to be conducted, then they should petition the PADEP under the state‘s water quality standards program. The TMDL established the endpoint for the TMDL. See General Response #1 for more information. Conducting a UASA is not a requirement or expectation of a TMDL. The PADEP, through comments on the TMDLs, have supported the approach used by EPA.**

Comment 1: Section 303(d) of the Clean Water Act (CWA) and EPA's Water Quality Planning Regulations (40 CFR Part 130) requires states to develop total maximum daily loads (TMDLs) for water quality limited segments that are not meeting designated uses under technology-based controls for pollution. Water Quality Standards determine the baseline water quality that all surface waters of the State must meet in order to protect their intended (designated) uses. The

State of Pennsylvania does not have at the moment numeric criteria for nutrients and sediments. Susquehanna Township is deeply concerned about the science behind the derivation of the endpoints. Numbers are what drive TMDLs, but they have to be accurate and representative. Errors can cause watershed stakeholders to pay a lot more to fix the problems. The reports state the TP/TN endpoints are the average values over the growing season. This means that the spatial and the temporal variability of the data was not taken into account which in turn could skew the endpoint values.

> **Response: See General Response #1 for a further discussion on the endpoint approach.**

Comment 2: The TMDLs appear to be based upon limited water samples collected over a decade or more in small parts of the watershed.

> **Response: EPA disagrees with this comment. In fact, specific monitoring plans were developed and implemented in 2006 as part of the development of TMDL. These recent data as well all the historic data as presented in Chapter 3 of the existing TMDL report.**

Comment 3: The TMDL's were developed with limited data without taking into consideration the following documents: Act 167 Stormwater Management Plan for Paxton Creek which includes stormwater management modeling, and BMP considerations; the Paxton Creek Rivers Conservation Plan of 2006; the Paxton Creek Roundtable (Builders for the Bay) document of 23 LID-type principles or guidelines that resulted from months of discussions among local developers, municipal officials, and environmental groups; the many reports of surveys and analyses of the 52+ linear miles of the creek corridors for erosion, and riparian landscapes for pollutant sources with opportunities for correcting the creek's problems.

> **Response: In the revised TDML report, EPA cited and used the data mentioned in this comment. In addition, land use data included Act 167 Stormwater Management Plan for Paxton Creek was specifically used to revise the estimation on nutrient and sediment loads.**

Comment 4: The TMDL reports did not include any water macro invertebrate data.

> **Response: The Susquehanna River Basin Commission collected such data over a two year period. The data was provided to EPA during the comment period. Please see the attachment to this Response Document for an evaluation of that data. These new data are included in the revised TMDL report and the results of the analysis clearly show that the impaired segment of Paxton Creek provides a poor habitat for macroinvertebrates and does not support its aquatic life use goals**

Comment 5: The report states that there is some biological activity in the Paxton Creek because of the rapid fluctuation in Dissolved Oxygen (DO) concentration during the day. However, the report states that there is no DO depletion. We conclude in Susquehanna Township that DO is not the driving force behind the high TP concentrations. Nutrient pollution has long been implicated in the degradation of lakes and ponds. Excess nutrients, especially phosphorus (in freshwater systems), can cause algal blooms that subsequently die off and deplete oxygen, leading to fish kills. As a rule streams and rivers do not suffer problems as severe as lakes.

Response: EPA disagrees. Streams and rivers suffer from high levels of nutrients. The way in which the nutrient issues manifest themselves in the free-flowing waters as compared to lakes and impoundments may differ but they are a problem just the same. Because of the major concerns with nutrient impacts on free-flowing waters, EPA has directed the states to develop and implement numeric water quality criteria that will address the issue. A memorandum dated November 14, 2001, —Development and Adoption of Nutrient Criteria into Water Quality Standards", from EA to State water pollution control administrators, has indicated the extent of the problem and the importance of establishing appropriate numeric criteria to address the issue.

Comment 6: The mitigating impacts of Wildwood Lake on TP concentration were not taken into consideration when these TMDL's were developed.

Response: Recent field observations in do not support the —mitigating impacts" of Wildwood Lake. This might have been true 20-30 years ago, however, considerable sediment deposits have changed Wildwood Lake into a flow-through system with insignificant pollutant reductions.

Comment 7: The focus on managing non-point source loading on a watershed basis is a critical element of any TMDL allocation. Paxton Creek Watershed is mostly a developed watershed. However, the software used to analyze the watershed through the Universal Soil Loss Equation (USLE) accounts only for rangeland area. The report says the sediment is mainly from croplands, but most of the farms in Paxton Creek Watershed are livestock farms. Several years ago, the watershed measured an average 30% impervious coverage (over 59% in Harrisburg and Penbrook Borough). It is erosion by stormwater from impervious surfaces that is causing many of the present problems, not erosion from farms. Therefore, the USLE method is not applicable for Paxton Creek Watershed.

Response: The Universal Soil loss Equation (USLE) is an acceptable method to estimate the sediment loads from urban areas. In the revised TDML report, EPA used a more recent land use data to reflect more accurately the existing cropland and urban areas in Paxton Creek.

Comment 8: There is potential for significant uncertainty in the model accurately predicting TP concentration in the Paxton Creek Watershed. A quantitative analysis of model uncertainty should be conducted and applied to assessments of compliance. A sensitivity analysis should be performed to evaluate the detection tolerance of the model.

Response: EPA understands that uncertainties are associated with any type of modeling. It should be noted that EPA did not predict the TP concentrations in Paxton Creek. In fact, EPA used a Pennsylvania-specific watershed model (AVGWLF) to estimate the TP target load and existed land-based loads to estimate the TP reduction.

Comment 9: Storm flows are significantly different from traditional point source discharges. Both flow rates and pollutant concentrations vary greatly from storm to storm, and over short timescales within storms, in both storm water discharges and in receiving waters. The TMDLs

are based on a "never-to-be-exceeded" numeric limit. This is equivalent to promulgating a much lower standard than the value inserted into the NPDES permit. This will result in an over-protective requirement that fails to recognize the inherent variability in storm flows.

> **Response: The TP endpoints are actually seasonal averages, not never-to-exceed as the commenter wrongfully suggests. Please review the endpoint study reports for more information on this issue. The sediment goals were based on annual loads.**

General Comment: We are concerned the TMDLs make the NPDES permittees responsible for nutrients/sediment pollution outside of their jurisdiction and control. The report did not address or review the effects of the TMDL on the local economy, the production of housing and general societal impacts.

> **Response: The TMDL did not address those issues. The TMDL is a water quality study that is directed to identify sources of the pollutant of concern and propose reductions necessary from those sources in order to attain and maintain applicable water quality standards.**

General Comment: There is no need for TMDLs because there is little evidence of excessive plant growth or impact on the animal community. Also, what are the anticipated beneficial effects of the TMDL when the impaired stream section consists of a concrete channel with lower nutrients than the upstream channel that has higher nutrients? As currently proposed, we believe that the TMDL will not have a beneficial impact on the impaired stream and it will only result in higher cost to municipalities, residents, and private developers.

> **Response: The PADEP made it clear in a letter dated August 23, 2003 to the City's LTCP contractor that it is important to work on the recovery of Paxton Creek as a viable aquatic community/resource. This was the basis for the LTCP and is no reason not to be the basis for the TMDL as well.**

Comment Letter #45: Swatara Township Comments on Paxton Creek TMDLs

Comment 1: Less than 50 acres of Swatara Township drains into the Paxton Creek. Two large features that generate run-off include State Route SR 3010 (Paxton Street) and Norfolk Southern Railroad as major collectors of stormwater run-off. Swatara Township neither owns nor maintains these facilities. Further, Swatara Township, while having authority as MS4's over private property does not have authority over the State of Pennsylvania nor do they have authority over Norfolk Southern. By what means can Swatara Township address phosphorus from these two facilities?

> **Response: EPA understands that both the state highways department and the railroad have individual MS4 permits. The commenter should discuss this issue with the permitting authority.**

Comment 2: Some run-off from 47 acres crosses municipal boundaries for the City of Harrisburg by sheet flow, thereafter utilizing Harrisburg's stormwater system which is a combined stormwater system. What BMP's can be used effectively to reduce phosphorus sheet flowing off of private property across a municipal boundary and entering Harrisburg's combined system?

> **Response: The loads should be controlled at the municipal boundary. BMP effectiveness for the reduction of sediment and nutrients should be addressed with the permitting authority.**

Comment 3: Since this is the first time that a TMDL reduction program is being put into place using a new formula based upon estimates, what period for compliance will be granted and what are penalties for non-compliance if a good faith effort is made and we are unable to reach satisfactory reduction?

> **Response: The TMDL was not based on estimates. Implementation is under the authority of the PADEP. See General response #8 for a discussion on implementation of storm water allocations.**

Comment 4: Swatara Township is being asked to reduce phosphorus from 29 pounds per year to three pounds per year. If Swatara is successful in its reduction of phosphorus and other municipalities contributing to the loading in Paxton Creek are unsuccessful will corrective action be taken against all municipalities or just those that failed to reach their reduction goal?

> **Response: Enforcement is a PADEP responsibility. But it would seem logical that the _good player" would not be penalized. Each source has its own responsibility to attain the allocated loads.**

Comment Letter #46: Telford Borough Comments on Indian Creek TMDL

Comment 1: The EPA has not provided sufficient supporting documents outlining the scientific basis, methodologies or data used in developing the associated TMDL limits in the Draft Report.

> **Response: EPA provided recent and historical stream data, a detailed endpoint determination report, a literature review report, modeling assumptions and results and nonpoint source evaluations.**

Comment 2: The EPA has not provided proof of the environmental benefits expected upon implementation of more stringent TP or TN TMDL limits for any watershed similar to Indian Creek.

> **Response: It is hard to present —poof" of something has not yet happened, such as implementation of the TMDLs. EPA believes the endpoint determination shows that if the instream TP concentrations are at or below 40ug/L and the sediment is controlled as required in the TMDL, then the stream will be restored to a diverse and healthy aquatic life community/resource.**

Comment 3: The EPA has not demonstrated or provided sufficient evidence regarding the impairment documentation or classification for this tributary of the Indian Creek.

> **Response: PADEP conducted numerous stream surveys that have shown aquatic life impairment. These were used to list the waters on the section 303(d) list of impaired waters for nutrients with the source identified as municipal facilities. The results of these surveys have been summarized in the TMDL and can be obtained from PADEP. EPA is not sure what the classification question refers to.**

Comment 4: The EPA has not demonstrated the legal approach to establish to implement this new TMDL.

> **Response: See General Response #2**

Comment 5: Telford is concerned with the cost of implementation that may increase the user fee to $800 per quarter.

> **Response: EPA understands the concern. The TMDL regulations do not require a cost analysis.**

Comment 6: We are also very concerned with the significant impact this TMDL will have upon our Borough MS4 program. Telford Borough is essentially built out and has very little open space. The costs required to lower the TP or TN required within this watershed, compounds the issue for our Borough workforce and our financial resources.

> **Response: See General Response #8. The Borough needs to discuss the MS4 implementation with the permitting authority – PADEP.**

Comment Letter #47: Upper Gwynedd Township Comments on Indian Creek, Southampton Creek and Chester Creek TMDLs

Comment 1: The TMDLs represent a significant departure in thinking, from the scientific and regulatory approaches applied to nutrient reduction issues over the last 10 years, without a convincing basis for doing so.

Because Pennsylvania does not have numerical water quality criteria for nutrients, the basis for any TMDL was and still is the Pennsylvania Department of Environmental Protection's (PADEP's) narrative water quality criterion for nutrients. PADEP has consistently interpreted this narrative criterion as dependent upon a showing that nutrients are causing excessive algae and/or dissolved oxygen fluctuation. Beginning in the late 1990s, PADEP listed several segments of the Wissahickon, and a number of other creeks, as nutrient impaired and subsequently set out to demonstrate a significant statistical correlation between phosphorus levels and periphyton growth and/or invertebrate impairment. At the time of the 2003 Wissahickon TMDL, EPA indicated that such correlations were not sufficiently established, and proceeded to base the final TMDL on Phosphorus reductions that would achieve compliance with PADEP water quality standards for dissolved oxygen.

PADEP subsequently continued to pursue establishment of statistical correlations, while frequently representing that promulgation of numerical nutrient criteria was imminent. Proposed TMDLs for Skippack and Neshaminy Creeks, and a draft proposal for the Wissahickon Creek were issued, based on such ostensible correlations. However, all three were ultimately withdrawn without any clear indication of how nutrient issues would be resolved.

Now we are seeing TMDLs calling for Phosphorus effluent limits as low as 0.04 mg/1, that are based on a new "weight of evidence" approach. These TMDLs appear to reflect abandonment of the need to demonstrate statistical correlation between nutrients and algae, in favor of a new "conditional probability" approach. We do not find the limited documentation in the TMDLs to be particularly convincing.

Moreover, the conclusions reached regarding the impact of nutrients on invertebrate population and nutrient levels necessary to prevent such impact, seem highly questionable, oversimplified, and not scientifically justified.

In light of the significant nutrient reductions being sought pursuant to these TMDLs, and the substantial costs associated with installing advanced nutrient treatment, particularly for publicly owned treatment works, it behooves EPA to put forth a more supportable basis for imposing such low levels on nutrient discharge. Such a supportable basis would necessarily include a more comprehensive analysis of potentially causative factors, such as habitat impairment.

> **Response: See General response #1. EPA stands behind the approach used to establish the endpoints. The weight of evidence approach used to develop Phosphorus effluent endpoints is thoroughly discussed in the document, *Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application*, by Drs. Mike Paul and Lei Zheng. The document**

is referenced in each of the TMDLs that are the subject of this comment letter and has been provided on EPA's TMDL website since these TMDLs were made available to the public in draft. The approach is supported by EPA for use in developing both nutrient criteria and as a method for determining nutrient endpoints for TMDLs. In addition, see General Response #11 for a discussion on the consideration of algal biomass and consistency with past TMDLs.

Comment 2: If EPA decides to finalize a nutrient TMDL at this time, it should focus on Phosphorus only, rather than simultaneous limits for P and N.

Response: See General Response #3

Comment 3: Facilities seeking to increase design capacity should not be capped at existing loads. In all three TMDLs, the following statement was included:

> In the event that a facility seeks to expand or increase its design capacity, they should be capped at their existing load, consistent with the current design flow within that relevant category.

While this approach may be appropriate for load allocations prepared for a lake or a bay, it is inappropriate for free flowing streams, particularly where the stream is effluent dominated. Increased flow from a WWTP will increase the flow in the stream, which will increase the assimilative capacity of the stream. Increased flow from a WWTP does not presumptively necessitate a reduction in nutrient concentration, and could actually facilitate an increase in the allocation to other point sources.

Response: Some growth has been included in the TMDL. If facilities want to expand beyond the growth allotment, then the TMDL must be reassessed.

Comment 4: The treatment technology necessary to consistently achieve effluent Phosphorus concentrations of 0.04 mg/1 has not been reliably demonstrated in wastewater treatment plants, and would pose exorbitant costs to taxpayers.

In addition to our concerns that the need for such strict nutrient standards is not well documented and not scientifically supported, we also wish to remind EPA of the implementation realities of what is being proposed. The construction of two-stage filtration plus additional treatment steps would be required to get anywhere the 0.04 mg/1 proposed TMDL for phosphorus. Section 5.3.2 of the Parsons Treatability Report appended to the draft TMDL states, on page 8, that two stages of chemical addition and filtration, biological treatment, and UF membrane systems would be required to get "...as low as 0.05 mg/1...". Please note that achieving consistent compliance with a 0.04 mg/1 permit limits means that the target treatment level would have to be significantly lower than 0.04 mg/1. Any treatment process submitted for a Part II Construction Permit requires a margin of safety. This means that to achieve consistent compliance with a permit limit of 0.04 mg/1 requires a target value that would be at or below the practical quantitation limit (PQL), also known as the limit of quantitation (LOQ). This seems impracticable. Assuming such low values could be accurately quantified, even EPA's Treatability Report casts considerable doubt, even with such complex, extraordinary, and costly treatment stated in the Treatability Report, on the ability to achieve consistent compliance, as would be required, with such a low phosphorus

TMDL.

The pilot testing, technology evaluation, design, permitting, public bid and construction processes for such an undertaking will require 3-4 years, and maybe more, in many cases. To the extent that the TMDLs result in effluent phosphorus limits below 0.1 mg/1 and nitrogen limits in the range of 3.7 mg/1, compliance would require utilization of advanced technology that is not in common use. There has been very little application of such technology in the wastewater area.

It is therefore reasonable to state that the efforts to design and construct such technology, as well as the potentially exorbitant costs which will be borne by taxpayers, is not justified. We would also state that if the costs included in Section 3.7 of the Treatability Study are in any way meant to be representative of what compliance costs would be in the three referenced Creeks for the proposed TMDLs, these costs grossly understate what the actual costs would be.

To support our view that such technology has not been successfully installed and operated and consistently met phosphorus levels of 0.04 mg/1, reference is made to Table 5.4 of the Treatability Report. Although there are several facilities that have achieved phosphorus concentrations of 0.04 mg/1 or less, as indicated in the last column, these values are the "...average of monthly average measurements..." This means that individual monthly averages are likely higher than the 0.04 mg/1 proposed TMDL limit. Such performance would result in NPDES permit non-compliance, which, of course, would be grounds for enforcement action by the PADEP. It is also important to note that in the fourth column from the left, there are no facilities which have a permit limit of 0.04 mg/1 or less. If the EPA had provided data with the individual monthly averages, this would have presented a much clearer picture as to the efficacy of the treatment technology referenced with regard to the proposed TMDL limit for phosphorus.

Of the 22 WWTPs listed in Table 5.4 of the Treatability Report, only one had total phosphorus NPDES permit limitation of less than 0.1 mg/1, and half of the WWTPs reported greater than 0.05 mg/1 total phosphorus, These WWTPs produced low effluent phosphorus, but were also well below their respective permit limits. We question whether some of the effluent numbers are actually median values as opposed to mean values.

One last and very important point regards the ability of the Treatability Report technology to achieve the EPA's water quality objectives. During the March 18, 2008 public meeting held at Lower Salford, EPA was asked a direct question regarding examples of WWTPs that have successfully achieved phosphorus levels of approximately 0.04 mg/1 and it was demonstrated that the water body met the intended water quality objectives. EPA said they know of no facilities anywhere in the United States where such effluent phosphorus levels have been consistently met and the water body attained the water quality objectives EPA states are to be attained in the Creeks for which draft TMDLs have been issued.

> **Response: EPA suggested an interim treatment approach. Actual implementation of the TMDL must be discussed with the permitting authority.**

Comment 5: The EPA has not provided data requested and needed for a thorough TMDL review. At the March 18, 2008 public meeting held at Lower Salford Township, EPA was asked about the raw data used in the TMDL development. EPA stated that they used a considerable

amount of data generated in both Maryland and Pennsylvania. When asked, EPA said they used the Maryland data but not the Pennsylvania data. We would like a detailed explanation of why the Pennsylvania data was not utilized, especially considering that the three Creeks referenced herein are all in Pennsylvania. Also, EPA was asked why the data was not included with the draft TMDLs. EPA said they would look into providing the data. We are not aware that any such data has been made available. It is very difficult to make fully informed comments when data used in the TMDL development process is not made available, especially after being requested,

> **Response: As we remember those discussions at the public meeting, there was considerable discussion and confusion between three members of the audience (John Interante, Bill Hall and Steve Hann) concerning exactly what was being requested. At the end of those audience discussions it was decided, EPA believes, that one of the lawyers had in their possession the data that was used. The final request by Mr. Hann was for EPA to provide the methods and approaches to data collection by Maryland. EPA made it clear at the meeting what information was going to be sent and to whom. EPA e-mailed that information to the person that requested the information the day following the meeting. Mr. Interante did not request any further information. If that were not correct and additional information was expected, EPA was not made aware of that until receipt of this comment letter. One would expect that a follow-up would be made by anyone requesting information and not receiving it. No such follow-up was received, leading EPA to believe that the information requested at the meeting was provided in a timely manner. Further the comment is miss-representing the comments by EPA concerning what data was used. While Maryland data was used, there were Pennsylvania data in the database used by EPA. EPA DID NOT say that NO Pennsylvania data was used.**

Comment 6: UGT does not agree with the basis for development of the draft TMDLs.

> **Response: This comment is so vague and without support EPA cannot possibly respond to it. EPA disagrees with the unsupported statement and believes that the total phosphorus limits are needed to help attain and maintain the existing water quality standards, including the aquatic life uses.**

Comment Letter #48: Warminster Municipal Authority Comments on Chester Creek TMDL

Comment 1: WMA's opinion and that of our technical experts is that nutrient reductions from point source contributors will not cure the listed impairments. In fact, our experts have provided data showing an increase in population levels of various stream health indicator invertebrates below point source outfalls when compared to populations existing above those outfalls.

> **Response: The commenter did not provide either the name of the Authority's expert or the data and analysis that led this expert to conclude that a healthier population of invertebrates below the discharges. EPA cannot respond to this unsupported statement.**

Comment 2: We understand there is uncertainty regarding correlations of nutrients and stream health indicators. In fact, EPA has stated in informal meetings that TMDLs are a work in progress. Unfortunately, the consequences to WMA are not at all uncertain if nutrient discharge levels similar to those proposed for Chester Creek are imposed for WMA facilities. In fact, the consequences are astounding in terms of capital expenditures and operational costs, with an increase in Authority debt of 250% and necessary' sewer rate increases of 60%, We have many needs for capital funds and expending enormous capital and operation expenditures without firm scientific benefit to the stream would be unwise and an imprudent use of ratepayer funds.

> **Response: We do not believe that we characterized TMDLs as works in progress. We do acknowledge that as additional information is collected or requests are made to expand facilities or other situations, TMDLs may be revisited and modified if warranted. We understand the commenter's concern with the cost of achieving the TP requirements. However, to predict the requirements that MAY be imposed on Warminster at this time is premature.**

Comment Letter #49: Borough of West Chester Comments on Chester Creek TMDL

Comment 1: The EPA has not clarified several technical or legal issues relating to the development of the TMDL limits. We previously requested EPA's clarification in writing and at meetings with EPA, PaDEP, PMAA, PWEA and various municipalities within Chester Creek Watershed.

> **Response: The commenter has not described the issues that need clarification. Therefore EPA cannot possibly respond to this comment. Possibly EPA's response to other comment letters can help resolve this commenter's concerns.**

Comment 2: The EPA has not provided and or sufficient supporting documents regarding the scientific basis, methodologies and data in developing the TMDL limits

> **Response: EPA has provided a detailed report on the method used to establish the TMDL endpoint. Also the commenter is referred to General Response #1 for additional information. The TMDL report also includes data that was used to develop the TMDL as well as modeling assumptions. Since the commenter did not provide specifics, we trust this information fulfills the needs.**

Comment 3: The EPA has not provided sufficient proof of the environmental benefits due to the more stringent TMDL limits for watersheds similar to Chester Creek.

> **Response: The benefits have been described on numerous occasions. Control of nutrients, in addition to the control of sediment loadings (as discussed in EPA's Chester Creek Watershed Report) including land runoff and stream bank erosion, into the waters will attain and maintain the aquatic life use as established by PADEP.**

Comment 4: The EPA has not demonstrated or provided sufficient evidence regarding the impairments & classifications of the streams in relation to the nutrients.

> **Response: PADEP has determined the impairments and placed the waters on the Section 303(d) list of impaired waters. EPA is not certain what the reference to classifications refers to.**

Comment 5: The EPA has not demonstrated the legal approaches to establish and to implement this TMDL.

> **Response: EPA does not understand this comment, particularly with respect to legal _approaches'. EPA developed the TMDL under Section 303(d) of the Clean Water Act (CWA) and the, implementing regulations under 40 CFR 130.7. Implementation is directed under CWA Section 404 and its implementing regulations at 40 CFR 122.44(d)(1). See General Response #2.**

Comment 7: Due to the amount of confusion between parties, a number of concerns, unanswered questions and the lack of supportive data of the Draft Report and associated TMDL

limits, the Borough hereby asks that the feat USEPA and PADEP, please consider our comments and then consider either withdrawing the current TMDL or look at some other more definitive process in addressing these pollutants.

Response: EPA believes the TMDLs are appropriate and will establish them as required by the federal Consent decree. Some modifications have been made to the draft TMDLs as the final TMDLs were finalized based on comments received.

Comment Letter #50: Westtown Township Comments on Chester Creek TMDL

Comment 1: The consulting firm of Hall and Associates has submitted comments on behalf of a coalition of municipalities relating to the legal and technical aspects of the new TMDL. Westtown Township fully supports these comments.

> **Response: Therefore please see our responses to the comments presented by Hall & Associates.**

Comment 2: So, if there is no true benefit of your proposed TMDLs, and if the only real effect is burden on municipalities and the public with pointless regulation and crushing debt, why are you doing this?

> **Response: EPA suspects that others have informed you that there are no benefits to these TMDLs. EPA disagrees with your summation that these TMDLs serve no purpose. PADEP biological and chemical data show that there are high concentrations of total phosphorus in the Chester Creek. The commenter is referred to the graphs at the end of this response document. PADEP has also established uses for the waters, including aquatic life uses. Proper implementation of the nutrient TMDL, along with the control of sediment form the land and stream bank erosion, will allow the waters to attain and maintain the state established standards, including the uses. Clean water is beneficial to everyone. As noted in General Comment #9, the TMDL has been modified to include only Goose Creek. Unfortunately, the remaining waters of the Chester Creek will not now have a TMDL. EPA still believes, however, that nutrients, along with sediment, are major concerns in the remaining waters of the watershed and need controls in place. EPA has produced a Chester Creek Watershed Report that recommends a certain level of control for both nutrients and sediment. EPA strongly recommends that the PADEP build on that watershed report and finalize, and implement, appropriate TMDLs and control requirements.**

Comment 3: If it is the desire of the EPA and our state DEP that the municipalities and authorities need to meet stricter limits, it should be up to these government agencies to provide funding to meet those limits. While the people using our sewer plant are citizens of Westtown, I should remind you that they are also citizens of the U.S. and the Commonwealth of Pennsylvania where they pay taxes and vote. If the EPA and the Commonwealth are so arrogant as to believe their TMDLs must be implemented to create a clean environment, it is up to these government bodies to pay for them.

> **Response: EPA is confused as to why fulfilling our charge to protect the environment and fulfill the requirements of Federal law and regulations is considered arrogance. These TMDLs are based on sound science, although your —experts" would try to convince you otherwise.**

Comment Letter #51: Borough of Whitehall Comments on Sawmill Run

Comment: Although we generally support the water quality restoration of Sawmill Run, we feel that this report is not appropriate as it relies on significant generalizations when the report should be based on information representing the actual Sawmill Run Watershed. This is especially pertinent since our region is currently under an EPA Consent Order and we are in the process of collecting data that can be used to report this watershed's characteristics and quality. There will be no need for the generalizations, estimates and assumptions used in the draft report you are proposing to use to generate TMDLs.

As you know, the financial impact to our residents to implement the reductions you are proposing will be substantial. We insist that you reconsider your position and allow time for the current consent order requirements be implemented and a subsequent TMDL report be develop based on actual watershed conditions.

> **Response: Since this is the same comment letter provided by the Borough of Brentwood, the commenter is referred to EPA's response for Comment Letter #10**

Comment Letter #52: Borough of Whitehall (Gateway) Comments on Sawmill Creek TMDL

Comment 1: The model used to determine the amount and sources of total phosphorus and total nitrogen assumes the only sources are CSOs, stormwater runoff and groundwater. The model simulation does not account for the SSOs present in the watershed that will be eliminated in their entirety as part of the consent order work that is taking place in the watershed. Currently flow monitoring and modeling is taking place under the consent order to verify the quantity of CSO and SSO discharges to the watershed. Depending on the quantities determined, significant changes in the model for source reduction could occur since SSOs would most likely be the highest concentration of phosphorus and nitrogen in mg/1. Elimination of the SSOs may have a significant impact on the amount of CSO, stormwater, and groundwater reductions to achieve the desired removal.

> **Response: Because this comment letter is the same as Comment Letter #11, we referred the commenter to EPA's response to Comment Letter #11**

Comment 2: The model assumes the CSO volume to be 30% of the urban runoff. The CSOs in this watershed are fed from municipal sewers in which some of the municipal sewers are combined and many are separate sewers. The model CSO volume should be adjusted after the flow monitoring and modeling are completed to determine an accurate quantity of CSO discharge volumes as well as accounting for the amount of reduction to be achieved as part of the consent order requirements.

> **Response: Because this comment letter is the same as Comment Letter #11, we referred the commenter to EPA's response to Comment Letter #11**

Comment 3: In the CSO discharges, the concentrations of total nitrogen and total phosphorus are assumed to be 9 mg/1 and 3 mg/1 respectively. This is a standard number used for combined sewer discharges. The sewers contributing to these structures are a combination of separate and combined sewers that would most likely lead to higher concentrations at. the discharge. This higher concentration would also affect the amount of reduction to achieve the levels required.

> **Response: Because this comment letter is the same as Comment Letter #11, we referred the commenter to EPA's response to Comment Letter #11**

Comment 4: The report does not provide a justification for the use of the 0.04 mg/1 standard for total phosphorus. The report also does not provide justification that if this value is achieved, the goal in respect to the aquatic life and water quality will be achieved. There is not sufficient data to backup this level of reduction.

> **Response: Because this comment letter is the same as Comment Letter #11, we referred the commenter to EPA's response to Comment Letter #11**

Comment 5: The total nitrogen TMDL should not be included since the report itself does not provide the justification for establishing a limit. In reality according to the report, the existing total nitrogen concentrations are below the target concentrations. In addition, Pennsylvania

should not be establishing requirements for total nitrogen until scientific proof has been established lying total nitrogen concentrations to periphyton densities.

Response: Because this comment letter is the same as Comment Letter #11, we referred the commenter to EPA's response to Comment Letter #11

Comment 6: In the report, it states that all of the 14 communities in the watershed have MS4 permits. This is not the case, Crafton is a combined community and does not and is not required to have an MS4 permit.

Response: Because this comment letter is the same as Comment Letter #11, we referred the commenter to EPA's response to Comment Letter #11

Comment 7: It is our opinion that setting TMDLs for total phosphorus and total nitrogen is premature due to the extensive work occurring with the sanitary sewers in the region as part of the consent decree issues to all communities in the ALCOSAN sewer system. Data is currently being collected to better refine the model used to determine the target concentrations from the various listed sources. At a minimum, the model should be adjusted once all of the data is in. and should account for the improvements required under the consent decree to determine if and how much of a reduction would be required from each source.

Response: Because this comment letter is the same as Comment Letter #11, we referred the commenter to EPA's response to Comment Letter #11

Comment Letter #53: Borough of Ingram Comments on Sawmill Run

Comment: Please consider this letter the Borough of Ingram's response to your request for public comments on the Draft Sawmill Run Watershed TMDL Report.

Although we generally support the water quality restoration of Sawmill Run, we feel that this report is not appropriate as it relies on significant generalizations when the report should be based on information representing the actual Sawmill Run Watershed. This is especially pertinent since our region is currently under an EPA Consent Order and we are in the process of collecting data that can be used to report this watershed's characteristics and quality. There will be no need for the generalizations, estimates and assumptions used in the draft report you are proposing to use to generate TMDLs.

As you know, the financial impact to our residents to implement the reductions you are proposing will be substantial. We insist that you reconsider your position and allow time for the current consent order requirements be implemented and subsequent TMDL report be developed based on actual watershed conditions.

> **Response: Since this is the same letter as Comment Letter #10, please see our response to Comment Letter #10**

Comment Letter #54: Borough Ingram Comments (Gateway Letter) on Sawmill Run TMDLs

Comment 1: The model used to determine the amount and sources of total phosphorus and total nitrogen assumes the only sources are CSOs, stormwater runoff and groundwater. The model simulation does not account for the SSOs present in the watershed that will be eliminated in their entirety as part of the consent order work that is taking place in the watershed. Currently flow monitoring and modeling is taking place under the consent order to verify the quantity of CSO and SSO discharges to the watershed. Depending on the quantities determined, significant changes in the model for source reduction could occur since SSOs would most likely be the highest concentration of phosphorus and nitrogen in mg/1. Elimination of the SSOs may have a significant impact on the amount of CSO, stormwater, and groundwater reductions to achieve the desired removal.

> **Response: Since this is the same set of comments as Comment Letter #11, please see our response to Comment Letter #11**

Comment 2: The model assumes the CSO volume to be 30% of the urban runoff. The CSOs in this watershed are fed from municipal sewers in which some of the municipal sewers are combined and many are separate sewers. The model CSO volume should be adjusted after the flow monitoring and modeling are completed to determine an accurate quantity of CSO discharge volumes as well as accounting for the amount of reduction to be achieved as part of the consent order requirements.

> **Response: Since this is the same set of comments as Comment Letter #11, please see our response to Comment Letter #11**

Comment 3: In the CSO discharges, the concentrations of total nitrogen and total phosphorus are assumed to be 9 mg/1 and 3 mg/1 respectively. This is a standard number used for combined sewer discharges. The sewers contributing to these structures are a combination of separate and combined sewers that would most likely lead to higher concentrations at the discharge. This higher concentration would also affect the amount of reduction to achieve the levels required.

> **Response: Since this is the same set of comments as Comment Letter #11, please see our response to Comment Letter #11**

Comment 4: The report does not provide a justification for the use of the 0.04 mg/1 standard for total phosphorus. The report also does not provide justification that if this value is achieved, the goal in respect to the aquatic life and water quality will be achieved. There is not sufficient data to backup this level of reduction.

> **Response: Since this is the same set of comments as Comment Letter #11, please see our response to Comment Letter #11**

Comment 5: The total nitrogen TMDL should not be included since the report itself does not

provide the justification for establishing a limit. In reality according to the report, the existing total nitrogen concentrations are below the target concentrations. In addition, Pennsylvania should not be establishing requirements for total nitrogen until scientific proof has been established tying total nitrogen concentrations to periphyton densities.

> **Response: Since this is the same set of comments as Comment Letter #11, please see our response to Comment Letter #11**

Comment 6: In the report, it states that all of the 14 communities in the watershed have MS4 permits. This is not the case, Crafton is a combined community and does not and is not required to have an MS4 permit.

> **Response: Since this is the same set of comments as Comment Letter #11, please see our response to Comment Letter #11**

Comment 7: It is our opinion that setting TMDLs for total phosphorus and total nitrogen is premature due to the extensive work occurring with the sanitary sewers in the region as part of the consent decree issues to all communities in the ALCOSAN sewer system. Data is currently being collected to better refine the model used to determine the target concentrations from the various listed sources. At a minimum, the model should be adjusted once all of the data is in, and should account for the improvements required under the consent decree to determine if and how much of a reduction would be required from each source.

> **Response: Since this is the same set of comments as Comment Letter #11, please see our response to Comment Letter #11**

Letter #55: Harrisburg Authority Clarifying Letter

Comment 1: As previously conveyed to you, the Harrisburg Authority ("Authority") has numerous concerns with and takes exception to the Proposed Paxton Creek Watershed TMDL. In particular, the CSO-related phosphorus loadings predicted to exist in the Berger Report are clearly incorrect and greatly overestimate the impact of the CSO nutrient loadings on Paxton Creek. CSO concentrations were overestimated by at least 85% leading to incorrect predictions of instream water quality. At the April 17th public workshop in Lower Paxton Township, the Berger Associates representative stated that the model used to predict instream TP levels does not respond directly to load inputs (i.e., the model is not linear). Consequently, EPA cannot claim that the current TMDL analysis and predicted CSO reductions needed to achieve the instream TP target created by EPA are still valid. The model predictions and necessary point source reductions all need to be revised given the information on the correct CSO concentrations and loadings. Given the very substantial revisions required for the TMDL, the public must be given an opportunity to review the new modeling results and load reduction predictions before this document is finalized.

> **Response: If any changes were made to the final TMDL, those changes were based on comments received during the comment period. EPA is under no requirement to obtain additional comment on those changes.**

Comment 2: Comments on the TMDL were previously provided by the Authority via letter dated April 18, 2008 whereby the Authority requested that the TMDL be withdrawn. That TMDL report failed to consider the DEP-approved Long Term Control Plan (LTCP), the extensive available data on TP levels and CSO discharge volumes and expected water quality improvements from LTCP implementation. As identified in the April 18, 2008 letter, that data shows that the existing loading of total phosphorus (TP) to Paxton Creek from the Authority‘s combined sewer overflows (CSOs) is significantly less than the assumptions made in the TMDL. We also informed EPA of the conflict at the April 17, 2008 meeting held at the Lower Paxton Township Municipal Building. EPA requested that this additional information be provided so the TMDL could be corrected.

> **Response: EPA requested the LTCP and associated information and data on April 18, 2008. In comment letter #34, the Authority indicated that additional information would be provided to EPA by April 30, 2008. A summary letter dated May 21, 2008 was received by EPA on May 28, 2008, without specific data or the LTCP. EPA requested the LTCP and information- not to correct the TMDL as noted in this comment - but to determine if modifications were appropriate based on the data. Unfortunately a month following EPA‘s request for the LTCP and data, only a summary letter was submitted by the Authority which left EPA with no actual data and information to review.**

Comment 3: This correspondence provides additional information and comments on the TP loadings to Paxton Creek. The proposed TMDL identified that TP loads to Paxton Creek from the Authority's CSOs were estimated using 2001 overflow volumes identified in the Authority's 2002 NPDES permit application and a literature concentration value of 3 mg/L for TP. The TMDL indicated that the existing annual average TP load to the Paxton Creek from the CSOs is 2,411 pounds per year (lb/yr) and an 87.6% reduction is required to meet a proposed 298 lb/year allocation. This degree of reduction was needed to achieve EPA's new instream TP target of 0.04 mg/1 growing season

average. It is not apparent how the annual average load predicted by the TMDL translates into requirements only applicable during the "growing season."

Response: EPA is aware of the Authority's concern with seasonal limits. The final TMDL has addressed that issue.

Comment 4: Analytical data compiled during completion of the Authority's CSO Long Term Control Plan, approved by the Pennsylvania Department of Environmental Protection (DEP) on February 1, 2006, shows that average TP concentrations during CSO events are significantly less than the literature value of 3 mg/1.

During preparation of the Long Term Control Plan, monitoring of CSO overflow volumes and TP concentrations was performed at eight (8) of the Authority's CSOs during three (3) wet-weather events which occurred between June and November 2003. Four (4) of the monitored CSOs discharge directly to Paxton Creek while the remainder of the CSOs monitored discharge directly to the Susquehanna River. During each of the wet-weather events, eight (8) sample sets were collected from each of the CSOs (time intervals of 0 minutes, 15 minutes, 30 minutes, 45 minutes, 1 hour, 2 hours, 3 hours and 4 hours after the beginning of the overflow event) and analyzed for TP concentration. Based on the measured overflow discharge volumes and the analytical results for TP, Event Mean Concentrations (EMCs) of TP for each of the wet-weather events were calculated. The EMC represents the volumetric flow-weighted mean concentration of TP over the duration of the wet-weather event. It should be noted that many of the CSO events occur for a small fraction of a day. It is not apparent how these short term events were used to determine daily average TP levels that could then be averaged over a "growing season." To the degree that these short term events were assumed to represent daily average conditions, that assumption would be clearly incorrect as the daily average condition would be far less.

A system-wide average EMC for TP of 0.60 mg/1 was calculated for the recorded CSO events, including discharges to both Paxton Creek and the Susquehanna River. The average EMC for TP for CSOs discharging directly to the Paxton Creek was calculated as 0.44 mg/1, excluding statistical outliers. These values are much less than the 3 mg/1 literature value assigned in the TMDL (i.e., over 85% lower than EPA's assumed CSO concentration). Please refer to the attached Table 5-2 from the Water Quality Monitoring Analytical Results Report completed during preparation of the Long Term Control Plan which displays the EMCs for TP at each of the monitored CSOs.

The TMDL indicated that the existing annual average TP load to Paxton Creek from the Authority's CSOs is 2,411 Lb/yr, which using the literature value of 3 mg/1 identifies the annual discharge volume from the CSOs to be approximately 96 million gallons (MG). Hydraulic modeling completed during preparation of the Authority's Long Term Control Plan estimated the annual volume discharged by the CSOs to be approximately 159 MG. However, the Plan recommended optimization of the CSO regulators and enhanced floatable controls to reduce overflow volumes to an estimated 137 MG based on the hydraulic modeling. Please refer to the attached Appendix 4C from the Plan which displays the CSO volumes for CSO overflows to Paxton Creek. Note that these are average annual overflow volume estimates which are dependent upon specific rainfall events for a given year. Much of this volume occurs in non-growing season months or in April/May when Paxton Creek stream flows are quite elevated. To properly model the impact of the CSO TP loads on instream water quality, the elevated stream flows generally occurring during such events

would have to be considered. Moreover, the planned regulator-related construction will disproportionately impact smaller CSO events occurring under the driest conditions which would also need to be properly considered in the modeling.

Utilizing the average EMC for TP for CSOs identified in the attached Table 5-2 and the estimated discharge volumes identified in the Long Term Control Plan, the estimated annual loading of TP to Paxton Creek from the Authority's CSOs is between 600 and 800 Lb/yr at existing conditions. Optimization of the CSO regulators, as recommended in the Plan, will reduce the estimated annual loading of TP to between 500 and 700 Lb/yr. Again, the growing season loading will be a fraction of this amount.

As you can see from these numbers, the TMDL overestimates the existing TP loading to Paxton Creek caused by the Authority's CSOs. Also, optimization of the CSO regulators as recommended in the Long Term Control Plan will result in an estimated annual reduction of TP loading to Paxton Creek of approximately 100 lb/yr.

It is also worth noting that the first flush (Time =0) TP concentrations are typically the highest concentrations observed during the overflow events. Please see the attached TP vs. time charts prepared for the observed Paxton Creek CSOs using data from the Water Quality Monitoring Analytical Results Report. The CSO regulator optimization recommended in the Long term Control Plan will assist in reducing the first flush TP concentrations and further reduce the TP loadings to Paxton Creek.

As previously stated in the April 18, 2008 letter, the Authority's CSO capture efficiencies are already in compliance with the DEP and EPA CSO Control Policies, and implementation of the recommendations contained within the Long Term Control Plan will further reduce overflow volumes, and subsequently, TP loadings to the Paxton Creek.

It is apparent that the modeling performed during preparation of the TMDL does not contain adequate detail to accurately depict existing or future TP loadings from the Authority's CSO facilities to Paxton Creek. Additional data collection, reporting and modeling is required by EPA to prove that the model is an accurate and reliable tool before the Authority is expected to proceed with the extremely cost prohibitive upgrades required to comply with the TMDL.

> **Response: The Authority's May 21, 2008 clarification letter did not provide sufficient information to show that the long term control plan (LTCP) properly addressed the nutrient issue. In fact it is apparent that the LTCP as prepared by the Authority eliminated TP from consideration simply because there were no numeric criteria available even though TP was listed in the report as a pollutant of concern. The August 26, 2003 letter from PADEP made it clear that Paxton Creek ‗…is included on the 303(d) list of impaired waters and one of the causes for its listing is the existence of CSOs. Although this stretch of creek through Harrisburg may not be ‗sensitive', it is important to work on its recovery as a viable aquatic community/resource." The Harrisburg Authority's CSO Management and Control Program, Development and Evaluation of CSO Control Alternatives, Chapter 3.3 provided a list of water quality standards that were included in the CSO evaluation. The list included TP. Chapter 3.3.1 recognized that Paxton Creek is classified as a warmwater fishery. The LTCP**

considered the use classification, so should the TMDL.

Table 3-2 of the CSO evaluation plan showed the water quality standard for each pollutant. The standard for TP was identified as _none‘. The City dismissed TP from further consideration simply because there were no numeric criteria. The plan did not address the narrative criteria or the state‘s other requirements for nutrient controls. At a minimum the water quality evaluation should have included analysis of instream TP concentrations, algal biomass and a biological evaluation. Dissolved oxygen violations were reported.

Because of this failure to properly evaluate TP impacts on Paxton Creek from CSOs, the City‘s plan failed to show that all water quality standards that apply to the creek and identified at Chapter 3.3 will be met under the selected plan.

Because of this failure, EPA was unable to properly evaluate the effectiveness of the LTCP in meeting the TP reductions required under the draft TMDL. As shown below the selected plan‘s flow reduction of 14% through regulator optimization will not achieve the draft TMDL needs. This is based on the City‘s claim that the event mean concentration (EMC) for the CSOs discharging to the Paxton Creek is 440ug/L. The City did not provide sufficient data, specifically the Water Quality Monitoring Analytical Results Report to allow an agency review of the data. Therefore we made estimates based on the basic concentration-time graphs provided by the City. Flows obtained during each time interval were not provided, preventing EPA from fully considering loading rates per overflow event.

EPA can provide some preliminary observations based on the brief, summarized data provided by the Authority. First, EPA is surprised at the minimal reductions in overflow volume under the selected alternative 1A. Based on the summarized information provided by the City, only 14% reduction in overflow volume is expected. The City provided, in the May 21, 2008 letter, neither the data analysis nor the system modeling they say they performed to show that this small reduction in overflows will allow Paxton Creek to attain and maintain water quality standards including the uses established by PADEP. However, the TMDL will assume that these reductions are acceptable to the permitting authority.

The City did not provide any residence time analysis to support their theory that the pollutants from the overflows are quickly flushed from the Paxton Creek and into the Susquehanna River before they have any time to play havoc with the aquatic community. EPA cannot base any decisions on unsupported claims.

The barely legible graphs provided by the City shows a time vs. TP concentration for 4 separate CSOs for 3 separate overflow events. Since the data behind the graphs were not provided, EPA was forced to make best estimates from the graphs. Based on this, the graphs show that, on average, the first flush concentrations ranged from 3100ug/L to 470ug/L, with an average for the 4 overflows of 2100ug/L. The concentration after 1 hour of overflow remained high at an average of 1250ug/L, with a range of 1700 to 300ug/L. The data presented for the tail end of

the overflow seems to level off at concentrations that are still much higher than the TMDL endpoint of 30ug/L, ranging from 500ug/L to 230ug/L. EPA notes that all values are well above the endpoint of 30ug/L.

Let‘s assume that the information provided by the City is accurate and we ignore the percent reduction required by the draft TMDL and focus on instead the load allowed from the CSOs in order to attain and maintain the applicable water quality standards, which after all is the important consideration. The draft TMDL allows a loading from the City‘s CSOs of 300lb/yr. The LTCP projects a loading after implementation of the LTCP of 500lb/yr. An additional 200lb/yr of TP must be removed in order to meet the draft TMDL loads, or a 48% reduction over the City‘s claimed existing loading.

A critical consideration in the evaluation of the impacts of TP on the aquatic community in the creek is the overflow residence time. The City did not provide any information on this issue. It has been argued by the City that much of the overflows will have a short residence time in the creek and therefore cannot impact the aquatic life. Based on EPA‘s own evaluation, EPA may accept that argument for much of the overflow event. However, the trailing end of the overflows may not flush through quickly and the City‘s data shows high concentrations of TP at the end of each of the overflow events. This does not convince EPA that CSO overflows have NO impact on aquatic life in the creek. However there is also no convincing evidence that the CSOs are a major source of TP as it relates to impacts on aquatic life. The City did not provide any information or analysis to support the residence time theory.

Review of the event data shows that only one TP value was available for CSO31. Yet the concentration-time graph shows this CSO to be one of the more significant in terms of TP concentrations. The graphs show the concentration for the initial flush to range from 3700 to 2600ug/L. In addition the value for CSO43 for the June 3, 2003 event was considered as an outlier and was not included in the event mean concentration calculations. EPA wonders, if a concentration-time curve can be developed for CSO43 for June 2003, why a sum of TP could not be calculated. We also wonder how a concentration-time plot could be developed for CSO31 if the activation monitor was removed for repair as noted on the Table. We also wonder why the concentration-time plot is date November 18, 2003 and Table 5-2 Event Mean Concentration (EMC) Statistical Outliers provided by the City identifies the event time as November 19, 2003. Were there two separate overflow events in November 2003?

Table 5-2 is also confusing. It is titled Statistical Outliers and the footnote says that the ―EMCnot calculated for the reason specified – Statistical Outliers”. Yet the handwritten notes calculate an EMC for Paxton Creek. The Table needs clarifications.

Based on the above the EMC provided by the City is somewhat suspect.

TMDL Data:

Q = 96.6MG
TP = 3000ug/l
TP = 2411lb/yr
% reduction = 87.6
TP remaining = 299lb/yr

LTCP Information – existing

Q = 159lb/yr
TP = 440ug/L
TP = 583lb/yr

LTCP – Alternative 1A information

Q = 137MG/yr
TP = 440ug/L
TP = 503lb/yr
% reduction = 14%
Total removed = 80lb/yr
Total TP remaining = 500lb/yr

TMDL vs LTCP

TMDL TP remaining = 300lb/yr
LTCP TP remaining = 500lb/yr
LTCP additional TP reductions needed = 200lb/yr
Total needed TP reduction = 48%

Comment 5: For the reasons set forth above and contained in the April 18, 2008 letter, The Harrisburg Authority respectfully requests that the TMDL be withdrawn at this time.

Response: Sufficient justification was not provided for EPA to withdraw the TMDL. EPA believes the analysis and resulting TMDLs are appropriate, supportable and based on best available data and information. EPA has fully considered all comments received and made modifications to the draft TMDLs as appropriate. Please see the final TMDL.

Appondlx ***4C*** **• CSO Volume** Summary

CSO	Interceptor	Overflow Volume (MO)													
		Existing	Future	Alternative 1	Alternative 1A	Alternative 2					AltemaUve 3				
						MBsntra 1.2-Month Return	08/28/1949 2.9-Month Raturn Frequency	07/31/1970 48-Monlh Return Frequency	07/22/1948 SS-Montti Return Frequency	06/27/1978 1-Year Return Frequency	04/25/1975 1 2-Montri Return Frequency	08/28/1949 2-9-Month Return Frequency	07/31/1970 4.8-Month Return Frequency	07/22/1948 S.SMonth Return Frequency	06/27/1976 1-Year Return Frequency
2. CSO Overflow lo Paxton Crmk															
OJ1	Paxton Creek Interceptor	1156	13.61	14.02	14.02	1.46	1.46	0.00	0,00	0.00	1.46	1.46	0.00	0.00	0.00
Oi2	Paxton Croak Interceptor	0.14	0.1S	0.69	0,69	0.69	0.74	0.00	0.00	0.00	0.69	0.74	0.00	0.00	0.00
OS	Paxton Creek Interceptor	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	OQO	0.00
OJ4	Paxlon Creek Interceptor	5.34	6.18	16.50	1650	5.56	2.31	0.05	0.05	0.00	5.56	2.31	0.05	0.05	0.00
OX	Paxton Creek Interceptor	3.63	4.08		0.00										
036	Paxton Creek Interceptor	4.42	4.64	15.14	15.14	5.94	2.76	0.07	0.07	0.00	5.94	Z76	0.07	0.07	0.00
OJ7	Paxlon Creek Interceptor	OSQ	OS9		0.00										
028	Paxton Creek Interceptor	0.53	0.64	0.04	0.04	193	1.21	0.08	0.08	0.00	1.93	1.21	0.06	0.08	0.00
029	Paxton Creelj Interceptor	4.46	4.47	0.26	0.26	0.0»	0.05	0.00	0.00	0.00	009	0.05	0.00	0.00	0.00
030	Paxton Creak Interceptor	4.27	4.90	3.52	3.52	0.29	0.18	0.00	0.00	0.00	0.28	0.18	0.00	0.00	0.00
031	Paxton Creek Interceptor	30.62	30.75	9.22	9.22	0.07	003	0.00	0.00	0.00	0.07	0.03	0.00	0.00	0.00
032	Paxton Creek Interceptor	1.95	2.22	1.68	1.68	0.47	0.30	0.00	0.00	0.00	0.47	0.30	0.00	0.00	0.00
033	Paxlon Cteek Interceptor	2.59	2.67	0.00	0.00	0.00	0.00	0.00	0.00	0,00	000	0.00	0.00	0.00	0.00
034	Paxton Creek Interceptor	6.08	616	2.03	2.03	0.61	0.32	0.01	0.01	0.00	0.51	0.32	0.01	0.01	000
03f	Paxion Creek Interceptor	3.51	3,64		0.00										
031	Paxton Creek Interceptor	0.01	001	16.74	16.74	0.96	0.55	0.03	0.03	0.00	0.96	0.55	0.03	0.03	0.00
03)	Paxton Creek Interceptor	1.79	1.86	8.34	8.34	1.35	0.79	0.05	0.05	0.00	1.35	0.79	0.05	0.05	0.00
041	Paxton Creek Interceptor	2.05	2.28	10,48	10.48	1.48	0.86	0.05	0.05	0.00	1.48	0.8?	0.05	0.05	0.00
041	Paxton Creek Interceptor	1.40	1.62	1051	10.61	1.25	0.72	0.04	0.04	0.00	125	0.72	0.04	0.04	0.00
04·	Paxton Creek Interceptor	0.66	0.73	0,00	0.00	1.25	0.72	0.03	0.03	0.00	1.25	0.72	0.03	0.03	0.00
041	Paxton Creek Interceptor	1759	17,83	6.24	5.24	1.29	0.75	0.03	0.03	0.00	1.2?	0.75	0.03	.... 0:9?.	0.00
04*	Paxton Creek Interceptor	37.03	36.57	13.27	13.27	0.00	0.00	000	0.00	0.00	0.00	0.00	0.00	0,00	0.00
061	Hemlock Street Interceptor	1.83	1.83	1.94	1.84	1.94	1.59	0.33	0.32	0.25	1.94	1.59	0.33	.,0,32	0.25
061	Hemlock Street Interceptor	9.37	S.37	0-00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
06·	Hemlock Street Interceptor	1.97	1.97	2.52	2.82	1.84	0.63	0.30	0.15	0.09	1.84	0.63	0.30	0.15	0.09
063	Hemlock Street Interceptor	2.60	2.60	4.94	4.94	1.02	038	0,02	0.06	0.00	1.02	0.38	0.02	0.06	000
064	Hemk»ck Street Interceptor	0.87	0.87	0.21	0.21	007	0.02	0.00	0.00	0.00	0.07	0.02	0.00	0.00	0.00
Tola CSO Overflow to Paxlon Crwk		159.031	1«2.31	137,28	138.28	29.47	16.39	i.oa	0.96	0.35	29.47	16.39	1.08	0.96	0.35
					~j^i'Ji										

The Harrisburg Authority
Combined Sewer Overflow Management and Control Program
Water Quality Data Analysis Report
Table 5-2 Event Mean Concentration (EMC) Statistical Outliers

6/3/2003 event

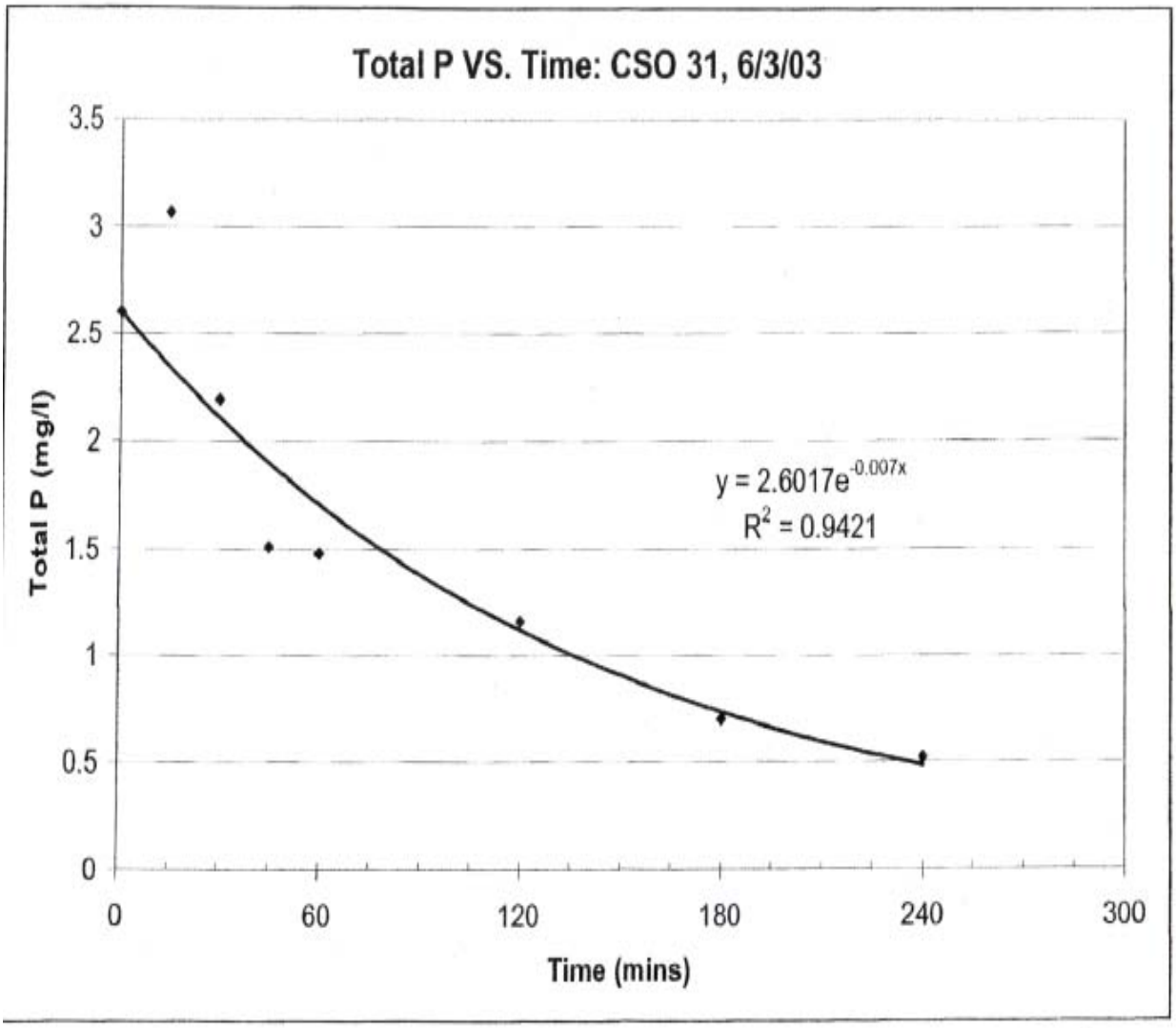
Parameter	£ Scttlcable Solids mg/L	TSS mg/L	BODj mg/L	£ Nitrogen mg/L	£ Phosphorus mg/L	Fecnl cfu/100 Ml
CSO04	1.77	53.30	15.18	2.76	0.46	420,730
CSO06						
CSO14	0.86	54.94	60.06	5.53	0.85	386,968
CSO43	2.87	155.96	104.04	13.47	2.52	1,424,943
CSO48	0.69	105.71	23.01	4.46	0.84	981.414
CSO49	1.33	59.48	56.70	3.92	0.59	387,512
CS062	0.36	103.10	4.11	1.68	0.19	117.346

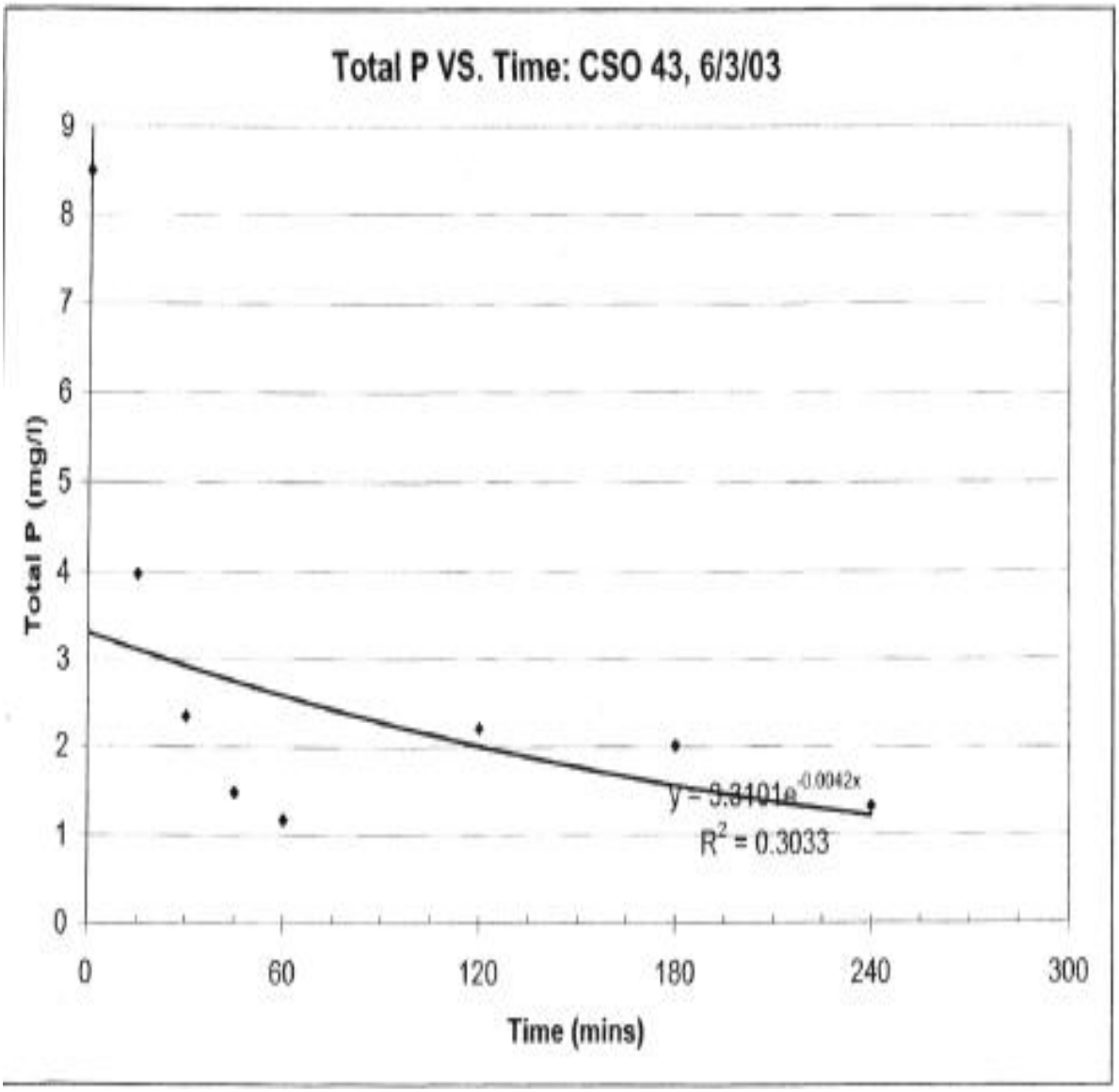
10/14/2003 event

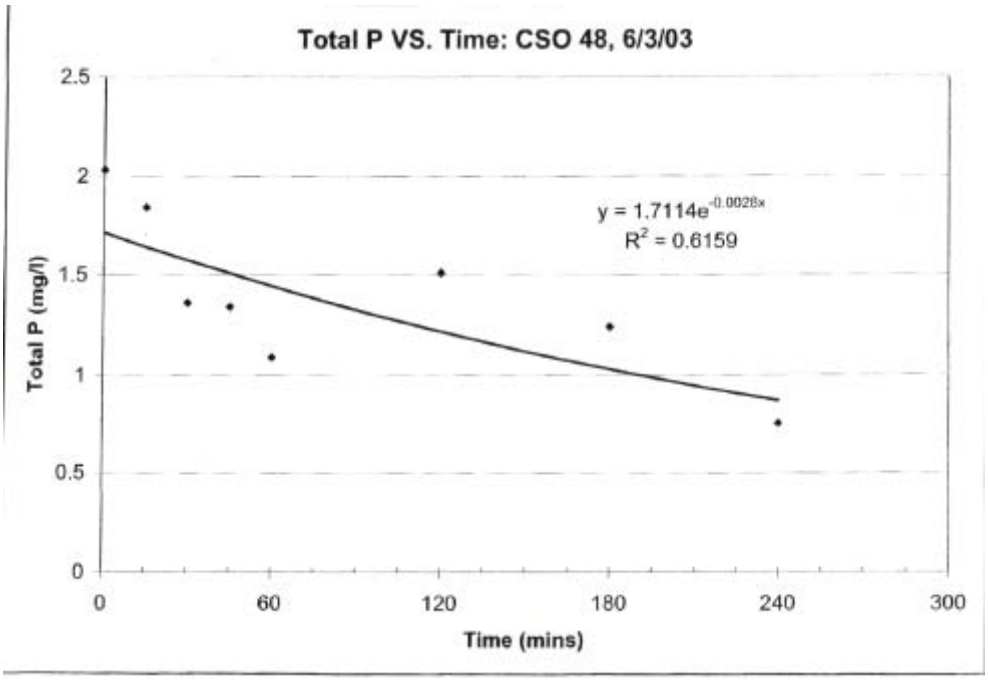
Pai'iimcler	£ Settleable Solids mg/L	TSS mg/L	BOD_S mg/L	£ Nitrogen mg/L	£ Phosphorus mg/L	Fecal Coliform cfu/100 mL
CSO04	0.64	36.51	11.17	1.91	0.44	53,759
CSO06	5 2.S	241.52	41.85	6.11	1.33	499,845
CSO14	8.32	374.97	34.99	6.95	1.39	272,818
CS043	2.14	72.21	31.38	2.91	0.43	225,195
CS048	2.20	130.84	45.26	5.19	0.83	144,349
CSO49						
CS062	2.13	95.68	6.92	l.46		1 9,538

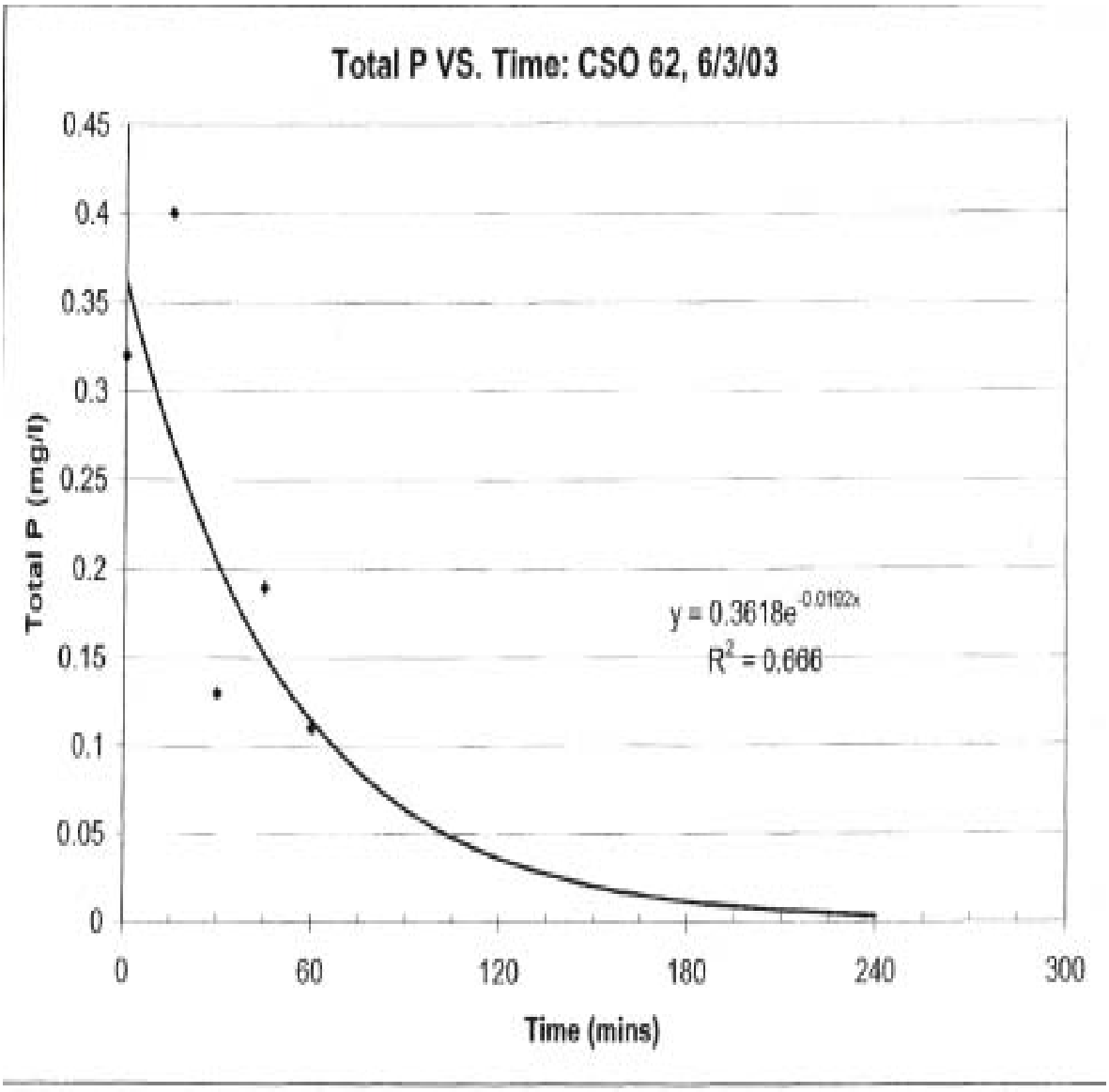
11/19/2003 event

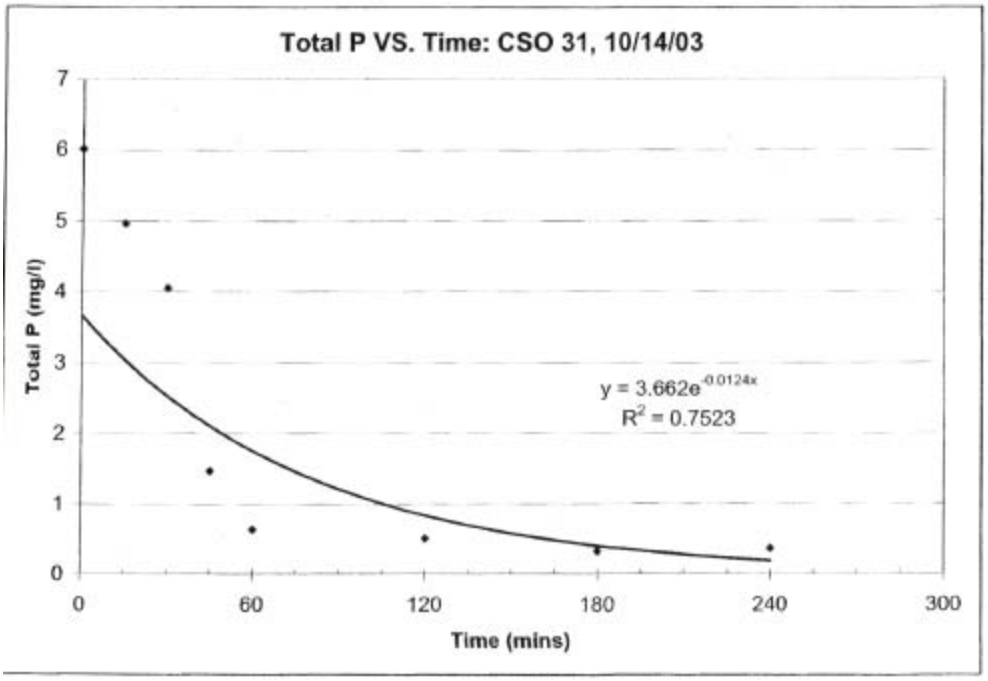
Parameter	£ Setlleablc Solids mg/L	TSS mg/L	BOD_5 mg/L	£ Nitrogen mg/L	£ Phosphorus mg/L	Fecal Coliform cfu/100 Ml
CS004	1.00	38.52	23.17	2.37	0.46	400,092
CSO06						
CSO14	0.23	50.17	19.56	1.|94	033	135,322
CSO31	2.75	63.33	22.96	2.58	0.45	158,729
CSO43						
CSO48						
CSO49						
CSO62	274	50.62	10.72	1.88	0.15	4,324
Average	2.00	78.14	24.78	3.44	0.60	230,466

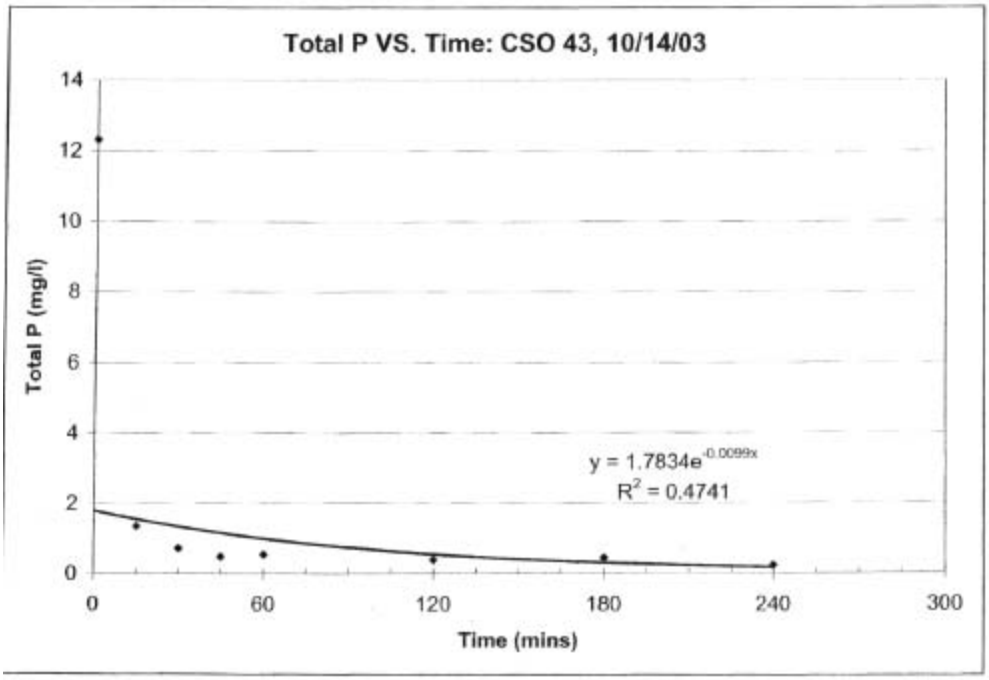

Total P VS. Time: CSO 31, 6/3/03
3.5
3
2.5
2
1.5
1
0.5
0
Total P (mg/l)
y = 2.6017e^-0.007x
R^2 = 0.9421
0
60
120
180
240
300
Time (mins)

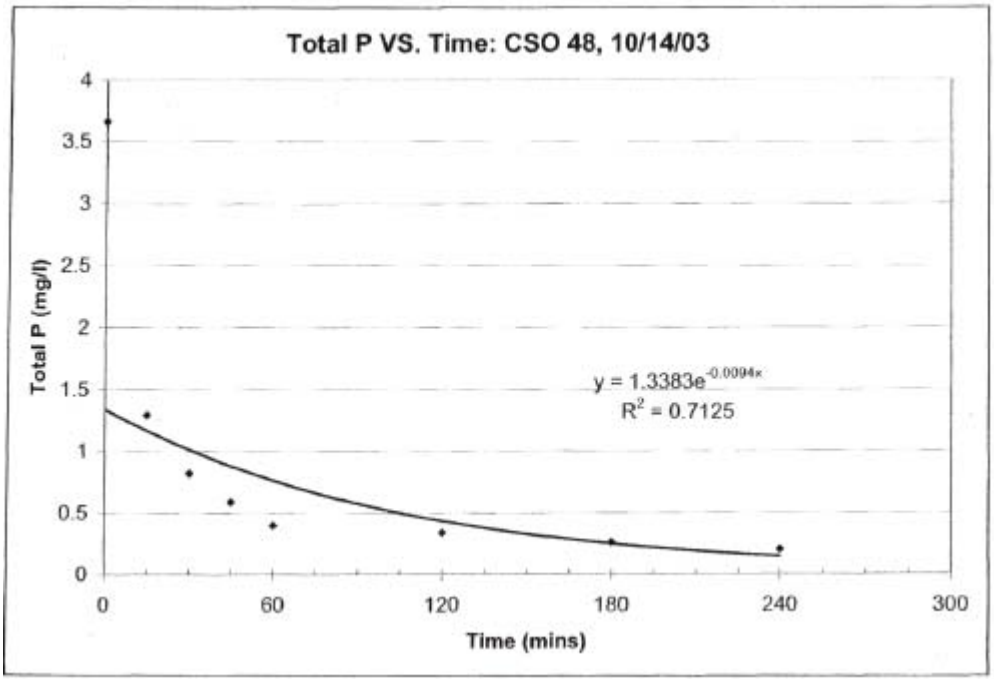

Total P VS. Time: CSO 43, 6/3/03
Total P (mg/l)
Time (mins)
y = 3.3101e^-0.0042x
R^2 = 0.3033
0
1
2
3
4
5
6
7
8
9
0
60
120
180
240
300

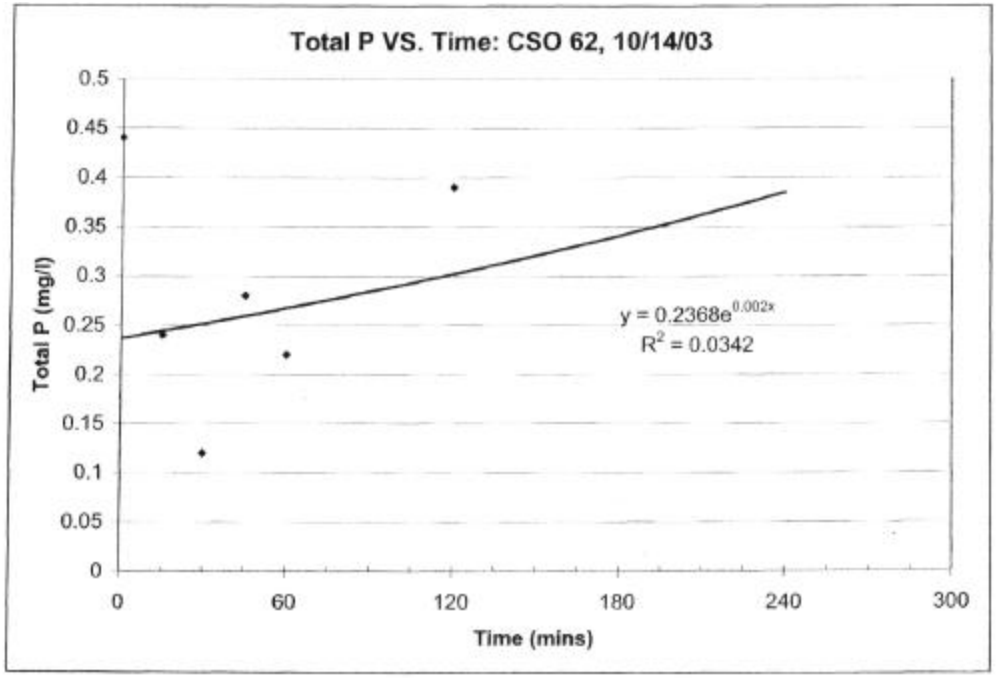

Total P VS. Time: CSO 48, 6/3/03
y = 1.7114e^-0.0028x
R^2 = 0.6159
Total P (mg/l)
Time (mins)
2.5
2
1.5
1
0.5
0
0
60
120
180
240
300

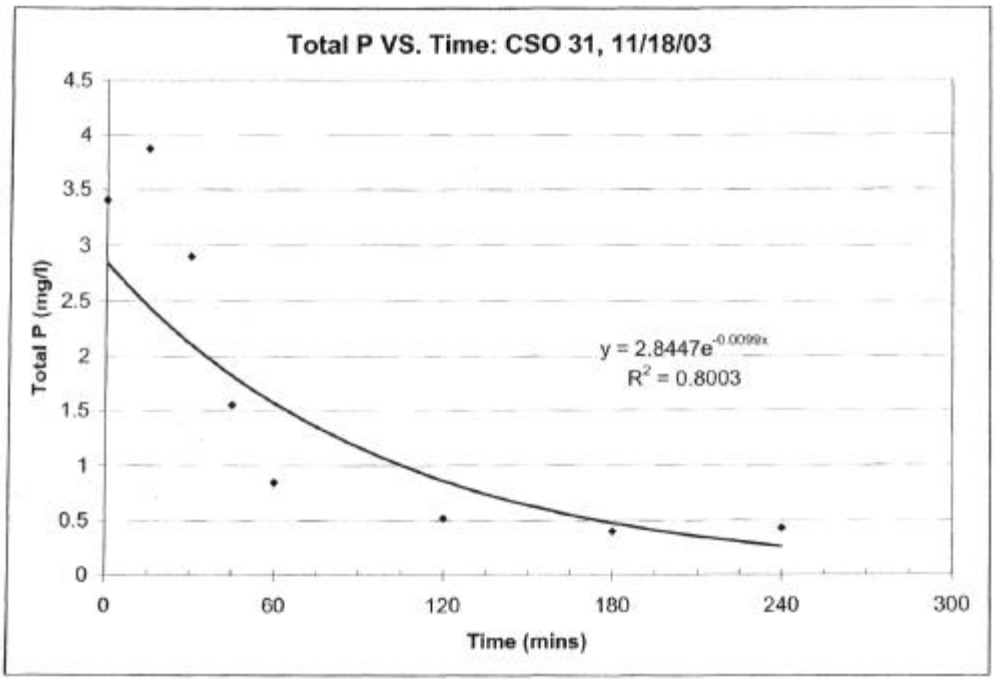

Total P VS. Time: CSO 62, 6/3/03
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Total P (mg/l)
y = 0.3618e^-0.0192x
R^2 = 0.666
0
60
120
180
240
300
Time (mins)

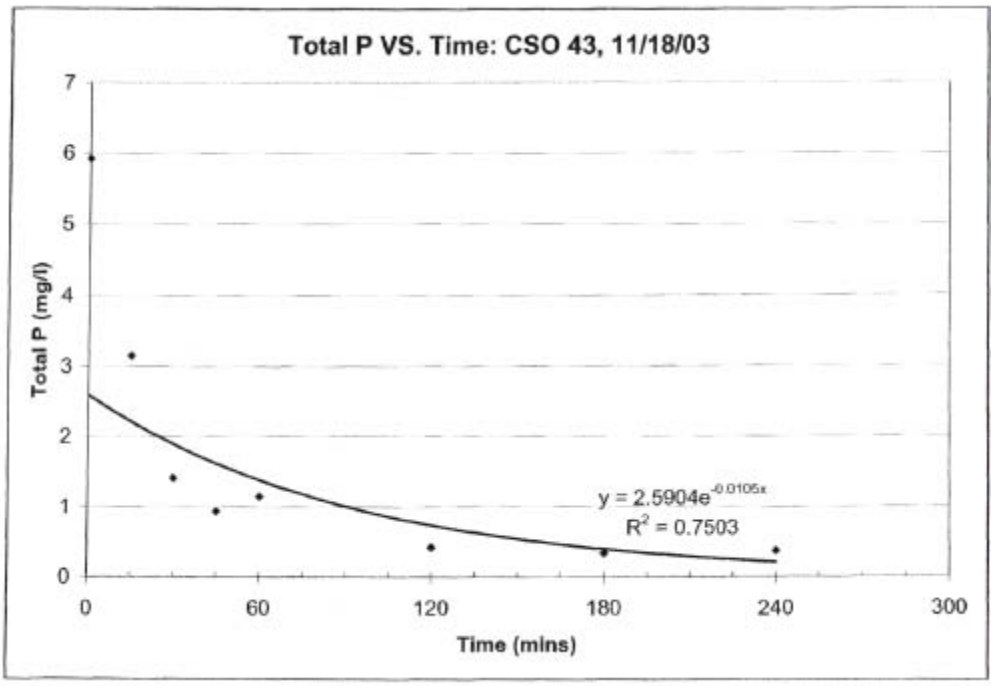

Total P VS. Time: CSO 31, 10/14/03
Total P (mg/l)
Time (mins)
y = 3.662e^-0.0124x
R^2 = 0.7523
0
1
2
3
4
5
6
7
0
60
120
180
240
300

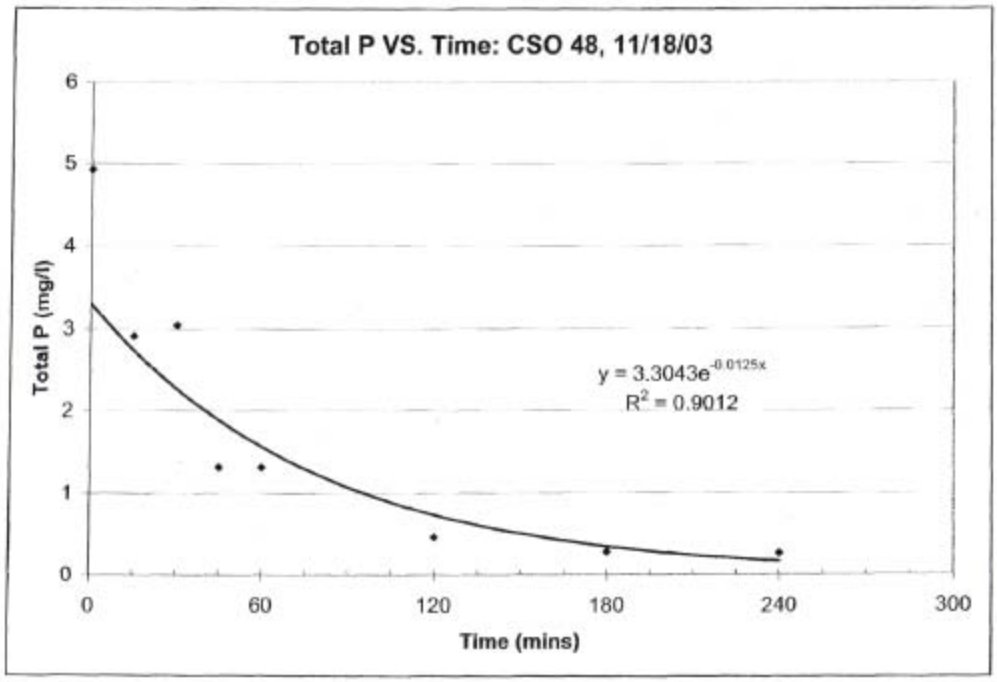

Total P VS. Time: CSO 43, 10/14/03
Total P (mg/l)
14
12
10
8
6
4
2
0
0
60
120
180
240
300
Time (mins)
y = 1.7834e^-0.0099x
R^2 = 0.4741

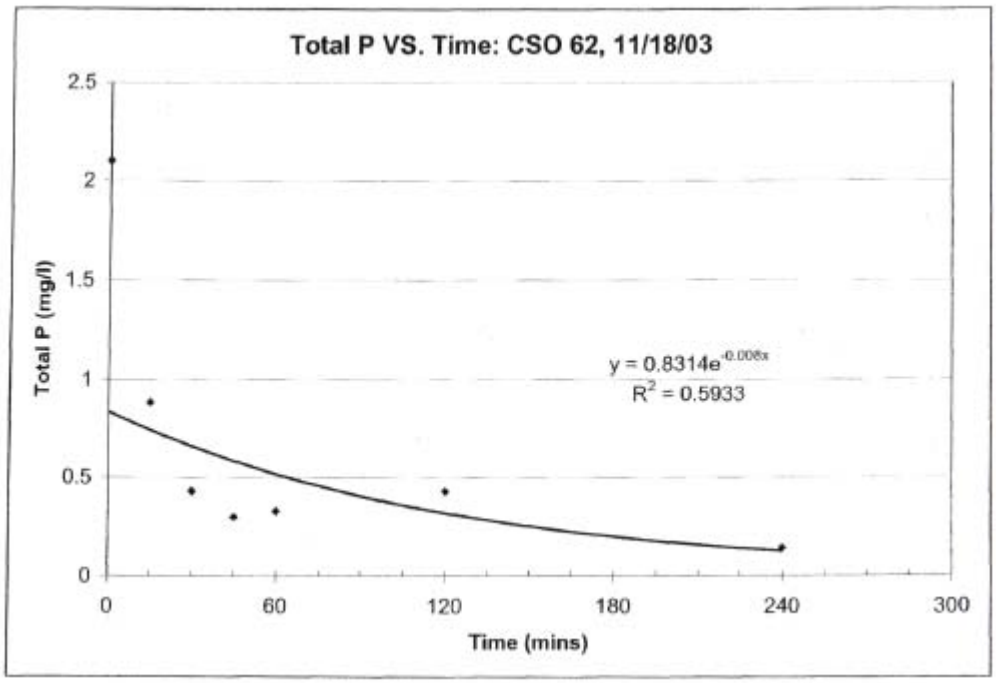

Total P VS. Time: CSO 48, 10/14/03
Total P (mg/l)
4
3.5
3
2.5
2
1.5
1
0.5
0
0
60
120
180
240
300
Time (mins)
y = 1.3383e^-0.0094x
R^2 = 0.7125


Total P VS. Time: CSO 62, 10/14/03
Total P (mg/l)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
60
120
180
240
300
Time (mins)
y = 0.2368e^0.002x
R^2 = 0.0342


Total P VS. Time: CSO 31, 11/18/03
Total P (mg/l)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
60
120
180
240
300
Time (mins)
y = 2.8447e^-0.0099x
R^2 = 0.8003


Total P VS. Time: CSO 43, 11/18/03
Total P (mg/l)
Time (mins)
y = 2.5904e^-0.0105x
R^2 = 0.7503
0
1
2
3
4
5
6
7
0
60
120
180
240
300


Total P VS. Time: CSO 48, 11/18/03
Total P (mg/l)
Time (mins)
y = 3.3043e^-0.0125x
R^2 = 0.9012
0
1
2
3
4
5
6
0
60
120
180
240
300


Total P VS. Time: CSO 62, 11/18/03
Total P (mg/l)
2.5
2
1.5
1
0.5
0
0
60
120
180
240
300
Time (mins)
y = 0.8314e^-0.008x
R^2 = 0.5933

Indian Creek Watershed Nutrient and Sediment TMDLs, Southampton Creek Watershed Nutrient and Sediment TMDLs, Chester Creek Watershed Nutrient TMDL, Paxton Creek Watershed Nutrient and Sediment TMDLs and Sawmill Run Watershed Nutrient TMDL

Response to Comments - Part C

Section C-I

Response Document References (In addition to the references cited in the EPA Literature Review)

Clean Water Act, 1972 with Amendments, at http://epw.senate.gov/water.pdf and for Section 303(d) http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=browse_usc&docid=Cite:+33USC1313

Part 130 of Title 40 of the Code of Federal Regulations, section 130.7 1995 at http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=68611527d82e2dcf115ba1a29e84efca&tpl=/ecfrbrowse/Title40/40cfr130_main_02.tpl

1997 TMDL Consent Decree

USEPA, Guidance for Water-Quality-based Decisions: The TMDL Process, US EPA, 1991, EPA440-4-91-001 at www.epa.gov/owow/tmdl/decisions

USEPA, Guidance for 1994 Section 303(d) Lists - Geoffrey H. Grubbs; November 26, 1993 AT http://www.epa.gov/owow/tmdl/guidance.html

USEPA, National Clarifying Guidance for 1998 State and Territory Section 303(d) Listing Decisions - Robert H. Wayland III - August 17, 1997 AT http://www.epa.gov/owow/tmdl/guidance.html

USEPA, New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs) - Bob Perciasepe - August 8, 1997 AT http://www.epa.gov/owow/tmdl/guidance.html

USEPA, 2002 Integrated Water Quality Monitoring and Assessment Report Guidance - Robert H. Wayland III - November 19, 2001 AT http://www.epa.gov/owow/tmdl/guidance.html

USEPA, Clarification of the Use of Biological Data and Information in the 2002 Integrated Water Quality Monitoring and Assessment Report Guidance -- Robert H.Wayland III - March 26, 2002 at http://www.epa.gov/owow/tmdl/guidance.html

USEPA, Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs - Robert H. Wayland, III and James A. Hanlon -- Nov. 22, 2002 at http://www.epa.gov/owow/tmdl/guidance.html

USEPA, Clarification Regarding "Phased" Total Maximum Daily Loads - Benita Best-Wong -- Aug. 2, 2006 at http://www.epa.gov/owow/tmdl/guidance.html

USEPA, Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA, et al.,

No.05-5015, (April 25, 2006) and Implications for NPDES Permits - Benjamin H. Grumbles - Nov. 15, 2006 at www.epa.gov/owow/tmdl/dailyloadguidance.html

USEPA, Options for Expressing Daily Loads in TMDLs – Draft, Office of Wetlands, Oceans and watersheds, U.S. Environmental Protection Agency, June 22, 2007 at www.epa.gov/owow/tmdl/draft_daily_loads_tech.pdf

USEPA, Total Maximum Daily Loads with Stormwater Sources: A Summary of 17 TMDLs, July 2007, EPA 841-R-07-002 at www.epa.gov/owow/tmdl/17_tmdls_stormwater_source.PDF

USEPA, Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the Clean Water Act, TMDL -01-03 - Diane Regas-- July 21, 2003 at www.epa.gov/owow/tmdl/tmdl0103/2004rpt_guidance.PDF

USEPA, Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act - Diane Regas-- July 29, 2005 at http://www.epa.gov/owow/tmdl/guidance.html

USEPA, Information Concerning 2008 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions - Diane Regas -- Oct. 12, 2006 at www.epa.gov/owow/tmdl/2008_ir_memorandum.html

USEPA, Stressor Identification Guidance, Dec. 2000, EPA 822-F-00-012 at www.epa.gov/waterscience/biocriteria/stressors

USEPA, Protocol for Developing Nutrient TMDLs (PDF) (137 pp, 2.5MB), November 1999, First Edition, EPA 841-B-99-007 at www.epa.gov/owow/tmdl/nutrient/pdf/nutrient.pdf

USEPA, Ecoregion IX: Southeastern Temperate Forested Plains and Hills (PDF) (EPA 822-B-00-019) at www.epa.gov/waterscience/criteria/nutrient/ecoregions/rivers/rivers_9.pdf

USEPA, Ecoregion XI: The Central and Eastern Forested Uplands (PDF) (EPA 822-B-00-020) at www.epa.gov/waterscience/criteria/nutrient/ecoregions/rivers/rivers_11.pdf

USEPA, RBPs for Use in Streams and Wadeable Rivers – Chapter 3: Elements of Biomonitoring, Office of Oceans, Wetlands and Watersheds, U.S. Environmental Protection Agency, at www.epa.gov/owow/monitoring/rbp/ch03main.html

USEPA, Summary Table for the Nutrient Criteria Documents (PDF) (68K) July 2002 at www.epa.gov/waterscience/criteria/nutrient/ecoregions/files/sumtable.pdf

USEPA, , Memorandum from Geoffrey Grubbs, Director, Office of Science and Technology, U.S. Environmental Protection Agency, “Development and

Adoption of Nutrient Criteria into Water Quality Standards, November 14, 2001 at www.epa.gov/waterscience/criteria/nutrient/files/nutrientswqsmemo.pdf

USEPA, Nutrient Criteria Technical Guidance Manual - Rivers and Streams, United States Environmental Protection Agency Office of Water Office of Science and Technology July 2000, EPA-822-B-00-002 Washington, DC 20460 at www.epa.gov/waterscience/criteria/nutrient/guidance/rivers/rivers-streams-full.pdf

USEPA, Ambient Water Quality Criteria Recommendations – Information Supporting the Development of State and Tribal Nutrient Criteria – Rivers and Streams in Nutrient Ecoregion IX, Office of Water, U.S. Environmental Protection Agency, EPA 822-B-00-019, December 2000 at http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/rivers/rivers_9.pdf

USEPA, Ambient Water Quality Criteria Recommendations – Information Supporting the Development of State and Tribal Nutrient Criteria – Rivers and Streams in Nutrient Ecoregion XI, Office of Water, U.S. Environmental Protection Agency, EPA 822-B-00-020, December 2000 at http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/rivers/rivers_11.pdf

Development and Adoption of Nutrient Criteria into Water Quality Standards, Memorandum, Geoffrey Grubbs, Director, Office of Science and Technology, November 14, 2001 at http://www.epa.gov/waterscience/criteria/nutrient/files/nutrientswqsmemo.pdf

USEPA, National Strategy for the Development of Regional Nutrient Criteria, United States Environmental Protection Agency, Office of Water, EPA 822-R-98-002, June 1998 at www.epa.gov/waterscience/criteria/nutrient/strategy/nutstra3.pdf

USEPA, AQUATOX (Release 2) - Modeling Environmental Fate and Ecological Effects in Aquatic Ecosystems - Volume 2: Technical Documentation, United States Environmental Protection Agency, Office of Water (4305) EPA-823-R-04-002, January 2004 at http://www.epa.gov/waterscience/models/aquatox/download.html#techdoc

USEPA, Water Quality Trading Assessment Handbook, EPA 841-B-04-001, Nov. 2004 at www.epa.gov/owow/watershed/trading/handbook

USEPA, Technical Support Document for Water Quality-Based Toxics Control, EPA 505-2-90-001, U.S. Environmental Protection Agency, Office of Water, Washington, DC. 1991 at www.epa.gov/npdes/pubs/owm0264.pdf

Total Maximum Daily Loads and National Pollutant Discharge Elimination System Stormwater Permits for Impaired Waterbodies: A Summary of State Practices September 15, 2007 (updated from March 9, 2007 version) at

http://www.epa.gov/region5/water/wshednps/pdf/state_practices_report_final_09_07.pdf

USEPA, Memorandum from William Swietlik, Chief, Ecological and Health Processes Branch, Office of Science and Technology, U.S. Environmental Protection Agency, to Robert Koroncai, Associate Director, Water Protection Agency, U.S. environmental Protection Agency, Region III, "Development of Nutrient Endpoints for TMDLs in Pennsylvania", June 11, 2008

USEPA, Memorandum from Thomas Henry, TMDL Program Manager, Water Protection Division, Region III, Environmental Protection Agency to files (Thomas Henry), "Modeling assumptions for nutrient TMDLs in PA – June 2008 waters", October 10, 2007

USEPA, Memorandum from Thomas Henry, TMDL Program Manager, Water Protection Division, Region III, Environmental Protection Agency to Lee McDonnell, PADEP, "PA TMDLs and the contracts", July 18, 2005.

USEPA, Memorandum from Thomas Henry, TMDL Program Manager, Water Protection Division, Region III, Environmental Protection Agency to Lee McDonnell, PADEP, "summary of meeting – July 28, 2004", July 29, 2004

USEPA, Memorandum from Thomas Henry, TMDL Program Manager, Water Protection Division, Region III, Environmental Protection Agency to Lee McDonnell, PADEP, "Remaining 1996 waters needing TMDLs", June 6, 2005

USEPA, "Summary of August 24, 20045 [mistyping – actual meeting year was 2005] TMDL meeting, unsigned and undated.

USEPA, Memorandum from Amy Bergdale, Analytical Services and Quality Assurance Branch, US EPA Region III Wheeling Office, to Mary Kuo, DE/PA/WV Branch, Water Protection Division, US EPA Region III, "PADEP TMDL Toxocity Test Results for Paxton Creek, July 6, 2006

Memorandum from Michael J. Paul, TetraTech, Inc to Thomas Henry, U.S. Environmental Protection Agency, "Analysis of Region 3 TP TMDL document", April 28, 2008

Memorandum from Michael J. Paul, TetraTech, Inc to Steve Potts, U.S. Environmental Protection Agency, "Analysis of Region 3 TP TMDL documents", April 21, 2008

Literature Review to Support Selection of Nutrient TMDL Endpoints for Northern Piedmont Ecoregion Streams in Southeastern Pennsylvania, December 2007, USEPA, Region III, 1650 Arch Street, Philadelphia, PA 19103, Prepared by Tetra Tech, Inc., 10306 Eaton Place, Suite 340, Fairfax, VA 22030

Nonpoint Source Nutrients Loading Simulation for Chester, Indian, Neshaminy, Skippack, Southampton and Wissahickon Creeks, Pennsylvania, TetraTech, Inc for U.S. Environmental Protection Agency, Region 3, January 2008

PADEP, 2008 Pennsylvania Integrated Water Quality Monitoring and Assessment Report - Clean Water Act Section 305(b) Report and 303(d) List For Public Comment: April 2008 at www.depweb.state.pa.us/watersupply/cwp/view.asp?a=1261&q=535678

PADEP, Pennsylvania DEP Multi-habitat Stream Assessment Protocol March 2007 at WWW.depweb/state.pa.us/watersupply/lib/watersupply/ibi_multihabitat.pdf

PADEP, A Benthic Index of Biotic Integrity for Wadeable Freestone Streams in Pennsylvania , Nov 2007 at www.depweb/state.pa.us/watersupply/lib/watersupply/ibi_rifflerun.pdf

PADEP, Pennsylvania DEP Summer 2 D-Frame Kick, 100-Organism Bioassessment Protocol September 2006 at www.depweb/state.pa.us/watersupply/lib/watersupply/ibi_rifflerunsummer.pdf

PADEP, Pennsylvania Department of Environmental Protection, Bureau of Water Standards and Facility Regulation, Instream Comprehensive Evaluation Surveys (ICE), (March 2005) at www.depweb/state.pa.us/watersupply/lib/watersupply/ice.pdf

PADEP, 2006 Pennsylvania Integrated Water Quality Monitoring and Assessment Report Clean Water Act Section 305(b) Report and 303(d) List at www.depweb.state.pa.us/watersupply/cwp/view.asp?a=1261&q=480056

PADEP, PA Code 25 Chapter 93.7 Water Quality Standards, Specific Water Quality Criteria at http://www.pacode.com/secure/data/025/chapter93/chap93toc.html

PADEP, PA Code 25 Chapter 96.4 Water Quality Standards Implementation, TMDLs and WQBELs at http://www.pacode.com/secure/data/025/chapter96/chap96toc.html

PADEP, PA Code 25 Chapter 93.4 Water Quality Standards, Statewide Water Uses at http://www.pacode.com/secure/data/025/chapter93/chap93toc.html

PADEP, PA Code 25 Chapter 93.6 Water Quality Standards, General Water Quality Criteria at http://www.pacode.com/secure/data/025/chapter93/chap93toc.html

PADEP, PA Code 25 Chapter 96.5 Water Quality Standards, Nutrient Discharges at http://www.pacode.com/secure/data/025/chapter96/chap96toc.html

PADEP, PA Code 25 Chapter 93.8 Water Quality Standards, Development of Site-Specific Water Quality Criteria at http://www.pacode.com/secure/data/025/chapter93/chap93toc.html

PADEP, Aquatic Biological Investigation – Unnamed Tributary to Indian Creek, Montgomery County, Lower Salford Township, Lower Salford Township Authority Harleysville, PA, PA Department of Environmental Protection, May 23, 2003 (April 14, 2003 survey)

PADEP, Aquatic Biological Investigation – Unnamed Tributary to Indian Creek, Montgomery County, Lower Salford Township, Lower Salford Township Authority Harleysville, PA, PA Department of Environmental Protection, February 3, 2003 (October 24, 2001 survey)

PADEP, Pennsylvania's 1996 List of Impaired Waters Requiring a TMDL

PADEP, Letter from Leon Oberdick, Program Manager, Water Quality Management, Pennsylvania Department of Environmental Protection, Southcentral Regional Office, to Ronald Cavalieri, Malcolm Pirnie, re: Harrisburg Authority's storm water Long Term Control Plan, August 26, 2003

PADEP, Pennsylvania Water Quality Standards, "Statewide Existing Use Classifications, Montgomery County", Updated April 7, 2006 at http://www.depweb.state.pa.us/watersupply/lib/watersupply/co46.pdf

PADEP, Pennsylvania Water Quality Standards, "Statewide Existing Use Classifications, Chester County", Updated August 26, 2005 at http://www.depweb.state.pa.us/watersupply/lib/watersupply/co15.pdf

Memorandum from Travis Stoe, Pennsylvania Department of Environmental Protection, to Mary Kuo, U.S. Environmental Protection Agency, "Chester Creek Information", April 9 2008

Memorandum from Alan Everett, Pennsylvania Department of Environmental Protection, to Brian Lee, Louis Berger Group, "Chester Creek TMDL – Nutrient/Organic Enrichment Listings", February 29, 2008

Memorandum from Alan Everett, Pennsylvania Department of Environmental Protection, to Brian Lee, Louis Berger Group, "RE: Chester Creek TMDL - Nutrient/Organic Enrichment Listings", February 28, 2008

Memorandum from Rodney Kime, Pennsylvania Department of Environmental Protection, to Bill Brown, Pennsylvania Department of Environmental Protection, "RE: Southampton Creek", May 5, 2008

Water Quality Assessment in Paxton Creek, Pennsylvania, Hunter J. Carrick, Ph.D, Assistant Professor of Aquatic Ecology, and Sara J. Mays, Graduate

Assistant, School of Forest Resources, The Pennsylvania State University, Final Report submitted to Louis Berger Group, November 6, 2006

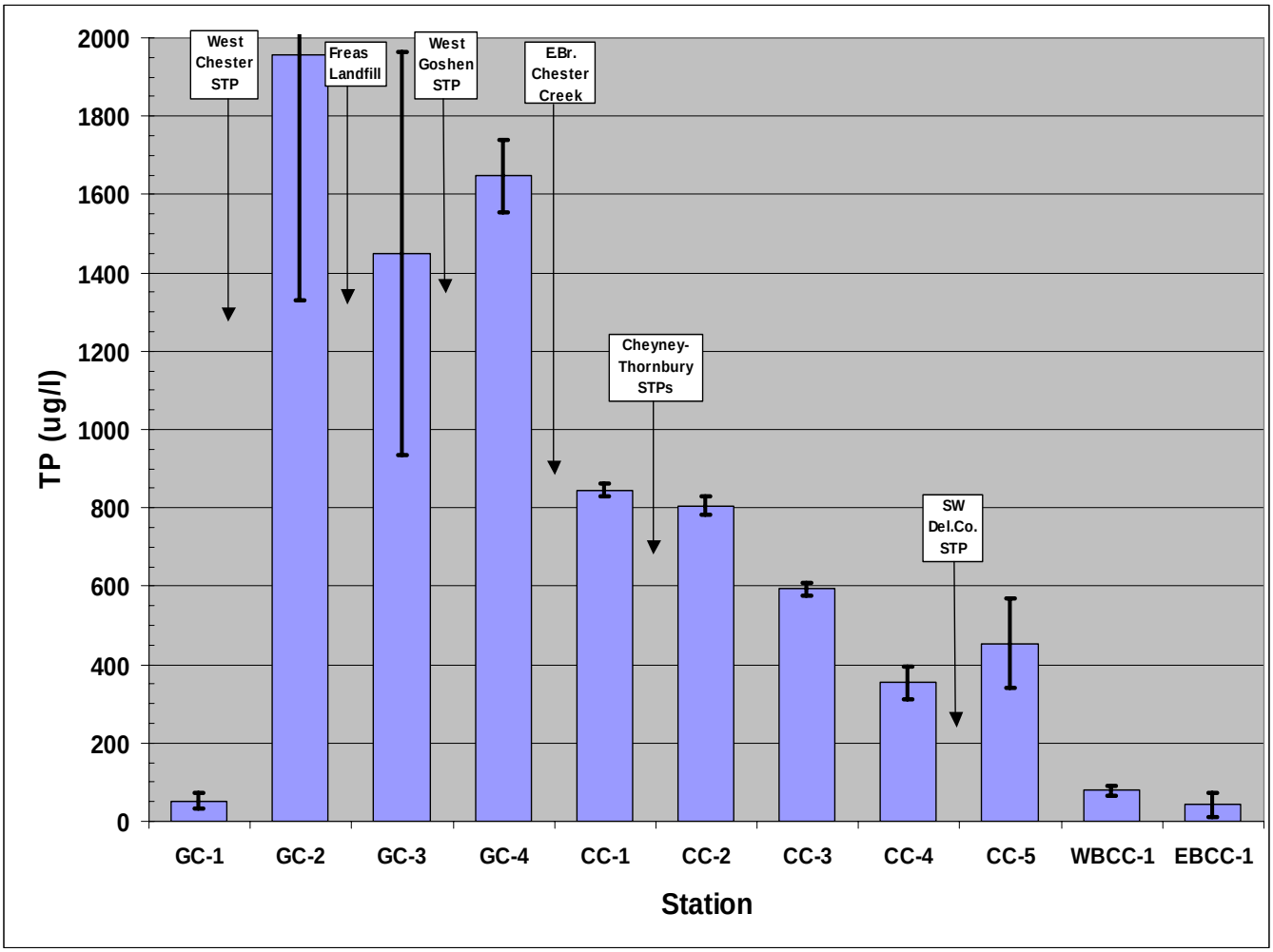
The Harrisburg Authority CSO Management and Control Program, Development and Evaluation of CSO Control Alternatives, Select Sections

University of Montana Watershed Health Clinic and Montana Department of Environmental Quality, How the Public Views Nuisance Algae in Montana Streams, 2006, http://www.umt.edu/watershedclinic/algaesurveypix.htm

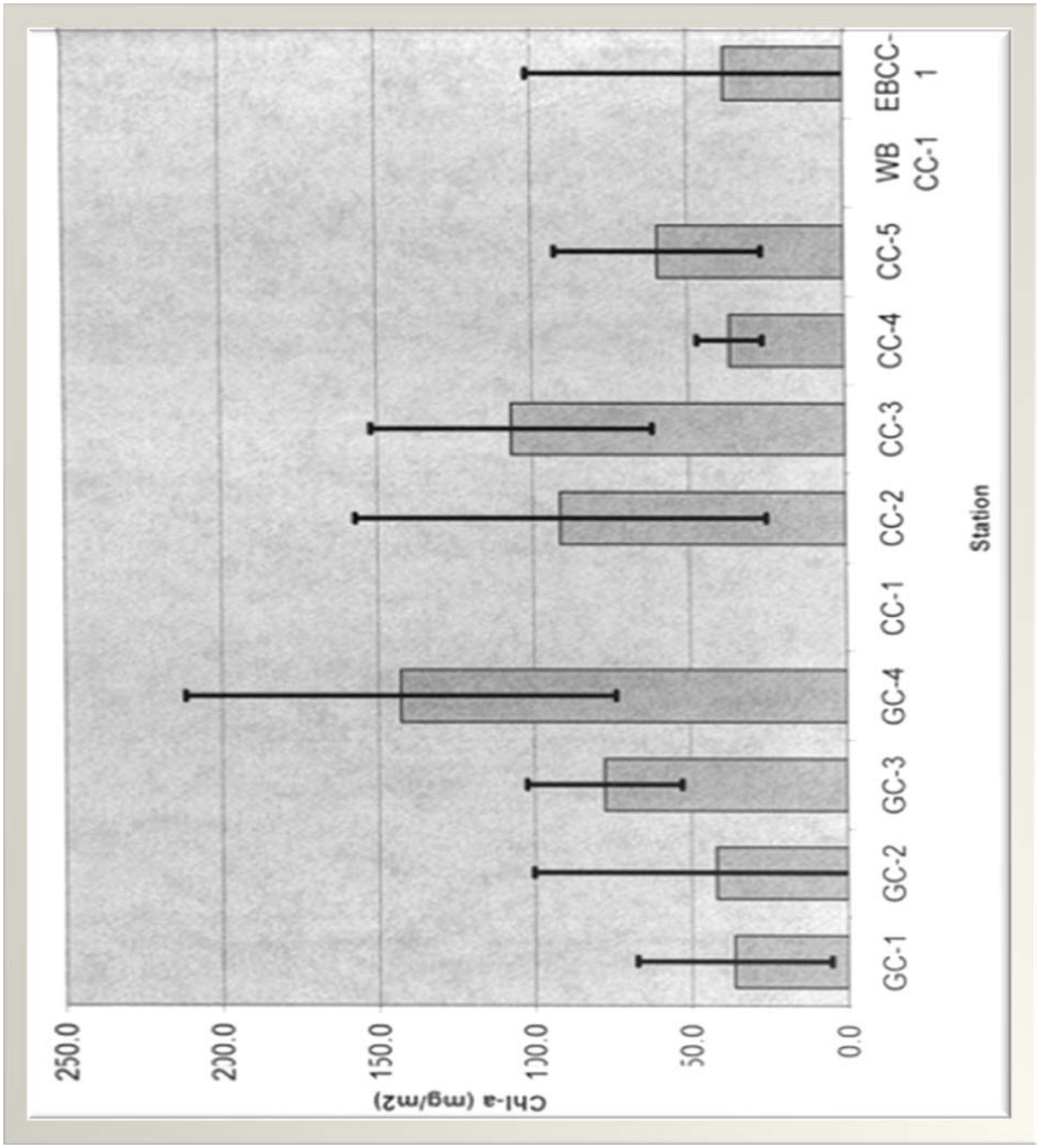
Section C-II

Supporting Documents, Graphs, Tables and Charts for the Response to Comments

Total Phosphorus Concentrations in Chester Creek - 2006

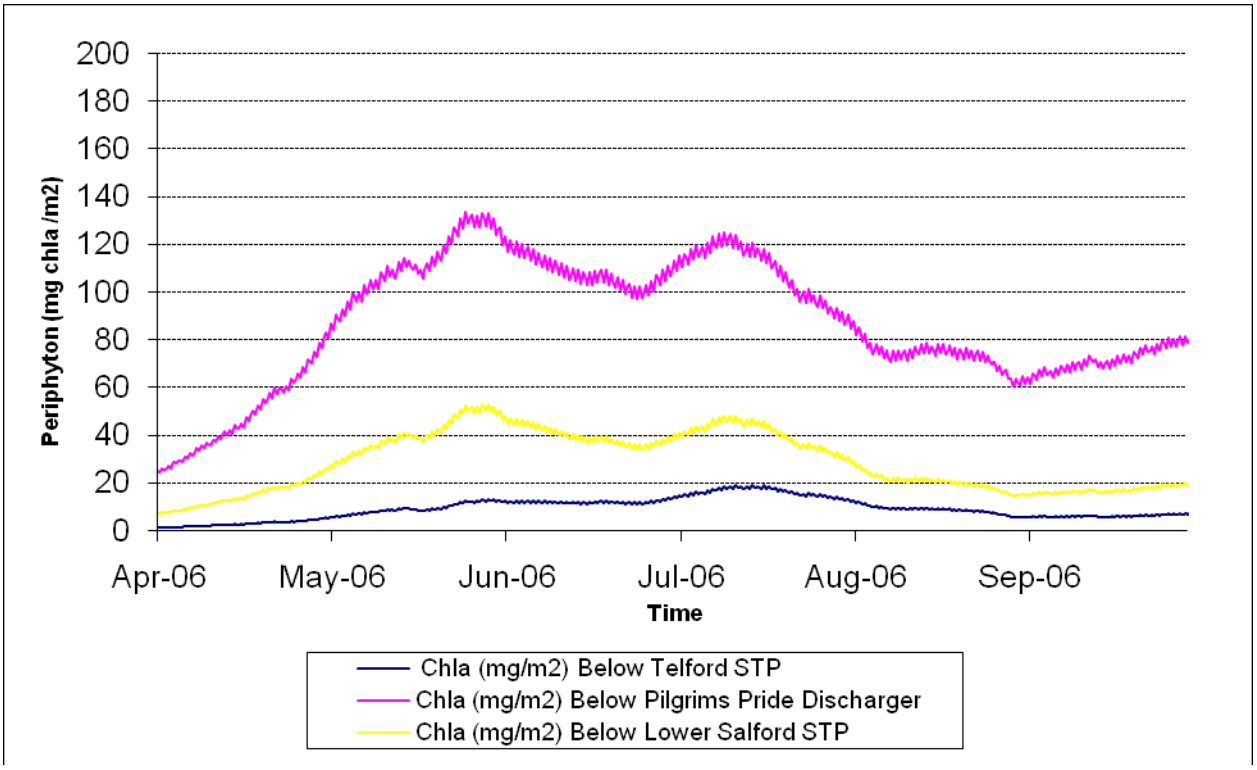


Chester Creek Chlorophyl 'a' - 2006

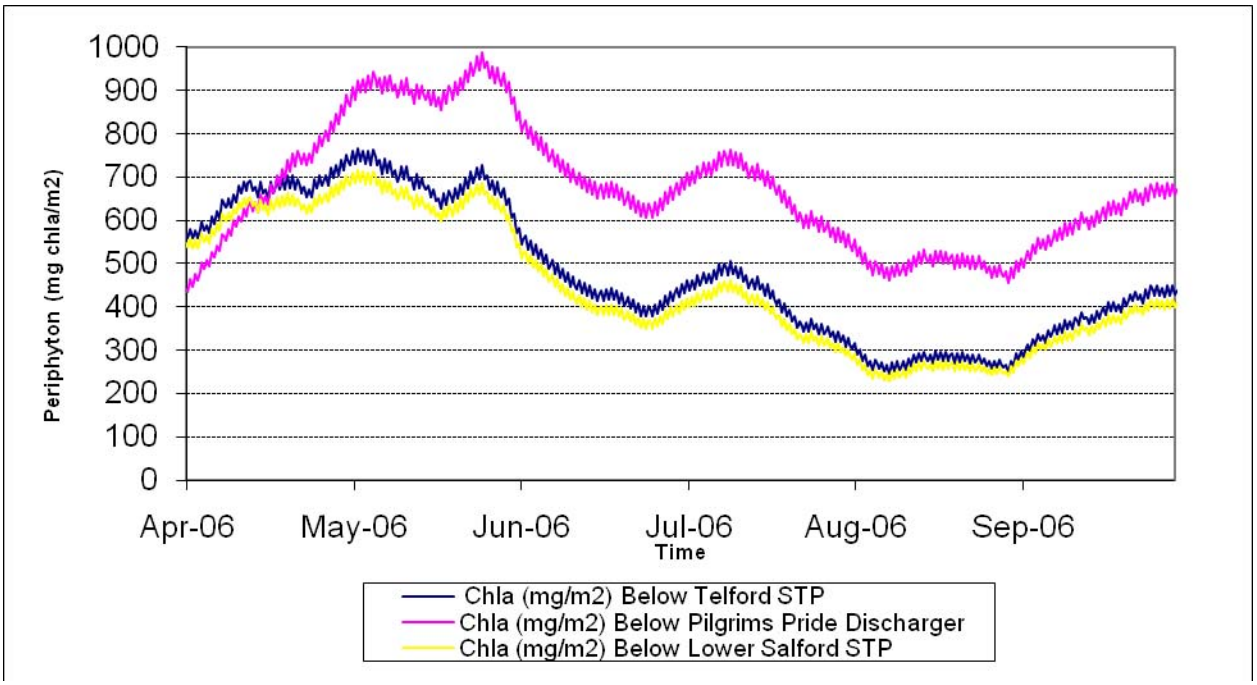


Predicted and Baseline Biomass in the Indian Creek Watershed

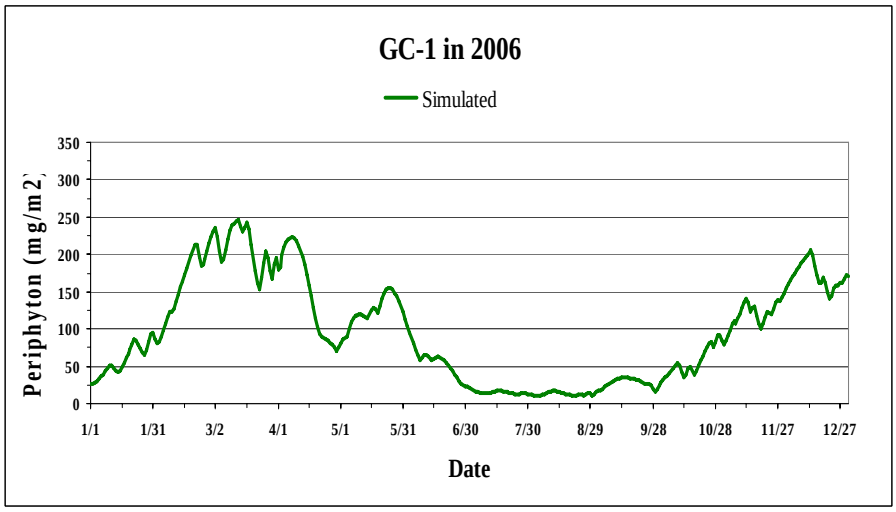
Predicted Biomass at Design Conditions (Permitted Conditions)

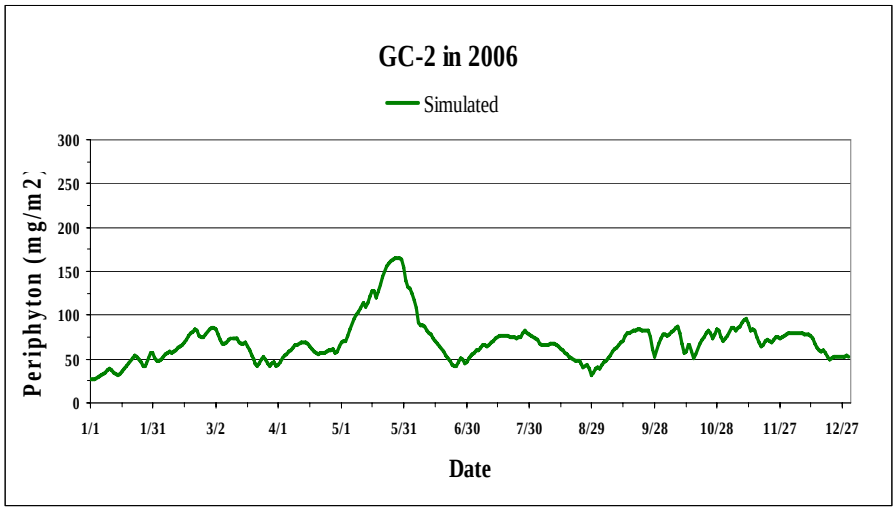


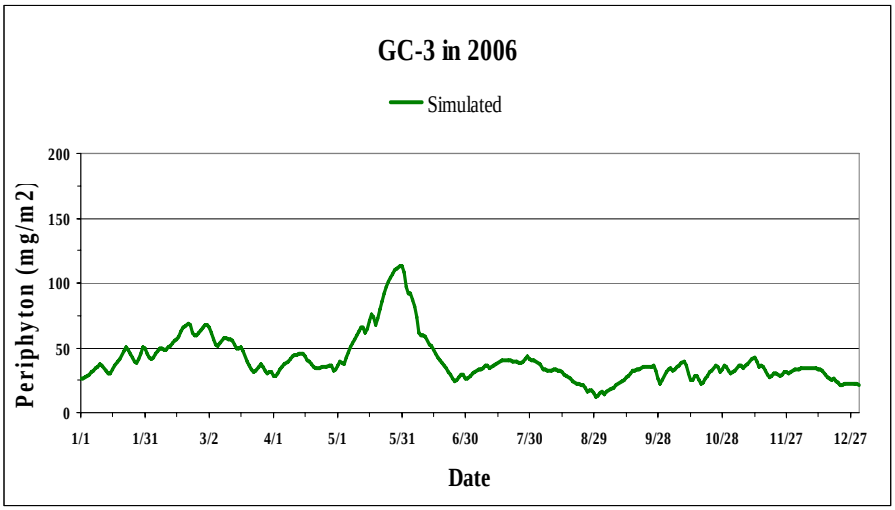
Baseline Biomass – At Existing Conditions



Goose Creek Projected Algal Biomass at TMDL Loads






GC-3 in 2006
Simulated
Periphyton (mg/m2)
200
150
100
50
0
1/1
1/31
3/2
4/1
5/1
5/31
6/30
7/30
8/29
9/28
10/28
11/27
12/27
Date

Pennsylvania Department of Environmental Protection
909 Elmerton Avenue
Harrisburg, PA 17110-8200
August 26, 2003

Southcentral Regional Office

717-705-4707
FAX - 717-705-4760

FILE COPY

Mr. Ronald R. Cavalieri
Malcolm Pirnie
40 Centre Drive
PO Box 1938
Buffalo, NY 14219-0138

Re: Sewage
Harrisburg Authority
Harrisburg City, Dauphin County

Dear Mr. Cavalieri:

This is in response to your letter dated August 12, 2003 regarding an identification of sensitive areas that might be impacted by Harrisburg Authority CSOs.

I agree with your list 1-3 but I'm unsure what the last one refers to. I believe the impoundment created by the Dock Street Dam in Harrisburg (including the City Island beach) creates a sensitive area due to the high level of recreational use in the entire impounded area which results in an increased level of human contact with the river water. Additionally, there are two private boat ramps located just downstream of the Route 83 bridge on the east shore.

I have not listed Paxton Creek. However, it is included on the 303(d) list of impaired waters and one of the causes for listing is the existence of CSOs. Although this stretch of creek through Harrisburg may not be "sensitive," it is important to work on its recovery as a viable aquatic community resource.

If you desire to meet with Water Management staff to further discuss the issue, please call me at 717-705-4795.

Sincerely,

Leon M. Oberdick
Program Manager
Water Quality Management

Algal Growth in the Indian Creek Watershed - 2006

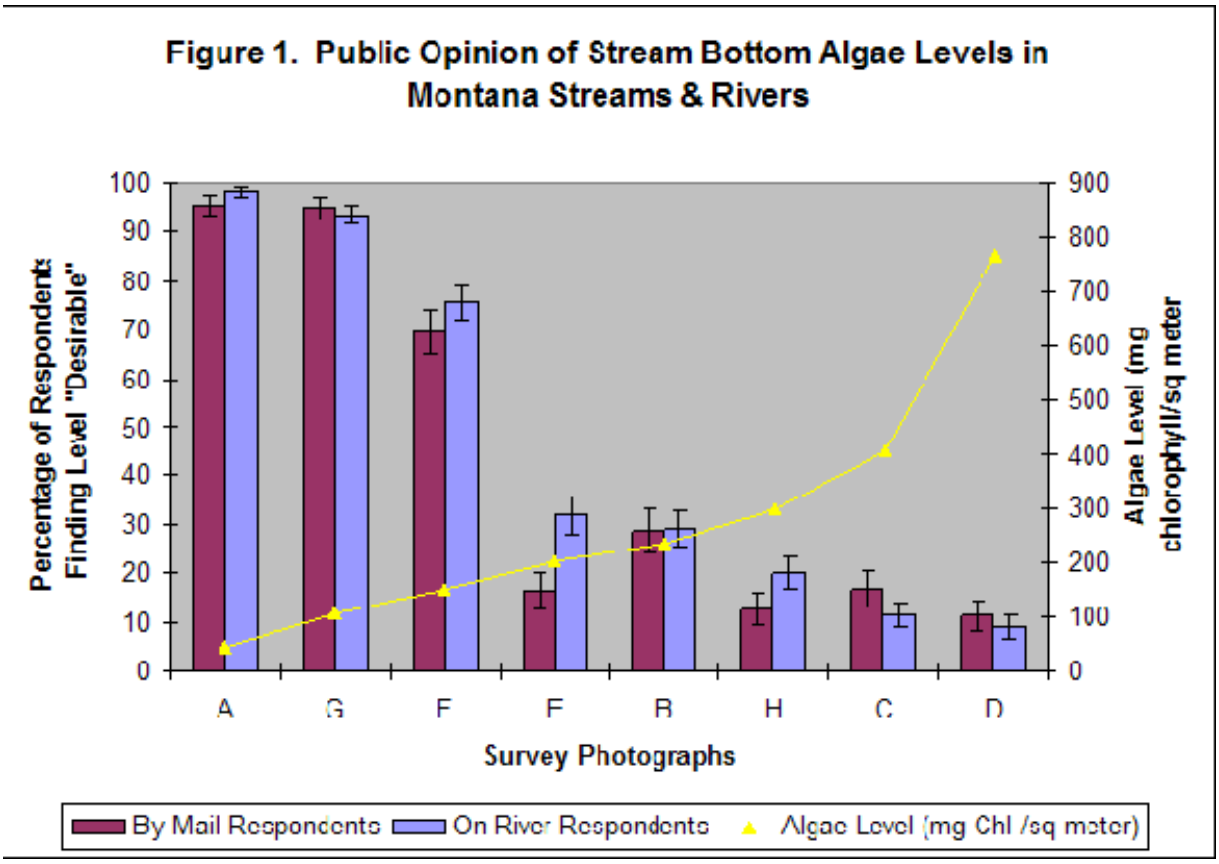
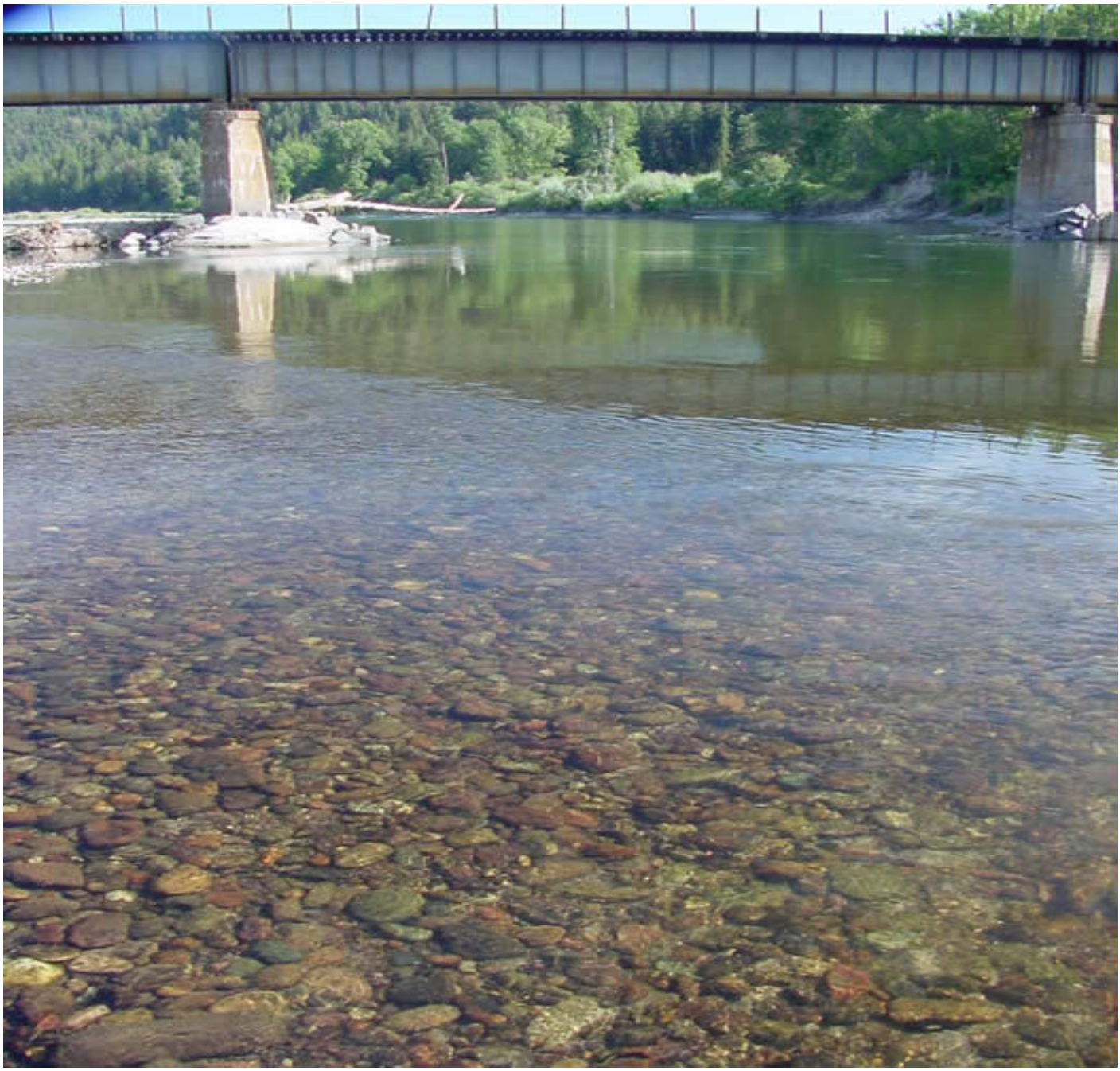


Figure 1. Public Opinion of Stream Bottom Algae Levels in Montana Streams & Rivers
Percentage of Respondents Finding Level "Desirable"
Algae Level (mg chlorophyll/sq meter
100
90
80
70
60
50
40
30
20
10
0
900
800
700
600
500
400
300
200
100
0
A
G
F
E
B
H
C
D
Survey Photographs
By Mail Respondents
On River Respondents
Algae Level (mg Chl /sq meter)

Picture A

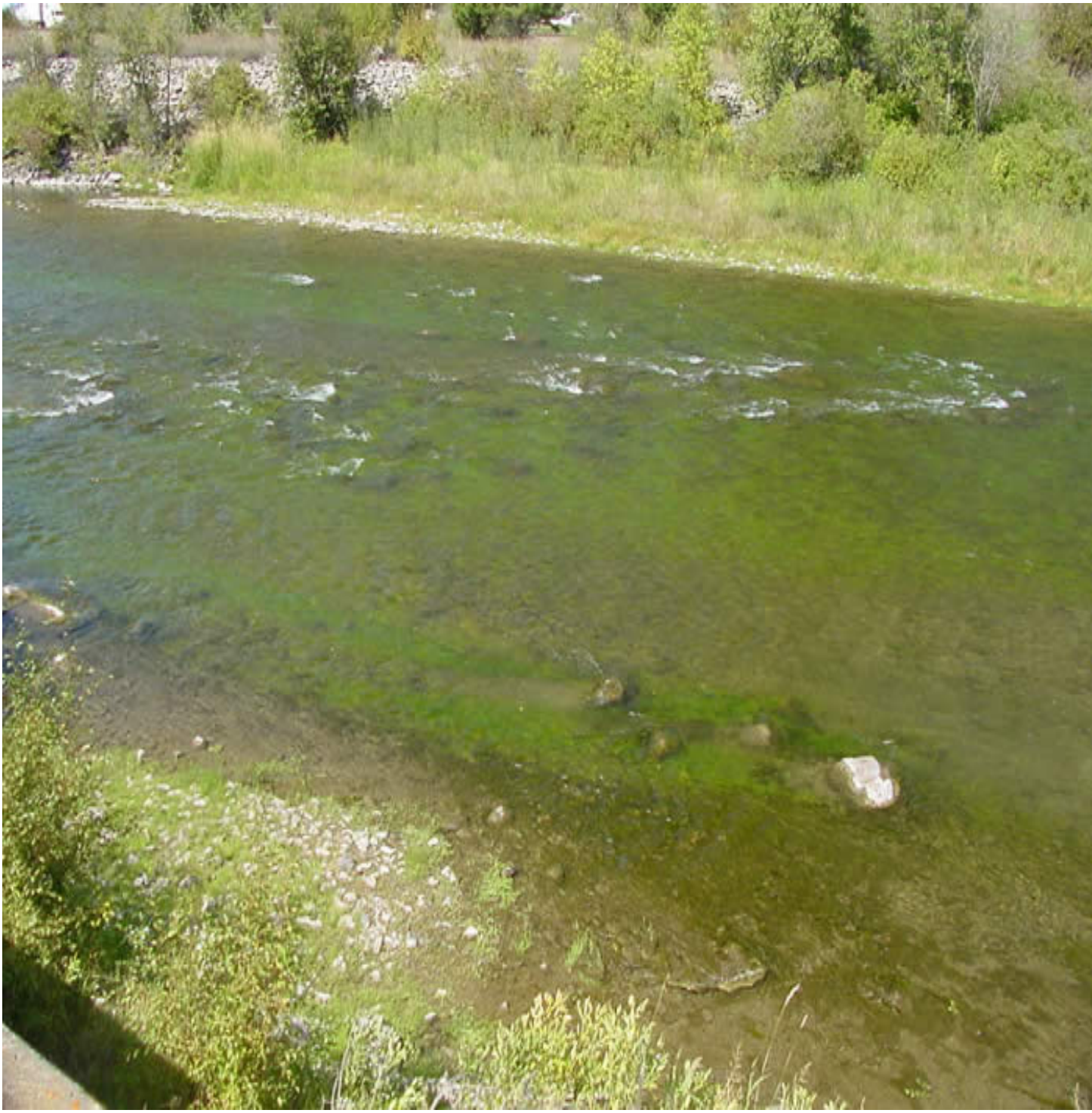


Picture B

Picture C

Picture D

Picture E



Picture F

Picture G

Picture H

SECTION C-III

Literature Review to Support Selection of Nutrient TMDL Endpoints for Northern Piedmont Ecoregion Streams in Southeastern Pennsylvania

January 2008

Prepared for:
USEPA Region III
1650 Arch Street
Philadelphia, PA 19103

Prepared by:
Tetra Tech, Inc.
10306 Eaton Place
Suite 340
Fairfax, VA 22030

Table of Contents

1. Introduction 1
2. Effect of Nutrients on the Algal Community 2
3. Other Factors Influencing Benthic Algal Growth 3
   3.1 Light 3
   3.2 Flooding 5
   3.3 Land Use 5
   3.4 Grazers 6
   3.5 Seasonality 6
4. Limitations of Periphyton Nutrient Ratios 7
5. Nuisance Thresholds 7
   5.1 Nuisance Biomass Values 7
   5.2 Visual Assessment of Algal Biomass 9
6. Phosphorus and Nitrogen Endpoints in the Literature 9
   6.1 Dodds Regression Equation 9
   6.2 Nutrient Studies in the Northern Piedmont Ecoregion 10
   6.3 Nutrient Studies in Other Regions of the United States 12
   6.4 Nutrient Studies on a National Scale 13
   6.5 Worldwide Nutrient Studies 14
   6.6 Summary of Other Representative Nutrient Studies 15
7. Effects of Dissolved Phosphorus and Nitrogen on Algal Growth 15
8. Endpoint Identification: Total Nutrients vs. Dissolved 15
9. Management Implications: Total Nitrogen or Total Phosphorus Control 16
10. Nutrient Endpoint Values Applied in Past TMDLs 17
   10.1 Chlorophyll a 17
   10.2 Dissolved Nitrogen and Phosphorus 17
   10.3 Total Phosphorus 18
11. Conclusions 18

List of Tables

Table 1. Suggested boundaries for trophic classification of streams from Dodd et al. (1998) 8
Table 2. Comparison of New England and EPA water quality recommendations for nutrients from Mitchell et al. (2003) 12
Table 3. Median flow-weighted concentrations for all basins from Clark et al. (2000) ... 14
Table 4. Summary of TP and chlorophyll concentrations and catchment area from Van Niewenhuyse and Jones (1996) 14
Table 5. Dodds et al. (2002) analysis of breakpoint values for total nitrogen and total phosphorus 16

1. Introduction

The United States Environmental Protection Agency (EPA) in Region III is developing nutrient Total Maximum Daily Loads (TMDLs) to protect aquatic life uses for six streams in the Northern Piedmont ecoregion of southeastern Pennsylvania: Chester, Indian, Neshaminy, Skippack, Southampton, and Wissahickon Creeks (Paul and Zheng 2007). The Northern Piedmont ecoregion includes portions of New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia, and Virginia (Auch 2002 as cited by USGS 2007). The ecoregion is a transition zone between coastal areas to the east and mountainous regions to the west and north. The Northern Piedmont includes portions of the New York, Philadelphia, Baltimore, and Washington metropolitan areas. Land use varies in the region, ranging from urban and suburban areas to agriculture and forested areas. The dominant land covers include agriculture, forest, and developed lands, but the mixture varies, depending on locale.

A TMDL must meet the applicable water quality standards for a particular waterbody and requires a quantitative target that can be used to evaluate the relationship between pollutant sources and their impact on water quality (USEPA 1999). Examples of quantitative targets for nutrients include values for "total phosphorus concentration, total nitrogen concentration, chlorophyll concentration, algal biomass, and percent macrophyte coverage (USEPA 1999, p. 4-1)." Neither the state of Pennsylvania nor EPA Region III currently has numeric nutrient criteria for these six streams. Therefore, a numeric target for nutrients had to be determined.

Paul and Zheng (2007) relied on a multiple lines of evidence approach to determine nutrient endpoints for developing TMDLs to protect aquatic life uses of Northern Piedmont streams in southeastern Pennsylvania. The multiple lines of evidence approach used all of the following approaches: frequency distribution based analysis, stressor-responses analyses, and literature based values.

Data analysis showed strong evidence of phosphorus limitation from nutrient ratios, and examination of all the metrics with total nitrogen (TN) and other nitrogen parameters did not find strong correlations with biological variables (Paul and Zheng 2007). Therefore, the Northern Piedmont streams were determined to be phosphorus-limited systems and determination of a nutrient TMDL target focused on total phosphorus (TP) concentrations.

Because there was no strong relationship between nitrogen and response measures, Paul and Zheng (2007) did not recommend a nitrogen TMDL target. Potential TN endpoints were provided using different approaches. The potential endpoints ranged from 0.260 mg/L (260 µg/L) to 3.7 mg/L (3,700 µg/L) (Paul and Zheng 2007). It does not appear that TN is limiting uses in the Northern Piedmont freshwater stream systems, but effects of nitrogen are possibly manifested downstream in saltwater and estuary waters. More research should be done so that these saltwater systems influence the choice of protective TN targets upstream.

The selected numeric nutrient TMDL target for the six watersheds is an average TP concentration for the growing season of 40 µg/L (Paul and Zheng 2007).

In addition to the multiple lines of evidence approach applied by Paul and Zheng to derive appropriate endpoints for the TMDLs in question, an additional review of existing literature

pertaining to periphyton, nutrients and free-flowing streams was conducted, the results of which are presented in this document. The *Decision Rationale for the Withdrawal of the Nutrient TMDLs for the Skippack Creek Watershed* (USEPA 2007) contains reviews of several relevant articles, some of which have been included in this literature review. While the Skippack Creek Decision Rationale document does review some of the same literature; it is EPA's intention to expand on those reviews with the in-depth literature review in this document.

The main purpose of the literature review is to provide a summary of studies related to nutrients and periphyton growth. The document is organized by the major re-occurring subjects that appeared throughout the reviewed studies and that were particularly relevant to selection of nutrient endpoints for TMDLs. Major topics include: effects of nutrients on algal communities, factors other than nutrients that influence benthic algal growth, using periphyton nutrient ratios to indicate nutrient limitation, nuisance thresholds, TP and TN endpoints identified in the literature, the appropriateness of using total or dissolved constituents as endpoints, and finally, nutrient target values applied in past TMDLs.

2. Effect of Nutrients on the Algal Community

Nutrients are often believed to be associated with algal blooms. Chetelat et al. (1999) found periphyton biomass to be strongly correlated with TP concentration and conductivity. Algal patterns were observed along a TP gradient. There was a high diversity of periphyton communities among sites with TP concentrations <20 mg/L. However, "nutrient-rich sites were associated with high periphyton standing crop and were dominated by particular filamentous taxa (p. 568)." *Cladophora*, *Audouinella*, and (or) *Melosira* were dominant taxa at sites >20 mg/L TP. Chetelat et al. (1999) cite other periphyton studies with wide ranging nutrient requirements for maximum growth rates: "0.5–1 mg/L P for diatoms (Bothwell 1989) to 25–40 mg/L P for filamentous greens such as *Stigeoclonium* or *Cladophora* (Rosemarin 1983) or even 60 mg/L TP for *Cladophora* (Wong and Clark 1976) (p. 567)."

Based on the existence of *Cladophora* as a dominant algal species at high TP concentrations, it might make sense to determine nutrient concentrations that would control *Cladophora*; however, Dodds et al. (1997) found that the control of *Cladophora* would be difficult. In his study, the lowest abundance of *Cladophora* occurred during extremely high TN and TP levels. Dodds et al. (1997) concluded that "…a loading management policy favoring high instream TN and TP concentrations designed to reduce Cladophora abundance would lead, in turn, to excessive total levels of chlorophyll *a* and would not be a viable management option (p. 1743)." *Cladophora* appeared to be nitrogen limited (Dodds et al. 1997) and "research suggests that this is also true in many other systems (Dodds and Gudder 1992). However, we were unable to develop models that could be used to predict management scenarios that would lower algal biomass and simultaneously reduce Cladophora dominance. Control of Cladophora will be as difficult as it has been in other systems (p. 1747)."

Riskin et al. (2003) did not find any relationship between chlorophyll *a* in phytoplankton and TN and TP; however, chlorophyll *a* in periphyton increased significantly with TN and TP concentrations in both open and shaded stream sites. "This suggests that periphyton may be a better indicator of eutrophication than phytoplankton in wadeable [New England] streams, regardless of canopy conditions (Riskin et al. 2003, p. 12)."

Pan et al. (1996) found that there is a strong relationship between diatoms and important environmental variables in the Appalachian Mountain portion of Pennsylvania, Maryland, West Virginia, and Virginia. Diatom species were highly correlated with a pH gradient and variables that were commonly associated with agricultural runoff (e.g., turbidity and TP). Pan et al. (1996) concluded that diatoms can be used as quantitative indicators of environmental conditions in streams.

Potapova et al. (2004) modeled diatom species responses to TP by means of parametric and non-parametric regression. The diatom dataset was collected in the Northern Piedmont Ecoregion including sampling sites in New Jersey, Pennsylvania, Maryland, and Delaware. Potapova et al. (2004) indicate that the estimated optimal nutrient concentrations for the diatom species with significant fit to a quadratic model varied from 10 to 891 µg/L TP. Species indicator values were calculated as the weighted averages of relative species abundance versus logTP. The range of optima was from 13 µg/L TP to 142 µg/L TP. The relative abundance of most species with low weighted averages (e.g., *Achnanthidium sp. 10 NAWQA and Navicula cryptocephala*), decreased exponentially with increasing TP. Species with high weighted averages (e.g., *Navicula recens, N. tripunctata, N. lanceolata, Luticola goeppertiana*,) tended to increase exponentially with TP. The authors further note that observed differences in species responses justifies development of regional models.

3. Other Factors Influencing Benthic Algal Growth

Borchardt (1996) states that "Benthic algal biomass and growth rate do not always relate to nutrient levels. Other factors, such as light, disturbance, and grazing, may be the primary determinants of biomass and growth while nutrients are either replete or secondarily limiting (pp. 206-207)." A number of studies have compared the effects of other factors (i.e., light availability and scouring) and nutrient availability on algal growth.

3.1 Light

"A strong relationship exists between nutrient levels, particularly phosphorus, and phytoplankton biomass (e.g., Vollenweider 1976). The relationship between nutrients and benthic algal biomass is weaker because of the effects of light, disturbance, and grazing (Cattaneo 1987). With regard to nutrients, this perhaps is the most significant difference between planktonic and benthic algae (Borchardt 1996, p. 207)."

Boston and Hill (1991) agree with Borchardt (1996). Their results suggest that the [photosynthesis-irradiance] P-I responses of periphyton under light and shade conditions differ from those of phytoplankton:

"The differences in P-I responses of periphytic and planktonic communities probably relate to intrinsic differences in environmental conditions in periphytic and planktonic communities: in the former, algae live in matrices where the tight packing of cells strongly influences light attenuation and nutrient availability (Sand-Jensen and Revsbech 1987; Riber and Wetzel 1987; Paul and Duthie (1989) (Boston and Hill 1991, p. 654)."

Brightbill and Koerkle (2003) found light availability to be more critical to periphyton growth than nutrients in Pennsylvania and West Virginia streams. Towns (1981) found a complete absence of periphyton from stream sections covered with artificial canopy. Greenwood and Rosemond (2005) found that nutrients do stimulate algal growth rates in shaded streams; however, the effects of nutrients may be suppressed by light availability. Stevenson et al. (1991) also found that algal growth rate increased in nutrient enriched streams, but abundance and growth rate decreased when enriched streams were shaded.

Arnwine and Sparks (2003) did not always find a strong relationship between periphyton and nutrients in Tennessee streams and suggest that other factors, including sunlight and warm temperatures also influence the growth rates of algae: "Many streams, especially small ones, have canopies that block sunlight and keep water temperatures down (Arnwine and Sparks 2003, p. 3)."

In an experiment by Pringle et al. (1986), both N and P appeared to be at growth saturating levels (i.e., mean NH4-N and (NO2 + NO3)-N concentrations were 28.6 µg/L and 100.2 µg/L, respectively. PO_4-P and TP concentrations were 60.9 µg/L and 94.0 µg/L, respectively), resulting in a lack of periphyton response to added nutrients. Pringle et al. (1986) suggest it is possible that this is because of micronutrient limitation and/or light limitation of periphyton growth in shaded portions of the stream.

Larned and Santos (2000) showed that the main effects of nitrate and phosphate enrichment were not significant in four Hawaiian streams, but the phosphate – light interaction was significant. Phosphate enrichment enhanced chlorophyll *a* accrual in partially-shaded pools, but not in heavily shaded pools. Nitrate enrichment was not significant at either light level. "Results of studies of periphyton photosynthesis-irradiance relationships in temperate streams indicate that irradiance levels between 100 and 400 $\mu E/m^2/s$ are saturating (Hill 1996). This range is well above the average irradiance levels measured in both partially-shaded and heavily-shaded pools…Irradiance rarely exceeded 100 $\mu E/m^2/s$ in partially-shaded pools, and never exceeded 25 $\mu E/m^2/s$ in heavily-shaded pools. This comparison suggests that periphyton productivity…may be light-limited much of the time, and that P may be limiting only under the highest available light conditions (p. 107)."

Hill et al. (1995) noted that nutrients generally only limit algal growth in streams where light levels exceed photosynthesis in conjunction with light at levels below the saturation point. Excessive algal growth in streams has been linked to increases in light and nutrient levels. Mosisch et al. (1999) note that "Periphyton communities in streams with high nutrient levels but without any shade-providing riparian vegetation can have chlorophyll *a* and biomass values up to four or five times higher that those growing under a full riparian tree canopy (see, e.g. Lowe et al., 1986; Hill and Knight, 1988). In unshaded or slightly shaded streams, nutrient availability can play a significant role in limiting primary production…(see e.g. Peterson et al, 1983; Pringle et al., 1986; Winterbourne, 1990). Nutrient enrichment probably has little effect on primary production in heavily shaded streams since, under these conditions algal growth is limited by light availability (Hill and Knight, 1988; Winterbourne, 1990) (p. 168)."

Light can also be a limiting factor in non-shaded streams when the streams have increased turbidity. A study by Kelly and Biggs (2002) indicates that light exposure is more important than nutrients in controlling periphyton growth. Increased turbidity and phytoplankton result in reduced light penetration, which likely restricts aquatic plant and periphyton growth. Figuerua-Nieves et al. (2006) found high concentrations of nutrients in 18 mid-western agricultural streams; however, chlorophyll *a* was generally not related to the concentration of nitrogen or phosphorus in the water column. In non-shaded streams periphyton often appeared to be light-limited because of turbidity. The interaction between hydrology and light (turbidity) likely controlled algal biomass in these streams.

3.2 Flooding

Murdock et al. (2004) found that rainfall events rather than nutrients regulated periphyton accumulation. Floods caused by small rainfalls events (1.3 cm) were capable of scouring all visible periphyton from an urban Texas stream. The high frequency of floods however, did not prevent nuisance levels (>100 mg chl *a*/m^2) of periphyton. In-stream processes did play a role in reducing nutrient concentrations; however, rainfall appeared to have a much greater effect.

Dodds and Welch (2000) suggest that an approach by Biggs (2000) that proposes a correlation method that considers hydrodynamic disturbances and inorganic nutrients in New Zealand streams may be useful. "Such an approach may prove useful within an ecoregion, and could be used to provide a sliding scale of nutrient criteria, with higher nutrient content allowed in more hydrodynamically unstable rivers (i.e., criteria may be more lenient because of regular scouring of algal biomass in rivers that flood frequently) (Dodds and Welch 2000, p. 190)."

Snelder et al. (2004) presented regression equations for Soluble Inorganic Nitrogen (SIN) and SRP that take into consideration a flow statistic that represents the mean number of flood events per year that exceed three times the median flow. As an example, application of these equations show that to maintain an in-stream benthic chlorophyll *a* value of 100 mg/m^2, a TN concentration of 10.7 µg/L at a 10-day frequency and a TN concentration of 105 µg/L at a 20-day frequency would be required. The more frequent the scouring the higher the allowable TN.

3.3 Land Use

Nutrients and algal biomass are often positively correlated with urban and agricultural land uses. Hill et al. (2000) developed a periphyton index of biotic integrity (PIBI) for the Mid-Appalachian region. The biomass metric was correlated with the percentage of the watershed in urban and suburban land uses, percentage of the streambed composed of sand and fine sediment, and total suspended solids in the stream water.

Taylor et al. (2004) found that streams in urbanized watersheds supported more benthic algae than streams with less urbanization. The urban density gradient strongly explained patterns of algal biomass in small urban streams. Median chlorophyll *a* concentration was more strongly correlated with drainage connection (direct connection of impervious surfaces to streams by

stormwater pipes) than with imperviousness. Taylor et al. (2004) suggest that nutrient stimulation resulting from piped stormwater runoff is the major mechanism explaining the strong correlation between connection and algal biomass, possibly in interaction with stormwater-related impacts on grazers.

Peterson and Femmer (undated) found that the periphyton community in Ozark streams was found to be positively and significantly correlated with the biovolume of blue-green algae and agricultural land use.

In a study of streams across the United States, Clark et al. (2000) found that 6 percent of the undeveloped basins had a flow-weighted TN concentration greater than 1 mg/L and 83 percent of 97 basins sampled by the USGS in agricultural and urban residential basins had a flow-weighted TN concentration of greater than "1.0 mg/L (USGS 1999b)" (Clark et al. 2000, p. 6-7)."

3.4 Grazers

There is not always a strong relationship between periphyton and nutrients (Greenwood and Rosemond 2005, Arwine and Sparks 2003). The effects of nutrients on algal biomass and species diversity can be suppressed by light availability as well as grazing and invertebrate consumption.

Bourassa and Cattaneo (1998) sampled periphyton and invertebrate biomass in 12 open canopy and shaded Canadian streams. Periphyton biomass was not related to nutrient concentration or canopy cover; however, grazer biomass and mean grazer size were positively correlated with phosphorus concentration. The results of this study indicate that grazer biomass, but not periphyton biomass, increases with nutrients, suggesting top-down control of periphyton biomass.

3.5 Seasonality

Seasonality should be considered when assessing the influence of nutrients on stream ecosystems. Benthic algal biomass accrual rates and nutrient limitation show significant seasonal differences (Francoeur et al. 1999). Biomass accrual rates are greatest in summer and least in winter. The prevalence and the severity of nutrient limitation is also greatest in summer and lowest in winter (i.e., periphyton is most responsive to nutrient amendments in summer and least responsive in winter). Francoeur et al. (1999) suggest that temperature could be the cause of these seasonal growth patterns.

A study by Meals et al. (1999) also supports seasonal nutrient variation. Meals et al. (1999) found that phosphorus uptake and retention was higher during warm weather low flows and active plant growth than during winter at low temperatures, higher flows, and lower biological productivity. Phosphorus retention was influenced by flow, temperature, concentration gradient, and biological activity.

"Short-term retention probably resulted from sorption by inorganic sediments and organic biofilms; long-term retention may have been a result of biological uptake. Instream phosphorus retention processes may not be capable of reducing phosphorus transport significantly during high flows and cold temperatures, but may temporally attenuate inputs delivered during small stormflows in the growing season (Meals et al. 1999, p. 185)."

4. Limitations of Periphyton Nutrient Ratios

Cellular nutrient ratios are often applied as indicators of nutrient limitation in phytoplankton studies; however, a similar ratio for periphyton is not common. Hillebrand and Sommer (1999) investigated the changes in cellular C: N: P stoichiometry of benthic microalgae in response to different levels and types of nutrient limitation and a variety of abiotic conditions. Hillebrand and Sommer (1999) state: "C: N ratios increased with decreasing growth rate, irrespective of the limiting nutrient. At the highest growth rates, the C: N ratio ranged uniformly around 7.5. N: P ratios <13 indicated N limitation, while N: P ratios > 22 indicated P limitation. Under P limitation, the C: P ratios increased at low growth rate and varied around 130 at highest growth rates. For a medium with balanced supply of N and P, an optimal stoichiometric ratio of C:N: P = 119 : 17 : 1 could be deduced for benthic microalgae, which is slightly higher than the Redfield ratio (106 : 16 : 1) considered typical for optimally growing phytoplankton…cellular nutrient ratios are proposed as an indicator for nutrient status in periphyton (p. 440)."

Stelzer and Lamberti (2001) studied the effects of nutrient ratios on algal community structure and algal growth in streams. The overall abundance of periphyton in the stream responded positively to increased total nutrient concentration (TNC), but not to N: P ratio. "Periphyton biomass was primarily limited by DIN and not SRP concentration, despite high N: P ratio in the ambient stream water and periphyton. This suggests that predicting nutrient limitation from stream water or periphyton nutrient ratios alone may have limitations. Algal community structure responded strongly to both N: P ratio and TNC…(p. 365)." Overall, the results showed that N: P ratio affected the community structure of periphyton, but did not have much of an effect on periphyton biomass. The results suggest that periphyton community structure may be more sensitive to changes in nutrient concentrations in the stream than periphyton biomass.

5. Nuisance Thresholds

Algal biomass in streams may be linked to nutrient enrichment and, therefore, nuisance thresholds may be associated with nutrient values that can be used as indicators of water quality impairment or excessive algal growth. Nutrient and algal biomass concentrations indicating eutrophic conditions in streams have not been strongly established as compared to lakes, but there have been some investigators that studied the response of algal biomass in streams to nutrient enrichment.

5.1 Nuisance Biomass Values

Studies suggest a range for values considered to be nuisance benthic algal biomass. Horner et al. (1983) and Welch et al. (1988) suggest a range from 100 to 150 mg/m^2. Nordin (1985) provides a range of 50 to 100 mg/m^2. A study by Biggs (2000) provides a range from 50 to 200 mg/m^2. Biggs

(1996) summarizes several studies that identified what constitutes nuisance algal growth, including Horner et al (2003) and Nordin (1985) discussed above. Chlorophyll *a* greater than 100-150 mg/m^2 or a cover greater than 20 percent by filamentous algae is unacceptable (Horner et al. 1983). Filamentous algae becomes conspicuous from the bank at greater than 40 percent and if cover is greater than 50 percent (50 g/m^2 ash-free dry mass) it usually results in smothering of the bed sediments (Biggs and Price 1987). Nordin (1985) recommended criteria for benthic algal biomass in streams of less than 50 mg/m^2 chlorophyll *a* for recreational use and less than 100 mg/m^2 for aquatic life. Zuur (1992) recommended a seasonal maximum cover by filamentous algae of 40 percent and biomass should not exceed 100 mg/m^2 chlorophyll *a*.

USEPA (2000a) presents EPA's recommended criteria for TP, TN, chlorophyll *a*, and turbidity for rivers and streams in Nutrient Ecoregion XI (Central and Eastern Forested Uplands). The recommended periphyton chlorophyll *a* value based on 25th percentiles for the ecoregion is 32.5 mg/m^2.

USEPA (2000b) presents EPA's recommended criteria for TP, TN, chlorophyll *a*, and turbidity for rivers and streams in Nutrient Ecoregion IX (Southeastern Temperate Forested Plains and Hills). The recommended chlorophyll *a* (spectrophotometric method) value based on 25th percentiles for the ecoregion is 20.35 mg/m^2 for periphyton chlorophyll *a*. The range of subecoregion reference conditions (based on 25th percentiles) for chlorophyll *a* is 3.13 – 20.35 mg/m^2 for periphyton chlorophyll *a*.

Kelly and Biggs (2002) cite New Zealand's Wamakariri Regional Plan (WRP) guidelines for periphyton cover (<40% filaments > 2 cm long or mats >3mm thick) and New Zealand's Ministry for the Environment (MfE) biomass guidelines for the protection of recreation and fish habitat (<120 mg/m^3 chlorophyll *a*), or benthic biodiversity (<50 mg/m^2 chlorophyll *a*).

Welch et al. (1989) assumed nuisance biomass levels of 150 and 200 mg chlorophyll *a*/m^2 and respective concentration ranges of 1-4 and 2-5 µg/L in a Spokane, Washington stream.

Dodds et al. (1998) analyzed published data for a large number of temperate stream sites for mean benthic chlorophyll *a*, maximum benthic chlorophyll *a*, sestonic chlorophyll *a*, TN, and TP as an effort to establish criteria for trophic boundaries in streams. The boundary between oligotrophic and mesotrophic categories is defined by the lower third of the cumulative distribution of the values and the mesotrophic-eutrophic boundary is defined by the upper third of the distribution (Table 1).

Table 1. Suggested boundaries for trophic classification of streams from Dodd et al. (1998)

Variable (units)	Oligotrophic-mesotrophic boundary	Mesotrophic-eutrophic boundary
Mean benthic chlorophyll (mg/m^2)	20	70
Maximum benthic chlorophyll (mg/m^2)	60	200
Sestonic chlorophyll (µg/L)	10	30

TN (µg/L)	700	1500
TP (µg/L)	25	75

5.2 Visual Assessment of Algal Biomass

The University of Montana Watershed Health Clinic and the Montana Department of Environmental Quality conducted a survey to evaluate the public's perception of benthic algae in Montana streams (University of Montana 2006). The intention of the survey was to use the information gathered on public opinions of algae levels and use it to help determine acceptable nutrient concentration standards for Montana's streams based on the strong link between algae levels and nutrient concentrations in water. The survey showed that all chlorophyll *a* levels at or above 200 mg/m^2 were determined to be "undesirable" by the majority of survey respondents. Chlorophyll *a* levels at or below 150 mg/m^2 were determined to be "desirable" by the majority of survey respondents. These results indicate that Montana's nutrient standards might be set at concentrations associated with benthic algae chlorophyll *a* levels of approximately 150 mg/m^2.

USDA (1998) provides a protocol for visual assessment of streams. The document provides guidance on how to assign a value to various elements of stream assessment including nutrient enrichment. A standard protocol for visual assessment can be useful for determining nuisance chlorophyll *a* levels. The USDA (1998) nutrient enrichment values range from 1 to 10, 1 being "pea green, gray, or brown water along entire reach; dense stands of macrophytes clog stream; severe algal blooms create thick algal mats in stream (p. 12)" and 10 being "clear water along entire reach; diverse aquatic plant community includes low quantities of many species of macrophytes; little algal growth present (p. 12)."

6. Phosphorus and Nitrogen Endpoints in the Literature

Studies and literature related to selection of phosphorus and nitrogen endpoints for water quality assessment purposes and TMDLs were reviewed and summarized. The findings of Dodds et al. (2002 and 2006), upon which initial TMDL endpoints were developed, are discussed first. Additional relevant study results are presented on a geographic basis, progressing from those conducted in the Northern Piedmont Ecoregion to other regional studies, to studies using data collected on a national scale, and finally, to studies conducted outside the United States. Factors evaluated include the effects of dissolved nutrients on algal growth, the appropriateness of using measures of total nutrients as indicators in comparison to dissolved constituents, and what is the most critical nutrient to control for algal management.

6.1 Dodds Regression Equation

Dodds et al. (2002) developed a regression equation to link in-stream nutrients to periphytic biomass based on seasonal means of periphyton biomass, nutrient concentrations, and other stream characteristics from almost 300 sampling periods from temperate streams. Data for benthic chlorophyll and nutrient concentrations from a subset of 620 stations in the United States National Stream Water-Quality Monitoring Networks were also analyzed. Dodds et al.

(2006) published an erratum to the 2002 paper *Erratum: Nitrogen and phosphorus relationships to benthic biomass in temperate streams* that states:

"This correction is related to two issues. First, a small number of data points from the literature data set had incorrect values of total phosphorus entered by the first author. Also, upon review of the entire literature data set, several chlorophyll values were found that did not match the criteria required for inclusion in the data set. Correcting these values resulted in modest changes…(p. 1190)."

One of the changes was to the regression equations developed by Dodds et al. (2002). The comparison of the Dodds et al. (2002) equation and the revised equation from Dodds et al. (2006) is presented below.

Equation from Dodds et al. (2002):

Log Chlorophyll *a* = 0.236×log(TN) = 0.443×log(TP) + 0.155

Revised equation from Dodds et al. (2006):

Log Chlorophyll *a* = 0.593×log(TN) + 0.204×log(TP) – 0.408

Dodds et al. (2002) states that:

"Probably the most prudent method for establishing nutrient criteria to control benthic chlorophyll is to use regression equations (best from the regions of interest, alternately those published here for the literature data set), keep in mind a potential breakpoint effect, and also use a reference site approach wherever reasonably pristine sites are available to employ as a baseline (p. 872)".

The Dodds (2002) equation was originally used to determine the TP endpoint in the TMDLs developed for Chester, Indian, Neshaminy, Skippack, Southampton, and Wissahickon Creeks, not all of which were finalized. The resulting TP endpoint was 248 µg/L (Carrick and Godwin 2006), much higher than the currently recommended 40 µg/L (Paul and Zheng 2007). Dodds (2003) notes that lower TN and TP values were obtained when using a detailed, smaller data set than those from a larger data set (TP of 55 µg/L for the larger data set versus 21 µg/L for the more specific data set). Dodds (2003) found that if a mean of 50 mg/m^2 chlorophyll *a* is the target (thus insuring chlorophyll *a* is less than 100 mg/m^2 most of the time), TN should be 470 µg/L and TP should be 60 µg/L. Lower numbers should be considered for more pristine waters.

6.2 Nutrient Studies in the Northern Piedmont Ecoregion

Studies in the region have shown consistent low values for TP required for the control of benthic chlorophyll *a*. An ongoing study by the Louis Berger Group on the Jackson River in Virginia is proposing an ortho-phosphorus endpoint of 38 µg/L. This is based on a regression equation developed using local data. In New Jersey, a trophic diatom index (TDI) was developed by Belton

et al. (undated paper). The index included a TP concentration below 25 µg/L for a low TDI and a range from 75µg/L to 100 µg/L for a high TDI.

EPA's nutrient threshold recommended for the Northern Piedmont Ecoregion is 2,225 µg/L for TN and 40 µg/L for TP (USEPA 2000b). Charles and Ponader (2004) applied EPA's reference approach to the Northern Piedmont Ecoregion in New Jersey and found close agreement with the EPA recommended numbers. The Charles and Ponader (2004) numbers were 1,300 µg/L TN and 40 µg/L TP.

The United States Geological Survey (USGS) conducted a study in 2001 that included the New River and Big Sandy River in Virginia (Robertson et al. 2001). Using the reference approach, USGS found that a TP concentration of 20 µg/L was appropriate for what is defined as Environmental Nutrient Zone 2. In a study of over 35 streams in Virginia, Ponader et al. (2005) observed changes in the diatom assemblages and suggested threshold limits of 500 µg/L TN and 50 µg/L TP to protect against nutrient impaired conditions.

Delaware uses TP in assessing the state's waters for reporting under Section 305(b) of the Clean Water Act. Delaware lists segments as impaired when one or more water quality stations have a Lower Confidence Limit at or above the moderate value of 1,000 to 3,000 µg/L TN and 50 to 100 µg/L TP. A preliminary study in Virginia suggests a total nitrogen threshold for benthic impairment between 350 and 900 µg/L (Hill and Devlin 2003).

An on-going study in the Paxton Creek, Pennsylvania is showing that nitrogen may be the controlling nutrient because of TP sufficiency. The investigators (Carrick and Mays 2006) developed regression equations for TN and TP using site-specific data and applied those equations to calculate TN and TP concentrations necessary to maintain a chlorophyll *a* value of 100 mg/m^2. It was determined that a TN concentration of 731 µg/L and a TP concentration of 95 µg/L were needed. The investigators considered benthic nutrient pools as well as nutrients available in the overlying waters.

USEPA (2000a) and USEPA (2000b) present EPA's recommended criteria for TP, TN, chlorophyll *a*, and turbidity for rivers and streams in Nutrient Ecoregions XI (Central and Eastern Forested Uplands) and Nutrient Ecoregion IX (Southeastern Temperate Forested Plains and Hills), respectively. Nutrient Ecoregion XI includes parts of Pennsylvania and Nutrient Ecoregion IX includes southeastern Pennsylvania.

The recommended values of TN and TP for Nutrient Ecoregion XI are 0.31 mg/L and 10 µg/L, respectively (based on reference condition 25th percentiles). The range of subecoregion reference conditions (based on 25th percentiles) for TP is 5.63 – 10.47 µg/L and the range for TN is 0.21 – 0.58 mg/L. The recommended chlorophyll *a* (spectrophotometric method) value based on 25th percentiles for the ecoregion is 1.61 µg/L, while the range of subecoregion reference conditions (based on 25th percentiles) is 0.25-3.36 µg/L.

The recommended values of TN and TP for Nutrient Ecoregion IX are 0.69 mg/L and 36.56 µg/L, respectively (based on reference condition 25th percentiles). The range of subecoregion reference conditions (based on 25th percentiles) for TP is 22.5 – 100.0 µg/L and the range for TN is 0.07 – 1.0 mg/L. The recommended chlorophyll *a* (spectrophotometric method) value based

on 25th percentiles for the ecoregion is 0.93 µg/L and 20.35 mg/m^2 for periphyton chlorophyll *a*. The range of subecoregion reference conditions (based on 25th percentiles) for chlorophyll *a* is 0.05-5.74 µg/L and 3.13 – 20.35 mg/m^2 for periphyton chlorophyll *a*. As mentioned earlier, EPA's nutrient threshold recommended for the Northern Piedmont Ecoregion, which is part of Nutrient Ecoregion IX, is 2,225 µg/L for TN and 40 µg/L for TP (USEPA 2000b). The chosen TP TMDL target of 40 µg/L (Paul and Zheng 2007) is very similar to the recommended aggregate ecoregion value of 36.56 µg/L (USEPA 2000b) and the same as the recommended Northern Piedmont Ecoregion value of 40 µg/L (USEPA 2000b).

6.3 Nutrient Studies in Other Regions of the United States

Mitchell et al. (2003) developed criteria for rivers in New England using the reference condition approach based on a nutrient and trophic parameter data set of 569 rivers and streams and an effects-based approach, based on a weight-of-evidence review of literature, models, and TMDL studies. Using the EPA approach for calculating ambient water quality recommendations, the 25th percentile of all rivers and streams and the 75th percentile of the reference waters provided relatively similar values. Mitchell et al. (2003) suggested that based on the weight-of-evidence that 40 µg/L TP and 800 µg/L TN would be upper bound nutrient criteria (i.e., approaching impaired aquatic community status). Table 2 presents a comparison of the New England water quality recommendations for nutrients and chlorophyll *a* based on Mitchell et al. (2003) to EPA's recommended ambient water quality criteria.

Table 2. Comparison of New England and EPA water quality recommendations for nutrients from Mitchell et al. (2003)

Sub-Ecoregion	Parameter	New England Ecoregion All Season 25th Value (µg/L)	Reference All Season 75th Value (µg/L)	EPA AWQC* Recommendation (µg/L)
EPA sub-ecoregion 83	Chlorophyll	1.6	1.5	1.6
	Total	470	538	480
	Total	31	44	24.1
EPA sub-ecoregion 82	Chlorophyll	1.7	2.5	
	Total	33	325	390
	Total	14	12	12
EPA sub-ecoregion 59	Chlorophyll	4.9		
	Total	560	458	570
	Total	20	22	23.5
EPA sub-ecoregion 58	Chlorophyll	2.2		3.4
	Total	360	121	420
	Total	10	12	5
Composite New England	Chlorophyll	1.9	1.8	
	Total	460	520	
	Total	20	23	

*AWQC = ambient water quality criteria

Denton et al. (2001) developed guidance for the interpretation of narrative nutrient criteria based on regional reference data in Tennessee. These data were used to develop recommended nutrient criteria for ecoregions in Tennessee. The resulting TP concentrations ranged from 0.01 – 0.25 mg/L. The resulting nitrate+nitrite concentrations ranged from 0.22 – 3.48 mg/L.

Riskin et al. (2003) provide a summary of the TN and TP concentrations for potential methods of nutrient criteria development in the Northeastern Coastal Zone in Massachusetts and New Hampshire. The suggested TN values range from 0.45 – 1.3 mg/L and the suggested TP values range from 0.024 – 0.120 mg/L.

Shock and Pratt (2003) indicate that water in the headwaters of rivers is usually very low in phosphorus, stating: "Typically many mountain lakes in the Cascades, central mountains of Idaho, and high mountain streams have less than 20 µg/L total phosphorus (p. 211)."

Montana Department of Environmental Quality (MT DEQ) evaluated the two statistical methods USEPA recommends for developing nutrient criteria using streams in 5 different ecoregions in Montana (Suplee et al. 2007). One method establishes a criterion as the 75th percentile of a reference-population frequency distribution; the other method uses the 25th percentile of a general-population distribution. "The study found that nutrient concentrations at high percentiles of reference- site frequency distributions (this study suggests the 86th) represent, fairly consistently, the threshold where impacts to beneficial water uses begin to occur (p. 469)." The ranges of 75th percentile TN and TP values for reference streams in this study are 0.09 – 1.3 mg/L and 0.003 – 0.17 mg/L, respectively (Suplee et al. 2007). The ranges of 25th percentile TN and TP values for non-reference streams in this study are 0.05 – 0.61 mg/L and 0.01 – 0.02 mg/L, respectively (Suplee et al. 2007).

6.4 Nutrient Studies on a National Scale

Several states have developed nutrient standards or guidelines. These values range from a maximum TP concentration of 100 µg/L to a summer average TP concentration of 25 µg/L to 70 µg/L (during the summer low flow period).

Rohm et al. (2002) conducted a national study to demonstrate how regional reference conditions and draft nutrient criteria could be developed. The country was divided into 14 regions and available nutrient data were analyzed using EMAP data (Environmental Monitoring and Assessment Program) from Central and Eastern Forested Uplands, an area that includes much of central Pennsylvania. This case study suggested a criterion of 375 µg/L for TN and 13 µg/L for TP. Rough estimates from the data presented for the region that includes eastern Pennsylvania gives rough values of 500 µg/L TN and 20 µg/L TP.

Clark et al. (2000) estimated concentrations of nutrients in streams in relatively undeveloped watersheds across the United States. The results of this study are intended to be used to "determine achievable baseline conditions for nutrients in basins with similar geographic and hydrologic conditions and to evaluate human effects on water quality in more intensively developed basins (Clark et al. 2000, p. 8)." The median flow-weighted concentrations for nutrients in all basins are provided in Table 3.

Table 3. Median flow-weighted concentrations for all basins from Clark et al. (2000)

Parameter	Median flow-weighted concentrations (mg/L)
Ammonia as N	0.020
Nitrate as N	0.087
Total nitrogen	0.26
Orthophosphate as P	0.010
Total phosphorus	0.022

The median flow-weighted concentration for TP (0.022 mg/L) was 5 times lower than the 0.1 mg/L concentration "generally recommended for prevention of nuisance aquatic growth in streams (USEPA, 1986) (Clark et al. 2000, p. 7)." Seven of the basins were located in Maine, Massachusetts, New Hampshire, New Jersey, New York, and Pennsylvania. Six of these seven basins had flow-weighted concentrations of TP less than 0.01 mg/L.

Smith et al. (2003) used data from 63 USGS reference watersheds to determine background TN and TP concentrations in the stream networks in 14 ecoregions of the United States. TN concentrations varied from < 0.02 mg/L (xeric west) to > 0.5 mg/L (southeastern coastal plain) and TP concentrations varied from < 0.006 mg/L (xeric west) to > 0.08 mg/L (great plains). The range of background nutrient concentrations is very large in some nutrient ecoregions because of local variation in runoff and other factors. "Across all regions, the average upper-quartile value for deposition-corrected background TN is less than half the lower-quartile EPA value (0.29 vs 0.63 mg/L), while the average upper-quartile background TP estimate is almost identical to the average lower-quartile EPA estimate (0.039 vs 0.041 mg/L). Similar distributions of actual stream nutrient conditions to those developed by the EPA were obtained by Dodds et al. [1998] based on TN and TP records for more than 1000 sites in temperate watersheds of widely varying size and land use in the United States, Europe, and New Zealand. Lower-quartile values for these databases were 0.56 mg/L for TN and 0.02 mg/L for TP (p. 3,045)."

6.5 Worldwide Nutrient Studies

Van Niewenhuyse and Jones (1996) found that summer mean chlorophyll *a* concentration has a strong positive relationship with summer mean TP concentrations in temperate streams (in Canada, the United States, and Europe). The Chl: TP ratio generally increases with stream catchment area. Table 4 presents the summary statistics for TP, chlorophyll, and catchment area.

Table 4. Summary of TP and chlorophyll concentrations and catchment area from Van Niewenhuyse and Jones (1996)

				Percentile		
Variable	**Mean**	**Minimum**	**Maximum**	**25%**	**50%**	**75%**
TP (mg/m^3)	192	5	1,030	48	100	263
Chlorophyll *a* (mg/m^3)	27	0.4	170	4.9	17	35
Catchment area (km^2)	33,060	1	541,310	450	8,130	42,000

6.6 Summary of Other Representative Nutrient Studies

Borchardt (1996) summarizes representative studies on nutrient limitation of benthic algae. Saturated growth rates range from 8 µg/L – 60 µg/L TP and 55 – 700 µg/L TN. The individual vales are as follows: saturated growth rate occurred at 8 µg/L P and 500-700 µg/L N (Wuhrmann and Eichenberger 1975); 60 µg/L P (Wong and Clark 1976); 40-50 µg/L P (Horner and Welch 1981); 25 µg/L P (Horner et al. 1983); and 55 µg/L N (Grimm and Fisher 1986). Borchardt's (1996) summary also indicates that maximum biomass occurs at 25-50 µg/L P (Bothwell 1989) and less than 100 µg/L N is growth limiting (Lohman et al. 1991).

7. Effects of Dissolved Phosphorus and Nitrogen on Algal Growth

Borchardt's (1996) summary of representative studies on nutrient limitation of benthic algae included saturation vales for dissolved nutrients of 3-4 µg/L SRP (Bothwell 1985); 0.3 – 0.6 µg/L PO_4-P (Bothwell 1988); and 8 µg/L SRP (Horner et al 1990).

As noted above, Bothwell (1985) found algal growth rates in the lower Thompson River, British Columbia to be nearly saturated at 3-4 µg/L SRP. "This finding confirms for natural river periphyton the long-standing observation from chemostat work that growth rates of unicellular algae saturate at very low ambient phosphorus concentrations (Fuhs 1969; Rhee 1973; Brown et al. 1978) (p. 539)." This study also found that periphyton in rivers with similar phosphorus levels can have very different growth rates.

Rier and Stevenson (2006) controlled nitrogen and phosphorus concentrations in stream mesocosms to develop relationships between periphyton growth rates and peak biomass with inorganic N and P concentrations. The saturating concentrations for algal growth were 16 µg/L SRP and 86 µg/L DIN. Saturation of peak biomass occurred at 308 µg/L DIN and 38 µg/L SRP.

Bowes et al. (2007) found that increasing the SRP concentration in flumes did not increase algal growth and algal biomass declined when SRP was reduced below 90 µg/L, with a 60 percent biomass reduction at < 40 µg/L. Phosphorus was decreased in the flumes by precipitating phosphorus with iron (II) sulfate solution. Bowes et al. (2007) suggests this iron-stripping approach can be used by watershed managers of nutrient-impacted waterbodies to determine phosphorus reduction targets.

Sosiak (2002) assessed the response of periphyton and aquatic macrophytes to improved phosphorus and nitrogen removal at Calgary's two municipal wastewater treatment plants in the Bow River. There was no change in periphytic biomass after phosphorus removal where total dissolved phosphorus (TDP) in river water remained relatively high (10–33 µg/L). However, periphytic biomass did decline with TDP < 10 µg/L. Nuisance periphyton biomass (>150 mg/m^2) occurred at TDP > 6.4 µg/L (equivalent to about 18 µg/L TP). There was no evidence that variables other than phosphorus caused the observed decline in periphytic biomass.

8. Endpoint Identification: Total Nutrients vs. Dissolved

The Clark River study states that "…practical regulations for general external nutrient loading for stream eutrophication control should not be based upon in-stream Soluble Reactive Phosphorus [SRP] or Dissolved Inorganic Nitrogen [DIN] levels, because the prediction uncertainty inherent in such an approach may preclude the satisfactory management of benthic chlorophyll *a* (Dodds et al. 1997, p. 1740)." The study further states: "Our analyses revealed that both total N and total P are related more strongly with benthic algal biomass than are dissolved inorganic N or P (Dodds et al. 1997, p. 1740)." In-stream TN and TP concentrations are more indicative of the nutrients that are ultimately available for the growth of algae.

Dodds (2003) suggests that control based on measured levels of dissolved inorganic nitrogen and phosphorus may not be effective because these pools are replenished rapidly by remineralization in surface waters. Dodds (2003) indicated that at high TN (i.e., .5 mg/L) and TP (i.e., .2 mg/L) concentrations, more than 60 percent of the nutrient is usually made up of dissolved inorganic forms, but at low levels the ratio of dissolved inorganic to total nutrients is highly variable. Therefore, DIN:SRP is a weak surrogate for TN:TP and should be used with caution to indicate nutrient limitation. Calculating TMDLs based on TN and TP criteria is also more practical than using dissolved forms of phosphorus and nitrogen because more total nitrogen and phosphorus water quality data are available than dissolved.

9. Management Implications: Total Nitrogen or Total Phosphorus Control

Dodds et al. (2002) notes that the literature data set included breakpoints that may provide important guidance in the control of benthic chlorophyll *a*. Dodds et al. (2002) states: "The breakpoints provide evidence for a saturation effect of nutrients on periphyton biomass accrual (p. 869)…They suggest there is little probability of low benthic algal chlorophyll above the breakpoint value for TN and TP. If TN or TP is below the breakpoint, there is more likely to be low chlorophyll…(p. 872)." Dodds et al. (2002) provided an analysis of breakpoints from regression for TN and TP. The values are presented in Table 5.

Table 5. Dodds et al. (2002) analysis of breakpoint values for total nitrogen and total phosphorus

Dependent Variable	Independent Variable	Breakpoint (µg/L)
Log(mean Chlorophyll *a*)	Log(total phosphorus)	43
Log(mean Chlorophyll *a*)	Log(total nitrogen)	537

Dodds et al. (2002) state that "The data reveal a significant N-P interaction in streams and suggest that it is necessary to consider both N and P as potentially limiting nutrients for periphyton biomass accrual in lotic ecosystems (p. 869)." If the TP cannot be controlled to below 43 µg/L in-stream, then TN must also be controlled. Note that the selected endpoint for TP for the southeastern Pennsylvania streams (40 µg/L) is similar to the Dodds et al. (2002) breakpoint concentration of 43 µg/L.

Dodds and Welch (2000) found that correlation does not support the idea of TP as the sole limiting nutrient in rivers and streams. A regression model using both TN and TP explained the highest proportion of variances in biomass. Dodds and Welch (2000) concluded that both TN and TP can control primary production in at least some streams and rivers. Dodds and Welch (2000) proposed that if pulses of TP occur, such as storm runoff, they can be taken up in excess

of requirements and stored inside algal cells. If control of TP pulses is not possible then control of TN may be necessary. Dodds and Welch (2000) suggested that given the bioassay and correlation data and that periphyton can consume phosphorus in excess of immediate needs, setting nutrient criteria for both TN and TP makes sense.

Francoeur (2001) states that: "Many experimental studies have confirmed that the single limiting nutrient paradigm is an accurate depiction of how unialgal cultures respond to altered N and P supply (see Tilman 1982, Tilman et al. 1982, Borchardt 1996; for specific exceptions see Ahlgren 1985, De Vries et al. 1985). This paradigm is often applied to multispecies algal communities, especially in reference to community biomass, despite a theoretical problem with such an extension. Algal species differ in their nutrient requirements (e.g., Rhee and Gotham 1980, Tilman et al. 1982, Borchardt 1996). Thus, in a multispecies algal community, different species could be limited by different nutrients. Therefore, application of the single limiting nutrient paradigm to multispecies communities is not strictly valid (Borchardt 1996) (p. 358)…"

Francoeur (2001) applied meta-analysis to previous nutrient amendment experiments in streams to determine whether benthic algal community biomass is typically limited by a single nutrient or more than one nutrient at any given time. The results showed that the addition of a limiting nutrient typically doubled algal biomass, whereas the addition of another nutrient generally increased algal biomass about 1.25 times. N was almost equally likely as P to be the limiting nutrient. Francoeur (2001) found simultaneous limitation of different benthic algal species in the same community by different nutrients to be common. Phosphorus cannot be assumed to be the only nutrient that constrains algal biomass since N additions were as likely as P additions to increase algal biomass. Therefore, both N and P inputs to streams should be considered when determining TMDL targets.

10. Nutrient Endpoint Values Applied in Past TMDLs

Several TMDLs across the United States have had to determine numeric endpoints for nutrient TMDLs. Some have chosen nitrogen or phosphorus endpoints, while others have chosen a nuisance level of chlorophyll *a*. This section briefly summarizes a few of the chosen endpoints.

10.1 Chlorophyll a

The chlorophyll *a* target of 150 mg/m^2 for the Calleguas Creek TMDL was chosen from the literature representing nuisance levels of algae (Larry Walker Associates 2001). The 150 mg/m^2 chlorophyll *a* target was not site-specific and was chosen based on guidance from USEPA's *Nutrient Criteria Technical Guidance Manual for Rivers and Streams* (USEPA 2000).

10.2 Dissolved Nitrogen and Phosphorus

Oregon's Department of Environmental Quality (2000) applied the Periphyton Control Model to the Grande Ronde River in Oregon. The Periphyton Control Model (PCM) is a numerical model that simulates periphyton in streams and evaluates the impact of potential control measures on

diurnal pH and dissolved oxygen. The load allocations for 6 reaches of the Grande Ronde River ranged from 15 – 32 µg/L DIN and 5 – 12 µg/L dissolved orthophosphate.

Davis (2002) found that nutrient flux is a more relevant measure of nutrient availability and indicator of high photosynthesis (P_t) rates than nutrient concentration. The results of this study were used to develop strategies for preventing high P_t rates and the associated exceedances of water quality criteria in two tributaries to the Christina River watershed in southeastern Pennsylvania (East Branch Brandywine River and Red Clay Creek). Davis (2002) found that reductions in soluble orthophosphorus (SOP) concentrations should be considered for lowering the P_t rates. Using the highest observed SOP flux associated with low P_t levels, SOP target concentrations of 74 g/L and 130 g/L for East Branch Brandywine River and Red Clay Creek, respectively, were derived. The SOP targets were calculated by dividing the flux by the stream velocities.

10.3 Total Phosphorus

Oregon Department of Environmental Quality (1988) developed a phosphorus TMDL for the Tualatin River. The goal of the TMDL was to reduce the chlorophyll *a* concentration in the river to a three-month average of 15 µg/L or less. The concentration of chlorophyll *a* was applied as an indicator of phytoplankton concentration. It was determined that a monthly median TP concentration of 70 µg/L or less would achieve this chlorophyll *a* concentration. 70 µg/L is the median concentration chosen as the target, but concentrations ranged from 20-70 µg/L for different reaches of the river. Shock and Pratt (2003) cite the Hells Canyon-Snake River TMDL as also establishing a TP criterion of 70 µg/L.

Ftn, Inc. (2005) applied a TP endpoint of 0.1 mg/L (100 µg/L) to a phosphorus TMDL in Osage Creek near Berryville, Arkansas. A previous version of Arkansas Regulation No. 2 included a guideline of 0.1 mg/L for TP in streams, therefore this value was applied as the TMDL endpoint.

11. Conclusions

Study results summarized as part of this literature review support the assertion that while a relationship may exist between periphyton growth and nutrients, the dynamics change as a function of multiple factors. These factors include antecedent conditions, water temperature, pH, light availability, flow regime, and grazing, among others. Nutrient levels may be secondary to other determinants of biomass and growth such as light, disturbance, and grazing. Additionally, nutrients and algal biomass are often positively correlated with urban and agricultural land uses; in one study, the urban density gradient strongly explained patterns of algal biomass in small urban streams (Taylor 2004). Reference conditions used to develop the original nutrient endpoints for the TMDLs in question were derived by selecting sites in watersheds with less than 30 percent developed lands.

Table 6 summarizes the nutrient target values identified in this literature review and compares them with the TMDL TP target identified by Paul and Zheng (2007).

Table 6. Summary of nutrient target values identified in this literature review

Parameter	Average from the literature	Range from literature	Range from past TMDLs	Chosen TMDL endpoints*
TP (µg/L)	45	8 – 130	20-100	40
TN (µg/L)	670	55 – 2,225	--	3,700
Chlorophyll *a* (mg/m^2)	80	20.35 – 200	15 – 150	--

*Paul and Zheng (2007)

The chosen TP TMDL endpoint of 40 µg/L (Paul and Zheng 2007) for the nutrient TMDLs for the six southeastern Pennsylvania streams is very similar to the average literature value or 45 µg/L. The average literature value of 670 µg/L TN also falls within the recommended range of potential TN endpoints of 260 µg/L to 3,700 µg/L (Paul and Zheng 2007). The 40 µg/L TP target is within the range of the past TMDL TP targets summarized in Section 10. The TP target selected for the TMDLs in question is in range of the Dodds et al.'s (2006) breakpoint value of 43 µg/L. It is also below the mesotrophic – eutrophic boundary concentration of 75 µg/L TP determined by Dodds et al. 1998.

Identification of total nutrient concentration endpoints as opposed to dissolved constituents is also supported by several studies as discussed in Section 8. Dodds et al. (1997) found that in-stream TN and TP concentrations are more indicative of the nutrients that are ultimately available for the growth of algae. Furthermore, available total water quality nutrient data tend to be more abundant than dissolved constituents.

References

Arnwine, D.H. and K.J. Sparks. 2003. Comparison of Nutrient Levels, Periphyton Densities and Diurnal Dissolved Oxygen Patterns in Impaired and Reference Quality Streams in Tennessee. Tennessee Department of Environment and Conservation. Nashville, TN.

Auch, R.F. 2002. Land use/land cover change in the northern piedmont ecoregion: 1970-2000. Brookings, South Dakota, South Dakota State University, Masters thesis, 211 p., cited by USGS (United States Geological Society) website: http://edc2.usgs.gov/LT/regions/eco64.php on December 6, 2007.

Belton, T.J., K.C. Ponader and D.F. Charles. Undated. Trophic Diatom Indices (TDI) and the Development of Site-specific Nutrient Criteria. Unpublished and undated paper

Biggs, B.J.F. 2000. Eutrophication of Streams and Rivers: Dissolved Nutrient-Chlorophyll Relationships for Benthic Algae. *Journal of the North American Benthological Society* 19:17-31.

Biggs, B.J.F. 1996. Patterns in Benthic Algae of Streams in Algal Ecology: Freshwater Benthic Ecosystems, edited by R.J. Stevenson, M.L. Bothwell, R.L. Lowe, and J.H. Thorp. San Diego, CA. pp. 31-51.

Borchardt, M.A., 1996. Nutrients in Algal Ecology: Freshwater Benthic Ecosystems, edited by R.J. Stevenson, M.L. Bothwell, R.L. Lowe, and J.H. Thorp. San Diego, CA. pp. 184-228.

Boston, H.L. and W.R. Hill. 1991. Photosynthesis-light relations of stream periphyton communities. *Limnology and Oceanography* 36:664-656.

Bothwell, M.L. 1985. Phosphorus limitation of lotic periphyton growth rates: an intersite comparison using continuous-flow troughs (Thompson River system, British Columbia), *Limnology and Oceanography* 30:527-542.

Bourassa, N., A. Cattaneo. 1998. Control of periphyton biomass in Laurentian streams (Quebec). *Journal of the North American Benthological Society* 17:40-429.

Bowes, M.J., J.T. Smith, J. Hilton, M.M. Sturt, and P.D. Armitage. 2007. Periphyton biomass response to changing phosphorus concentrations in a nutrient-impacted river: a new methodology for phosphorus target setting. *Canadian Journal of Fisheries and Aquatic Sciences* 64:227-238.

Brightbill, R.A. and E.H. Koerkle. 2003. Relations of biological indicators to nutrient data for lakes and streams in Pennsylvania and West Virginia, 1990-98. U. S. Geological Survey, Water-Resources Investigations Report 03-4033. New Cumberland, PA.

Carrick and Godwin. 2006. TMDL endpoint estimates for an urban-suburban stream based upon in-stream periphyton biomass (Wissahickon Creek Watershed, Pennsylvania). University Park, PA.

Carrick, H.J. and S.J. Mays. 2006. Water Quality Assessment in Paxton Creek, Pennsylvania.

Charles, D. and K. Ponader. 2004. New Jersey Periphyton Bioassessment Development Projects – Trophic Diatom Inference Models and Index Development for New Jersey Wadeable Streams – Final Reports (2000 – 2005). Patrick Center for Environmental Research.

Chetelat, J., F.R. Pick, A. Morin and P.B. Hamilton. 1999. Periphyton biomass and community composition in rivers of different nutrient status. *Canadian Journal of Fisheries and Aquatic Sciences* 56:560-569.

Clark, G.M., D.K. Mueller and M.A. Mast. 2000. Nutrient concentrations and yields in undeveloped basins of the United States. *Journal of the American Water Resources Association* 36:849-860.

Davis, J.F. 2002. Factors affecting photosynthesis rates of periphyton in shallow streams of southeastern Pennsylvania. *Water Environmental Research* 74:370-376.

Denton, G.M., D.H. Arnwine and S.H. Wang. 2001. Development of regionally-based interpretations of Tennessee's narrative nutrient criterion. Tennessee Department of Environment and Conservation. Nashville, TN.

Dodds, W.K. 2003. Misuse of inorganic N and soluble reactive P concentrations to indicate nutrient status of surface waters. *Journal of the North American Benthological Society* 22:171–181.

Dodds, W.K., J.R. Jones and E.B. Welch. 1998. Suggested classification of stream trophic state: distribution of temperate stream types by chlorophyll, total nitrogen and phosphorus. *Water Research* 32:1455-1462.

Dodds, W.K., V.H. Smith and K. Lohman. 2002. Nitrogen and phosphorus relationships to benthic algal biomass in temperate streams. *Canadian Journal of Fisheries and Aquatic Science* 59:865-874.

Dodds, W.K., V.H. Smith and K. Lohman. 2006. Erratum: nitrogen and phosphorus relationships to benthic algal biomass in temperate streams. *Canadian Journal of Fisheries and Aquatic Science* 59:865–874.

Dodds, W.K., V.H. Smith and B. Zander. 1997. Developing nutrient targets to control benthic chlorophyll levels in streams: a case study of the Clark Fork River. *Water Research* 31:1738-1750.

Dodds, W.K. and E.B. Welch. 2000. Establishing nutrient criteria in streams. *Journal of the North American Benthological Society* 19:186-196.

Figuerua-Nieves, D., T. Toyer and M. David. 2006. Controls on chlorophyll-a in nutrient-rich agricultural streams in Illinois, USA. *Hydrobiologia* 568:287-298.

Francoeur, S.N. 2001. Meta-analysis of lotic nutrient amendment experiments: detecting and quantifying subtle responses. *Journal of the North American Benthological Society* 20:358-368.

Francoeur, S.N., B.J.F. Biggs and R.L. Lowe. 1999. Nutrient limitation of algal biomass accrual in streams: seasonal patterns and a comparison of methods. *Journal of the North American Benthological Society* 18:242-260.

FTN Associates. 2005. TMDL for Phosphorus on Osage Creek Near Berryville, AR (Reach 1010001-045L). Little Rock, AR.

Greenwood, J.L. and A.D. Rosemond. 2005. Periphyton response to long-term nutrient enrichment in a shaded headwater stream. *Canadian Journal of Fisheries and Aquatic Sciences* 62:2033-2045.

Hill, J. and G. Devlin. 2003. Memorandum: Associations Between Biological, Habitat, and Ambient Data in Upland Western Virginia Ecoregions. Virginia Department of Environmental Quality, West Central Regional Office. Roanoke, VA.

Hill, B.H., A.T. Herlihy, P.R. Kaufmann, R.J. Stevenson, F.H. McCormick, C. Burch Johnson. 2000. Use of periphyton assemblage data as an index of biotic integrity. *Journal of the North American Benthological Society* 19:50-67.

Hillebrand, H. and U. Sommer. 1999. The nutrient stoichiometry of benthic microalgal growth: redfield proportions are optimal. *Limnology and Oceanography* 44:440-446.

Horner, R.R., E.B. Welch, and R.B. Veenstra. 1983. Development of nuisance periphytic algae in laboratory streams in relation to enrichment and velocity. Pages 121-134 in R.G. Wetzel (ed.). Periphyton of Freshwater Ecosystems. Dr. W. Junk Publishers. The Hague.

Kelly, D.J. and B.J.F. Biggs. 2002. Periphyton growth and nutrient dynamics and their relationship to the proposed Rangiora STP discharge in the Cam River. National Institute of Water and Atmospheric Research Ltd. Christchurch, New Zealand.

Larned, S.T. and S.R. Santos. 2006. Light- and nutrient-limited periphyton in low order streams of Oahu, Hawaii. *Hydrobiologia* 432:101-111.

Larry Walker Associates. 2001. Calleguas Creek Nutrient TMDLs – Final Draft.

Louis Berger Group. 2006. Jackson River Benthic TMDL Development, A Powerpoint presentation. September 28, 2006

Meals, D.W., S.N. Levine, D. Wang, J.P. Hoffmann, E.A. Cassell, J.C. Drake, D.K. Pelton, H.M. Galarneau and A.B. Brown. 1999. Retention of spike additions of soluable phosphorus in a northern eutrophic stream. *Journal of the North American Benthological Society* 18:185-198.

Mitchell, D.F.. 2003. Riffles vs. reservoirs – nutrient criteria and downstream effects. National TMDL Science and Policy 2003 Specialty Conference. Water Environment Federation.

Mosisch, T.D., S.E. Bunn, P.M. Davies and C.J. Marshall. 1999. Effects of shade and nutrient manipulation on periphyton growth in a subtropical stream. *Aquatic Biology* 64:167-177.

Murdock, J., D. Roelke and F. Gelwick. 2004. Interactions between flow, periphyton and nutrients in a heavily impacted urban stream: implications for stream restoration effectiveness. *Ecological Engineering* 22:197-207.

Nordin, R.N. 1985. Water Quality Criteria for Nutrients and Algae. Water Quality Unit, Resource Quality Section, Water Management Branch, British Columbia Ministry for the Environment, Victoria, Canada.

ODEQ (Oregon Department of Environmental Quality). 1988. Tualatin River Sub-basin: Appendix C: Supporting Documents for the Chlorophyll A/PH (Phosphorus) TMDL.

Oregon Department of Environmental Quality. 2000. The Periphyton Control Model and its Application to the Grande Ronde River, Oregon; Appendix B: Periphyton Analysis. State of Oregon.

Pan, Y.D., R.J. Stevenson, B.H. Hill, A.T. Herlihy and G.B. Collins. 1996. Using diatoms as indicators of ecological conditions in lotic systems: a regional assessment. *Journal of the North American Benthological Society* 15:481-495.

Paul, M.J and L. Zheng. 2007. Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application. Owings Mills, MD.

Peterson, J.C. and S.R. Femmer. Undated. Periphyton Communities in Streams of the Ozark Plateaus and Their Relations to Selected Environmental Factors. Water-Resources Investigations Report 02-4210. U.S. Geological Survey.

Ponader, K., C. Flinders, and D. Charles. 2005. The Development of Algae-based Water Quality Monitoring Tools for Virginia Streams. Report No. 05-09 for the West Central Regional Office, Virginia Department of Environmental Quality. Patrick Center for Environmental Research, Academy of Natural Sciences. Philadelphia, PA.

Potapova, M.G., D.F. Charles, K.C. Ponader and D.M. Winter. 2004. Quantifying species indicator values for trophic diatom indices: a comparison of approaches. *Hydrobiologia* 517:25-41.

Pringle, C.M., P. Paaby-Hansen, P.D. Vaux and C.R. Goldman. 1986. *In situ* nutrient assays of periphyton growth in a lowland Costa Rican stream. *Hydrobiologia* 134:207 - 213.

Rier, S.T. and R.J. Stevenson. 2006. Response of periphytic algae to gradients in nitrogen and phosphorus in streamside mesocosms. *Hydrobiologia* 561:131-147.

Riskin, M.L., J.R. Deacon, M.L. Liebmand and K.W. Robinson. 2003. Nutrient and Chlorophyll Relationships in Selected Streams of the New England Coastal Basins in Massachusetts and New

Hampshire, June-September 2001. United States Geological Survey, National Water-Quality Assessment Program, Water-Resources Investigations Report 03-4191. Pembroke, NH.

Robertson, D.M., D.A. Saad, A.M. Wieben, U.S. Environmental Protection Agency Region V, U.S. Environmental Protection Agency Region VII, and U.S. Geological Survey. 2001. An Alternative Regionalization Scheme for Defining Nutrient Criteria for Rivers and Streams. U.S. Geological Survey Water-Resources Investigations Report 01-4073. Middleton, WI.

Rohm, C.M., J.M. Omernik, A.J. Woods and J.L. Stoddard. 2002. Regional characteristics of nutrient concentrations in streams and their application to nutrient criteria development. *Journal of the American Water Resources Association* 38:213-239.

Shock, C.C. and K. Pratt. 2003. Phosphorus Effects on Surface Water Quality and Phosphorus TMDL Development. Western Nutrient Management Conference 5:211-220. Salt Lake City, UT.

Smith, R.A., R.B. Alexander and G.E. Schwarz. 2003. Natural background concentrations of nutrients in streams and rivers of the coterminous United States. *Environmental Science and Technology* 37:3039-3047.

Snelder, T.H., B.J.F. Biggs and M.A. Weatherhead. 2004. Nutrient concentration criteria and characterization of patterns in trophic state for rivers in heterogeneous landscapes. *Journal of the American Water Resources Association* 40:1-13.

Sosiak, A. 2002. Long-term response of periphyton and macrophytes to reduced municipal nutrient loading to the bow river (Alberta, Canada). *Canadian Journal of Fisheries and Aquatic Sciences* 59:987-1001.

Stelzer, R.S. and G.A. Lamberti. 2001. Effects of N:P ratio and total nutrient concentration on stream periphyton community structure, biomass, and elemental composition. *Limnology and Oceanography* 46:356-367.

Stevenson, R.J., C.G. Peterson, D.B. Kirschtel, C.C. King and N.C. Tuchman. 1991. Density-Dependent growth, Ecological Strategies, and Effects of Nutrients and Shading on Benthic Diatom Succession in Streams. *Journal of Phycology* 27:59-69.

Suplee, M.W., A. Varghese and J. Cleland. 2007. Developing nutrient criteria for streams: an evaluation of the frequency distribution method. *Journal of the American Water Resources Association* 43:453-472.

Taylor, S.L., S.C. Roberts, C.J. Walsh and B.E. Hatt. 2004. Catchment urbanisation and increased benthic algal biomass in streams: linking mechanisms to management. *Freshwater Biology* 49:835-851.

Towns, D.R. 1981. Effects of artificial shading on periphyton and invertebrates in a New Zealand stream. *New Zealand Journal of Marine and Freshwater Research* 15:185-19.

University of Montana. 2006. Watershed Health Clinic, How the Public Views Nuisance Algae in Montana Streams.

USDA (United States Department of Agriculture). 1998. Stream Visual Assessment Protocol. National Water and Climate Center Technical Note 99-1. Washington, DC.

USEPA (United States Environmental Protection Agency). 1999. Protocol for Developing Nutrient TMDLs. EPA 841-B-99-007. Washington, DC.

USEPA (United States Environmental Protection Agency). 2000. Ambient Water Quality Criteria Recommendations, Information Supporting the Development of State and Tribal Nutrient Criteria, Rivers and Streams in Nutrient Ecoregion XI. EPA 822-B-00-020. Washington, DC.

USEPA (United States Environmental Protection Agency). 2000. Ambient Water Quality Criteria Recommendations, Information Supporting the Development of State and Tribal Nutrient Criteria, Rivers and Streams in Nutrient Ecoregion IX. EPA 822-B-00-019. Washington, DC.

USEPA (United States Environmental Protection Agency). 2007. Decision Rationale for the Withdrawal of the Nutrient TMDLs for the Skippack Creek Watershed, Montgomery County, Pennsylvania. United States Environmental Protection Agency Region III. Philadelphia, PA.

Van Niehwenhuyse, E.E. and J.R. Jones. 1996. Phosphorus – chlorophyll relationship in temperate streams and its variation with stream catchment area. *Canadian Journal of Fisheries and Aquatic Science* 53:99-105.

Welch, E.B., R.R. Horner and C.R. Patmont. 1989. Prediction of nuisance biomass: a management approach. *Water Research* 23:401-405.

Welch, E.B., J.M. Jacoby, R.R. Horner, and M.R. Seeley. 1988. Nuisance biomass levels of periphytic algae in streams. *Hydrobiologia* 157:161-168.