FINAL

Total Maximum Daily Loads of Biochemical Oxygen Demand (BOD) for Conococheague Creek

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Submitted to:

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List of Abbreviations

7Q10	7-day consecutive lowest flow expected to occur every 10 years, also known as the "design stream flow"
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
CWA	Clean Water Act
MDNR	Maryland Department of Natural Resources
DMR	Discharge Monitoring Report
EPA	Environmental Protection Agency
FA	Future Allocation
fps	feet per second
LA	Load Allocation for nonpoint sources
MDA	Maryland Department of Agriculture
MDE	Maryland Department of the Environment
MOS	Margin of Safety
NBOD	Nitrogenous BOD
NH_3- N	Total Ammonia as Nitrogen
NO_{23}- N	(Nitrate + Nitrite) as Nitrogen
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
ON- N	Organic Nitrogen as Nitrogen
OP- P	Organic Phosphorus as Phosphorus
PO_4- P	Orthophosphate or Inorganic Phosphorus as Phosphorus
PS	Point Source
TMDL	Total Maximum Daily Load
TKN	Total Kjeldahl Nitrogen (Combination of NH_3 and ON) as N
USGS	United States Geological Survey
WLA	Waste Load Allocation for point sources
WWTP	Wastewater Treatment Plant

PREFACE

Section 303(d) of the federal Clean Water Act directs States to identify and list waters, known as water quality limited segments (WQLS), in which currently required controls of specified substances are inadequate to achieve water quality standards. For each WQLS, the State is to establish a Total Maximum Daily Load (TMDL) of the specified substances that the water can receive without violating water quality standards.

Conococheague Creek was identified on the State's 1996 list of WQLS as a waterbody potentially impacted by nutrients (nitrogen and phosphorus) and suspended sediments. The Creek was listed for nutrients due to historically low levels of dissolved oxygen. Recent data does not show violations of the dissolved oxygen standard in the Maryland portion of Conococheague Creek, partially because the Conococheague Wastewater Treatment Plant (WWTP) has discharged effluent of better quality and lower flow than the maximum allowed under its NPDES permit. It is suspected, however, that violations of the dissolved oxygen standard could occur in the future, if Carbonaceous Biochemical Oxygen Demand (CBOD) and Nitrogenous Biochemical Oxygen Demand (NBOD) loadings are increased. This report documents the proposed establishment of a TMDL for the Maryland portion of Conococheague Creek to maintain dissolved oxygen at levels equal to or higher than the dissolved oxygen standard. A possible TMDL for suspended sediments will be addressed separately.

Once approved by the United States Environmental Protection Agency (EPA), the TMDL will be reflected in the State's Continuing Planning Process. In the future, the established TMDL will support regulatory and voluntary measures needed to protect water quality in Conococheague Creek.

EXECUTIVE SUMMARY

This document establishes a Total Maximum Daily Load (TMDL) that addresses pollutants affecting dissolved oxygen levels in Conococheague Creek. Conococheague Creek is a freshwater stream. It is a tributary of the Potomac River, and is part of the Upper Potomac River Tributary Strategy Basin. Dissolved oxygen levels in Conococheague Creek are affected primarily by CBOD and NBOD contributions from the nonpoint and point sources. The water quality goal of the TMDL is to establish allowable BOD inputs at levels that will ensure the maintenance of the dissolved oxygen standard.

This BOD TMDL was developed using a mathematical model for free flowing streams. As part of the TMDL process, load allocations were determined for distributing allowable loads between point and nonpoint sources.

The allocation of BOD for nonpoint source was based on the available water quality data. The point source load allocation was based on the current design flows and effluent limits for the Conococheague Wastewater Treatment Plant (WWTP), the Broadfording Brethern Church WWTP and Resh Road Sanitary Landfill. The Conococheague WWTP contributes significant amounts of BOD loads while the other two facilities contribute only small amounts (less than one-half percent) the of BOD loads. The TMDL for BOD was established using 7Q10 low-flow conditions for the period of May through October. As both the CBOD and NBOD can affect the dissolved oxygen levels in the Creek, the NBOD loading was also incorporated to establish the TMDL for BOD.

The overall BOD TMDL for Conococheague Creek is 56,520 lbs/month. The BOD load of 26,884 lbs/month in background flow at the Maryland (MD)/Pennsylvania (PA) boundary line represent the total BOD contribution from Pennsylvania. This includes 21,492 lbs/month for combined wasteload and load allocation, (2) 4,029 lbs/month for future allocation (3) and 1,363 lbs/month as margin of safety (MOS) (3). The remaining BOD load of 29,636 lbs/month represents BOD contributions from Maryland that include 20,586 lbs/month for point sources waste load allocation (1), 3,142 lbs/month for nonpoint sources load allocation (2), 2,515 lbs/month for future allocation (3) and 3,393 lbs/month as MOS (3).

Two factors provide assurance that this TMDL will be implemented. First, National Pollutant Discharge Elimination System (NPDES) permits will be written to be consistent with the load allocations in the TMDL. Second, Maryland has adopted a watershed cycling strategy, which will ensure that future water quality monitoring and evaluations are routinely conducted.

(1) TKN limit of 17 mg/l monthly average and dissolved oxygen limit of 5.0 mg/l minimum are included for Conococheague WWTP to establish BOD waste load allocations for point sources.

(2) Instream TKN concentration of 0.91 mg/l and dissolved oxygen of 7.0 mg/l are included for background and tributary flows to establish BOD load allocations for nonpoint sources.

(3) Additional TKN concentrations of 4.0 mg/l for point sources and 0.23 mg/l for nonpoint sources are incorporated for future allocations and margin of safety.

1.0 INTRODUCTION

The Clean Water Act Section 303(d)(1)(C) and federal regulation 40CFR§130.7(c)(1) direct each State to develop Total Maximum Daily Loads (TMDLs) for all impaired waters on the Section 303(d) list. States must consider seasonal variations and must include a margin of safety (MOS) to account for uncertainty in the monitoring and modeling processes. A TMDL reflects the total pollutant loading of the impairing substance a waterbody can receive and still meet water quality standards.

TMDLs are established to achieve and maintain water quality standards. A water quality standard is the combination of a designated use for a particular body of water and the water quality criteria designed to protect that use. Designated uses include activities such as swimming, drinking water supply, and shellfish propagation and harvest. Water quality criteria consist of narrative statements and numeric values designated to protect the designated uses. Criteria may differ among waters with different designated uses.

The Maryland portion of Conococheague Creek was identified on the State's 1996 303(d) submitted to EPA by the Maryland Department of the Environment**.** It was listed as being potentially impacted by nutrients (nitrogen and phosphorus) and suspended sediments. The recent water quality data shows that the chlorophyll-a levels are not high enough to warrant nutrient control. Although the recent data does not show the stream being impaired by low dissolved oxygen, it is suspected that violations of the dissolved oxygen standard could occur with the future increase in BOD and TKN loadings. Conococheague Creek is designated as Use IV-P water according to the Code of Maryland Regulations (COMAR) 26.08.02. The dissolved oxygen standard for this use of water is 5.0 mg/l minimum at any time. This document demonstrates that the BOD loading in conjunction with TKN primarily affects the dissolved oxygen, and describes the development of a TMDL for BOD in Conococheague Creek.

2.0 DESCRIPTION OF THE WATERSHED

Conococheague Creek, a tributary of the Potomac River, is a free flowing stream that originates in Pennsylvania and empties into the Potomac River in Maryland. It is approximately 80 miles in length with 58 miles in Pennsylvania and 22 miles in Maryland. The watershed of Conococheague Creek has an area of approximately 566 sq. miles out of which only 65 sq. miles (12% of the area) are in Maryland. Refer to Figure 1 for Conococheague Creek watershed. The land use/land cover data for each watershed in Maryland and Pennsylvania is abstracted from the Maryland Office of Planning and EPA Land-use Database, 1994. The watershed's predominant land use is agricultural (344 sq. miles or 60%), forest cover (191 sq. miles or 34%) and urban (30 sq. miles or 5%). The agricultural land use in Maryland is approximately 43 sq. miles and in Pennsylvania approximately 301 sq. miles. Refer to Figure 2 for land uses in Conococheague Creek watershed, and to Figure 3 for land uses in the Maryland watershed. The forest cover in Maryland is approximately 11 sq. miles and in Pennsylvania approximately 180 sq. miles. The urban area in Maryland is approximately 10 sq. miles and in Pennsylvania approximately 20 sq. miles. Land uses are summarized in Table 1.

In Maryland, Conococheague Creek has a moderate streambed slope with estimated average stream velocities ranging from 0.56 to 0.76 fps during low-flow conditions. The watershed soils are typically classified as rocky consisting of carbonate and silliciclastic. The streambeds are generally rocky.

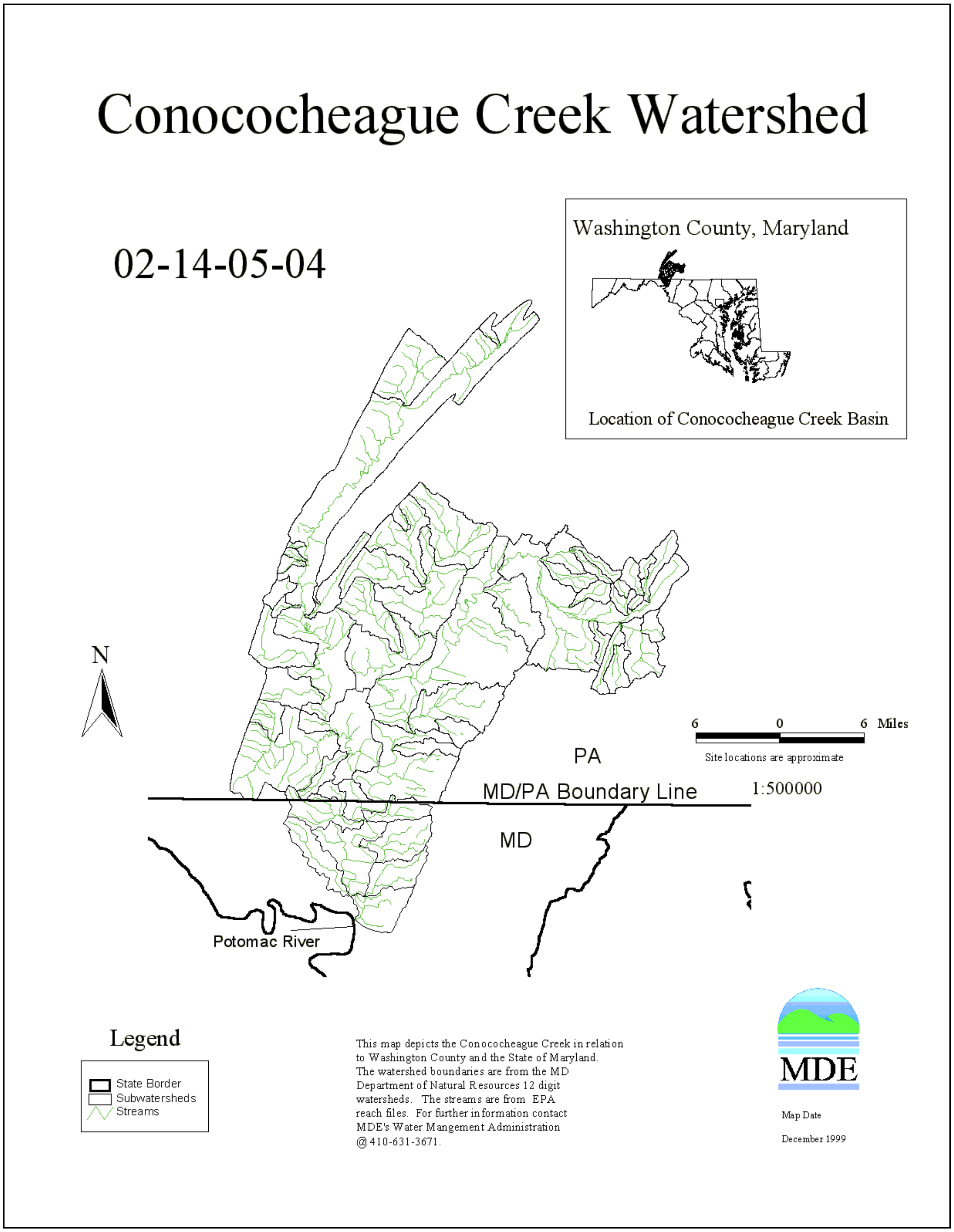

Figure 1: Watershed for Conococheague Creek

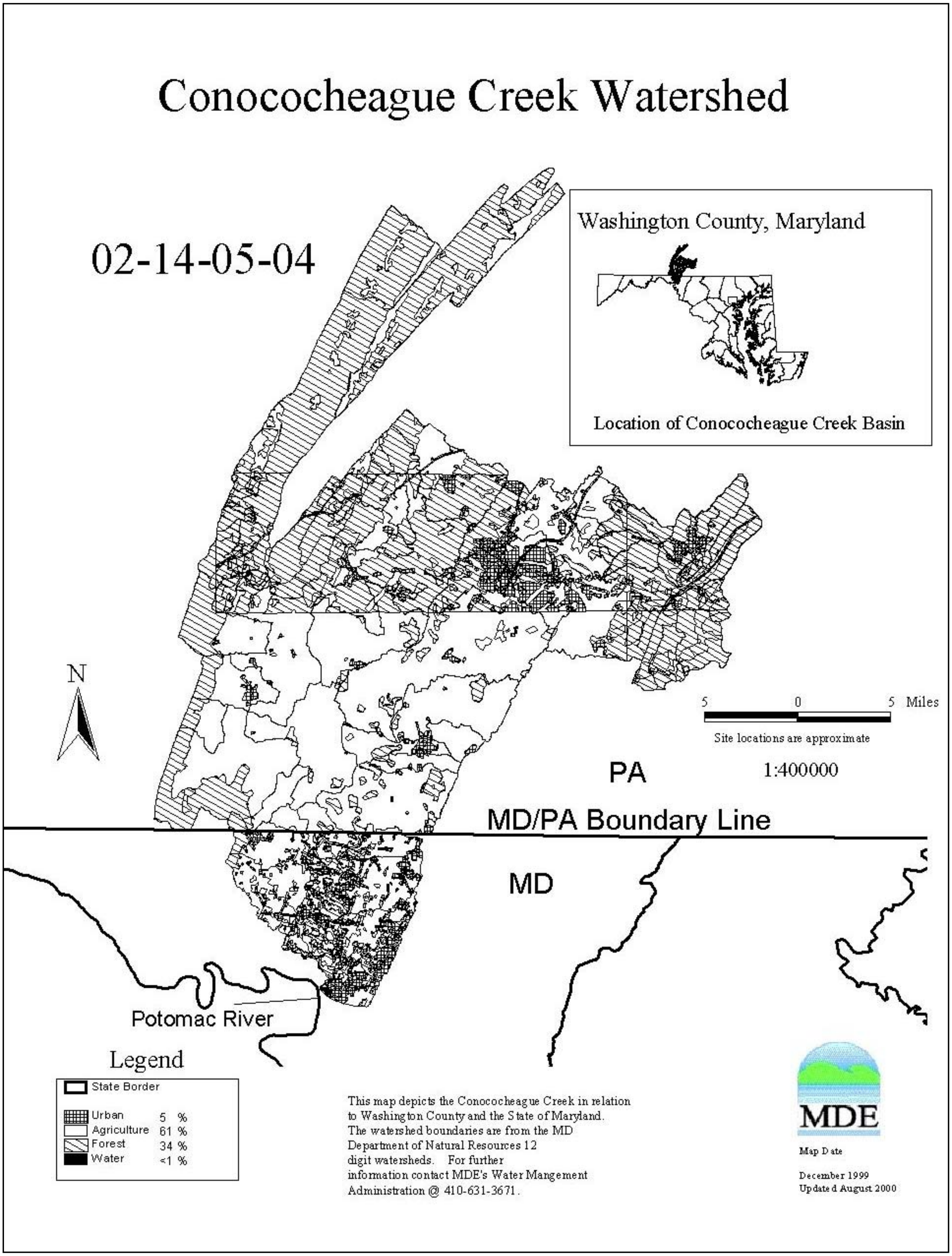

Figure 2: Land Use in Conococheague Creek Watershed

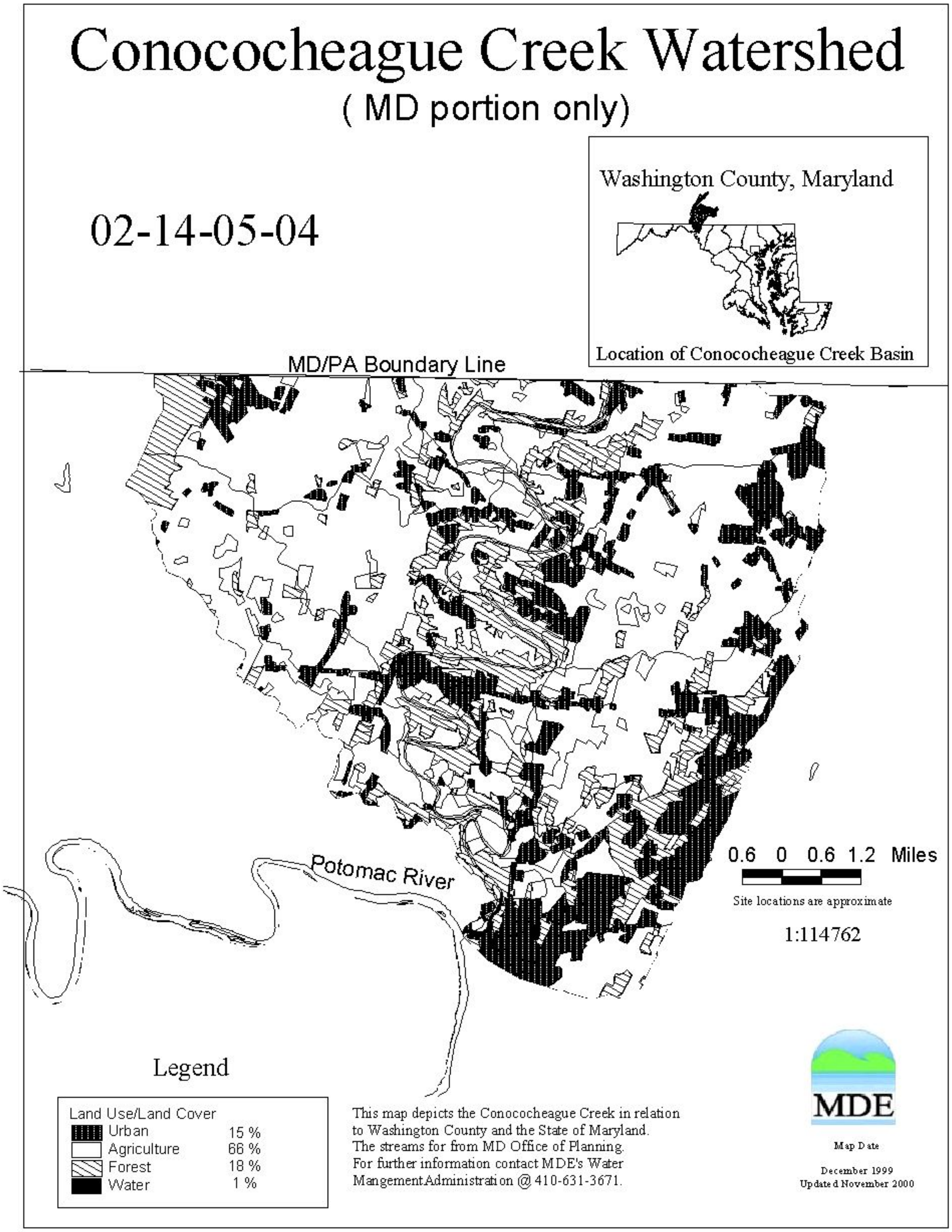

Figure 3: Land Uses in Maryland Portion of Conococheague Creek Watershed

Table 1: Predominant Land-Uses in Conococheague Creek Watershed

Land-Use		Drainage Area, Hectares			Drainage Area, Square Miles		
Category	Sub-Category	Maryland	Pennsylvania	Total	Maryland	Pennsylvania	Total
Agriculture	Farming	9,894	76,110	86,004	38.2	293.9	332.1
	Pasture	1,313	1,822	3,135	5.1	7.0	12.1
Agriculture	**(Total)**	**11,207**	**77,931**	**89,139**	**43.3**	**300.9**	**344.2**
Forest	With Trees	2,421	46,571	48,993	9.3	179.8	189.1
	Brush	533	0	533	2.0	0	2.0
Forest	**(Total)**	**2,954**	**46,571**	**49,526**	**11.3**	**179.8**	**191.1**
Urban	Residential	1,849	4,297	6,145	7.1	16.6	23.7
	Commercial	647	523	1,170	2.5	2.0	4.5
	Industrial	108	386	494	0.5	1.5	2
	Open Land	4	0	4	0	0	0
Urban	**(Total)**	**2,608**	**5,205**	**7,813**	**10.1**	**20.1**	**30.2**
Miscellaneous	Waterways	19	0	19	0.1	0.0	0.1
	Wetland	102	0	102	0.4	0.0	0.4
Water/wetland	**(Total)**	**121**	**0**	**121**	**0.5**	**0.0**	**0.5**
Drainage Area	**(Total)**	**16,890**	**129,708**	**146,598**	**65.2**	**500.8**	**566**

Source: "Maryland Office of Planning and EPA Land-use Database, 1994 "

3.0 WATER QUALITY

Conococheague Creek was listed as being impaired by nutrients and suspended sediments on the 1996 303(d) list, which was submitted to the EPA by MDE. No recent water quality (WQ) data for instream BOD has been collected for Conococheague Creek, and hence, historical data for BOD collected at WQ stations (CON0051, CON0005 and CON0001) is considered for this TMDL. The water quality data for other parameters collected during May' 1994 to October' 1998 at two WQ stations (CON0180 and CON0005), are incorporated to access the water quality of Conococheague Creek. Refer to Figure 4 and Table 2 for the WQ stations' locations. The WQ data summary can be seen in the Appendix A. Based on the WQ data, graphs are plotted to show the minimum yearly or yearly average instream values of the constituents collected at WQ stations CON0005 and CON0180. Refer to Figures 5 to 14 for these graphs.

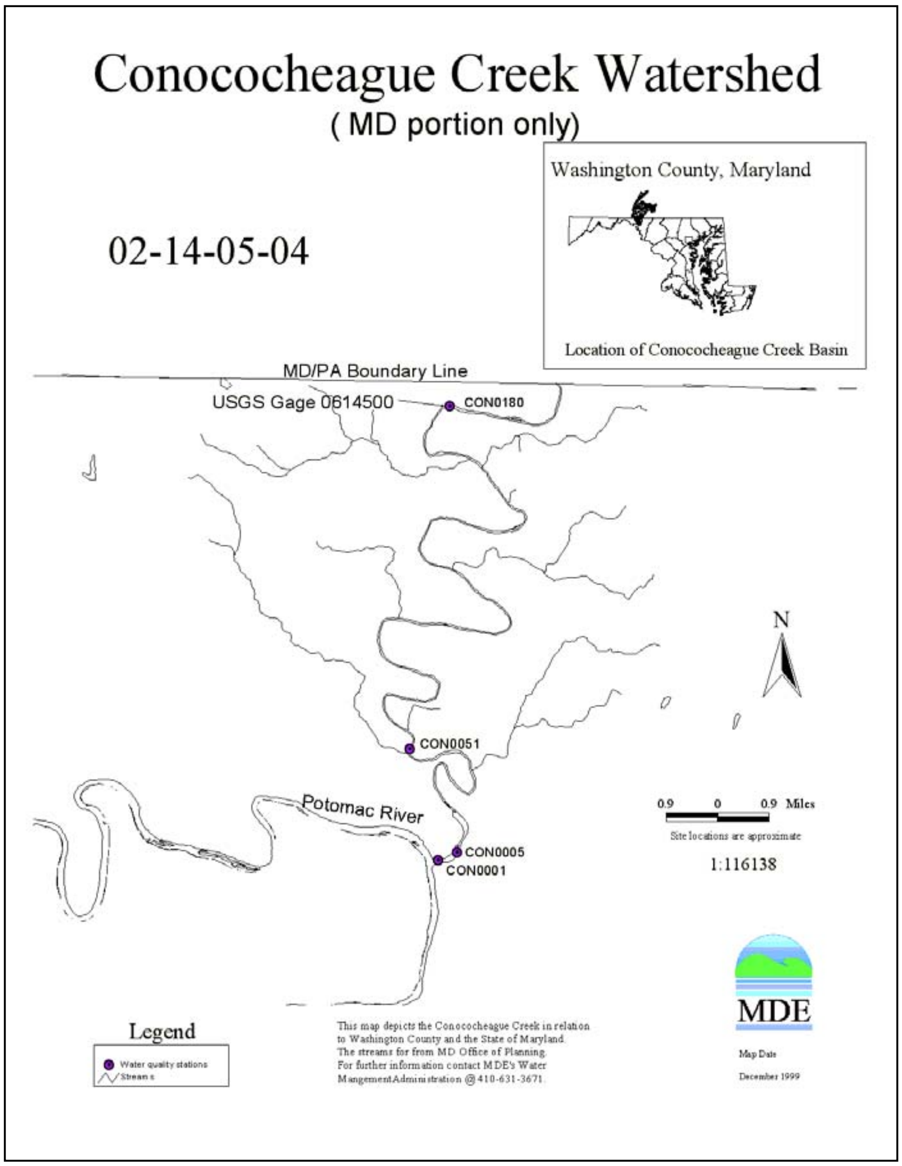

Figure 4: Water Quality Stations Location

Table 2: Location of Water Quality Stations

Water Quality Station	Distance from Confluence with the Potomac River,	Distance from MD/PA Boundary line, miles
CON0001	0.1	21.3
CON0005	0.5	20.9
CON0051	5.1	16.3
CON0180	18.9	2.5

Graphical Presentation of Water Data Collected During May'1994 to October'1998:

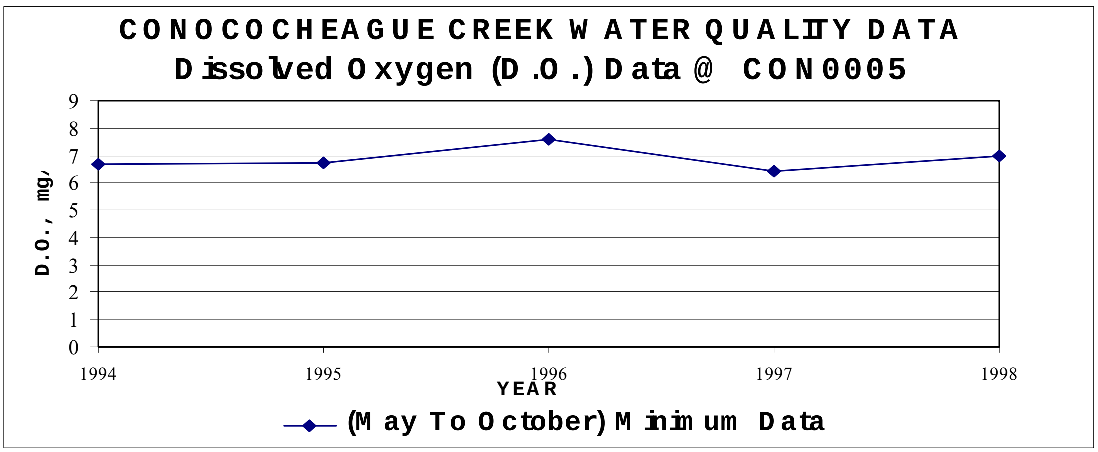

Figure 5: Graphical Presentation of the Water Quality Data

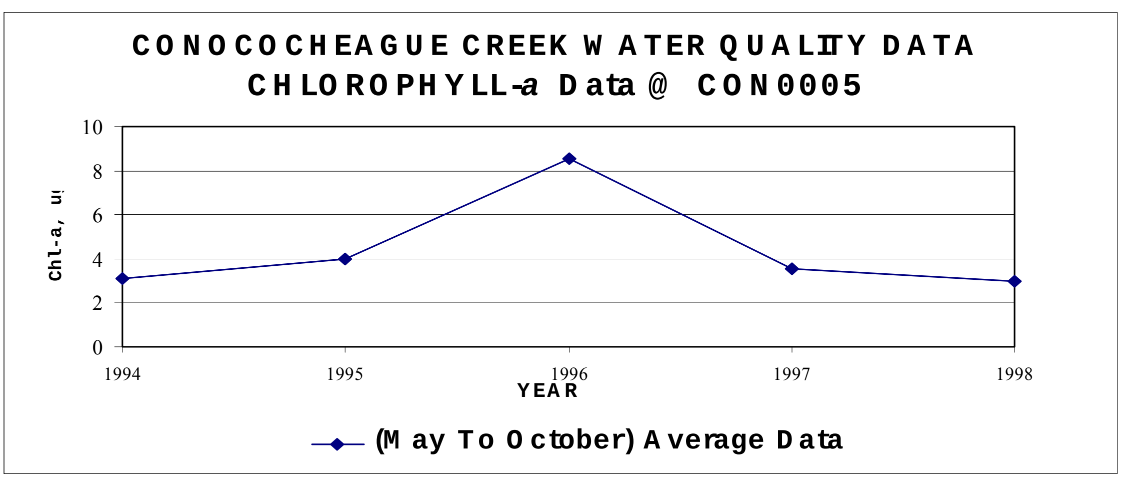

Figure 6: Graphical Presentation of the Water Quality Data

Graphical Presentation of the Water Quality Data, Continued

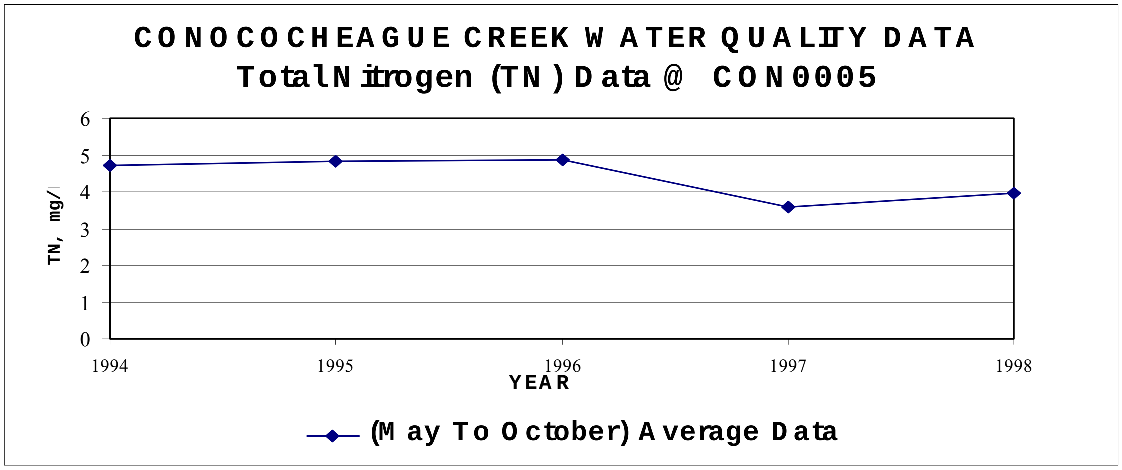

Figure 7: Graphical Presentation of the Water Quality Data

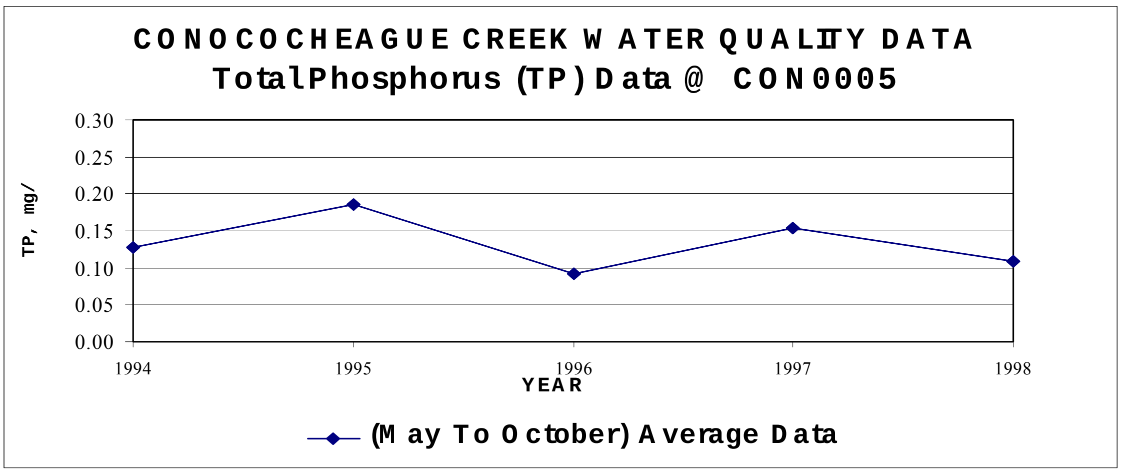

Figure 8: Graphical Presentation of the Water Quality Data

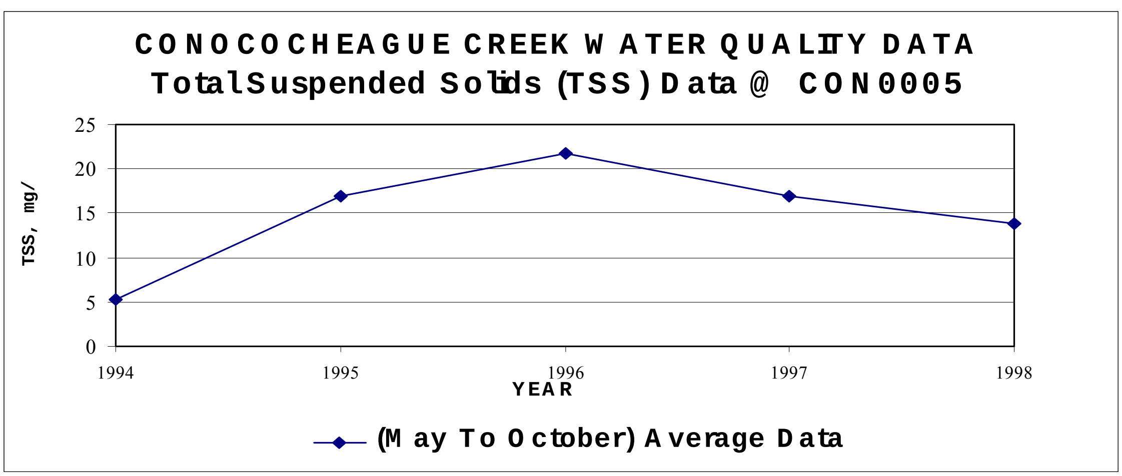

Figure 9: Graphical Presentation of the Water Quality Data

Graphical Presentation of the Water Quality Data, Continued

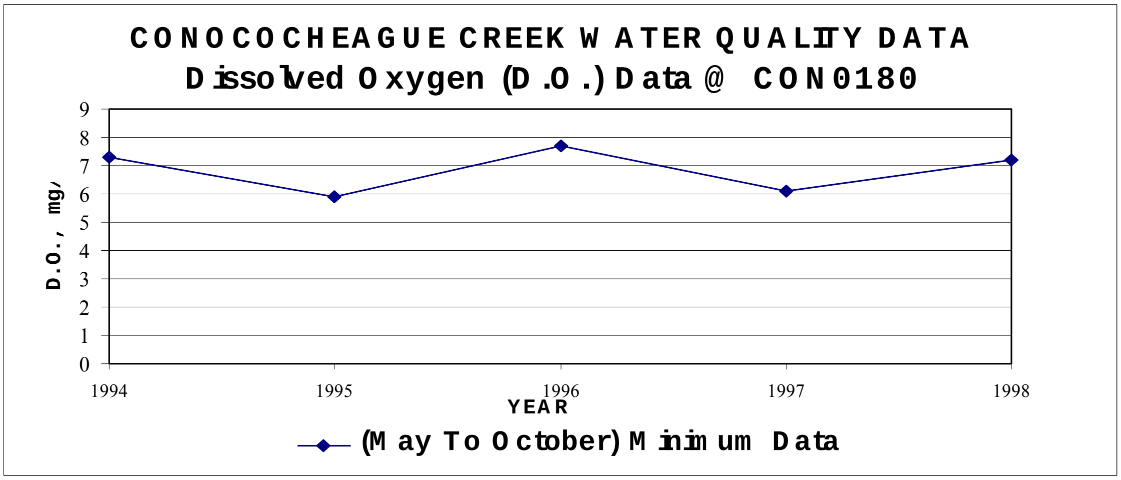

Figure 10: Graphical Presentation of the Water Quality Data

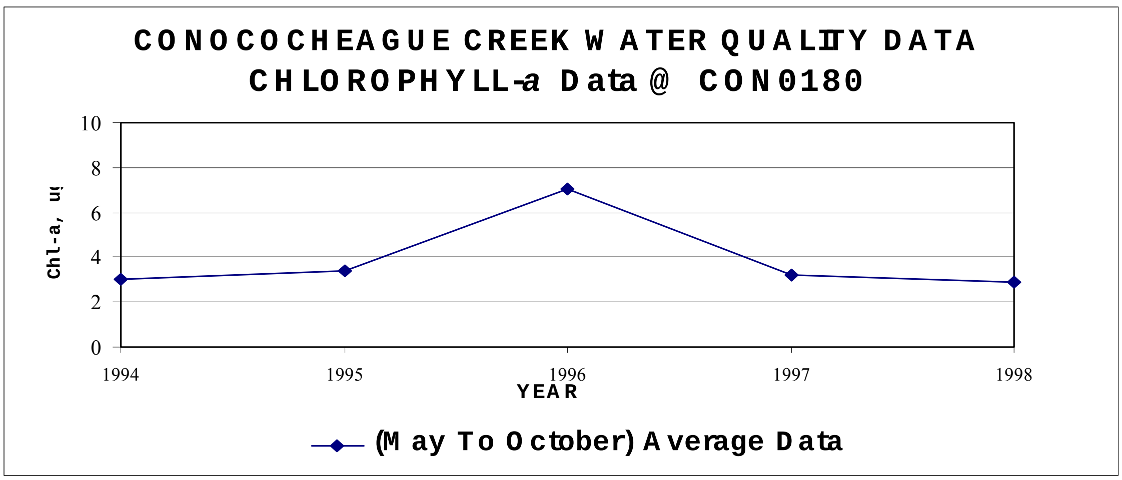

Figure 11: Graphical Presentation of the Water Quality Data

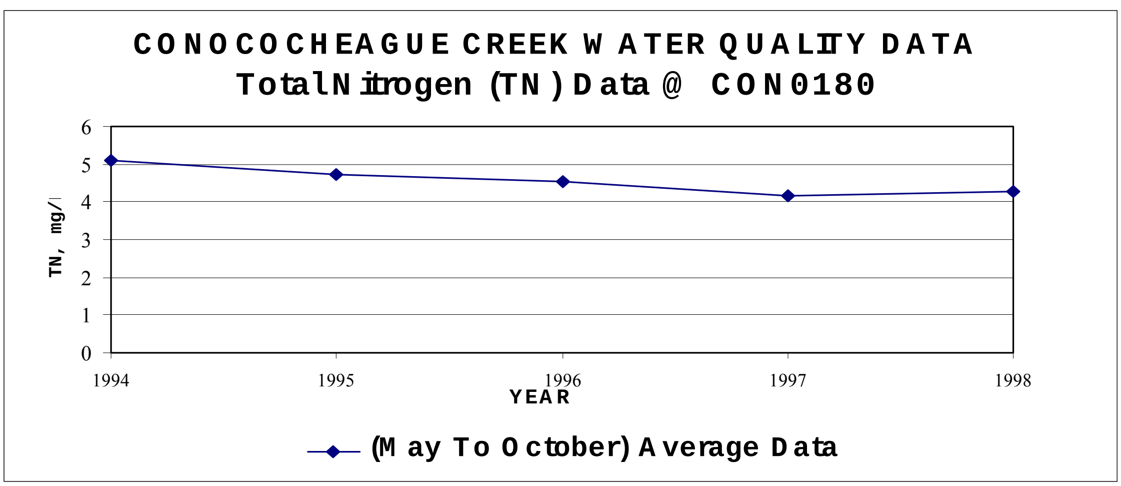

Figure 12: Graphical Presentation of the Water Quality Data

Graphical Presentation of the Water Quality Data, Continued

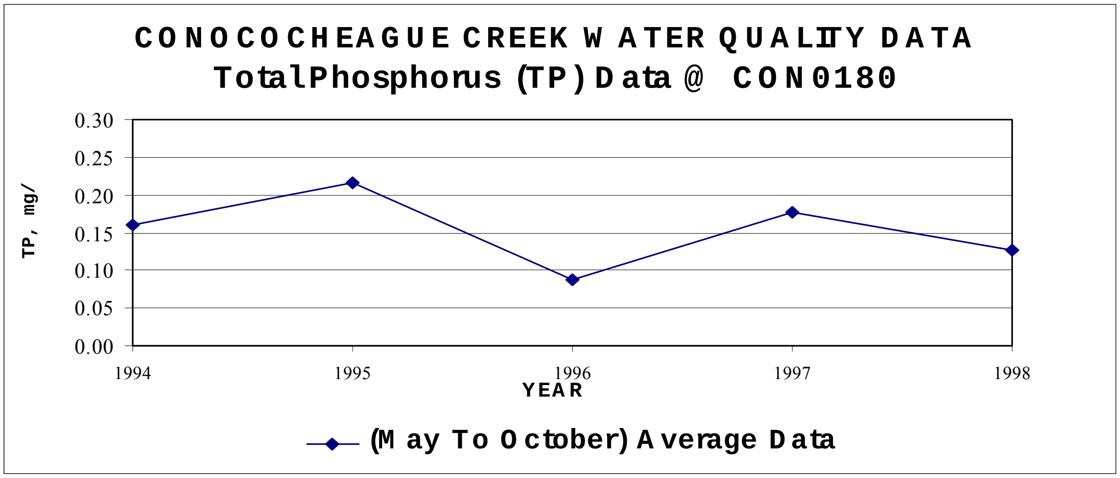

Figure 13: Graphical Presentation of the Water Quality Data

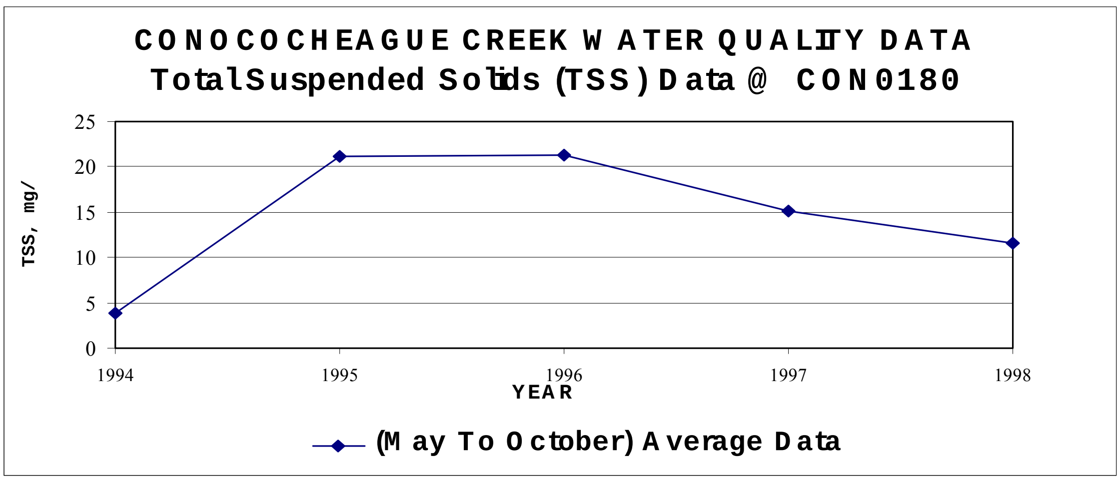

Figure 14: Graphical Presentation of the Water Quality Data

4.0 SOURCES OF THE IMPAIRING SUBSTANCE

The primary substance of concern in this watershed is BOD, which is a composite term that describes consumption of dissolved oxygen through oxidation of carbonaceous and nitrogenous matters by bacteria in the water column. Sources of BOD contribution include total (combined point and nonpoint source) loads from Pennsylvania, and point and nonpoint source loads from Maryland.

4.1 Combined Sources from Pennsylvania:

The background flow concentrations at model point 1 (Maryland/Pennsylvania boundary line) represent combined (nonpoint and point sources) load contributions from Pennsylvania to Conococheague Creek. At present, the majority of BOD (84% of total loads) loads enter the system as background flows at Maryland/Pennsylvania boundary line.

4.2 Nonpoint Sources in Maryland:

The nonpoint source values used in this document come from recent as well as historical water quality data collected for Conococheague Creek at several stations. Tributary flows are incorporated as the nonpoint source contributions to Conococheague Creek in Maryland. The nonpoint source contributions from the background flow at station 1 and tributaries at stations 2 through 20 (except for wastewater discharges) are estimated using the 90th percentile values for BOD and TKN, and 10th percentile value of the dissolved oxygen. Refer Appendix-A for the water quality data summary.

4.3 Point Sources in Maryland:

The wastewater treatment plant discharges represent the point source contribution. There are five facilities discharging to Conococheague Creek. Refer to Figure 15 for facilities locations. Only three facilities, two municipal (Conococheague WWTP & Broadfording Brethern Church WWTP) and one industrial (Resh Road Sanitary Landfill), contribute BOD loads to Conococheague Creek. The Conococheague WWTP discharges a significant quantity of the treated wastewater to Conococheague Creek, while other two facilities discharges less than one percent of the wastewater. The point source values used in this document come from the Discharge Monitoring Reports and discharge permits for these facilities. Refer to Appendix-A for details.

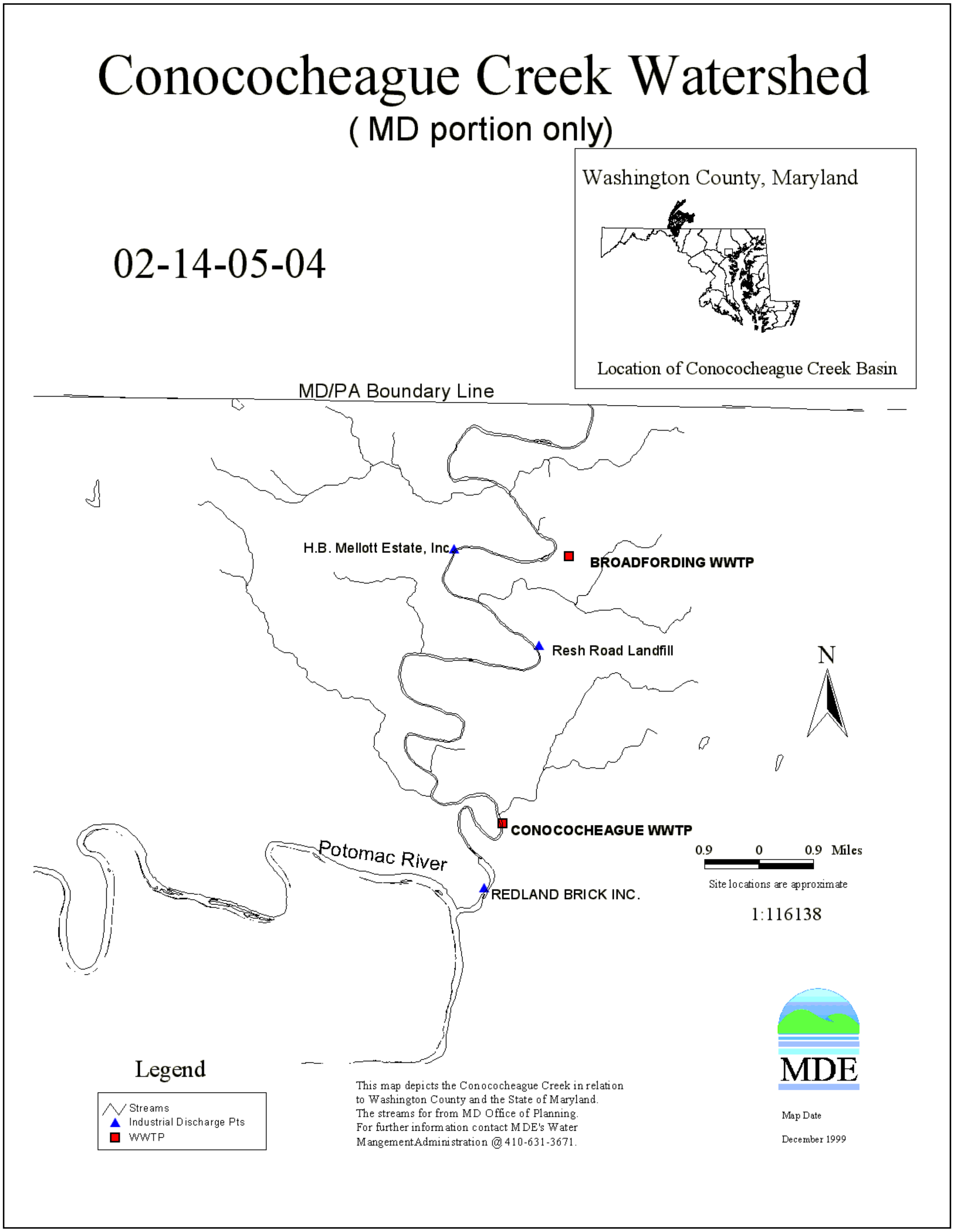

Figure 15: WWTPs Discharging in to Conococheague Creek in Maryland

4.4 Other Factors Affecting Stream Dissolved Oxygen:

In addition to accounting for the sources of the substances of concern, the processes that deplete dissolved oxygen should also be considered. These processes include those that consume oxygen (sinks) as well as those that generate oxygen (sources). These processes and some additional factors are presented in Figure 16. As mentioned before, BOD reflects the amount of oxygen consumed through two processes: carbonaceous biochemical oxygen demand (CBOD) and nitrogenous biochemical oxygen demand (NBOD). CBOD is the reduction of organic carbon material to its lowest energy state, CO_2, through the metabolic action of microorganisms (principally bacteria). NBOD is the term for the oxygen required for nitrification, which is the biological oxidation of ammonia to nitrate. The BOD values seen throughout this document represent the amount of oxygen consumed by the oxidation of carbonaceous and nitrogenous waste materials over a 5-day period, at 20° C. This is referred to as a 5-day, 20° C BOD and is the standard reference value utilized internationally by both design engineers and regulatory agencies. The 5-day BOD represents primarily consumption of carbonaceous material and minimal nitrogenous material. The ultimate BOD represents the total oxygen consumed by carbonaceous and nitrogenous material, over an unlimited length of time.

Another factor influencing dissolved oxygen concentrations is the sediment oxygen demand (SOD). As with BOD, SOD is a combination of several processes. Primarily it is the aerobic decay of organic materials that settle to the bottom of the stream. The organic materials are from several sources. One, as mentioned in reference to nutrients, is decaying algae. Another is dead leaves and other organic debris, which is swept into the system from the land surfaces and upper portions of the watershed during rain events. Because SOD captures the effects of decaying organic material deposited during storm events, it can also indirectly account for the effects of high stream flow events. Conococheague Creek has the characteristics of a fast free flowing stream that should minimize deposition of decaying organic to the streambed, and therefore, SOD should be negligible. Algae also affect instream dissolved oxygen through photosynthesis and respiration. The water quality data for Conococheague Creek show that chlorophyll-*a* concentrations are very low: the fact that the diurnal dissolved oxygen is not taken into account will not affect the final results.

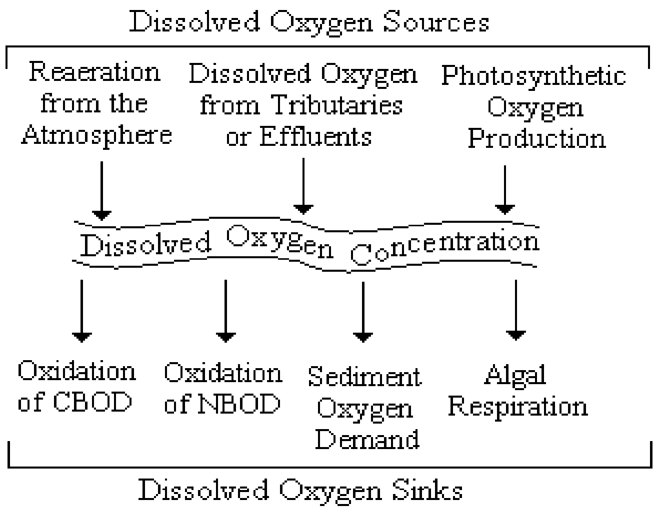

Figure 16: Sources and Sinks for Dissolved Oxygen in Conococheague Creek

5.0 TARGETED WATER QUALITY GOAL

The water quality data does not show violations of the dissolved oxygen standard at the present time. The overall objective of the development of the TMDL in the Maryland portion of Conococheague Creek is to determine the maximum allowable BOD inputs from point and nonpoint sources that will allow for the maintenance of dissolved oxygen standards. BOD loads in the basin are expected to increase in the future. Thus the development of the TMDL is intended to assure that dissolved oxygen concentrations remain above a minimum of 5 mg/l in the Maryland portion of Conococheague Creek. This dissolved oxygen goal is based on specific numeric criteria for Use IV-P waters in the Code of Maryland Regulations 26.08.02.

6.0 TOTAL MAXIMUM DAILY LOADS AND ALLOCATION

6.1 Overview

This section describes how the TMDL and load allocations for point and nonpoint sources were developed for the Maryland portion of Conococheague Creek. The first section describes the modeling framework, and simulation of the water quality constituents and hydrology. The second section summarizes the scenarios that were explored using the model. The third section presents modeling results in terms of TMDLs, and a summary of the TMDL allocations between point sources and nonpoint sources. The fourth section explains the rationale for the MOS and remaining future allocation. Finally, the pieces of the equation are combined in a summary accounting of the TMDL.

6.2 Description of Modeling Framework:

Conococheague Creek is a relatively fast flowing freshwater stream with characteristics of one-dimensional downstream load transport. The computational framework or model chosen for determining the TMDL for the Maryland portion of Conococheague Creek is an in-house model developed for free-flowing streams called INPRG. It is capable of simulating steady state conditions, one-dimensional system and linear kinetic water quality problems related to BOD and dissolved oxygen. The Streeter-Phelps equation and other equations, as listed in Appendix- A, for dissolved oxygen sag projections in the stream are incorporated in this model. The model can project net CBOD, NBOD and dissolved oxygen values at each modeling point.

The spatial modeling domain represents a segment of Conococheague Creek that was included in the model. It is approximately 21½ miles long and extends from MD/PA boundary line to the confluence with the Potomac River. A total of 20 modeling points are selected on this segment. Refer to Figure 17 for locations of the modeling points.

Other Input Data Information

The model requires input of background flow and/or tributary flow at modeling points. The summer low flow condition, which represents seven consecutive day lowest average flow expected to occur once every 10 years (7Q10), is incorporated in all model runs. The stream flow data collected at USGS Gaging Station 01614500 is used to estimate the 7Q10 low flow runoff rate of 0.1128 cfs/sq. mile for May to October period. See Appendix A for 7Q10-flow estimation. Refer to Figure 17 for the gaging station's location. This runoff rate is applied to compute background and/or tributary flows for all model runs.

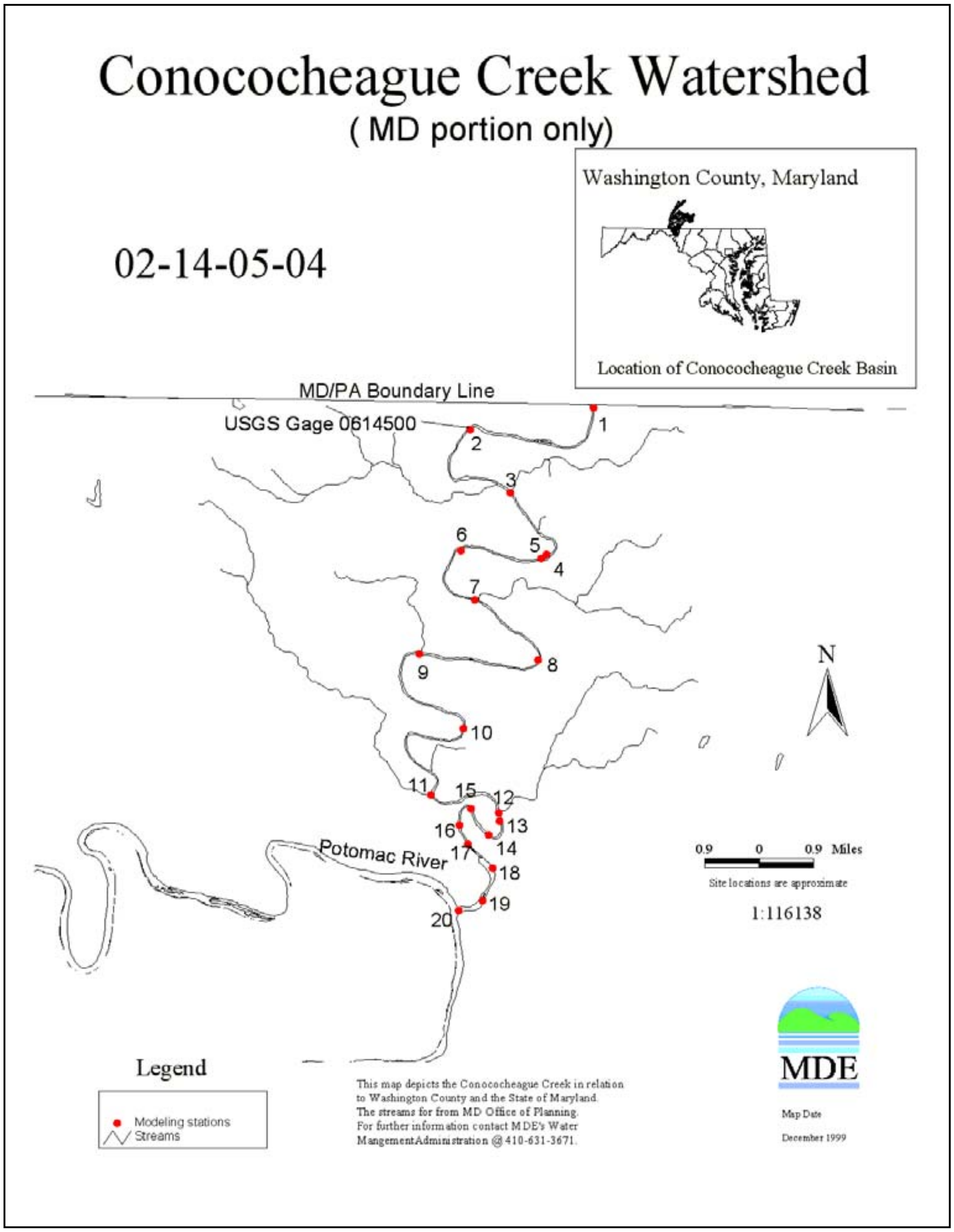

Figure 17: Location of Modeling Station Points

The 90th percentile water temperature was calculated from the water quality data for summer period. It was incorporated to compute temperature dependent parameters: CBOD reaction rates (k_c), NBOD reaction rates (k_n), and - reaeration rates (k_a). The stream segment velocities were estimated using the low flow-velocity relationship, which was developed using the available data at USGS gaging station 0614500. See Appendix-A. Reaeration rates were calculated using Tsivoglou's formula (Appendix-A).

The model runs required an input of CBOD and NBOD to incorporate the total BOD (biochemical oxygen demand) loads. The CBOD and NBOD values were calculated by multiplying BOD by 1.5 and TKN by 4.6, respectively. The 90th percentile values for BOD and TKN and 10th percentile value of dissolved were used for the background flow at modeling point 1 and for tributary flows at subsequent modeling points. These values were estimated from the available water quality data for June through October.

The background and tributary flow values used in the model were estimated from the flow data available for the USGS gaging station (01614500) which is located on Conococheague Creek approximately 2½ miles downstream of the MD/PA boundary line at Fairview, Maryland.

6.3 Preliminary Model Run for Simulation of Water Quality Constituents and Hydrology:

The main idea of the preliminary model run is to predict the BOD, TKN and dissolved oxygen of Conococheague Creek that can best describe the existing water quality of the stream during low flow period. For freshwater streams, as the summer months are critical when the stream flows are expected low and water temperatures are expected high, the existing water quality of the stream for May to October was incorporated to make the preliminary model run. The summer low flow 7Q10 condition was also incorporated in this run. Input data for CBOD, NBOD and dissolved oxygen was prepared using the available water quality data and facilities performance records. The water quality data for the period of May to October was used to estimate CBOD, NBOD, and dissolved oxygen for background/tributary flows. Refer to Appendix-A for a summary of the water quality data. The recent plant performance data for Conococheague WWTP and Broadfording Brethern Church WWTP was used as point sources loads at station points 5 and 13 for this model run. As no data is available for Resh Road Sanitary Landfill discharge, the permit limits are used. Refer to Appendix-A for summary of the plant performance data. Detailed analysis and results for the Preliminary Run can be seen in Appendix-A.

6.4 TMDL Modeling Scenario Descriptions:

To project the water quality response of the system, the estimated values of rate coefficients (k_c, k_n and k_a) based on the preliminary model run, were applied to different model runs using various CBOD and NBOD loading conditions. The summer period 7Q10 low-flow conditions are conservative for the BOD TMDL analysis, and are applied to all model runs.

Model Run 1 (for Permitted Flows and Effluent Limits to WWTPs):

For this model run, only the point source loading rates are changed to reflect the permitted monthly average effluent limitations and design flows for Conococheague WWTP, Broadfording Brethern Church WWTP and Resh Road Sanitary Landfill. The design flows for these WWTPs are included in the current Washington County Water and Sewer Plan. The CBOD, NBOD, dissolved oxygen and discharge flow values are taken from the NPDES permits for each of the facilities. Refer to Appendix-A for permit effluent limitations' requirements. The Conococheague WWTP will be upgraded to increase the design flow from 2.5 mgd to 4.1 mgd flow. Upon completion of this upgrade, the Al Nicodemus WWTP will be abandoned and the wastewater will be diverted to the Conococheague WWTP. The Washington County Water and Sewer Department has already asked MDE to renew Conococheague WWTP discharge permit using discharge flow rate of 4.1 mgd which is a combined wastewater flow allocations of 2.5 mgd for the Conococheague WWTP and 1.6 mgd for the Al Nicodemus WWTP.

Other conditions including nonpoint source CBOD, NBOD and dissolved oxygen values are kept the same as preliminary model run. This model run 1 provides projections of BOD and dissolved oxygen concentrations in Conococheague Creek, if future BOD loadings do not change from the current waste load allocations.

Model Run 2 for Allowable BOD TMDL Allocations:

Model Run 2 estimates total allowable BOD loads such that the dissolved oxygen concentrations in Conococheague Creek does not fall below the standard of 5.0 mg/l. It predicts the daily average dissolved oxygen concentrations in the stream, which should be higher than the daily minimum dissolved oxygen concentrations that occur during a 24-hour period. The prime reason for the diurnal dissolved oxygen variations is photosynthesis and algal respiration of algae. As Conococheague Creek is fast flowing stream and has low concentrations of chlorophyll-a, the diurnal dissolved oxygen variations due to algal photosynthesis and respiration are too small to affect the stream dissolved oxygen results. Also, the sediment oxygen demand is not accounted for the in dissolved oxygen calculation because of the fast-moving and rocky streambed characteristics of Conococheague Creek.

To compensate for the instream dissolved oxygen variations/depletion and to provide a margin of safety, target dissolved oxygen of 5.5 mg/l minimum is considered in the model instead of the dissolved oxygen standard of 5.0 mg/l. The model calculates dissolved oxygen by including oxidation of CBOD and NBOD matters, and reaeration process only. This model run is intended to determine the proposed TMDL, including MOS and future allocations. The CBOD and NBOD loads were increased in proportion for the point and nonpoint sources that also include future allocations as well as the MOS to offset errors in modeling prediction and seasonal variations. The effluent/water quality parameters' quantities or concentrations considered in all model runs are summarized below in Table 3 for point sources, and in Table 4 for nonpoint sources.

Table 3: Discharge flows and Effluent Concentrations Used in Model Runs

Model Run	Effluent Parameter Quantity or Concentration											
	For Broadfording Brethern Church WWTP				For Resh Road Sanitary Landfill				For Conococheague WWTP			
	Plant Flow, mgd	BOD_5 mg/l	TKN Mg/l	D.O. mg/l	Plant Flow [(1)], mgd	BOD_5 mg/l	TKN mg/l	D.O. mg/l	Plant Flow , mgd	BOD_5 mg/l	TKN mg/l	D.O. Mg/l
Preliminary	0.0018	1.7	1.3	6.8	0.0059	2.4	0.91	7.0	0.989	3.3	2.39	6.9
1	0.003[(1)]	18[(1)]	7[(1)]	5.0	0.0059[(1)]	30[(1)]	25[(1)]	5.0	4.1[(1)]	20[(1)]	17[(1)]	5.0
2	0.003[(1)]	30[(1)]	25[(1)]	5.0	0.0059[(1)]	30[(1)]	25[(1)]	5.0	4.1[(1)]	25[(1)]	21[(1)]	5.0

[(1)] The plant flows from WWTPs are not a limitation. They are considered in conjunction with the parameters' concentrations for wasteload allocation calculation only.

Table 4: Background/tributary Flows and Concentrations Used in Model Runs

Model Run	Water Quality Parameter Quantity or Concentration							
	For Background Flow from PA at Modeling Point 1				For MD Tributaries Flows at Modeling Points: 2 to 4, 6 to 7, 9 to 12, and 14 to 20			
	Stream Flow Cfs	BOD_5 mg/l	TKN mg/l	D.O. mg/l	Stream Flow Cfs	BOD_5 mg/l	TKN mg/l	D.O. mg/l
Preliminary	55.351	2.4	0.91	7.0	8.089	2.4	0.9	7.0
1	55.351(1)	2.4(1)	0.91(1)	7.0	8.089(1)	2.4(1)	0.9(1)	7.0
2	55.351(1)	3.7(1)	1.4(1)	7.0	8.089(1)	3.7(1)	1.4(1)	7.0

(1) The stream flows are considered in conjunction with the parameters' concentrations for load allocation calculations only.

6.5 Modeling Runs Results

In the absence of intensive water quality surveys for Conococheague Creek, these assumptions provide conservative results for Conococheague Creek's BOD TMDL:

- Estimated 7Q10 low flow for a period May to October.
- Estimated 90th percentile water temperature during June through October to calculate reaeration rates, and CBOD and NBOD reaction rates.
- Estimated 90th percentile instream BOD and TKN values during June through October for the background flow and tributary flows for Preliminary Run and Model Run 1.
- Estimated 90th percentile BOD_5 and TKN values from facilities performance records of June through October for point source contributions for Preliminary Run.
- As per the Surface Discharge Permits Division's guidelines, BOD values were multiplied by a factor 1.5 to calculate CBOD values. TKN values were multiplied by a factor of 4.6 to calculate NBOD values.
- Estimated 10th percentile instream dissolved oxygen values during June through October for background flow and tributary flows.
- Estimated 10th percentile wastewater dissolved oxygen values during June through October using facilities performance records for point source contributions for Preliminary Run.

Preliminary Model Run:

The Preliminary Model Run results do not predict any water quality problems related to dissolved oxygen and BOD. Refer to Appendix-A for the output results. Also, refer to Figure 18 for graphs plotted to show the parameter's concentration (at WQ Stations) calculated from the WQ data and the parameter's profile based on the Preliminary Model Run results.

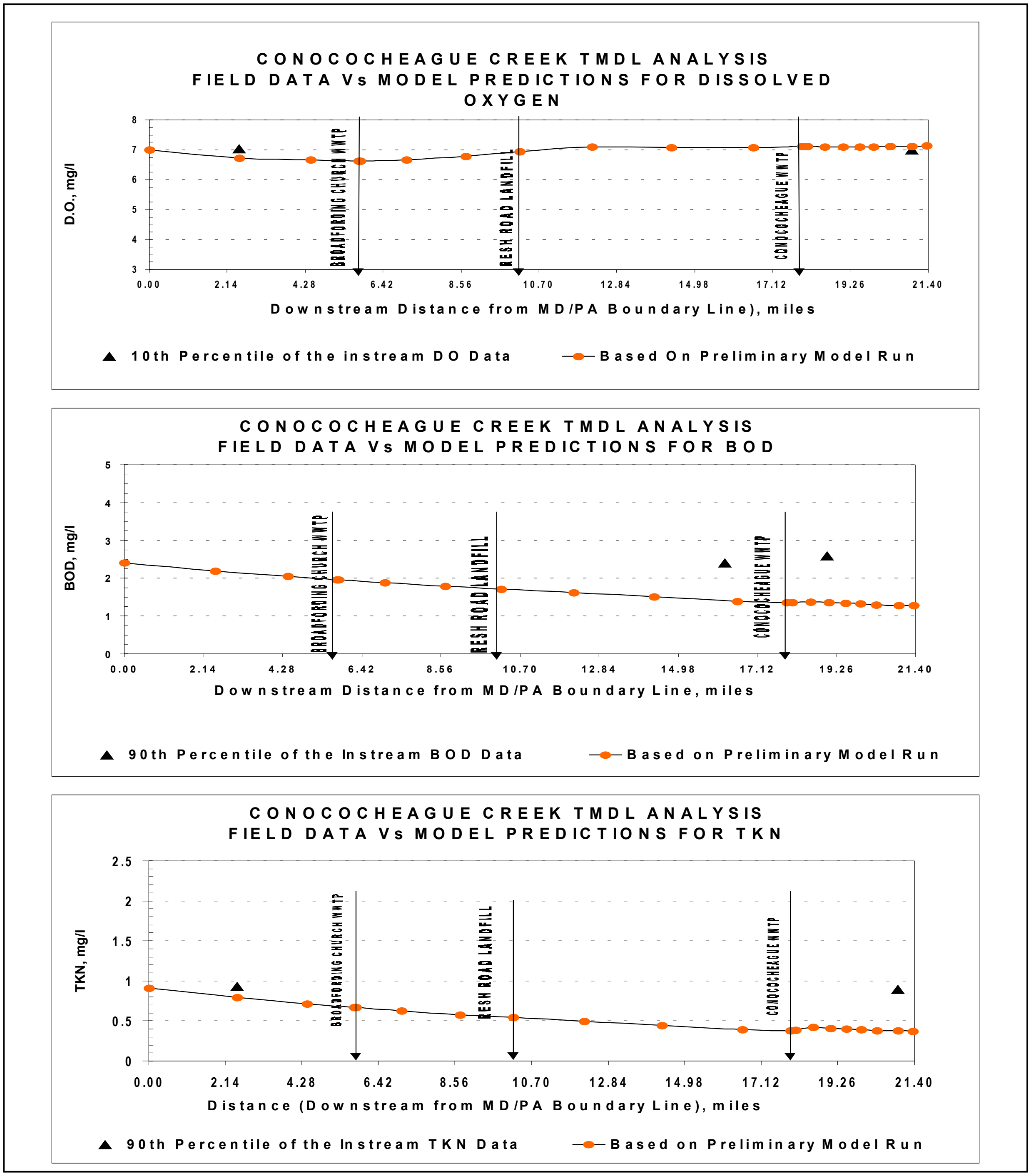

Figure 18: Comparison of Preliminary Model Run Results with Water Quality Data

Model Runs 1 and 2:

Model Runs 1 and 2 were made using different sets of CBOD and NBOD loads for point as well as nonpoint sources. In Model Run 1, the point source loads were increased to include the permitted loads for three WWTPs located in Maryland while the nonpoint source loads were kept the same as for the Preliminary Model Run. Its output results show that the instream dissolved oxygen levels in Conococheague Creek would be higher than the target-dissolved oxygen, and therefore, the Creek has some assimilative capacity for more BOD loads to be expressed as future allocations. Refer to Appendix-A for the output results. In Model Run 2, the point and nonpoint source BOD loads (in conjunction with the increased TKN) were increased in proportion such that the instream dissolved oxygen levels remain above the target dissolved oxygen value of 5.5 mg/l. The increased BOD loads were distributed between Future Allocations and MOS. Refer to Figures 19 to 21 for the graphs plotted to show the projected effects of increased BOD and TKN loads on Conococheague Creek water quality.

As the high dilution is available in the Potomac River even during the 7Q10 low flow period, the BOD loads entering from Conococheague Creek would have minimal effect on the dissolved oxygen level in the Potomac River.

Graphs Plotted to Show Effects of Increased BOD and TKN Loads on the Stream Water Quality:

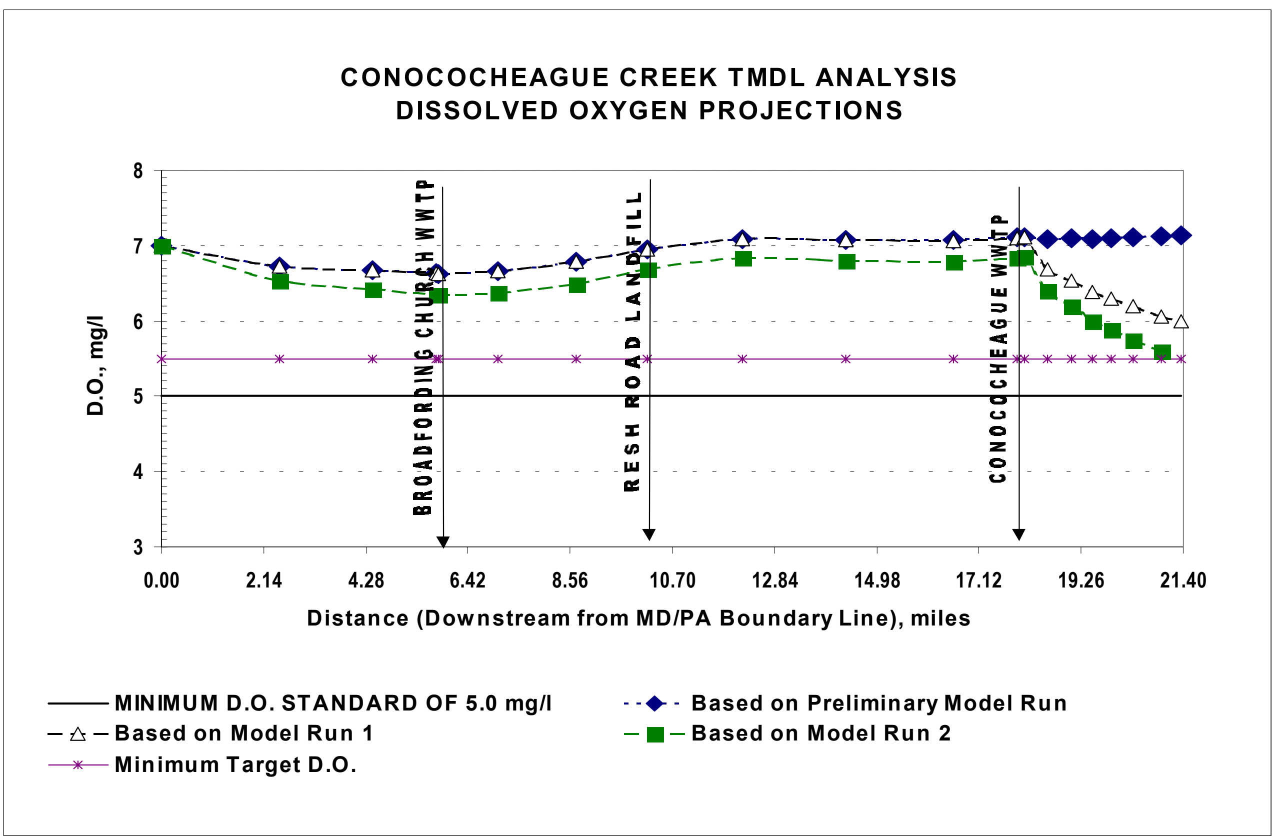

Figure 19: Effects of Increased BOD and TKN Loads on Stream Dissolved Oxygen

Graphs Plotted to Show Effects of Increased BOD and TKN Loads on the Stream Water Quality, Continued:

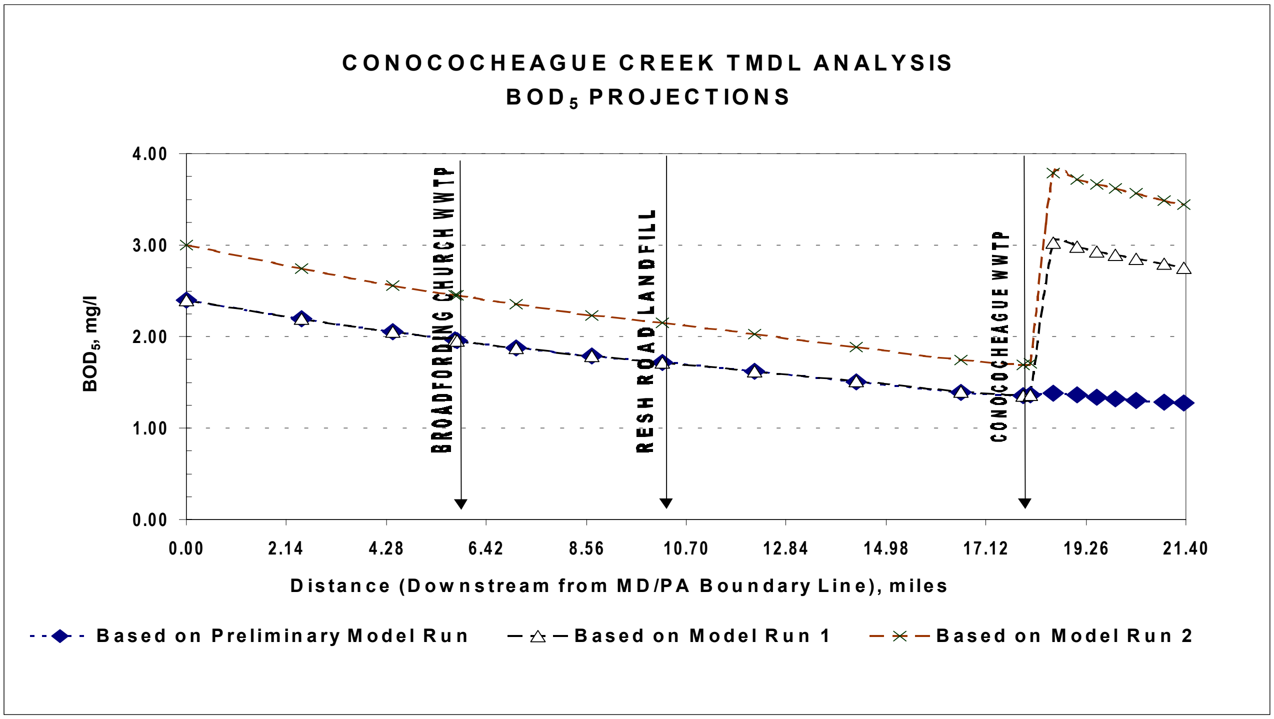

Figure 20: Effects of Increased BOD and TKN Loads on Stream BOD

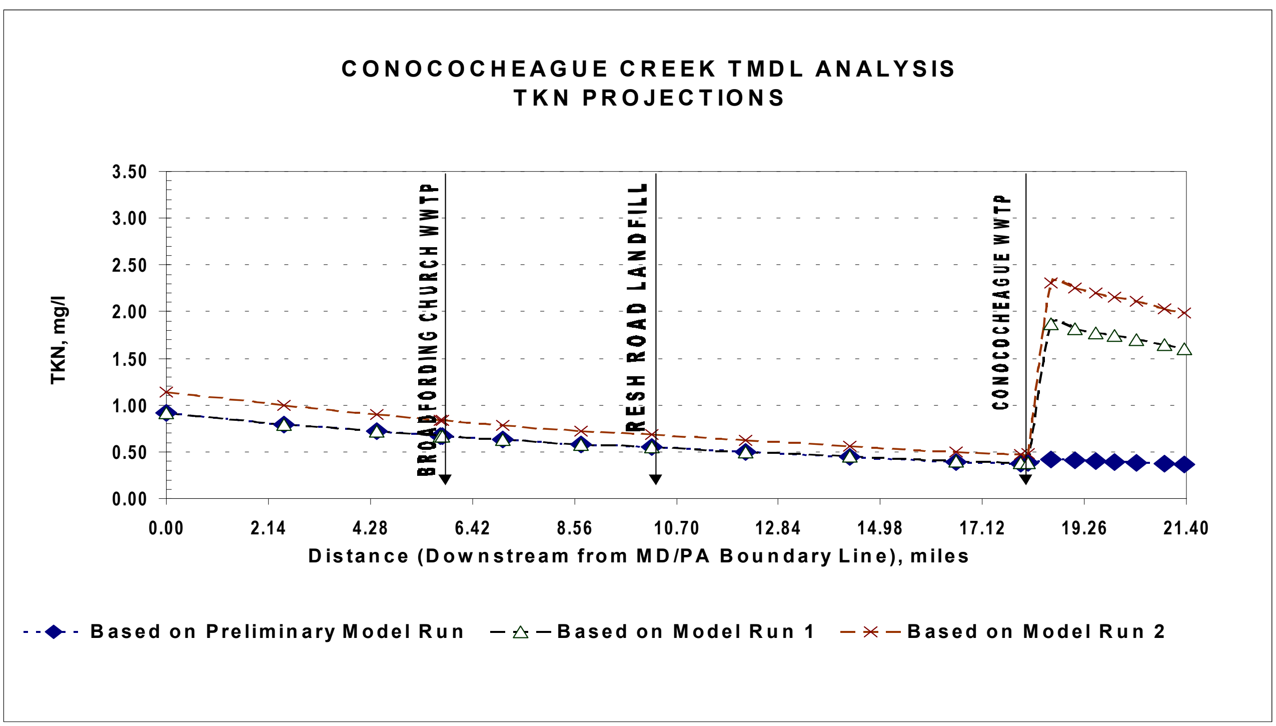

Figure 21: Effects of Increased BOD and TKN Loads on Stream TKN

6.6 TMDL Loading Cap

As Conococheague Creek is a freshwater stream, the instream concentrations of BOD, TKN and dissolved oxygen are mainly affected by dilution of effluent discharges from point sources, and oxidation and reaeration process. The stream flow data show that there is low flow in summer, which provide less dilution to the effluent discharges. Also, the water temperatures are high in the summer, which accelerate oxidation of the CBOD and NBOD, consuming instream dissolved oxygen at faster rates. The combined effects of low flows and high water temperatures that occur in summer are the critical conditions for the BOD TMDL. Thus, Model Run 2 indicates that, under future projected conditions with the proposed BOD TMDL, the target dissolved oxygen of 5.5 mg/l are maintained in Conococheague Creek at the critical summer low flow conditions. The TMDL was calculated for the critical summer conditions because this is when the water quality violations are most likely to occur. Model Run 2 scenario represents the final TMDL loading scenario. The resultant TMDL loading for BOD is:

Overall BOD TMDL (May to October) = 56,520 lbs/month

6.7 TMDL Load Allocations for Point Sources and Nonpoint Sources

As Conococheague Creek flows through Pennsylvania and Maryland, the TMDL load allocations for Pennsylvania and Maryland are described as follows:

Load Allocations for Pennsylvania:

Based on the available water quality data, the instream BOD concentration of 2.4 mg/l is used in the background flow at the PA/MD boundary line. It is a representative value which is multiplied by the 7Q10 flow of 55.351 cfs to produce total BOD load allocations of 21,492 lbs/month for the TMDL. Please note that this load allocation represents the combined point and nonpoint source contribution that will have to be evaluated, confirmed and agreed upon by Pennsylvania.

Load Allocations for Maryland State:

(a) Waste Load Allocation for Point Sources:

The point source load allocation for BOD is represented as the projected monthly average loads from the Conococheague WWTP, Broadfording Brethern Church WWTP and Resh Road Sanitary Landfill, assuming daily average design flow and monthly average BOD concentration limit. The total monthly load allocation was calculated directly from the existing monthly permit limits multiplied by 30 days. To ensure that sampling variability issues are addressed, the limits will also require, as a minimum, the same minimum sampling frequencies, which were associated with the current permits' limits and with historical data.

The BOD load allocation for point sources in Maryland is estimated to be 20,586 lbs/month. It is based on the understanding that, in addition to the BOD limit of 20 mg/l monthly average, the Conococheague WWTP will have a dissolved oxygen limit of 5.0 mg/l minimum at any time and a seasonal (May to October) TKN limit of 17 mg/l as monthly average. The other two facilities contribute less than 0.3% of the BOD load.

(b) Load Allocations for Nonpoint Sources:

The in-stream concentrations of BOD from nonpoint sources is estimated to be 2.4 mg/l. This is a representative value determined from several water quality stations located on Conococheague Creek. The BOD concentration of 2.4 mg/l was multiplied by 7Q10 flow of 8.089 cfs as tributary flows in MD to produce the nonpoint source load allocation for TMDL. The low flow nonpoint source loads are attributable to the base flow contributions. The nonpoint source loads that were assumed in the model account for both "natural" and human-induced components. The load allocation for nonpoint sources is estimated to be 3,142 lbs/month from MD tributaries.

The load allocations for BOD are summarized in Table 5.

Table 5: Point Source and Nonpoint Source Load Allocations (lbs/month)

State	BOD Load Allocation		
	Nonpoint Sources, lbs/month	Point Sources, lbs/month	Total, lbs/month
Maryland	3,142	20,586	23,728
Pennsylvania	21,492*	-	21,492
Total	24,634	20,586	45,220

* Though it is incorporated as a nonpoint source in TMDL allocation calculations, it represents the total (combined source) BOD load contributions from Pennsylvania at PA/MD boundary line.

The nonpoint source load allocations were calculated based on the 7Q10 low flow. It must be made clear that the above load allocations assume no runoff loads due to rainfall. To allocate loads at higher flows a more detailed analysis of the instream concentrations of water quality constituents would have to be performed. This TMDL document only allocates loads during 7Q10 conditions. The load allocations may differ from the TMDL stated above for higher flows and TKN and BOD loads.

6.8 TMDL Allowable Additional BOD Loads

The additional allowable BOD loads represent surplus assimilative loading capacity that is either currently available, or projected to become available due to planned implementation of the environmental controls or other changes. The BOD load allocations for point and nonpoint sources are estimated to be 20,586 lbs/month and 24,634 lbs/month, respectively. Model Run 2 predicts that additional BOD loads are allowable provided that they do not cause a localized impairment. It was determined that an additional BOD load of 11,300 lbs/month (5,141 lbs/month from point sources and 6,159 lbs/month from nonpoint sources) could be introduced, and the in-stream water quality would still be met. This load was distributed between Margin of Safety and Future Allocations.

Margin of Safety (MOS)

A Margin of Safety (MOS) must be included in each TMDL in recognition of the uncertainties in our scientific and technical understanding of the water quality in natural system. Specifically, we cannot know the exact nature and magnitude of pollutant loads from various sources and the specific impacts of those pollutants on the chemical and biological quality of complex waterbodies. The MOS is intended to account for such uncertainties in a manner that is conservative from the standpoint of protection of the environment. Based on the EPA guidelines, the MOS can be achieved through one of two approaches, either (1) reserve a portion of the loading capacity as a separate term in the TMDL, or (2) incorporate the MOS as part of the waste load allocations (WLA) and the load allocations (LA) computations (EPA, April 1991).

The TMDL for BOD in Maryland portion of Conococheague Creek employs both of these approaches to estimate the required MOS. The MOS includes 5% of the current and future load allocations for nonpoint sources, and 25% of the difference between monthly and weekly BOD limits for WWTPs discharging in Maryland. The MOS of 25% for WWTPs is considered appropriate because it is unlikely that these facilities will go above their monthly limits more than a quarter of the time during a month. In the TMDL, 3,375 lbs/month of loading capacity was set aside as MOS.

In addition to the set-aside MOS, the design conditions for the WLA and the LA computations include two implicit MOS. First, the critical condition of the 7Q10 low flow was used to determine the final TMDL load allocation. Because the 7Q10 flow conditions constitute a worst case scenario, it builds a conservative assumption into the TMDL. Second, the modeling was done using the NPDES monthly permit limits for all effluent concentrations. The monthly limits are conservative because they represent an upper limit that the WWTPs will strive not to exceed to avoid violation penalties.

Future Allocation (FA)

The Future Allocation or FA for the BOD TMDL is calculated to be 6,550 lbs/month that is a difference between additional allowable BOD loads and MOS. It is estimated for critical low flow conditions, and it will also increase as the flows rise above the 7Q10. To allocate loads at higher flows a more detailed analysis of the instream concentrations would have to be performed. This document only allocates a BOD load during 7Q10 conditions. The future allocation may differ in the TMDL for higher flows and TKN loads.

The FA and MOS are listed in Table 6.

Table 6: FA for Conococheague Creek BOD TMDL and MOS

State	FA, lbs/month	MOS, lbs/month
Maryland	2,515	3,393
Pennsylvania	4,029	1,363
Total	**6,544**	**4,756**

6.9 Summary of Total Maximum Daily Load

The overall BOD TMDL (lbs/month) for the Maryland portion of Conococheague Creek is as follows:

TMDL	=	LA	+	WLA	+	FA	+	MOS
56,520	=	24,634	+	20,586	+	6,544	+	4,756

A summary of the values used in the overall BOD TMDL calculations is provided in a "Technical Memorandum for Conococheague Creek BOD TMDL" attached to this report.

7.0 ASSURANCE OF TMDL IMPLEMENTATION

This section provides the basis for reasonable assurances that the BOD TMDL developed for the Maryland portion of Conococheague Creek will be achieved and maintained. Accordingly, achievement of the TMDL will depend on the cooperation of the State of Pennsylvania and USEPA in enforcing state and federal water pollution laws and ensuring that the effluent limits consistent with this TMDL are established for point sources discharging to the Conococheague Creek. The certainty of implementation of the BOD loads control in this watershed will be enhanced by several well-established specific programs: the Water Quality Improvement Act of 1998 (WQIA), the EPA-sponsored Clean Water Action Plan of 1998 (CWAP), the State's Chesapeake Bay Agreement's Tributary Strategy for Nutrient Reduction, and through enforceable NPDES permits for the wastewater dischargers in the basin).

Maryland's WQIA requires that comprehensive and enforceable nutrient management plans be developed, approved and implemented for all agricultural lands throughout Maryland. This act specifically requires that the phosphorus nutrient management plan be developed and implemented by 2004. Implementation of the nutrient management plan will also result in a reduction of nonpoint BOD loads.

The Chesapeake Bay Tributary Strategy, which expects a 40% reduction in controllable NPS nutrient load, should also reduce BOD loadings, even though this TMDL does not require any reduction in NPS loading. Enforceable NPDES permits written for the WWTPs in Maryland provide confidence in assuring implementation of this TMDL. Also, MDE has adopted a five-year watershed cycling strategy to manage its waters. Pursuant to this strategy, the State is divided into five regions, and management activities will cycle through these regions over a five-year period. The cycle begins with intensive monitoring, followed by computer modeling, TMDL development, implementation activities, and follow-up evaluation. The choice of a five-year cycle is motivated by the five-year federal NPDES permit cycle. This continuing cycle ensures that, within five years of establishing a TMDL, intensive follow-up monitoring will be performed. Thus, the watershed cycling strategy establishes a TMDL evaluation process that assures accountability.

REFERENCES

Maryland Department of the Environment, "Water Quality Database for Maryland Tributaries, August 1999".

Maryland Department of the Environment, "INPRG Program Manual, June 1987".

Municipal Surface Discharge Permits Division, "Calculations for Setting Discharge Permit Limits for the Conococheague WWTP, May, 1989"

U.S. EPA, "Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling, 2nd Edition, EPA/600/3-85/040, June 1985".