# Total Maximum Daily Load of Sediment in the Conococheague Creek Watershed, Washington County, Maryland

**FINAL**

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Submitted to:

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## List of Abbreviations

| | |
|---|---|
| BIBI | Benthic Index of Biotic Integrity |
| BIP | Buffer Incentive Program |
| BMP | Best Management Practices |
| BOD | Biochemical Oxygen Demand |
| CBP P5 | Chesapeake Bay Program Phase 5 |
| CV | Coefficient of Variation |
| CWA | Clean Water Act |
| DNR | Maryland Department of Natural Resources |
| EOF | Edge-of-Field |
| EOS | Edge-of-Stream |
| EPA | Environmental Protection Agency |
| EPSC | Environmental Permit Service Center |
| EPT | Ephemeroptera, Plecoptera, and Trichoptera |
| ETM | Enhanced Thematic Mapper |
| FIBI | Fish Index of Biologic Integrity |
| GIS | Geographic Information System |
| IBI | Index of Biotic Integrity |
| Ind. | Indeterminate |
| LA | Load Allocation |
| MACS | Maryland Agriculture Water Quality Cost Share Program |
| MBSS | Maryland Biological Stream Survey |
| MD 8-digit | Maryland 8-digit Watershed |
| MDE | Maryland Department of the Environment |
| MDL | Maximum Daily Load |
| MGD | Millions of Gallons per Day |
| mg/l | Milligrams per liter |
| MOS | Margin of Safety |
| MS4 | Municipal Separate Storm Sewer System |
| N/A | Not Applicable |
| NPDES | National Pollutant Discharge Elimination System |

| | |
|---|---|
| NRCS | Natural Resource Conservation Service |
| NRI | Natural Resources Inventory |
| PSU | Primary Sampling Unit |
| RESAC | Regional Earth Science Applications Center |
| SSDI | Sediment Stream Disturbance Index |
| TM | Thematic Mapper |
| TMDL | Total Maximum Daily Load |
| ton/yr | Tons per Year |
| TSD | Technical Support Document |
| TSS | Total Suspended Solids |
| USGS | United Stated Geological Survey |
| WLA | Waste Load Allocation |
| WTP | Water Treatment Plant |
| WQIA | Water Quality Improvement Act |
| WQLS | Water Quality Limited Segment |
| WWTP | Wastewater Treatment Plant |

## EXECUTIVE SUMMARY

This document, upon approval by the U.S. Environmental Protection Agency (EPA), establishes a Total Maximum Daily Load (TMDL) for sediment in the Maryland 8-digit (MD 8-digit) Conococheague Creek watershed (basin number 02140504) (303(d) Assessment Unit ID: MD-02140504). Section 303(d) of the federal Clean Water Act (CWA) and the EPA's implementing regulations direct each state to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards. For each WQLS, the State is required to either establish a TMDL of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met (CFR 2007b).

The Maryland Department of the Environment (MDE) has identified the waters of the MD 8-digit Conococheague Creek watershed on the State's 303(d) List as impaired by sediments (1996), pH (2002), bacteria (2002), dissolved oxygen (1996), and impacts to biological communities (2004) (MDE 2007). The designated use of the MD 8-digit Conococheague Creek and its tributaries is Use IV-P (Recreational Trout Waters and Public Water Supply) (COMAR 2007a,b).

A data solicitation for sediments was conducted by MDE, and all readily available data from the past five years have been considered. A TMDL for Biochemical Oxygen Demand (BOD) to address the 1996 dissolved oxygen listing was approved by the EPA in 2001. The listings for pH and impacts to biological communities will be addressed separately at a future date, and the bacteria listing is being addressed via a TMDL that is scheduled to be submitted to the EPA in the Summer of 2008.

The MD 8-digit Conococheague Creek watershed aquatic health scores, consisting of the Benthic Index of Biotic Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI), indicate that the biological metrics for the watershed exhibit a significant negative deviation from reference conditions (Roth et al. 2005). The objective of the TMDL established herein is to ensure that there will be no sediment impacts affecting aquatic health, thereby establishing a sediment load that supports the Use IV-P designation for the MD 8-digit Conococheague Creek watershed.

Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic health of non-tidal stream systems. To determine whether aquatic health is impacted by elevated sediment loads, a weight-of-evidence stressor identification approach was used. This approach applies a composite stressor indicator, defined as the *sediment stream disturbance index* (SSDI). Similar to the Index of Biotic Integrity (IBI), the SSDI is based on a comparison of specific watershed parameters with those from streams with a healthy aquatic community (i.e., reference watersheds) and is scored separately for the benthic and fish communities. Watershed specific SSDI values indicate whether sediment is one of the stressors affecting the biological community.

In order to quantify the impact of sediment on the aquatic health of non-tidal stream systems, a reference watershed TMDL approach was used and resulted in the establishment of a *sediment loading threshold* (Currey et al. 2006). This threshold is based on a detailed analysis of sediment loads from watersheds that are identified as supporting aquatic life (i.e., reference watersheds) based on Maryland's biocriteria (Roth et al. 1998, 2000; Stribling et al. 1998). This threshold is then used to determine a watershed specific sediment TMDL.

The computational framework chosen for the MD 8-digit Conococheague Creek watershed TMDL was the Chesapeake Bay Program Phase 5 (CBP P5) watershed model target *edge-of-field* (EOF) land use sediment loading rate calculations combined with a *sediment delivery ratio*. The *edge-of-stream* (EOS) sediment load is calculated per land use as a product of the land use area, land use target loading rate, and loss from the EOF to the main channel. The spatial domain of the CBP P5 watershed model segmentation aggregates to the Maryland 8-digit watersheds, which is consistent with the impairment listing.

EPA's regulations require TMDLs to take into account seasonality and critical conditions for stream flow, loading, and water quality parameters (CFR 2007b). The intent of this requirement is to ensure that the water quality of the waterbody is protected during times when it is most vulnerable. The biological monitoring data used to determine the reference watersheds integrates the stress effects over the course of time and thus inherently addresses critical conditions. Seasonality is captured in two components. First, it is implicitly included in biological sampling. Second, the Maryland Biological Stream Survey (MBSS) dataset included benthic sampling in the spring and fish sampling in the summer.

All TMDLs need to be presented as a sum of waste load allocations (WLAs) for permitted point sources and load allocations (LAs) for nonpoint sources generated within the assessment unit, natural background, tributary, and adjacent segment loads. Furthermore, all TMDLs must include a margin of safety (MOS) to account for any lack of knowledge and uncertainty concerning the relationship between loads and water quality (CFR 2007a,b). It is proposed that the estimated variability around the reference watershed group used in this analysis already accounts for such uncertainty. This results in an implicit margin of safety of approximately 8%.

The MD 8-digit Conococheague Creek Total Baseline Sediment Load is 100,610.3 tons per year (ton/yr). This baseline load consists of upstream loads generated outside the assessment unit (i.e., MD 8-digit watershed): a Pennsylvania Upstream Baseline Load ($BL_{PA}$) of 86,152.5 ton/yr, and loads generated within the assessment unit: a MD 8-digit Conococheague Creek Watershed Baseline Load Contribution of 14,457.8 ton/yr. The MD 8-digit Conococheague Creek Watershed Baseline Load Contribution is further subdivided into nonpoint source baseline loads (Nonpoint Source $BL_{CC}$) and two types of point source baseline loads: National Pollutant Discharge Elimination System (NPDES) regulated stormwater (NPDES Stormwater $BL_{CC}$) and regulated process water (Process Water $BL_{CC}$) (see Table ES-1).

**Table ES-1: MD 8-digit Conococheague Creek Baseline Sediment Loads (ton/yr)**

| | | **Upstream Baseline Load[1]** | | **MD 8-digit Conococheague Creek Watershed Baseline Load Contribution** | | | | |
|---|---|---|---|---|---|---|---|---|
| **Total Baseline Load (ton/yr)** | = | **$BL_{PA}$** | + | **Nonpoint Source $BL_{CC}$** | + | **NPDES Stormwater $BL_{CC}$** | + | **Process Water $BL_{CC}$** |
| 100,610.3 | = | 86,152.5 | + | 10,599.3 | + | 3,670.2 | + | 188.3 |

**Note**: [1]Although the Upstream Baseline Load is reported here as a single value, it could include point and nonpoint sources.

The MD 8-digit Conococheague Creek Average Annual TMDL of Sediment/Total Suspended Solids (TSS) is 94,634.7 ton/yr. Biological results from both the Maryland Department of Natural Resources (DNR) Core/Trend and MBSS stations along the mainstem of the MD 8-digit Conococheague Creek indicate that mainstem water quality can be classified as good. Based on this information, MDE concluded that the sediment impairment in the Maryland portion of the Conococheague Creek watershed is restricted to the lower order streams within Segment 2 of the watershed. Consequently, sediment reductions have been applied to the loads transported via the lower order stream network within Segment 2 (located mostly in Maryland) and not the loads transported via the main channel from Segment 1 (located mostly in Pennsylvania). The TMDL consists of allocations attributed to loads generated outside the assessment unit referred to as Upstream Load Allocations: a Pennsylvania Upstream Load Allocation ($LA_{PA}$) of 85,870.9 ton/yr, and allocations attributed to loads generated within the assessment unit: a MD 8-digit Conococheague Creek Watershed TMDL Contribution of 8,763.8 ton/yr. The MD 8-digit Conococheague Creek Watershed TMDL Contribution is further subdivided into point and nonpoint source allocations and is comprised of a Load Allocation ($LA_{CC}$) of 6,567.4 ton/yr, an NPDES Stormwater Wasteload Allocation (NPDES Stormwater $WLA_{CC}$) of 2,008.1 ton/yr, and a Process Water Wasteload Allocation (Process Water $WLA_{CC}$) of 188.3 ton/yr (see Table ES-2). This TMDL will ensure that the sediment loads and resulting effects are at a level to support the IV-P designation for the MD 8-digit Conococheague Creek watershed, and more specifically, at a level to support aquatic health.

**Table ES-2: Average Annual MD 8-digit Conococheague Creek TMDL of Sediment/ TSS (ton/yr)**

| | | **LA** | | | | **WLA** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **TMDL (ton/yr)** | = | **$LA_{PA}$[1]** | + | **$LA_{CC}$** | + | **NPDES Stormwater $WLA_{CC}$** | + | **Process Water $WLA_{CC}$** | + | **MOS** |
| 94,634.7 | = | 85,870.9 | + | 6,567.4 | + | 2,008.1 | + | 188.3 | + | Implicit |

Upstream Load Allocation[2,3] — MD 8-digit Conococheague Creek Watershed TMDL Contribution

**Notes:**[1] $LA_{PA}$ was determined to be necessary in order to meet Maryland water quality standards within the MD 8-digit Conococheague Creek watershed.
[2] Although for the purpose of this analysis the upstream load is referred to as an LA, it could include loads from point and nonpoint sources.
[3] A delivery factor of 1 was used for the Upstream Load Allocation.

**Table ES-3: MD 8-Digit Conococheague Creek Baseline Load, TMDL, and Total Reduction Percentage**

| Baseline Load (ton/yr) | TMDL (ton/yr) | Total Reduction (%) |
|---|---|---|
| 100,610.3 | 94,634.7 | 5.9 |

In addition to the TMDL value, a Maximum Daily Load (MDL) is also presented in this document. The calculation of the MDL, which is derived from the TMDL average annual loads is explained in Appendix C and presented in Table C-1.

Once the EPA has approved this TMDL and it is known what measures must be taken to reduce pollution levels, implementation of best management practices (BMPs) is expected to take place. MDE intends for the required reduction to be implemented in an iterative process that first addresses those sources with the largest impact to water quality, with consideration given to ease and cost of implementation.

Maryland has several well-established programs to draw upon, including the Water Quality Improvement Act of 1998 (WQIA) and the Federal Nonpoint Source Management Program (§ 319 of the Clean Water Act). Several potential funding sources for implementation are available, such as the Buffer Incentive Program (BIP), the State Water Quality Revolving Loan Fund, and the Stormwater Pollution Cost Share Program.

## 1.0 INTRODUCTION

This document, upon approval by the U.S. Environmental Protection Agency (EPA), establishes a Total Maximum Daily Load (TMDL) for sediment in the Maryland 8-digit (MD 8-digit) Conococheague Creek watershed (basin number 02140504) (303(d) Assessment Unit ID: MD-02140504). Section 303(d)(1)(C) of the federal Clean Water Act (CWA) and the EPA's implementing regulations direct each state to develop a TMDL for each impaired water quality limited segment (WQLS) on the Section 303(d) List, taking into account seasonal variations, critical conditions, and a protective margin of safety (MOS) to account for uncertainty (CFR 2007b). 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 determine the pollutant load reductions needed 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, protection of aquatic life, and shellfish propagation and harvest. Water quality criteria consist of narrative statements and numeric values designed to protect the designated uses. Criteria may differ among waters with different designated uses.

The Maryland Department of the Environment (MDE) has identified the waters of the MD 8-digit Conococheague Creek watershed on the State's 303(d) List as impaired by sediments (1996), pH (2002), bacteria (2002), dissolved oxygen (1996), and impacts to biological communities (2004) (MDE 2007). The designated use of the MD 8-digit Conococheague Creek and its tributaries is Use IV-P (Recreational Trout Waters and Public Water Supply) (COMAR 2007a,b).

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The objective of the TMDL established herein is to ensure that there will be no sediment impacts affecting aquatic health, thereby establishing a sediment load that supports Use IV-P designation for the MD 8-digit Conococheague Creek watershed. Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic health of non-tidal stream systems. Therefore, to determine whether aquatic health is impacted by elevated sediment loads, a weight-of-evidence stressor identification approach was used. This approach applies a composite stressor indicator, defined as the *sediment stream disturbance index* (SSDI). Similar to the Index of Biotic Integrity (IBI), the SSDI is based on a comparison of specific watershed parameters with those from streams with a healthy aquatic community (i.e., reference watersheds) and is scored separately for the benthic and fish communities. Watershed specific SSDI values indicate whether sediment is one of the stressors affecting the biological community.

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# 2.0 SETTING AND WATER QUALITY DESCRIPTION

## 2.1 General Setting

**Location**

The MD 8-digit Conococheague Creek watershed is located in the Potomac River basin within Washington County, Maryland (see Figure 1). Conococheague Creek 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 22 miles in Maryland and 58 miles in Pennsylvania. The total watershed area covers 568 square miles, with approximately 66 square miles in Maryland and 502 square miles in Pennsylvania. Approximately 5% of the total watershed is covered by water (i.e. streams, ponds, etc.). The total population in the MD 8-digit Conococheague Creek watershed is estimated to be approximately 21,000 (US Census Bureau 2000).

**Geology/Soils**

The MD 8-digit Conococheague Creek watershed lies within the Ridge and Valley Province of Western Maryland, between South Mountain in Washington County and Dans Mountain in western Allegany County. Two distinct topographic and geologic zones separate the Province: the Great Valley (Hagerstown Valley) and the Allegheny Ridge. The Great Valley is a wide, flat, and open valley formed on Cambrian and Ordovician limestone, dolomite, and alluvial fan deposits alongside the bordering mountains. The Allegheny Ridge is characterized by erosion-resistant sandstone aligned in the northeast-southwest direction. The surface geology is characterized by folded and faulted sedimentary rocks, layered limestone and shale, and mountainous soils composed of clay, clay loams, and sandy and stony loams (DNR 2007b; MGS 2007; MDE 2000).

The soils in the watershed are in the Elliber-Dekalb-Opequon Association. The Elliber soils are very deep on both the tops and sides of the ridges where they cover a cherty limestone. They also contain large quantities of chert fragments. The Dekalb soils are moderately deep, very stony, and cover a sandstone, and the Opequon soils are generally found on the sides of the limestone ridges (USDA 1962).

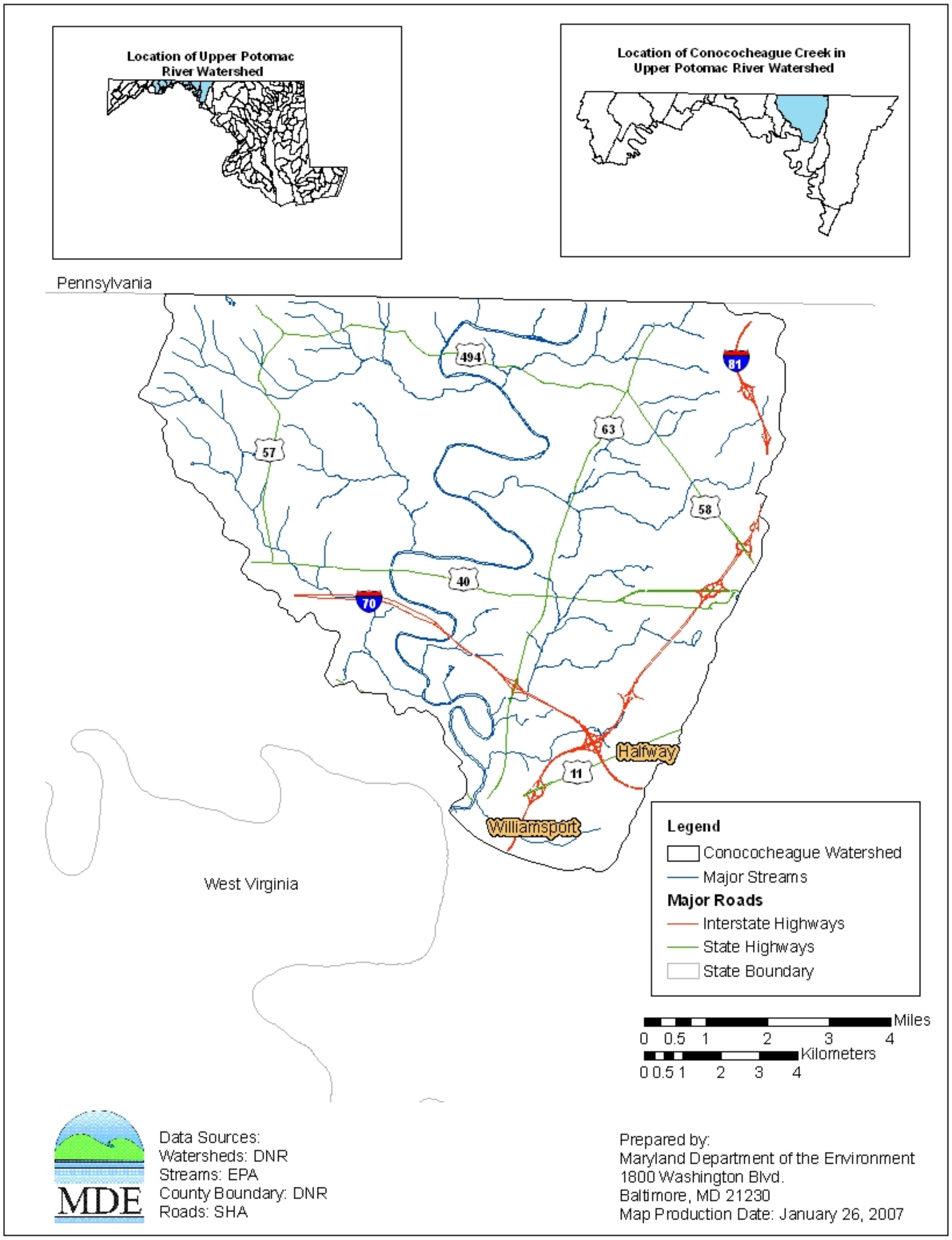


**Figure 1: Location Map of the MD 8-digit Conococheague Creek in Washington County, Maryland**

### 2.1.1. Land Use

**Land Use Methodology**

The land use framework used to develop this TMDL was originally developed for the Chesapeake Bay Program Phase 5 (CBP P5) watershed model.[1] The CBP P5 land use Geographic Information System (GIS) framework was based on two distinct layers of development. The first GIS layer was developed by the Regional Earth Science Applications Center (RESAC) at the University of Maryland and was based on satellite imagery (Landsat 7-Enhanced Thematic Mapper (ETM) and 5-Thematic Mapper (TM)) (Goetz et al. 2004). This layer did not provide the required level of accuracy that is especially important when developing agricultural land uses. In order to develop accurate agricultural land use calculations, the CBP P5 used county level U.S. Agricultural Census data as a second layer (USDA 1982, 1987, 1992, 1997, 2002).

Given that land cover classifications based on satellite imagery are likely to be least accurate at edges (i.e., boundaries between covers), the RESAC land uses bordering agricultural areas were analyzed separately. If the agricultural census data accounted for more agricultural use than the RESAC's data, appropriate acres were added to agricultural land uses from non-agricultural land uses. Similarly, if census agricultural land estimates were smaller than RESAC's, appropriate acres were added to non-agricultural land uses.

Adjustments were also made to the RESAC land cover to determine developed land uses. RESAC land cover was originally based on the United States Geological Survey (USGS) protocols used to develop the 2000 National Land Cover Database. The only difference between the RESAC and USGS approaches was RESAC's use of town boundaries and road densities to determine urban land covered by trees or grasses. This approach greatly improved the accuracy of the identified urban land uses, but led to the misclassification of some land adjacent to roads and highways as developed land. This was corrected by subsequent analysis. To ensure that the model accurately represented development over the simulation period, post-processing techniques that reflected changes in urban land use have been applied.

The result of this approach is that CBP P5 land use does not exist in a single GIS coverage; instead it is only available in a tabular format. The CBP P5 watershed model is comprised of 25 land uses. Most of these land uses are differentiated only by their nitrogen and phosphorus loading rates. The land uses are divided into 14 classes with distinct sediment erosion rates. Table 1 lists the CBP P5 generalized land uses, detailed land uses, which are classified by their erosion rates, and the acres of each land use in the Conococheague Creek watershed. Details of the land use development methodology have been summarized in the report entitled "Chesapeake Bay Phase 5 Community Watershed Model: Tracking Nutrient and Sediment Loads on a Regional and Local Scale" (US EPA 2007).

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[1] The EPA Chesapeake Bay Program developed the first watershed model in 1982. There have been many upgrades since the first phase of this model. The CBP P5 was developed to estimate flow, nutrient, and sediment loads to the Bay.

## Conococheague Creek Watershed Land Use Distribution

The Conococheague Creek watershed land use distribution was evaluated separately for Maryland and Pennsylvania. The land use distribution in Maryland consists primarily of crop (35.6%) and urban (28.7%) land uses, with lesser amounts of forest (19.1%) and pasture (16.2%). In Pennsylvania, the land use consists mainly of forest (49.3%) and crop (32.9%) land use, with smaller amounts of urban (9.9%) and pasture (7.8%).

A land use map is provided in Figure 2 and a summary of the watershed land use areas is presented in Table 1.

**Table 1: Land Use Percentage Distribution for the Conococheague Creek Watershed**

| | | Maryland | | | Pennsylvania | | |
|---|---|---|---|---|---|---|---|
| **General Land Use** | **Detailed Land Use** | **Area (Acres)** | **Percent** | **Grouped Percent of Total** | **Area (Acres)** | **Percent** | **Grouped Percent of Total** |
| Crop | Animal Feeding Operations | 23.1 | 0.1 | | 223.8 | 0.1 | |
| | Hay | 4,981.3 | 12.6 | | 37,034.6 | 12.1 | |
| | High Till | 2,779.5 | 7.0 | | 20,604.4 | 6.8 | |
| | Low Till | 6,296.5 | 15.9 | | 42,086.5 | 13.8 | |
| | Nursery | 39.2 | 0.1 | 35.6 | 471.7 | 0.2 | 32.9 |
| Extractive | Extractive | 149.6 | 0.4 | 0.4 | 149.4 | N/A[1] | N/A[1] |
| Forest | Forest | 7,504.7 | 18.9 | | 149,053.2 | 48.9 | |
| | Harvested Forest | 75.8 | 0.2 | 19.1 | 1,505.6 | 0.5 | 49.3 |
| Pasture | Natural Grass | 65.4 | 0.2 | | 2,229.9 | 0.7 | |
| | Pasture | 6,344.0 | 16.0 | | 21,319.3 | 7.0 | |
| | Trampled Pasture | 33.2 | 0.1 | 16.2 | 111.6 | 0.0 | 7.8 |
| Urban | Urban: Barren | 236.2 | 0.6 | | 433.7 | 0.1 | |
| | Urban: Imp | 2,398.8 | 6.0 | | 7,229.4 | 2.4 | |
| | Urban: perv | 8,762.7 | 22.1 | 28.7 | 22,652.3 | 7.4 | 9.9 |
| | | | | | | | |
| | Total | 39,689.8 | 100.0 | 100.0 | 305,105.4 | 100.0 | 100.0 |

**Note**: [1] Percentage of total land area is minimal.

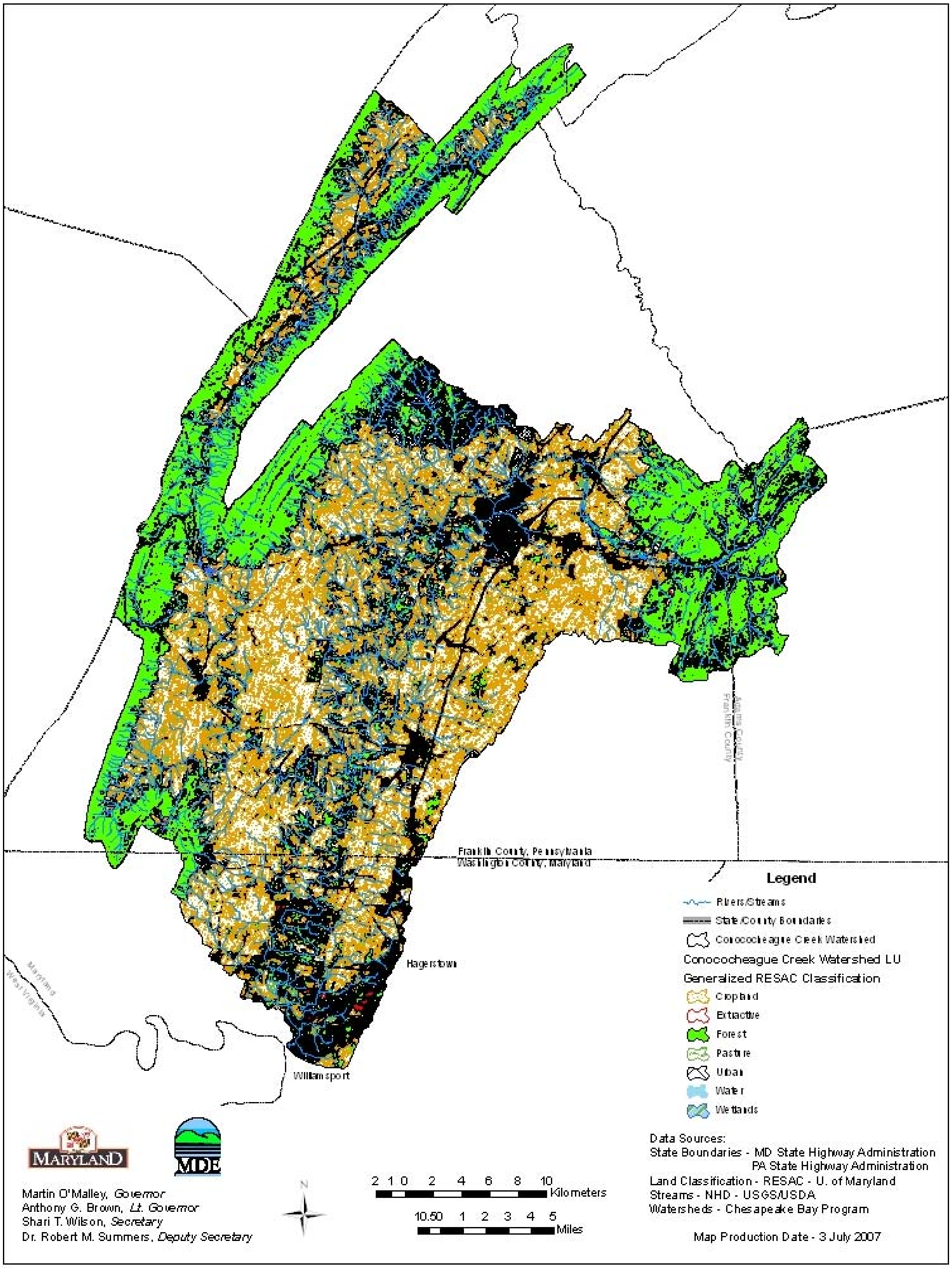



**Figure 2: Land Use of the Conococheague Creek Watershed**

## 2.2 Source Assessment

The MD 8-digit Conococheague Creek Total Baseline Sediment Load consists of loads generated outside this 8-digit assessment unit, referred to as Upstream Baseline Loads, and loads generated within the assessment unit, referred to as the MD 8-digit Conococheague Creek Watershed Baseline Load Contribution. The MD 8-digit Conococheague Creek Watershed Baseline Load Contribution can be further subdivided into nonpoint and point source loads. This section summarizes the methods used to derive each of these distinct source categories.

### 2.2.1 Nonpoint Source Assessment

In this document, the nonpoint source loads account for sediment loads from unregulated storm water runoff within the MD 8-digit watershed. This section provides the background and methods used to characterize the nonpoint source baseline loads generated within the MD 8-digit Conococheague Creek watershed (Nonpoint Source $BL_{CC}$). This approach was also used to estimate the Pennsylvania Upstream Baseline Load.

**General Load Estimation Methodology**

Nonpoint source sediment loads generated within the MD 8-digit watershed are estimated based on the *edge-of-stream (EOS)* calibration target loading rates from the CBP P5 model. This approach is based on the fact that not all of the *edge-of-field* (EOF) sediment load is delivered to the stream or river (some of it is stored on fields down slope, at the foot of hillsides, or in smaller rivers or streams that are not represented in the model). To calculate the actual EOS loads, a *sediment delivery ratio* (the ratio of sediment reaching a basin outlet compared to the total erosion within the basin) is used. Details of the methods used to calculate sediment load have been summarized in the report entitled "Chesapeake Bay Phase 5 Community Watershed Model: Tracking Nutrient and Sediment Loads on a Regional and Local Scale" (US EPA 2007).

**Edge-of-Field Target Erosion Rate Methodology**

EOF target erosion rates for agricultural land uses and forested land use were based on erosion rates determined by the National Resource Inventory (NRI). NRI is a statistical survey of land use and natural resource conditions conducted by the Natural Resources Conservation Service (NRCS) (USDA 2007). Sampling methodology is explained by Nusser and Goebel (1997).

Estimates of average annual erosion rates for pasture and cropland are available on a county basis at five-year intervals, starting in 1982. Erosion rates for forested land uses are not available on a county basis from NRI; however, for the purpose of the CBP Phase 2 watershed model, NRI calculated average annual erosion rates for forested land use on a watershed basis. These rates are still being used as targets in the CBP P5 model.

The average value of the 1982 and 1987 surveys was used as the basis for EOF target loads. The erosion rates from this period do not reflect best management practices

(BMPs) or other soil conservation policies introduced in the wake of the effort to restore the Chesapeake Bay. To compensate for this, a BMP factor was included in the loading estimates using best available "draft" information from the CBP. However, the effect of these factors were minimal, as most of the anticipated reductions are expected to result from land use changes (e.g. high till to low till). Rates for urban pervious, urban impervious, and barren land were based on a combination of best professional judgment, literature analysis, and regression analysis. Table 2 lists erosion rates specific to the Conococheague Creek watershed.

**Table 2: Summary of EOF Erosion Rate Calculations**

| **Land Use** | **Data Source** | **Washington County (MD) (tons/acre/year)** | **Franklin County (PA) (tons/acre/year)** | **Adams County (PA) (tons/acre/year)** |
|---|---|---|---|---|
| Forest | Phase 2 NRI | 0.31 | 0.33 | 0.29 |
| Harvested Forest[1] | Average Phase 2 NRI (x 10) | 3 | 3 | 3 |
| Natural Grass | Average NRI Pasture (1982-1987) | 1.5 | 1.5 | 1.5 |
| Pasture | Pasture NRI (1982-1987) | 1.28 | 0.74 | 0.17 |
| Trampled Pasture[2] | Pasture NRI (x 9.5) | 12.16 | 7.03 | 1.62 |
| Animal Feeding Operations[2] | Pasture NRI (x 9.5) | 12.16 | 7.03 | 1.62 |
| Hay[2] | Crop NRI (1982-1987)(x 0.32) | 1.6 | 2 | 1.44 |
| High Till Without Manure[2] | Crop NRI (1982-1987)(x 1.25) | 6.24 | 7.82 | 5.61 |
| High Till With manure[2] | Crop NRI (1982-1987) (x 1.25) | 6.24 | 7.82 | 5.61 |
| Low till With Manure[2] | Crop NRI (1982-1987) (x 0.75) | 3.74 | 4.69 | 3.36 |
| Pervious Urban | Intercept Regression Analysis | 0.74 | 0.74 | 0.74 |
| Extractive | Best professional judgment | 10 | 10 | 10 |
| Barren | Literature survey | 12.5 | 12.5 | 12.5 |
| Impervious | 100% Impervious Regression Analysis | 5.18 | 5.18 | 5.18 |

**Notes:** [1] Based on an average of NRI values for the Chesapeake Bay Phase 5 segments.
[2] NRI score data adjusted based on land use.

**Sediment Delivery Ratio:** The base formula for calculating *sediment delivery ratio*s in the CBP P5 model is the same as the formula used by the NRCS (USDA 1983).

$$DF = 0.417762 * A^{-0.134958} - 0.127097 \qquad \text{(Equation 2.1)}$$

Where:
DF (delivery factor) = the sediment delivery ratio
A = drainage area in square miles

In order to account for the changes in sediment loads due to distance traveled to the stream, the CBP P5 model uses the *sediment delivery ratio*. Land use specific *sediment delivery ratios* were calculated for each river segment using the following procedure:

(1) mean distance of each land use from the river reach was calculated; and

(2) *sediment delivery ratio*s for each land use were calculated (drainage area in Equation 2.1 was assumed to be equal to the area of a circle with radius equal to the mean distance between the land use and the river reach).

**<u>Edge-of-Stream Loads</u>**

*Edge-of-stream* loads are the loads that actually enter the river reaches (i.e., the mainstem of a watershed). Such loads represent not only the erosion from the land but all of the intervening processes of deposition on hillsides and sediment transport through smaller rivers and streams.

### 2.2.2 Point Source Assessment

A list of 26 active permitted point sources that contribute to the sediment load in the MD 8-digit Conococheague Creek watershed was compiled using MDE's Environmental Permit Service Center (EPSC) database. The types of permits identified include individual municipal, general mineral mining, general industrial stormwater, and general municipal separate storm sewer systems (MS4s). The permits can be grouped into two categories, process water and stormwater. The stormwater category includes all National Pollutant Discharge Elimination System (NPDES) regulated stormwater discharges. The process water category includes those loads generated by continuous discharge sources whose permits have total suspended solids (TSS) limits. Other permits that do not meet these conditions are considered *de minimis* in terms of the total sediment load.

The sediment loads for the 5 process water permits (Process Water $BL_{CC}$) are calculated based on their TSS limits and corresponding flow information. The 21 NPDES Phase I or Phase II stormwater permits identified throughout the MD 8-digit Conococheague Creek watershed are regulated based on BMPs and do not include TSS limits. In the absence of TSS limits, the NPDES regulated stormwater baseline load (NPDES Stormwater $BL_{CC}$) is calculated using methods described in Section 2.2.1 and watershed specific urban land use sediment delivery factors. A detailed list of the permits appears in Appendix B.

### 2.2.3 Upstream Loads Assessment

For the purpose of this analysis, only one upstream watershed has been identified: the Pennsylvania portion of the Conococheague Creek watershed. Subsequently, sediment baseline loads from this watershed will be presented as a Pennsylvania Upstream Baseline Load ($BL_{PA}$). The $BL_{PA}$ is estimated based on land use specific sediment delivery ratios (this method is described in Section 2.2.1).

### 2.2.4 Summary of Baseline Loads

Table 3 summarizes the MD 8-digit Conococheague Creek Baseline Sediment Load, reported in tons per year (ton/yr) and presented in terms of Upstream Baseline Loads and MD 8-digit Conococheague Creek Watershed Baseline Load Contribution nonpoint and point source loadings.

**Table 3: MD 8-digit Conococheague Creek Baseline Sediment Loads (ton/yr)**

| | | Upstream Baseline Load[1] | | MD 8-digit Conococheague Creek Watershed Baseline Load Contribution | | | | |
|---|---|---|---|---|---|---|---|---|
| **Total Baseline Load (ton/yr)** | = | **$BL_{PA}$** | + | **Nonpoint Source $BL_{CC}$** | + | **NPDES Stormwater $BL_{CC}$** | + | **Process Water $BL_{CC}$** |
| 100,610.3 | = | 86,152.5 | + | 10,599.3 | + | 3,670.2 | + | 188.3 |

**Note**: [1]Although the Upstream Baseline Load is reported here as a single value, it could include point and nonpoint sources.

Table 4 presents a breakdown of the MD 8-digit Conococheague Creek Total Baseline Sediment Loads, detailing loads per land use and state. It is broken down into nonpoint and point source loadings. The majority of the sediment load in both Maryland and Pennsylvania is from cropland (58.3% of the total sediment budget in Maryland and 75.8% in Pennsylvania). In Maryland, the next largest sediment sources are urban (25.4%), pasture (9.8%), and forest (3.5%). In Pennsylvania, the next largest sediment sources are urban (11.8%), forest (9.1%), and pasture (3.0%).

**Table 4: Conococheague Creek Watershed Detailed Baseline Sediment Budget Loads**

| | | Maryland | | | Pennsylvania | | |
|---|---|---|---|---|---|---|---|
| **General Land Use** | **Description** | **Load (ton/yr)** | **Percent** | **Grouped Percent of Total** | **Load (ton/yr)** | **Percent** | **Grouped Percent of Total** |
| Crop | Animal Feeding Operations | 49.5 | 0.3 | | 250.2 | 0.3 | |
| | Hay | 1,346.5 | 9.3 | | 12,079.4 | 14.0 | |
| | High Till | 2,901.7 | 20.1 | | 20,242.7 | 23.5 | |
| | Low Till | 4,049.6 | 28.0 | | 32,173.7 | 37.3 | |
| | Nursery | 83.1 | 0.6 | 58.3 | 540.6 | 0.6 | 75.8 |
| Extractive | Extractive | 248.3 | 1.7 | 1.7 | 291.0 | 0.3 | 0.3 |
| Forest | Forest | 461.5 | 3.2 | | 7,209.3 | 8.4 | |
| | Harvested Forest | 45.1 | 0.3 | 3.5 | 671.6 | 0.8 | 9.1 |
| Pasture | Natural Grass | 16.2 | 0.1 | | 383.8 | 0.4 | |
| | Pasture | 1,327.0 | 9.2 | | 2,064.7 | 2.4 | |
| | Trampled Pasture | 70.7 | 0.5 | 9.8 | 102.8 | 0.1 | 3.0 |
| Urban[1] | Urban: Barren | 445.2 | 3.1 | | 702.5 | 0.8 | |
| | Urban: Imp | 2,116.6 | 14.6 | | 6,504.7 | 7.6 | |
| | Urban: perv | 1,108.4 | 7.7 | 25.4 | 2,935.6 | 3.4 | 11.8 |
| N/A | Process Water | 188.3 | 1.3 | 1.3 | N/A | N/A | N/A |
| | **Total** | **14,457.8** | **100.0** | **100.0** | **86,152.5** | **100.0** | **100.0** |

**Note:** [1] The Maryland urban land use load represents the permitted stormwater load.

## 2.3 Water Quality Characterization

The MD 8-digit Conococheague Creek watershed was originally listed on Maryland's 1996 303(d) List as impaired by elevated sediments from nonpoint sources, with supporting evidence cited in Maryland's 1996 305(b) report. The 1996 305(b) report did not directly state that elevated sediments were a concern, and it has been determined that the sediment listing was based on best professional judgment (MDE 2004; DNR 1996).

Currently in Maryland, there are no specific numeric criteria for suspended sediments. However, the Maryland 2004 303(d) report states that degraded stream water quality resulting in a sediment impairment is characterized by erosional impacts, depositional impacts, and decreased water clarity (MDE 2004). Therefore, the evaluation of suspended sediment loads will be based on how the sediment related impacts are influencing the designated use of supporting aquatic health, as defined by Maryland's biocriteria (Roth et al. 1998, 2000; Stribling et al. 1998).

Recently, MDE developed a stressor identification methodology entitled "Using MBSS Data to Identify Stressors for Streams that Fail Biocriteria in Maryland" (Southerland et al. 2007). This document proposes a conceptual model (see Figure 3) that establishes a link between sediment loads and aquatic health. Specifically, it identifies whether current sediment loads have a negative impact on a watershed's aquatic health based on the observed sediment impacts. This linkage between sediment loads, sediment impacts, and aquatic health is used to evaluate a sediment impairment.

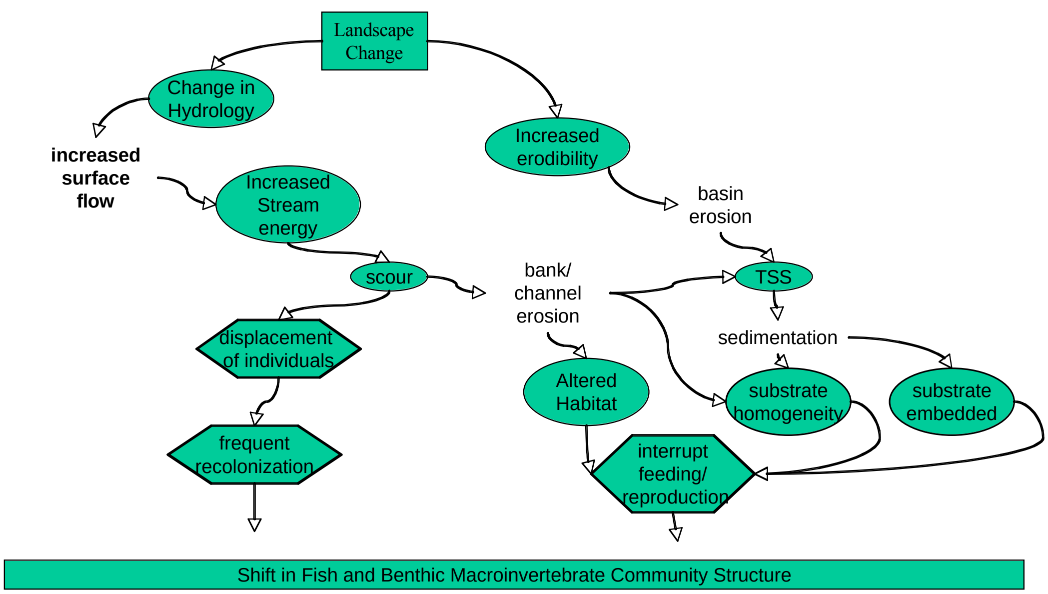



**Figure 3: Sediment Stressor Conceptual Model**

The sediment stressor conceptual model (adapted from Southerland et al. 2007) illustrates that changes in the landscape result in two possible paths, one triggered by changes in hydrology and the other triggered by increased land erodibility. Both paths ultimately result in changes in TSS and sediment loads, which, if increased, will result in a negative shift in the structure of the biological community.

Furthermore, the stressor conceptual model identifies water column TSS as the most direct measure of sediment loadings. Therefore, TSS was chosen as the most appropriate parameter for the sediment TMDL analysis. While an effective TSS concentration threshold would include both exposure duration and concentration magnitude, due to natural variations in geology, topography, and episodic flows, such a threshold would be extremely difficult to quantify (Rowe et al. 2003). In addition, the collection of sufficient instantaneous TSS concentration and flow data would be difficult due to high cost and limited site access during high flow events. Thus, MDE has not established a specific TSS water column concentration criteria. As a result, the water quality characterization of TSS impacts to aquatic life will be based on the cumulative impacts identified from observed streambed measures. Upon identification of sediment impacts, the TMDL will be estimated as a cumulative loading based on a comparison of the current watershed sediment loads with the acceptable levels derived from reference watersheds.

The streambed measures used to determine the water quality characterization were gathered from the Maryland Biological Stream Survey (MBSS) dataset. The MBSS uses a fixed length (75 m) randomly selected stream segment for collecting site level information within a primary sampling unit (PSU), also defined as a watershed. The randomly selected stream segments, from which field data are collected, are selected using either stratified random sampling with proportional allocation, or simple random sampling (Cochran 1977). This allocation ensures that all sites in a PSU stream network have the same probability of being selected. The random sample design allows for unbiased watershed estimates of mean conditions by averaging results at multiple stations. The average watershed estimates are then used to determine if streams within a watershed have a degraded biology (fish or benthic) and subsequently whether or not sediment is contributing to the observed degradation (Roth et al. 2005).

## MD 8-digit Conococheague Creek Watershed Monitoring Stations

A total of 12 water quality monitoring stations were used to characterize the MD 8-digit Conococheague Creek Watershed. There were 10 biological/physical habitat monitoring stations from the MBSS program and 2 biological monitoring stations from the Maryland Core/Trend monitoring network. The stations are presented in Figure 4 and listed in Table 5.

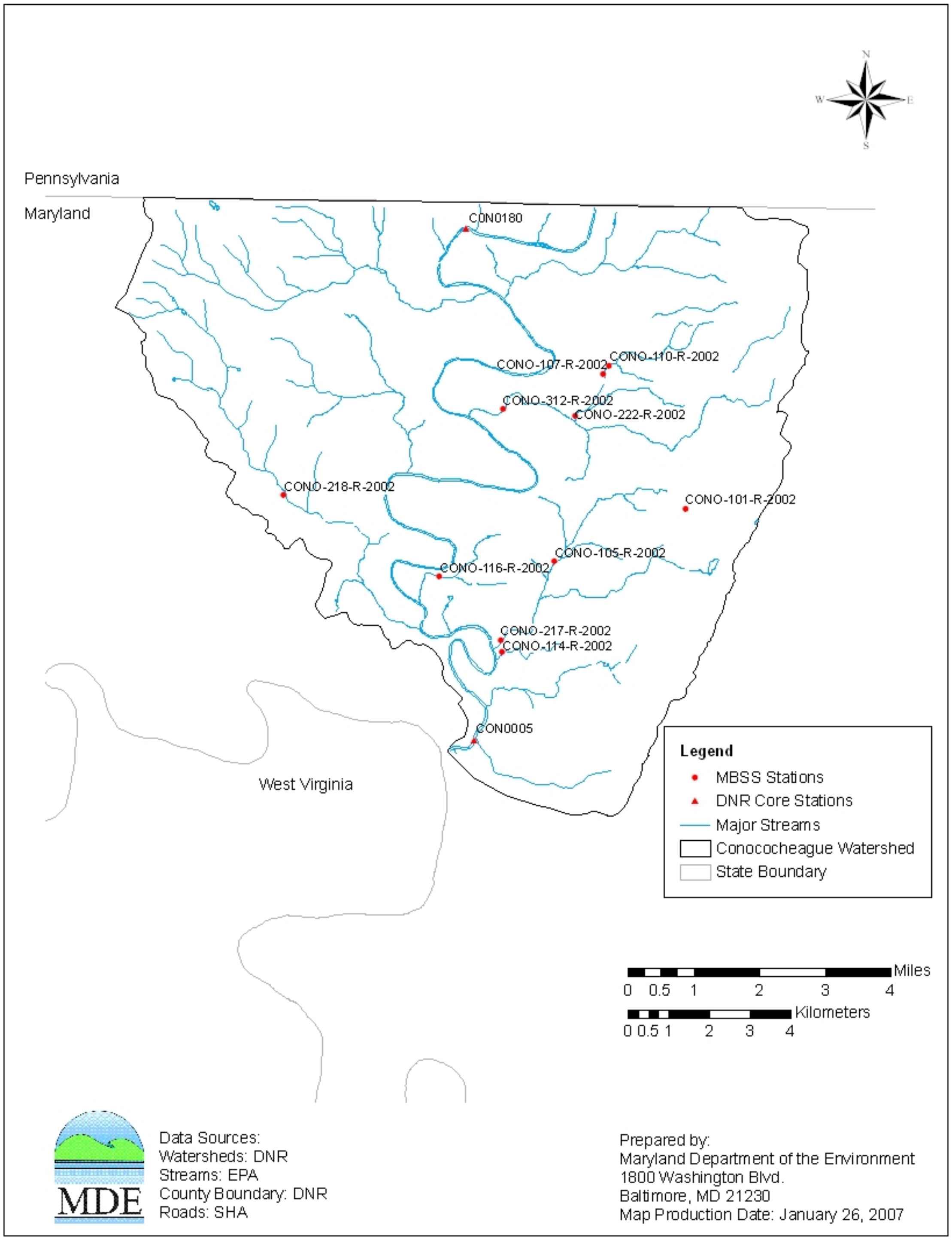



**Figure 4: Monitoring Stations in the MD 8-Digit Conococheague Creek Watershed**

**Table 5: Monitoring Stations in the MD 8-digit Conococheague Creek Watershed**

| Site Number | Sponsor | Site Type | Site Name | Latitude (dec degrees) | Longitude (dec degrees) |
|---|---|---|---|---|---|
| CONO-101-R-2002 | MD DNR | MBSS | Conococheague Creek, unnamed tributary 2 | 39.65451 | -77.76195 |
| CONO-105-R-2002 | MD DNR | MBSS | Conococheague Creek, unnamed tributary 2 | 39.64265 | -77.79920 |
| CONO-107-R-2002 | MD DNR | MBSS | Troupe Run | 39.68421 | -77.78604 |
| CONO-110-R-2002 | MD DNR | MBSS | Troupe Run | 39.68604 | -77.78435 |
| CONO-114-R-2002 | MD DNR | MBSS | Conococheague Creek, unnamed tributary 1 | 39.62258 | -77.81407 |
| CONO-116-R-2002 | MD DNR | MBSS | Conococheague Creek, unnamed tributary 3 | 39.63905 | -77.83207 |
| CONO-217-R-2002 | MD DNR | MBSS | Conococheague Creek, unnamed tributary 2 | 39.62516 | -77.81458 |
| CONO-218-R-2002 | MD DNR | MBSS | Meadow Bridge | 39.65671 | -77.87679 |
| CONO-222-R-2002 | MD DNR | MBSS | Troupe Run | 39.67471 | -77.79390 |
| CONO-312-R-2002 | MD DNR | MBSS | Rush Run | 39.67610 | -77.81437 |
| CONO005 | MD DNR | Core | Williamsport – Rte 68 | 39.603056 | -77.821944 |
| CONO180 | MD DNR | Trend | Fairview Road | 39.715833 | -77.825278 |

**MD 8-digit Conococheague Creek MBSS Monitoring Stations**

The MBSS program monitored 10 locations in the MD 8-digit Conococheague Creek watershed in 2002 (see Figure 4 and Table 5). The MBSS parameters recommended from the stressor identification model for determining a sediment stressor were: percent embeddedness, epifaunal substrate score, instream habitat score, bank stability index, and number of benthic tolerant species. These specific parameters were chosen based on their ecological and statistical significance (Southerland et al. 2007) as well as their linkage to increased terrestrial and/or instream erosion. High percent embeddedness indicates that fine particulates are filling the spaces between cobbles, thus covering habitat and limiting food supply. Low epifaunal substrate is an indication of either stream erosion or excess deposition limiting the quality of the streambed to support a benthic community. Decreased instream habitat is an indication of potential erosion removing woody debris and is primarily linked with the Fish Index of Biotic Integrity (FIBI). Bank stability index is a composite score that indicates the lack of channel erosion, based on the presence or absence of riparian vegetation and other stabilizing bank materials. The number of benthic tolerant species is an indicator of frequent stream scouring, which prevents more sensitive species from colonizing the streambed.

Observed values of the above parameters, along with Benthic Index of Biotic Integrity (BIBI) and FIBI scores, are presented in Table 6.

**Table 6: MD 8-digit Conococheague Creek MBSS Data**

| Site | FIBI | BIBI | Epifaunal Substrate | Percent Embeddedness | Instream Habitat | Bank Stability Index | Benthic Tolerant Species |
|---|---|---|---|---|---|---|---|
| CONO-101-R-2002 | 1.00 | 1.50 | 5 | 55 | 11 | 20.00 | 7.00 |
| CONO-105-R-2002 | 1.00 | 1.50 | 4 | 75 | 6 | 20.00 | 6.25 |
| CONO-107-R-2002 | 2.00 | 1.25 | 3 | 85 | 12 | 18.67 | 6.17 |
| CONO-110-R-2002 | 2.00 | 1.50 | 3 | 80 | 8 | 18.87 | 5.50 |
| CONO-114-R-2002 | 4.33 | 1.75 | 10 | 75 | 15 | 19.13 | 5.63 |
| CONO-116-R-2002 | 1.00 | 3.25 | 12 | 20 | 3 | 20.00 | 6.10 |
| CONO-217-R-2002 | 4.33 | 2.50 | 10 | 80 | 12 | 20.00 | 6.00 |
| CONO-218-R-2002 | 1.00 | 2.00 | 1 | 90 | 2 | 11.07 | 6.55 |
| CONO-222-R-2002 | 4.00 | 3.00 | 5 | 65 | 9 | 8.17 | 6.72 |
| CONO-312-R-2002 | 4.67 | 2.25 | 7 | 30 | 16 | 20.00 | 5.40 |

## MD 8-digit Conococheague Creek Core Monitoring Stations

Additional data for the MD 8-digit Conococheague Creek watershed was obtained from the Maryland Department of Natural Resources (DNR) Core/Trend Program. The program collected benthic macroinvertebrate data between 1976 and 2006. This data was used to calculate four benthic community measures: total number of taxa, the Shannon-Weiner diversity index, the modified Hilsenhoff biotic index, and percent Ephemeroptera, Plecoptera, and Trichoptera (EPT). DNR has extensive monitoring information for two stations in the mainstem of the MD 8-digit Conococheague Creek through the Core/Trend Program. The stations are located near Williamsport-Rte 68 (CONO005) and Fairview Road (CONO180) (see Table 5 and Figure 4). These stations have between 21 and 28 years of benthic macroinvertebrate data (DNR 2007a). A summary of the results for each of the stations is presented in Table 7.

**Table 7: MD 8-digit Conococheague Creek DNR Core/Trend Data**

| Site Number | Current Water Quality Status | Trend Since 1970's |
|---|---|---|
| CONO005 | Good | No change |
| CONO180 | Good | No change |

## 2.4 Water Quality Impairment

The Maryland water quality standards surface water use designation for the MD 8-digit Conococheague Creek mainstem and its tributaries is Use IV-P (Recreational Trout Waters and Public Water Supply) (COMAR 2007a,b). The water quality impairment of the MD 8-digit Conococheague Creek watershed addressed by this TMDL is caused by an elevated sediment load beyond a level that is supportive of aquatic health, where aquatic health is evaluated based on BIBI and FIBI scores (BIBI and FIBI ≥ 3).

To determine whether aquatic health is impacted by elevated sediment loads, a weight-of-evidence stressor identification approach was used. This approach applies a composite stressor indicator, defined as the *sediment stream disturbance index*. Similar to the Index of Biotic Integrity, the SSDI is based on a comparison of specific watershed parameters with those from streams with a healthy aquatic community (i.e., reference watersheds) and is scored separately for the benthic and fish communities. The benthic SSDI includes benthic tolerant species, percent embeddedness, epifaunal substrate condition, and bank stability index. The fish SSDI includes embeddedness, epifaunal substrate, and instream habitat condition. Watershed specific SSDI values indicate whether sediment is one of the stressors affecting the biological community.

The SSDI is developed by scoring each parameter result (see Section 2.3) and then calculating the average of the scores to form an index value. Each parameter result is scored a value of 1, 3, or 5, depending on whether the parameter value at a site approximates (5), deviates slightly from (3), or deviates greatly from (1) conditions at reference sites (Karr et al. 1986). This discrete scoring approach was based on Maryland's IBI methodology, so that a direct comparison could be made between the SSDI and the IBI thresholds. Per Maryland's biocriteria, FIBI and BIBI scores less than 3 are indicative of water quality conditions that are not protective of aquatic life (Roth et al. 1998, 2000; Stribling et al. 1998). Similarly, an SSDI score less than 3 provides evidence of a sediment stressor or sediment impact to the aquatic community. An SSDI score greater than 3 indicates that there is no evidence of an adverse sediment impact to the aquatic community.

The threshold values for each selected parameter were established based on how they compared to the values observed at the reference sites (i.e., sites with FIBI & BIBI>3.0). For parameters expected to decrease with degradation, values below the $10^{th}$ percentile were scored as 1. Values between the $10^{th}$ and $50^{th}$ percentiles were scored as 3. Values above the $50^{th}$ percentile were scored as 5. Scoring was reversed for metrics expected to increase with degradation (i.e., values below the $50^{th}$ percentile were scored as 5, and values above the $90^{th}$ percentile were scored as 1). In this method, both the upper and lower thresholds are independently derived from the distribution of reference site values. This approach is based on the assumption that in Maryland, and most other states, even reference sites are expected to have some degree of anthropogenic impact (Southerland et al. 2005). Thresholds used for scoring the SSDI are summarized in Table 8. Further details are found in Appendix A.

**Table 8: Sediment Stream Disturbance Index Scoring**

| Parameter | Score | | |
|---|---|---|---|
| | 1 | 3 | 5 |
| Benthic Tolerant Species Limits | x ≥ 5.3 | 5.3 > x ≥ 4.2 | x <4.2 |
| Bank Stability Index Limits | x < 12 | 12 ≤ x < 19 | x ≥ 19 |
| Embeddedness Limits | x > 40 | 40 ≥ x > 25 | x ≤ 25 |
| Epifaunal Substrate Limits | x < 10 | 10 ≤ x < 15 | x ≥ 15 |
| Instream Habitat Condition Limits | x < 10 | 10 ≤ x < 16 | x ≥ 16 |

The MD 8-digit Conococheague Creek watershed average BIBIs, FIBIs, and corresponding SSDIs are listed in Table 9. The BIBIs and FIBIs indicate that the watershed is exhibiting a negative deviation from reference conditions. Both the benthic and fish based SSDIs indicate that sediment is a stressor to the aquatic community. Therefore, it is concluded that a sediment TMDL is required.

**Table 9: MD 8-digit Conococheague Creek Watershed IBI and SSDI Scores**

| SITE | BIBI | Benthic SSDI | FIBI | Fish SSDI |
|---|---|---|---|---|
| CONO-101-R-2002 | 1.50 | 2.00 | 1.00 | 1.67 |
| CONO-105-R-2002 | 1.50 | 2.00 | 1.00 | 1.00 |
| CONO-107-R-2002 | 1.25 | 1.50 | 2.00 | 1.67 |
| CONO-110-R-2002 | 1.50 | 1.50 | 2.00 | 1.00 |
| CONO-114-R-2002 | 1.75 | 2.50 | 4.33 | 2.33 |
| CONO-116-R-2002 | 3.25 | 3.50 | 1.00 | 3.00 |
| CONO-217-R-2002 | 2.50 | 2.50 | 4.33 | 2.33 |
| CONO-218-R-2002 | 2.00 | 1.00 | 1.00 | 1.00 |
| CONO-222-R-2002 | 3.00 | 1.00 | 4.00 | 1.00 |
| CONO-312-R-2002 | 2.25 | 2.50 | 4.67 | 3.00 |
| **Average** | **2.05 ± 0.36** | **2.00 ± 0.41** | **2.53 ± 0.83** | **1.80 ± 0.43** |

Biological results from both of the DNR Core/Trend stations along the mainstem of the MD 8-digit Conococheague Creek indicate that mainstem water quality can be classified as good. Statistical analysis of the long-term Core/Trend data indicates that since 1976 there has been no noticeable trend in the water quality of the Conococheague Creek mainstem (DNR 2007a).

Since biological monitoring results from the DNR Core/Trend stations on the Conococheague Creek mainstem indicate good conditions, it is concluded that sediment loads located upstream of station CON0180, are not impacting water quality in the MD 8-

digit Conococheague Creek mainstem. Thus, MDE concludes that the sediment impairment is within the lower order (smaller) streams in the Maryland portion of the watershed, extending up to station CON0180, and is subsequently dividing the watershed into two TMDL segments. TMDL Segment 1, upstream of CON0180, is not impaired but will receive an informational allocation based on current conditions. TMDL Segment 2, downstream of CON0180, will require a TMDL and a reduction in sediment loads to correct the impairment.

## 3.0 TARGETED WATER QUALITY GOAL

The objective of the sediment TMDL established herein is to reduce sediment loads, and subsequent effects on aquatic health, in the MD 8-digit Conococheague Creek watershed to levels that support the Use IV-P designation (Recreational Trout Waters and Public Water Supply)(COMAR 2007a,b). Assessment of aquatic health is based on Maryland's biocriteria protocol, which evaluates both the amount and diversity of the benthic and fish community through the use of the IBI (Roth et al. 1998, 2000; Stribling et al. 1998).

Reductions of sediment loads are expected to result from decreased watershed and streambed erosion, which will then lead to improved benthic and fish habitat conditions. Specifically, sediment load reductions are expected to result in an increase in the number of benthic sensitive species present, an increase in the available and suitable habitat for a benthic community, a possible decrease in fine sediment (fines), and improved stream habitat diversity, all of which will result in improved water quality.

# 4.0 TOTAL MAXIMUM DAILY LOADS AND SOURCE ALLOCATION

## 4.1 Overview

This section describes how the sediment TMDL and the corresponding allocations were developed for the MD 8-digit Conococheague Creek. Section 4.2 describes the analysis framework for estimating sediment loading rates and the assimilative capacity of the watershed stream system. Section 4.3 summarizes the scenarios that were used in the analysis and presents results. Section 4.4 discusses critical conditions and seasonality. Section 4.5 explains the calculations of TMDL loading caps. Section 4.6 details the load allocations, and Section 4.7 explains the rationale for the margin of safety. Finally, Section 4.8 summarizes the TMDL.

## 4.2 Analysis Framework

The stressor identification methodology (see Section 2.3) identifies the most direct measure of sediment pollutant loading as water column TSS concentrations. Elevated TSS loads are linked with negative sediment impacts to stream geomorphology and aquatic health. Since a TSS numeric criterion is not available, a reference watershed approach will be used to establish the TMDL.

**Watershed Model**

The watershed model framework chosen for the MD 8-digit Conococheague Creek TMDL was the CBP P5 long-term average annual watershed model EOS loading rates. The spatial domain of the CBP P5 watershed model segmentation aggregates to the Maryland 8-digit watersheds, which is consistent with the impairment listing. The EOS loading rates were used because actual time variable CBP P5 calibration and scenario runs are currently being developed and are not yet available. These target-loading rates are used to calibrate the land use EOS loads within the CBP P5 model and thus should be consistent with future CBP modeling efforts.

The nonpoint source and NPDES stormwater baseline sediment loads generated within the MD 8-digit Conococheague Creek are calculated as the sum of corresponding land use EOS loads within the watershed and represent a long-term average loading rate. Individual land use EOS loads are calculated as a product of the land use area, land use target loading rate, and loss from the EOF to the main channel. The loss from the EOF to the main channel is the *sediment delivery ratio* and is defined as the ratio of the sediment load reaching a basin outlet to the total erosion within the basin. A *sediment delivery ratio* is estimated for each land use type based on the proximity of the land use to the main channel. Thus, as the distance to the main channel increases, more sediment is stored within the channels (i.e., *sediment delivery ratio* decreases). Details of the data sources for the unit loading rates can be found in Section 2.2 of this report.

The MD 8-digit Conococheague Creek watershed was evaluated using two TMDL segments, both of which include loads from Maryland and Pennsylvania (see Figure 5). TMDL Segment 1 represents the sediment loads transported from Pennsylvania to the Maryland state line via the Conococheague Creek mainstem and also includes a small area within the Maryland portion of the watershed. TMDL Segment 2 represents the sediment loads generated in Maryland and also includes the sediment loads from two small areas of Pennsylvania that flow into Maryland in the Northwest and Northeast portions of the watershed. Based on the analysis in Section 2.4, TMDL Segment 1 of the watershed is not impaired, but to protect downstream water quality will be given an informational allocation equivalent to its current baseline loads. TMDL Segment 2 will require a reduction in sediment loads.

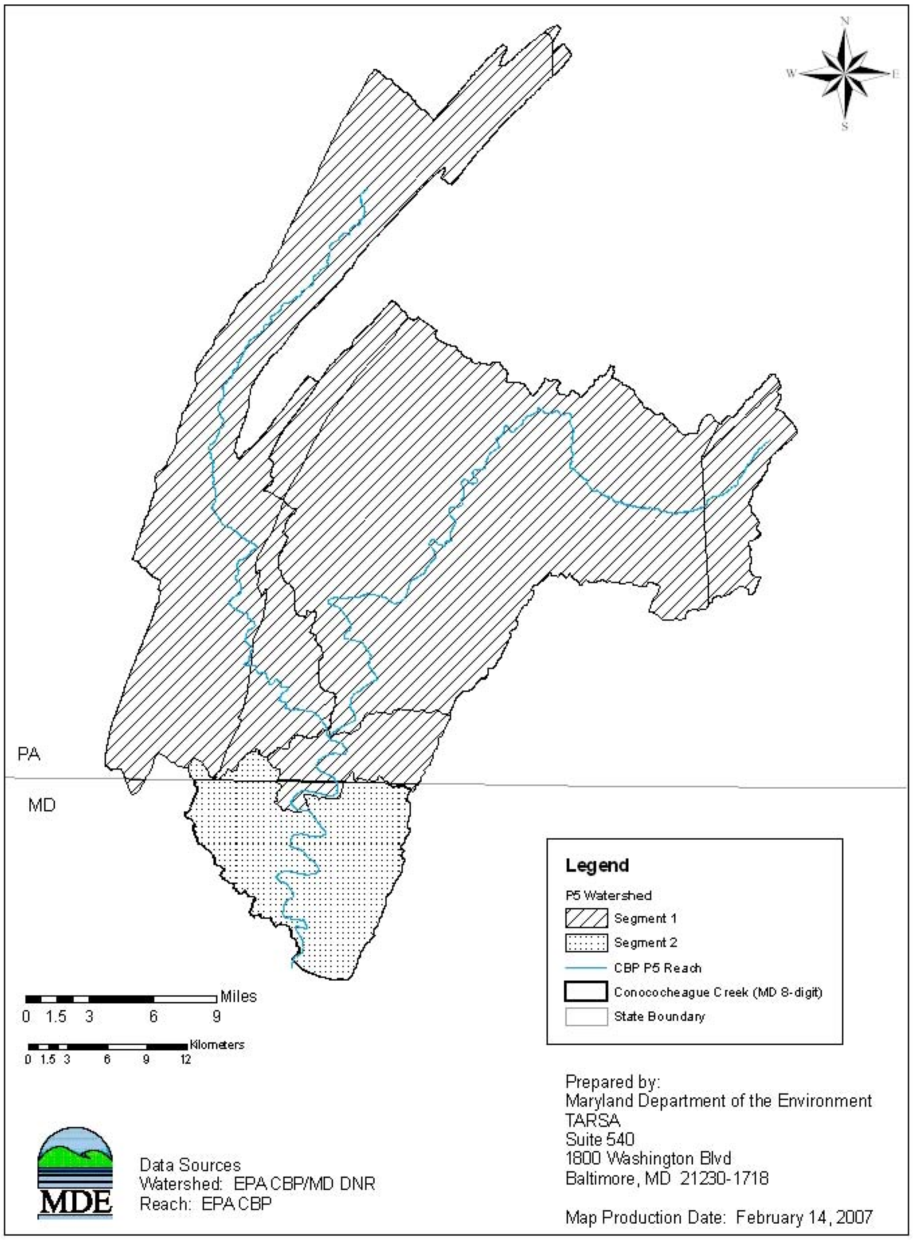



**Figure 5: Conococheague Creek Watershed Segmentation**

## Reference Watershed Approach

Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic health of non-tidal stream systems. Therefore, in order to quantify the impact of sediment on the aquatic health of non-tidal stream systems, a reference watershed TMDL approach was used and resulted in the establishment of a *sediment-loading threshold* for watersheds within the Highland and Piedmont physiographic regions (Currey et al. 2006). In summary, reference watersheds were determined based on the BIBI/FIBI average watershed scores significantly greater than 3.0 (based on a scale of 1 to 5). A threshold of 3.0 was selected because this is the level indicative of satisfactory water quality per Maryland's biocriteria (Roth et al. 1998, 2000; Stribling et al. 1998). In determining if the average watershed score is significantly greater than 3.0, a 90% confidence interval was calculated for each watershed based on the individual MBSS sampling results.

Comparison of watershed sediment loads to loads from reference watersheds requires that the watersheds be similar in physical and hydrological characteristics. To satisfy this requirement, Currey et al. (2006) selected reference watersheds only from the Highland and Piedmont physiographic regions (see appendix A for the list of reference watersheds). This region is consistent with the non-coastal region that was identified in the 1998 development of FIBI and subsequently used in the development of BIBI (Roth et al. 1998; Stribling et al. 1998).

To reduce the effect of the variability within the Highland and Piedmont physiographic regions, the watershed sediment loads were then normalized by a constant background condition, the all forested watershed condition. This new normalized term, defined as the *forest normalized sediment load* ($Y_n$), represents how many times greater the current watershed sediment load is than the *all forested sediment load*. A similar approach was used by EPA Region 9 for sediment TMDLs in California (e.g., Navarro River or Trinity River TMDLs), where the loading capacity was based on an analysis of the amount of human-caused sediment delivery that can occur in addition to natural sediment delivery, without causing adverse impacts to aquatic life. The *forest normalized sediment load* for this TMDL is calculated as the current watershed sediment load divided by the *all forested sediment load*. The equation for the *forest normalized sediment load* is as follows:

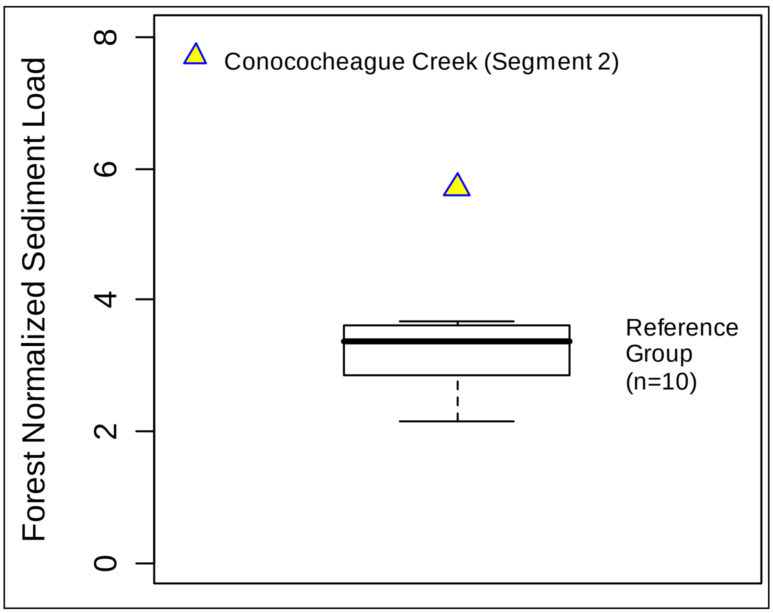
$$Y_n = \frac{y_{ws}}{y_{for}} \tag{4.1}$$

where:

$Y_n$ = forest normalized sediment load
$y_{ws}$ = current watershed sediment load (ton/yr)
$y_{for}$ = all forested sediment load (ton/yr)

An average *sediment loading threshold* of approximately 3.6 was established in Currey et al. (2006) with an 80% confidence interval ranging from 3.3 to 4.1. The lower confidence interval of 3.3, which also represents the median value of the reference watersheds, was chosen as an environmentally conservative approach to develop this TMDL (see Appendix A for more details).

A comparison of the Conococheague Creek watershed *forest normalized sediment load* to the *forest normalized reference sediment load* (also referred to as the *sediment loading threshold*) is shown in Figure 6. The comparison was only completed for TMDL Segment 2 because TMDL Segment 1 has been previously identified as not impaired. As seen in Figure 6, the TMDL Segment 2 *forest normalized sediment load* exceeds the *sediment loading threshold*, indicating that it is receiving loads that are above the maximum allowable load that the watershed can sustain and still meet water quality standards.




**Note**: The *forest normalized sediment load* is unitless and represents how many times greater the current watershed sediment load is than the *all forested sediment load.*

**Figure 6: Conococheague Creek (TMDL Segment 2) Forest Normalized Sediment Load Compared to Reference Watershed Group**

### 4.3 Scenario Descriptions and Results

The following analyses allow a comparison of baseline conditions (under which water quality problems exist) with future conditions, which project the water quality response to various simulated sediment load reductions. The analyses are grouped according to baseline conditions and future conditions associated with TMDLs. Sediment loads are calculated for TMDL segment 1 and TMDL segment 2 separately.

**Baseline Conditions**

The baseline conditions are intended to provide a point of reference by which to compare the future scenario that simulates conditions of a TMDL. The baseline conditions typically reflect an approximation of nonpoint and upstream source loads during the monitoring time frame, as well as estimated point source loads based on discharge data for the same period.

The Conococheague Creek watershed baseline sediment loads are estimated using the CBP P5 target EOS land use sediment loading rates with the CBP P5 2000 land use. Watershed loading calculations, based on the CBP P5 segmentation scheme, are represented by multiple CBP P5 model segments within each TMDL analysis segment. The TSS loads from these segments are combined to represent the baseline condition. The Maryland point source sediment loads are estimated based on the existing permit information. Details of these loading source estimates can be found in Section 2.2, Section 4.6, and Appendix B of this report.

**Future (TMDL) Conditions**

This scenario represents the future conditions of maximum allowable sediment loads that will support a healthy biological community. In the TMDL calculation, the allowable load for the impaired watershed is calculated as the product of the *sediment loading threshold* (determined from watersheds with a healthy benthic community) and the Conococheague Creek *all forested sediment load* (see Section 4.3). The resulting load is considered the maximum allowable load the watershed can receive and still meet water quality standards.

The TMDL loading and associated reductions are first estimated at the model segment scale (see Figure 5) and then partitioned at the Maryland 8-digit watershed scale, which is consistent with the original listing scale. It is important to recognize that some subwatersheds may require higher reductions than others, depending on the distribution of the land use.

The formula for estimating the TMDL is as follows:

$$TMDL = \sum_{i=1}^{n} Yn_{ref} \cdot y_{forest_i} \qquad (4.2)$$

where
TMDL = allowable load for impaired watershed (ton/yr)
$Yn_{ref}$ = sediment loading threshold = forest normalized reference sediment load (3.3)
$y_{forest_i}$ = all forested sediment load for segment *i* (ton /yr)
*i* = CBP P5 model segment
*n* = number of CBP P5 model segments in watershed

The allocation for the Conococheague Creek TMDL Segment 1 is equivalent to its baseline load because it was identified as not impaired. The allocation for the Conococheague Creek TMDL Segment 2 is estimated using equation 4.2.

### 4.4 Critical Condition and Seasonality

EPA's regulations require TMDLs to take into account seasonality and critical conditions for stream flow, loading, and water quality parameters (CFR 2007b). The intent of this requirement is to ensure that the water quality of the waterbody is protected during times when it is most vulnerable. The biological monitoring data used to determine the reference watersheds integrates the stress effects over the course of time and thus inherently addresses critical conditions. Seasonality is captured in two components. First, it is implicitly included in biological sampling. Second, the MBSS dataset included benthic sampling in the spring and fish sampling in the summer.

### 4.5 TMDL Loading Caps

This section presents the average annual MD 8-digit Conococheague Creek watershed TMDL of TSS. This load is considered the maximum allowable long-term average annual load the watershed can receive and still meet water quality standards.

TMDL allocations were developed for TMDL Segments 1 and 2 independently. The TMDL Segment 1 allocation is equivalent to its baseline conditions and is considered informational since no Maryland water quality impact from sediment was identified. As described in Section 2.4, the DNR Core/Trend monitoring data demonstrates that the MD 8-digit Conococheague Creek mainstem exhibits good aquatic health conditions. Based on this information, it was concluded that loads from TMDL Segment 1 do not have a negative impact on the aquatic health of the MD 8-digit Conococheague Creek mainstem.

The TMDL Segment 2 allocation was based on equation 4.2 and set at a load 3.3 times the all forested condition. A constant reduction was estimated for the predominant controllable sources (i.e., significant contributors of sediment to the stream system) in TMDL Segment 2, independent of jurisdiction. If only these predominant (generally the largest) sources are controlled, water quality standards can be achieved in the most effective, efficient, and equitable manner. Predominant sources typically include urban land, high till crops, low till crops, hay, pasture, and harvested forest, but additional sources might need to be controlled in order to ensure that the water quality standards are attained.

The MD 8-digit Conococheague Creek Baseline Load and TMDL are presented in Table 10.

**Table 10: MD 8-digit Conococheague Creek Baseline Load and TMDL**

| | Baseline Load (ton/yr) | TMDL (ton/yr) | Reduction (%) |
|---|---|---|---|
| **TMDL Segment 1** [1] | 86,815.0 | 86,815.0 | 0.0 |
| **TMDL Segment 2** | 13,795.3 | 7,819.7 | 43.3 |
| **Total** | 100,610.3 | 94,634.7 | 5.9 |

**Note**: [1] The allocation presented for TMDL Segment 1 is informational only. It is equivalent to the current baseline load of the segment.

### 4.6 Load Allocations Between Point and Nonpoint Sources

The allocations described in this section summarize a TMDL of TSS established to meet the water quality standards in the MD 8-digit Conococheague Creek watershed. Per EPA regulation, all TMDLs need to be presented as a sum of waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint source loads generated within the assessment unit, as well as natural background, tributary, and adjacent segment loads (CFR 2007a). Consequently, the MD 8-digit Conococheague Creek TMDL allocations are presented in terms of WLAs (i.e., point source loads identified within the assessment unit) and LAs (i.e., the assessment unit's nonpoint source loads and loads entering the watershed from outside of the assessment unit boundary). The State reserves the right to revise these allocations provided the revisions are consistent with achieving water quality standards.

As described in Section 4.5, a constant reduction was applied to the predominant controllable sources in TMDL Segment 2, independent of jurisdiction. In this watershed, crop, pasture, and urban land were identified as the predominant controllable sources. Forest is the only non-controllable source, as it represents the most natural condition in the watershed. No reductions were applied to permitted process load sources because at 0.19% of the total load, such controls would produce no discernable water quality benefit.

Table 11 summarizes the TMDL reductions derived by applying the reduction equally to the predominant controllable sediment sources within TMDL Segment 2. The source categories in Table 11 represent aggregates of multiple sources (e.g., crop source is an aggregate of high till, low till, hay, animal feeding operations, and nursery sources). The TMDL results in a 39.4% reduction for the MD 8-digit Conococheague Creek Watershed

Contribution, a 0.3% reduction from the Pennsylvania Upstream Baseline Load, and a total 5.9% reduction for the entire Conococheague Creek watershed.

**Table 11: MD 8-digit Conococheague Creek TMDL Reductions by Source Category**

| | Baseline Load Source Categories | | Baseline Load (ton/yr) | TMDL Components | TMDL (ton/yr) | Reduction (%) |
|---|---|---|---|---|---|---|
| MD 8-digit Conococheague Creek Watershed Contribution | Nonpoint Source | Crop | 8,430.4 | LA | 4,944.1 | 41.3 |
| | | Extractive | 248.3 | | 248.3 | 0.0 |
| | | Forest | 506.6 | | 506.6 | 0.0 |
| | | Pasture | 1,413.9 | | 868.4 | 38.6 |
| | Point Source | Urban | 3,670.2 | WLA | 2,008.1 | 45.3 |
| | | Permits | 188.3 | | 188.3 | 0.0 |
| **Sub-total** | | | **14,457.8** | | **8763.8** | **39.4** |
| Upstream | Pennsylvania | | 86,152.5 | Upstream LA | 85,870.9 | 0.3 |
| **Total** | | | **100,610.3** | | **94,634.7** | **5.9** |

**Note:** [1] Biological results from the DNR Core/Trend stations along the mainstem of the MD 8-digit Conococheague Creek indicate that mainstem water quality can be classified as good. Based on this information, MDE concluded that the sediment impairment in the Maryland portion of the Conococheague Creek watershed is restricted to the lower order streams within Segment 2 of the watershed. Consequently, sediment reductions have been applied to the loads transported via the lower order stream network within Segment 2 (located mostly in Maryland) and not the loads transported via the main channel from Segment 1 (located mostly in Pennsylvania).

The WLA generated within the MD 8-digit Conococheague Creek watershed is allocated to two permitted source categories, Process Water WLA and Stormwater WLA. The categories are described below.

Process Water WLA

Process Water permits with specific TSS limits and corresponding flow information are assigned to the WLA. In this case, detailed information is available to accurately estimate the WLA. If specific TSS limits are not explicitly stated in the process water permit, then TSS loads are expected to be *de minimis*. If loads are *de minimis*, then they pose little or no risk to the aquatic environment and are not a significant source.

Process water permits with specific TSS limits include:

- Individual municipal facilities,
- General mineral mining facilities.

There are 5 process water sources with explicit TSS limits (see Appendix B), which include 3 municipal sources and 2 mineral mines. The total estimated TSS load from all of the process water sources is based on current permit limits and is equal to 188.3 ton/yr. As mentioned above, no reductions were applied to this source because at 0.19% of the total load, such controls would produce no discernable water quality benefit.

NPDES Stormwater WLA

Per EPA requirements, "stormwater discharges that are regulated under Phase I or Phase II of the NPDES stormwater program are point sources that must be included in the WLA portion of a TMDL" (US EPA 2002). Phase I and II permits can include the following types of discharges:

- Small, medium, and large MS4s – these can be owned by local jurisdictions, municipalities, and state and federal entities e.g., departments of transportation, hospitals, military bases),
- General industrial stormwater permitted facilities, and
- Small and large construction sites.

EPA recognizes that available data and information are usually not detailed enough to determine WLAs for NPDES regulated stormwater discharges on an outfall-specific basis (US EPA 2002). Therefore, NPDES regulated stormwater loads within the MD 8-digit Conococheague Creek watershed will be expressed as a single NPDES stormwater WLA. Upon approval of the TMDL, "NPDES-regulated municipal stormwater and small construction storm water discharge effluent limits should be expressed as BMPs or other similar requirements, rather than as numeric effluent limits" (US EPA 2002).

The Conococheague Creek NPDES stormwater WLA is based on reductions applied to the sediment load from the urban land use of the watershed and may include legacy or other sediment sources. Some of these sources may also be subject to controls from other management programs. The Conococheague Creek NPDES stormwater WLA requires an overall reduction of 45.3% (see Table 11).

As stormwater assessment and/or other program monitoring efforts result in a more refined source assessment, MDE reserves the right to revise the current NPDES stormwater WLA provided the revisions are consistent with achieving water quality standards.

For more information on all methods used to calculate the baseline urban sediment load, see Section 2.2.2. Additionally, Appendix B provides a detailed summary of point source allocations.

### 4.7 Margin of Safety

All TMDLs must include a margin of safety to account for any lack of knowledge and uncertainty concerning the relationship between loads and water quality (CFR 2007b). It is proposed that the estimated variability around the reference watershed group used in this analysis already accounts for such uncertainty. Analysis of the reference group *forest normalized sediment loads* indicates that approximately 75% of the reference watersheds have a value of less than 3.6, consistent with the recommended value reported by Currey et al. (2006). Also, 50% of the reference watersheds have a value less than 3.3, consistent with the lower confidence interval value reported in Currey et al. (2006). Based on this analysis, the *forest normalized reference sediment load* (also referred to as the *sediment loading threshold*) was set at the median value of 3.3. This is considered an environmentally conservative estimate, since 50% of the reference watersheds have a load above this value, which when compared to the 75% value, results in an implicit margin of safety of approximately 8%.

### 4.8 Summary of Total Maximum Daily Loads

The average annual MD 8-digit Conococheague Creek TMDL is summarized in Table 12. The TMDL is the sum of the LAs, NPDES Stormwater WLA, Process Water WLA, and MOS. The LAs include nonpoint source loads generated within the MD 8-digit Conococheague Creek watershed and loads from upstream sources. The Maximum Daily Load (MDL) is summarized in Table 13 (see Appendix C for more details).

**Table 12: Average Annual MD 8-digit Conococheague Creek TMDL of Sediment/TSS (ton/yr)**

| TMDL (ton/yr) | = | LA | | | + | WLA | | | + | MOS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $LA_{PA}$[1] | + | $LA_{CC}$ | | NPDES Stormwater $WLA_{CC}$ | + | Process Water $WLA_{CC}$ | | |
| 94,634.7 | = | 85,870.9 | + | 6,567.4 | + | 2,008.1 | + | 188.3 | + | Implicit |

Upstream Load Allocation[2,3] (85,870.9); MD 8-digit Conococheague Creek Watershed TMDL Contribution (6,567.4 through 188.3)

**Note:**[1] $LA_{PA}$ was determined to be necessary in order to meet Maryland water quality standards within the MD 8-digit Conococheague Creek watershed.

[2] Although for the purpose of this analysis the upstream load is referred to as an LA, it could include loads from point and nonpoint sources.

[3] A delivery factor of 1 was used for the Upstream Load Allocation.

**Table 13: MD 8-digit Conococheague Creek Maximum Daily Load of Sediment/TSS (ton/day)**

| MDL (ton/day) | = | Max. Daily LA | | | + | Max. Daily WLA | | | + | MOS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $LA_{PA}$[1] | + | $LA_{CC}$ | | NPDES Stormwater $WLA_{CC}$ | + | Process Water $WLA_{CC}$ | | |
| 3,496.1 | | 3,177.2 | | 243.0 | | 74.3 | | 1.6 | + | Implicit |

Upstream MDL[2,3] (3,177.2); MD 8-digit Conococheague Creek Watershed MDL Contribution (243.0 + 74.3 + 1.6)

**Notes:**[1] $LA_{PA}$ was determined to be necessary in order to meet Maryland water quality standards within the MD 8-digit Conococheague Creek watershed.

[2] Although for the purpose of this analysis the upstream load is referred to as an LA, it could include loads from point and nonpoint sources.

[3] A delivery factor of 1 was used for the Upstream Load Allocation**.**

## 5.0 ASSURANCE OF IMPLEMENTATION

This section provides the basis for reasonable assurances that the sediment TMDL will be achieved and maintained. Section 303(d) of the Clean Water Act and current EPA regulations require reasonable assurance that the TMDL load and wasteload allocations can and will be implemented (CFR 2007b). Maryland has several well-established programs to draw upon, including the Water Quality Improvement Act of 1998 (WQIA) and the Federal Nonpoint Source Management Program (§ 319 of the Clean Water Act).

Potential funding sources for implementation include the Buffer Incentive Program (BIP) and the Maryland Agriculture water quality cost share program (MACS). Other funding available for local governments includes the State Water Quality Revolving Loan Fund and the Stormwater Pollution Cost Share Program. Details of these programs and additional funding sources can be found at:
http://www.dnr.state.md.us/bay/services/summaries.html.

Potential best management practices for reducing sediment loads and resulting impacts can be grouped into three general categories. The first is directed toward agricultural lands, the second to urban (developed) land, and the third applies to all land uses.

In agricultural areas comprehensive soil conservation plans can be developed that meet criteria of the USDA-NRCS Field Office Technical Guide (USDA 1983). Soil conservation plans help control erosion by modifying cultural practices or structural practices. Cultural practices may change from year to year and include changes to crop rotations, tillage practices, or use of cover crops. Structural practices are long-term measures that include, but are not limited to, the installation of grass waterways (in areas with concentrated flow), terraces, diversions, sediment basins, or drop structures. The reduction percentage attributed to cultural practices is determined based on changes in land use, while structural practices have a reduction percentage of up to 25%. In addition, livestock can be controlled via stream fencing and rotational grazing. Sediment reduction efficiencies of methods applicable to pasture land use range from 40% to 75% (US EPA 2004).

Sediment from urban areas can be reduced by stormwater retrofits, impervious surface reduction, and stream restoration. Stormwater retrofits include modification of existing stormwater structural practices to address water quality. Reductions range from as low as 10% for dry detention to approximately 80% for wet ponds, wetlands, infiltration practices, and filtering practices. Impervious surface reduction results in a change in hydrology that could reduce stream erosion (US EPA 2003).

All non-forested land uses can benefit from improved riparian buffer systems. A riparian buffer reduces the effects of upland sediment sources through trapping and filtering. Riparian buffer efficiencies vary depending on type (grass or forested), land use (urban or agriculture), and physiographic region. The CBP estimates riparian buffer sediment reduction efficiencies in the Conococheague Creek region to be approximately 50% (US EPA 2006).

While a portion of sediment loads that contribute to the MD 8-digit Conococheague Creek impairment originate in the Pennsylvania portion of the watershed, implementation actions in this area of the watershed are beyond the jurisdictional and regulatory authority of the Maryland Department of the Environment. MDE looks forward to working with the Commonwealth of Pennsylvania and the EPA to ensure that the Upstream Load Allocations presented in this document are achieved to meet Maryland's downstream water quality standards.

In summary, through the use of the aforementioned funding mechanisms and best management practices and assuming the cooperation of upstream jurisdictions, there is reasonable assurance that this TMDL can be implemented.

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## APPENDIX A – Watershed Characterization Data

### Table A-1: Reference Watersheds

| MD 8-digit Name[1] | MD 8-digit | FIBI n | BIBI n | FIBI[4] | BIBI | Forest Normalized[2] Sediment Load |
|---|---|---|---|---|---|---|
| Deer Creek | 02120202 | 28 | 28 | Ind. | Pass | 3.63 |
| Broad Creek | 02120205 | 10 | 10 | Ind. | Pass | 3.67 |
| Little Gunpowder Falls | 02130804 | 19 | 20 | Ind. | Pass | 3.26 |
| Prettyboy Reservoir | 02130806 | 11 | 11 | Pass | Pass | 2.87 |
| Liberty Reservoir | 02130907 | 31 | 31 | Pass | Pass | 3.28 |
| S Branch Patapsco | 02130908 | 10 | 10 | Pass | Pass | 3.57 |
| Rocky Gorge Dam | 02131107 | 10 | 10 | Pass | Pass | 3.43 |
| Brighton Dam | 02131108 | 11 | 11 | Ind. | Pass | 3.61 |
| Town Creek | 02140512 | 16 | 20 | Ind. | Pass | 2.17 |
| Savage River | 02141006 | 13 | 14 | Pass | Pass | 2.48 |
| | | | | | | |
| Median[3] | | | | | | 3.3 |
| 75th Percentile | | | | | | 3.6 |

**Notes:** 1 Potomac River Lower North Branch determined to be an outlier through statistical analysis and best professional judgment; Fifteen Mile Creek watershed was removed because the majority of the watershed is in Pennsylvania.

2 Forest normalized sediment loads based on Maryland watershed area only (consistent with MBSS random monitoring data).

3 Median rounded down (3.36 to 3.3) as conservative estimate.

4 Ind.= Indeterminate.

**Table A-2: Benthic SSDI Calculation**

| Site | Epifaunal Substrate | Percent embeddedness | Bank Stability Index | Benthic Tolerant Species | Benthic SSDI |
|---|---|---|---|---|---|
| CONO-101-R-2002 | 1 | 1 | 5 | 1 | 2.00 |
| CONO-105-R-2002 | 1 | 1 | 5 | 1 | 2.00 |
| CONO-107-R-2002 | 1 | 1 | 3 | 1 | 1.50 |
| CONO-110-R-2002 | 1 | 1 | 3 | 1 | 1.50 |
| CONO-114-R-2002 | 3 | 1 | 5 | 1 | 2.50 |
| CONO-116-R-2002 | 3 | 5 | 5 | 1 | 3.50 |
| CONO-217-R-2002 | 3 | 1 | 5 | 1 | 2.50 |
| CONO-218-R-2002 | 1 | 1 | 1 | 1 | 1.00 |
| CONO-222-R-2002 | 1 | 1 | 1 | 1 | 1.00 |
| CONO-312-R-2002 | 1 | 3 | 5 | 1 | 2.50 |
| **Average** | **1.6** | **1.6** | **3.8** | **1.0** | **2.00 ± 0.41** |

**Table A-3: Fish SSDI Calculation**

| Site | Epifaunal Substrate | Instream habitat | Percent embeddedness | Fish SSDI |
|---|---|---|---|---|
| CONO-101-R-2002 | 1 | 3 | 1 | 1.67 |
| CONO-105-R-2002 | 1 | 1 | 1 | 1.00 |
| CONO-107-R-2002 | 1 | 3 | 1 | 1.67 |
| CONO-110-R-2002 | 1 | 1 | 1 | 1.00 |
| CONO-114-R-2002 | 3 | 3 | 1 | 2.33 |
| CONO-116-R-2002 | 3 | 1 | 5 | 3.00 |
| CONO-217-R-2002 | 3 | 3 | 1 | 2.33 |
| CONO-218-R-2002 | 1 | 1 | 1 | 1.00 |
| CONO-222-R-2002 | 1 | 1 | 1 | 1.00 |
| CONO-312-R-2002 | 1 | 5 | 3 | 3.00 |
| **Average** | **1.6** | **2.2** | **1.6** | **1.80 ± 0.43** |

## APPENDIX B – MDE Permit Information

### Table B-1: Permit Summary

| MDE Permit | NPDES # | Facility | County | City | Type | TMDL |
|---|---|---|---|---|---|---|
| 00DP1006 | MD0051373 | BROADFORDING BIBLE CHURCH WWTP | WASHINGTON | HAGERSTOWN | WMA2 | Process Water WLA |
| 03DP3229 | MD0067881 | CEDAR RIDGE CHILDREN'S HOME SCHOOL | WASHINGTON | WILLIAMSPORT | WMA2 | Process Water WLA |
| 03DP2563 | MD0063509 | CONOCOCHEAGUE WWTP | WASHINGTON | WILLIAMSPORT | WMA2M | Process Water WLA |
| 00MM3039 | MDG493039 | H.B. MELLOTT - ROCKDALE QUARRY | WASHINGTON | CLEAR SPRING | WMA5 | Process Water WLA |
| 00MM3050 | MDG493050 | HAGERSTOWN BLOCK COMPANY - READY-MIX | WASHINGTON | HAGERSTOWN | WMA5 | Process Water WLA |
| 02SW0409 | N/A | RUST-OLEUM CORPORATION | WASHINGTON | WILLIAMSPORT | WMA5SW | Stormwater WLA |
| 02SW0439 | N/A | WASHINGTON COUNTY RUBBLE LANDFILL | WASHINGTON | WILLIAMSPORT | WMA5SW | Stormwater WLA |
| 02SW0725 | N/A | D.M. BOWMAN, INC. - HAGERSTOWN | WASHINGTON | HAGERSTOWN | WMA5SW | Stormwater WLA |
| 02SW0803 | N/A | RICHARDS WILBERT, INC. | WASHINGTON | HAGERSTOWN | WMA5SW | Stormwater WLA |
| 02SW0952 | N/A | XERXES CORPORATION | WASHINGTON | WILLIAMSPORT | WMA5SW | Stormwater WLA |
| 02SW1042 | N/A | PACKAGING SERVICES OF MARYLAND, INC. | WASHINGTON | WILLIAMSPORT | WMA5SW | Stormwater WLA |
| 02SW1082 | N/A | INTERSTATE BRANDS CORP. - HAGERSTOWN | WASHINGTON | HAGERSTOWN | WMA5SW | Stormwater WLA |
| 02SW1150 | N/A | ALLIED WASTE SERVICES | WASHINGTON | HAGERSTOWN | WMA5SW | Stormwater WLA |
| 02SW1194 | N/A | PERFORMANCE PIPE | WASHINGTON | HAGERSTOWN | WMA5SW | Stormwater WLA |
| 02SW1281 | N/A | CERTAIN-TEED CORPORATION | WASHINGTON | WILLIAMSPORT | WMA5SW | Stormwater WLA |
| 02SW1293 | N/A | PURINA MILLS, INC. | WASHINGTON | HAGERSTOWN | WMA5SW | Stormwater WLA |
| 02SW1295 | N/A | RESH ROAD II/ WASHINGTON COUNTY LANDFILL | WASHINGTON | HAGERSTOWN | WMA5SW | Stormwater WLA |
| 02SW1385 | N/A | BLUE SEAL FEEDS, INC. | WASHINGTON | HAGERSTOWN | WMA5SW | Stormwater WLA |
| 02SW1396 | N/A | FORTY WEST MUNICIPAL LANDFILL | WASHINGTON | HAGERSTOWN | WMA5SW | Stormwater WLA |
| 02SW1726 | N/A | CONOCOCHEAGUE WWTP | WASHINGTON | WILLIAMSPORT | WMA5SW | Stormwater WLA |
| 02SW1820 | N/A | HAGERSTOWN CITY/COUNTY LANDFILL | WASHINGTON | HAGERSTOWN | WMA5SW | Stormwater WLA |
| 02SW1867 | N/A | ROLLING FRITO-LAY SALES - HAGERSTOWN BIN | WASHINGTON | WILLIAMSPORT | WMA5SW | Stormwater WLA |
| 02SW1930 | N/A | FEDEX GROUND PACKAGE SYSTEMS, INC. | WASHINGTON | HAGERSTOWN | WMA5SW | Stormwater WLA |
| MS4-WA-003 | N/A | WASHINGTON COUNTY MS4 | WASHINGTON | ALL | WMA6G | Stormwater WLA |
| 05SS5501 | MD0055501 | STATE HIGHWAY ADMINISTRATION MS4 | ALL | ALL | WMA6 | Stormwater WLA |
| | | MDE GENERAL PERMIT TO CONSTRUCT | ALL | ALL | N/A | Stormwater WLA |

**Notes:** [1] TMDL column identifies how the permit was considered in the TMDL allocation
[2] WTP = Water Treatment Plant
[3] WWTP = Wastewater Treatment Plant

**Table B-2: Municipal Permit Data**

| Facility Name | MDE Permit # | NPDES # | Flow (MGD) | Permit Avg Monthly Conc. (mg/l) | Permit Daily Max Conc. (mg/l) |
|---|---|---|---|---|---|
| BROADFORDING BIBLE CHURCH WWTP | 00DP1006 | MD0051373 | 0.015 | 30 | 45 |
| CEDAR RIDGE CHILDREN'S HOME SCHOOL | 03DP3229 | MD0067881 | 0.01 | 30 | 45 |
| CONOCOCHEAGUE WWTP | 03DP2563 | MD0063509 | 4.1 | 30 | 45 |

**Notes**: [1] MGD = Millions of gallons per day
[2] mg/l = Milligrams per liter

**Table B-3: General Mine Permit Data**

| Facility Name | MDE Permit # | NPDES # | Flow (MGD) | Permit Avg Monthly Conc. (mg/l) | Permit Daily Max Conc. (mg/l) |
|---|---|---|---|---|---|
| H.B. MELLOTT - ROCKDALE QUARRY | 00MM3039 | MDG493039 | 0.001 | 15 | 31 |
| HAGERSTOWN BLOCK COMPANY - READY-MIX | 00MM3050 | MDG493050 | 0.004 | 30 | 60 |

**Table B-4: Stormwater Permit Data**[1]

| MDE Permit | Facility | NPDES group |
|---|---|---|
| 02SW0409 | RUST-OLEUM CORPORATION | Phase-I |
| 02SW0439 | WASHINGTON COUNTY RUBBLE LANDFILL | Phase-I |
| 02SW0725 | D.M. BOWMAN, INC. - HAGERSTOWN | Phase-I |
| 02SW0803 | RICHARDS WILBERT, INC. | Phase-I |
| 02SW0952 | XERXES CORPORATION | Phase-I |
| 02SW1042 | PACKAGING SERVICES OF MARYLAND, INC. | Phase-I |
| 02SW1082 | INTERSTATE BRANDS CORP. - HAGERSTOWN | Phase-I |
| 02SW1150 | ALLIED WASTE SERVICES | Phase-I |
| 02SW1194 | PERFORMANCE PIPE | Phase-I |
| 02SW1281 | CERTAIN-TEED CORPORATION | Phase-I |
| 02SW1293 | PURINA MILLS, INC. | Phase-I |
| 02SW1295 | RESH ROAD II/ WASHINGTON COUNTY LANDFILL | Phase-I |
| 02SW1385 | BLUE SEAL FEEDS, INC. | Phase-I |
| 02SW1396 | FORTY WEST MUNICIPAL LANDFILL | Phase-I |
| 02SW1726 | CONOCOCHEAGUE WWTP | Phase-I |
| 02SW1820 | HAGERSTOWN CITY/COUNTY LANDFILL | Phase-I |
| 02SW1867 | ROLLING FRITO-LAY SALES - HAGERSTOWN BIN | Phase-I |
| 02SW1930 | FEDEX GROUND PACKAGE SYSTEMS, INC. | Phase-I |
| MS4-WA-003 | WASHINGTON COUNTY MS4 | Phase-II |
| 05SS5501 | STATE HIGHWAY ADMINISTRATION MS4 | Phase-I |
| | MDE GENERAL PERMIT TO CONSTRUCT | Phase-I/II |

**Notes:** [1] Although not listed in this table, some individual permits from Tables B-2 and B-3 incorporate stormwater requirements and are accounted for within the NPDES Stormwater WLA.

**APPENDIX C – Technical Approach Used to Generate Maximum Daily Loads**

## Summary

This appendix documents the technical approach used to define maximum daily loads of TSS consistent with the average annual TMDL, which is protective of water quality standards in the MD 8-digit Conococheague Creek watershed. The approach builds upon the modeling analysis that was conducted to determine the loadings of TSS and can be summarized as follows.

- The approach defines maximum daily loads for each of the source categories.
- The approach builds upon the TMDL modeling analysis that was conducted to ensure that average annual loading targets result in compliance with water quality standards.
- The approach converts daily time-series loadings into TMDL values in a manner that is consistent with available EPA guidance on generating daily loads for TMDLs.
- The approach considers a daily load level of a resolution based on the specific data that exists for each source category.

## Introduction

This appendix documents the development and application of the approach used to define total maximum daily loads on a daily basis. It is divided into sections discussing:

- Basis for approach
- Options considered
- Selected approach
- Results of approach

## Basis for approach

The overall approach for the development of daily loads was based upon the following factors:

- **Average Annual TMDL:** The basis of the average annual sediment TMDL is that cumulative high sediment loading rates have negative impacts on the biological community. Thus, the average annual sediment load was calculated to be protective of the aquatic life designated use.
- **CBP P5 Watershed Model Sediment Loads:** There are two spatial calibration points for sediment within the CBP P5 watershed model framework. First, EOS loads are calibrated to long-term EOS target loads. These target loads are the loads used to determine an average annual TMDL. Furthermore, the target loads were used in the TMDL because, as calibration targets, they are expected to remain relatively unchanged during the final calibration stages of the CBP P5 model, and therefore will be the most consistent with the final CBP P5 watershed model TSS loading estimates. Currently, the CBP P5 model river segments are being calibrated to daily monitoring information for watersheds with a flow greater that 100 cfs, or an approximate area of 100 square miles.

- **Draft EPA guidance document entitled "Developing Daily Loads for Load-based TMDLs"**: This guidance document provides options for defining maximum daily loads when using TMDL approaches that generate daily output.

The rationale for developing TMDLs expressed as daily loads was to accept the existing average annual TMDL, but then develop a method for converting this number to a maximum *daily* load – in a manner consistent with EPA guidance and available information.

## Options Considered

The draft EPA guidance document for developing daily loads does not specify a single allowable approach that must be adhered to, but rather it contains a range of acceptable options. The selection of a specific method for translating a time-series of allowable loads into the expression of a TMDL requires decisions regarding both the level of resolution (e.g., single daily load for all conditions vs. loads that vary with environmental conditions) and level of probability associated with the TMDL.

This section describes the range of options that were considered when developing methods to calculate MD 8-digit Conococheague Creek Maximum Daily Loads.

Level of Resolution

The level of resolution pertains to the amount of detail used in specifying the maximum daily load. The draft EPA guidance on daily loads provides three categories of options for level of resolution, all of which are potentially applicable for the MD 8-digit Conococheague Creek Watershed:

1. **Representative daily load:** In this option, a single daily load (or multiple representative daily loads) is specified that covers all time periods and environmental conditions.
2. **Flow-variable daily load:** This option allows the maximum daily load to vary based upon the observed flow condition.
3. **Temporally-variable daily load:** This option allows the maximum daily load to vary based upon seasons or times of varying source or water body behavior.

Probability Level

All TMDLs have some probability of being exceeded, with the specific probability being explicitly specified or implicitly assumed. This level of probability directly or indirectly reflects two separate phenomena:

1. Water quality criteria consist of components describing acceptable magnitude, duration, and frequency. The frequency component addresses how often conditions can allowably surpass the combined magnitude and duration components.

2. Pollutant loads, especially from wet weather sources, typically exhibit a large degree of variability over time. It is rarely practical to specify a "never to be exceeded value" for a daily load, as essentially any loading value has some finite probability of being exceeded.

The draft daily load guidance document states that the probability component of the maximum daily load should be "based on a representative statistical measure" that is dependent upon the specific TMDL and best professional judgment of the developers. This statistical measure represents how often the maximum daily load is expected/allowed to be exceeded. The primary options for selecting this level of protection would be:

1. **The maximum daily load reflects some central tendency:** In this option, the maximum daily load is based upon the mean or median value of the range of loads expected to occur. The variability in the actual loads is not addressed.
2. **The maximum daily load reflects a level of protection implicitly provided by the selection of some "critical" period**: In this option, the maximum daily load is based upon the allowable load that is predicted to occur during some critical period examined during the analysis. The developer does not explicitly specify the probability of occurrence.
3. **The maximum daily load is a value that will be exceeded with a pre-defined probability:** In this option, a "reasonable" upper bound percentile is selected for the maximum daily load based upon a characterization of the variability of daily loads. For example, selection of the 95$^{th}$ percentile value would result in a maximum daily load that would be exceeded 5% of the time.

## Selected Approach

The approach selected for defining the MD 8-digit Conococheague Creek Maximum Daily Load was based upon the specific data that exists for each source category. The approach consists of unique methods for each of the following categories of sources:

- Approach for Nonpoint Sources and Stormwater Point Sources within the MD 8-digit Conococheague Creek watershed,
- Approach for Process Water Point Sources within the MD 8-digit Conococheague Creek watershed,
- Approach for upstream sources.

<u>Approach for Nonpoint Sources and Stormwater Point Sources within the MD 8-digit Conococheague Creek watershed</u>

The level of resolution selected for the MD 8-digit Conococheague Creek Maximum Daily Load was a representative daily load, expressed as a single daily load for each loading source. This approach was based upon the specific data that exists for nonpoint sources and stormwater point sources within the MD 8-digit Conococheague Creek watershed. Currently, the best available data is the CBP P5 model daily time series calibrated to long term average annual loads (per land use). The CBP reach simulation results are calibrated to daily monitoring information for watershed segments with a flow typically greater that 100 cfs, but they have not been through appropriate peer review. Therefore it was concluded that it would not be appropriate to apply the absolute values of the reach simulation model results to the TMDL, and the annual loads were used instead. However, it was assumed that the distribution of the daily values was correct, in order to calculate a normalized statistical parameter to estimate the maximum daily loads.

The maximum daily load was estimated based on three factors: a specified probability level, the average annual sediment TMDL, and the coefficient of variation (CV) of the CBP P5 MD 8-digit Conococheague Creek reach simulation daily loads. The probability level (or exceedance frequency) is based upon guidance from EPA (US EPA 1991) where examples suggest that when converting from a long-term average to a daily value, the z-score corresponding to the 99th percentile of the log-normal probability distribution should be used.

The CBP P5 Conococheague Creek reach simulation consisted of a daily time series beginning in 1985 and extending to the year 2005. The CV was estimated by first converting the daily sediment load values to a log distribution and then verifying that the results approximated the normal distribution (see Figure C-1). Next, the CV was calculated using the arithmetic mean and standard deviation results from the log transformation. The log-transformed values were used to reduce the possible influence of outliers. The resulting CV was 5.75 and calculated as follows:

$$CV = \frac{\beta}{\alpha} \qquad \text{(Equation C.1)}$$

where
CV = coefficient of variation
$\beta = \alpha\sqrt{e^{\sigma^2} - 1}$
$\alpha = e^{(\mu + 0.5*\sigma^2)}$
$\alpha$ = mean (arithmetic)
$\beta$ = standard deviation (arithmetic)
$\mu$= mean of logarithms
$\sigma$=standard deviation of logarithms

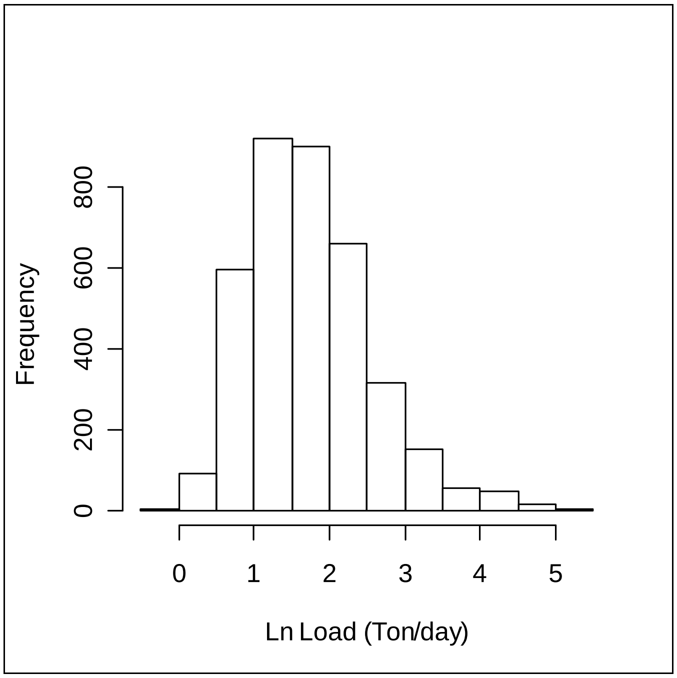


**Figure C-1: Histogram of CBP River Segment Daily Simulation Results for the MD 8-digit Conococheague Creek Watershed**

The maximum "daily" load for each contributing source is estimated as the long-term average annual load multiplied by a factor that accounts for expected variability of daily loading values. The equation is as follows:

$$MDL = LTA * e^{(z\sigma - 0.5\sigma^2)} \quad \text{(Equation C.2)}$$

where:

MDL = Maximum daily load
LTA = Long-term average (average annual load)
Z = z-score associated with target probability level
$\sigma = \ln(CV^2+1)$
CV = Coefficient of variation based on arithmetic mean and standard deviation

Using a z-score associated with the $99^{th}$ percent probability, a CV of 5.75, and consistent units, the resulting dimensionless conversion factor from long-term average loads to a maximum daily value is 13.54. The average annual MD 8-digit Conococheague Creek TMDL of sediment/TSS is reported in ton/year, and the conversion from ton/year to a maximum daily load in ton/day is 0.037 (e.g. 13.54/365).

<u>Approach for Process Water Point Sources within the MD 8-digit Conococheague Creek watershed</u>

The TMDL also considers contributions from other point sources (i.e., sources other than stormwater point sources) in the MD 8-digit Conococheague Creek watershed that have NPDES permits with sediment limits. As these sources are generally minor contributors to the overall sediment load, the TMDL analysis that defined the average annual TMDL did not propose any reductions for these sources and held each of them constant at their existing technology-based NPDES permit monthly (or daily if monthly was not specified) limit for the entire year.

The approach used to determine maximum daily loads for these sources was dependent upon whether a maximum daily load was specified within the permit. If a maximum daily limit was specified, then the reported average flow was multiplied by the daily maximum limit to obtain a maximum daily load. If a maximum daily limit was not specified, the maximum daily loads were calculated from guidance in the Technical Support Document (TSD) for Water Quality-based Toxics Control (US EPA 1991). The long-term average annual TMDL was converted to maximum daily limits using Table 5-2 of the TSD assuming a coefficient of variation of 0.6 and a $99^{th}$ percentile probability. This results in a dimensionless multiplication factor of 3.11. The average annual MD 8-digit Conococheague Creek TMDL of sediment/TSS sediment is reported in ton/yr, and the conversion from ton/yr to a maximum daily load in ton/day is 0.0085 (e.g. 3.11/365).

<u>Approach for Upstream Sources</u>

For the purpose of this analysis only one upstream watershed has been identified: the Pennsylvania portion of the Conococheague Creek watershed. The Pennsylvania Maximum Daily Load was calculated based on the same approach used for nonpoint sources and NPDES regulated stormwater point sources within the MD 8-digit Conococheague Creek watershed.

## Results of Approach

This section lists the results of the selected approach to define MD 8-digit Conococheague Creek Maximum Daily Loads.

- Calculation Approach for Nonpoint Sources and Stormwater Point Sources within the MD 8-digit Conococheague Creek watershed

$LA_{CC}$ (ton/day) = Average Annual TMDL $LA_{CC}$ (ton/yr) * .037

NPDES Stormwater $WLA_{CC}$ (ton/day) = Average Annual TMDL NPDES Stormwater $WLA_{CC}$ (ton/yr) * .037

- Calculation Approach for Process Water Point Sources within the MD 8-digit Conococheague Creek watershed
    - For permits with a daily maximum limit:

Process Water $WLA_{CC}$ (ton/day) = Permit flow (mgd) * Daily maximum permit limit(mg/l) * 0.0042

- For permits without a daily maximum limit:

Process Water $WLA_{CC}$ (ton/day) = Average Annual TMDL Process Water $WLA_{CC}$ (ton/yr)* 0.0085

- Calculation Approach for Upstream Sources
    - For Pennsylvania Upstream Sources

$LA_{PA}$ (ton/day) = Average Annual TMDL $LA_{PA}$ (ton/yr) * .037

**Table C-1: MD 8-digit Conococheague Creek Maximum Daily Load of Sediment/TSS (ton/day)**

| MDL (ton/day) | = | Max. Daily LA | | | + | Max. Daily WLA | | | + | MOS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $LA_{PA}$[1] | + | $LA_{CC}$ | | NPDES Stormwater $WLA_{CC}$ | + | Process Water $WLA_{CC}$ | | |
| 3,496.1 | | 3,177.2 | | 243.0 | | 74.3 | | 1.6 | + | Implicit |

Upstream MDL[2,3] (under $LA_{PA}$); MD 8-digit Conococheague Creek Watershed MDL Contribution (under $LA_{CC}$ through Process Water $WLA_{CC}$)

**Notes:**[1] $LA_{PA}$ was determined to be necessary in order to meet Maryland water quality standards within the MD 8-digit Conococheague Creek watershed.

[2] Although for the purpose of this analysis the upstream load is referred to as an LA, it could include loads from point and nonpoint sources.

[3] A delivery factor of 1 was used for the Upstream Load Allocation**.**