Total Maximum Daily Load of Sediment in the Potomac River Montgomery County Watershed, Montgomery and Frederick Counties, Maryland

FINAL

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List of Abbreviations

BIBI	Benthic Index of Biotic Integrity
BIP	Buffer Incentive Program
BMP	Best Management Practices
BSID	Biological Stressor Identification
CBP P4.3	Chesapeake Bay Program Model Phase 4.3
CBP P5.2	Chesapeake Bay Program Model Phase 5.2
CFS	Cubic Feet per Second
CV	Coefficient of Variation
CWA	Clean Water Act
DI	Diversity Index
DNR	Maryland Department of Natural Resources
EOF	Edge-of-Field
EOS	Edge-of-Stream
EPA	Environmental Protection Agency
EPT	*Ephemeroptera*, *Plecoptera*, and *Trichoptera*
EPSC	Environmental Permit Service Center
EQIP	Environmental Quality Incentives Program
ESD	Environmental Site Design
ETM	Enhanced Thematic Mapper
FIBI	Fish Index of Biologic Integrity
FDC	Flow Duration Curve
GIS	Geographic Information System
HBI	Hilsenhoff Biotic Index
HSPF	Hydrological Simulation Program – FORTRAN
IBI	Index of Biotic Integrity
LA	Load Allocation
m	Meter
MACS	Maryland Agricultural Cost Share Program
MAL	Minimum Allowable IBI Limit
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	Number of Samples
NIH	National Institute of Health
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NRI	Natural Resources Inventory
PCBs	Polychlorinated Biphenyls
PSU	Primary Sampling Unit
RESAC	Regional Earth Science Applications Center
SCS	Soil Conservation Service
TMDL	Total Maximum Daily Load
Ton/yr	Tons per Year
TSD	Technical Support Document
TSS	Total Suspended Solids
TM	Thematic Mapper
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UT	Unnamed Tributary
WLA	Waste Load Allocation
WQA	Water Quality Analysis
WQIA	Water Quality Improvement Act
WQLS	Water Quality Limited Segment
WSSC	Washington Suburban Sanitary Commission
WTP	Water 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) Potomac River Montgomery County watershed (basin number 02140202) (2008 *Integrated Report of Surface Water Quality in Maryland* Assessment Unit ID: MD-02140202). 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 2010b).

The Maryland Department of the Environment (MDE) has identified the waters of the MD 8-digit Potomac River Montgomery County watershed on the State's 2008 Integrated Report as impaired by nutrients – phosphorus (1996), sediments (1996), bacteria - mainstem only (2002), impacts to biological communities (2006), and polychlorinated biphenyls (PCBs) in fish tissues (2008) (MDE 2008). The designated use of the MD 8-digit Potomac River Montgomery County mainstem and its tributaries is Use I-P (Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply) (COMAR 2010a,b).

The TMDL established herein by MDE will address the 1996 sediments listing, for which a data solicitation was conducted, and all readily available data from the past five years have been considered. The MD 8-digit watershed mainstem was delisted for bacteria in 2004. A Water Quality Analysis (WQA) for eutrophication to address the nutrients/phosphorus listing is scheduled to be submitted to the EPA in 2011. In the 2012 Integrated Report, the listing for impacts to biological communities will include the results of a stressor identification analysis. The PCBs in fish tissue listing will be addressed at a future date.

The MD 8-digit Potomac River Montgomery County watershed aquatic life assessment 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 based on Maryland's biocriteria listing methodology. The biocriteria listing methodology assesses the overall average condition of MD 8-digit watersheds (1st though 4th order streams only) by measuring the percentage of sites, translated into watershed stream miles, that are assessed as having BIBI and/or FIBI scores significantly lower than 3.0 (on a scale of 1 to 5), and then calculating whether the percentage differs significantly from reference conditions (i.e., an unimpaired watershed is one where <10% of stream miles differ from reference conditions) (Roth et al. 2005; MDE 2008). The objective of the TMDL established herein is to ensure that watershed sediment loads are at a level to support the Use I-P designation for the MD 8-digit Potomac River Montgomery County watershed, and more specifically, at a level to support aquatic life.

Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic life of nontidal stream systems. Therefore, to determine whether aquatic life is impacted by elevated sediment loads, MDE's *Biological Stressor Identification* (BSID) methodology was applied. The BSID identifies the most probable cause(s) for observed biological impairments throughout MD's 8-digit watersheds (1^{st} though 4^{th} order streams only) by ranking the likely stressors affecting a watershed using a suite of physical, chemical, and land use data. The ranking of stressors was conducted via a risk-based, systematic, weight-of-evidence approach. The risk-based approach estimates the strength of association between various stressors and an impaired biological community. The BSID analysis then identifies individual stressors (pollutants) as probable or unlikely causes of the poor biological conditions within a given MD 8-digit watershed and subsequently concludes whether or not these individual stressors or groups of stressors are contributing to the impairment (MDE 2009).

The BSID analysis for the MD 8-digit Potomac River Montgomery County watershed concludes that biological communities are likely impaired due to flow/sediment related stressors. Individual stressors within the sediment and habitat parameter groupings that are associated with sediment related impacts and an altered hydrologic regime were identified as being probable causes of the biological impairment. Furthermore, the degradation of biological communities in the watershed is strongly associated with urban land use and its concomitant effects (MDE 2011).

In order to quantify the impact of sediment on the aquatic life 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; MDE 2008). This threshold is then used to determine a watershed specific sediment TMDL.

The computational framework chosen for the MD 8-digit Potomac River Montgomery County watershed TMDL was the Chesapeake Bay Program Phase 5.2 (CBP P5.2) 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 P5.2 watershed model segmentation aggregates to the MD 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 2010b). 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 reflect the impacts of stressors (i.e., sediment impacts to stream biota) over the course of time (i.e., captures the impacts of all high and low flow events). Thus, critical conditions are inherently addressed. Seasonality is captured in two components. First, it is implicitly included in biological sampling as biological communities reflect the impacts of stressors over time, as described above. 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 point sources and load allocations (LAs) for nonpoint sources generated within the assessment unit, accounting for 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 2010a,b). It is proposed that the estimated variability around the reference watershed group used in this analysis already accounts for such uncertainty, and therefore the MOS is implicitly included.

The MD 8-digit Potomac River Montgomery County Total Baseline Sediment Load is 24,469.2 tons per year (ton/yr). This baseline load consists of:

- Upstream loads generated outside the assessment unit (i.e., MD 8-digit watershed)
  - A District of Columbia Upstream Baseline Load (BL_{DC}) of 556.3 ton/yr
- Loads generated within the assessment unit
  - A MD 8-digit Potomac River Montgomery County Watershed Baseline Load Contribution of 23,913.0 ton/yr.

The MD 8-digit Potomac River Montgomery County Watershed Baseline Load Contribution is further subdivided into a nonpoint source baseline load (Nonpoint Source BL_{PR}) and two types of point source baseline loads: National Pollutant Discharge Elimination System (NPDES) regulated stormwater (NPDES Stormwater BL_{PR}) and regulated process water (Process Water BL_{PR}) (see Table ES-1).

Table ES-1: MD 8-digit Potomac River Montgomery County Baseline Sediment Loads (ton/yr)

Total Baseline Load (ton/yr)		**Upstream Baseline Load**[1]		**MD 8-digit Potomac River Montgomery County Watershed Baseline Load Contribution**				
	=	**BL_{DC}**	+	**Nonpoint Source BL_{PR}**	+	**NPDES Stormwater BL_{PR}**	+	**Process Water BL_{PR}**
24,469.2	=	556.3	+	16,317.6	+	7,499.9	+	95.5

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

The MD 8-digit Potomac River Montgomery County Average Annual TMDL of Sediment/Total Suspended Solids (TSS) is 16,524.0 ton/yr (a 32.4% reduction from the baseline load). This TMDL consists of:

- Allocations attributed to loads generated outside the assessment unit, referred to as Upstream Load Allocations
  - A District of Columbia Upstream Load Allocation (LA_{DC}) of 359.9 ton/yr
- Allocations attributed to loads generated within the assessment unit
  - A MD 8-digit Potomac River Montgomery County Watershed TMDL Contribution of 16,164.1 ton/yr.

The MD 8-digit Potomac River Montgomery County TMDL Contribution is further subdivided into point and nonpoint source allocations and is comprised of a Load Allocation (LA_{PR}) of 11,286.6 ton/yr, an NPDES Stormwater Waste Load Allocation (NPDES Stormwater WLA_{PR}) of 4,782.0 ton/yr, and a Process Water Waste Load Allocation (Process Water WLA_{PR}) of 95.5 ton/yr (see Table ES-2).

Table ES-2: MD 8-digit Potomac River Montgomery County Average Annual TMDL of Sediment/Total Suspended Solids (ton/yr)

TMDL (ton/yr)	=	**LA_{DC}**[1]	+	**LA_{PR}**	+	**NPDES Stormwater WLA_{PR}**	+	**Process Water WLA_{PR}**	+	**MOS**
16,524.0.0	=	359.9	+	11,286.6	+	4,782.0	+	95.5	+	Implicit
		Upstream Load Allocation[2,3]		MD 8-digit Potomac River Montgomery County Watershed TMDL Contribution						

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

Table ES-3: MD 8-digit Potomac River Montgomery County Baseline Load, TMDL, and Total Reduction Percentage

Baseline Load (ton/yr)	**TMDL** (ton/yr)	**Total Reduction** (%)
24,469.2	16,524.0	32.4 %

Since, 1) the BSID analysis only applies to the 1st though 4th order streams within the MD 8-Digit watershed; and 2) the biological results from the Maryland Department of Natural Resources (DNR) CORE/TREND stations along the mainstem of the MD 8-digit Potomac River Montgomery County indicate that mainstem water quality can be classified as “FAIR” to “GOOD”, MDE concluded that the sediment impairment in the MD 8-digit Potomac River Montgomery County watershed is restricted to the lower order streams within the watershed. Therefore, this sediment TMDL will be restricted to the tributaries in the MD 8-digit watershed draining to the Potomac River and will exclude the mainstem of the Potomac River itself. The baseline load analysis is also restricted to the 1st through 4th order streams in the MD 8-digit watershed and does not include upstream loads that discharge directly into the mainstem. DC upstream loads, however, are included in the analysis, since the DC loads discharge into the MD 8-digit watershed tributary streams and not directly into the Potomac River mainstem.

This TMDL will ensure that watershed sediment loads are at a level to support the designation for the MD 8-digit Potomac River Montgomery County watershed, and more specifically, at a level to support aquatic life. However, further reductions may be required in order to meet downstream water quality goals quantified in the Chesapeake Bay Nutrient and Sediment TMDLs established by EPA on December 29, 2010, specifically the allocations assigned to the Potomac River Tidal Fresh Chesapeake Bay Water Quality Segment. Additionally, the TMDL will not completely resolve the impairment to biological communities within the watershed. Since the BSID watershed analysis identifies chlorides, sulfates, and high pH as other possible stressors impacting the biological conditions, this impairment remains to be fully addressed through the Integrated Report listing and TMDL development processes. This impairment to aquatic life will only be fully addressed when all impairing substances identified as impacting biological communities in the watershed are reduced to levels that will meet water quality standards, as established in future TMDLs for those substances (MDE 2009, 2011).

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. Relative to the required reduction in sediment loads from the regulated sector of the TMDL, specifically the NPDES Stormwater WLA, as no reductions are required from the Process Water WLA, BMP implementation will primarily occur via the municipal separate storm sewer system (MS4) permitting process for medium and large municipalities. 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 cost of implementation.

Maryland has several well-established programs to draw upon, including the Water Quality Improvement Act of 1998 (WQIA) and NPDES programs for both direct and stormwater discharges. The Federal Nonpoint Source Management Program (§ 319 of the Clean Water Act), Buffer Incentive Program (BIP), State Water Quality Revolving Loan Fund, Bay Restoration Fund, Chesapeake Bay Trust Fund, Maryland Agricultural Cost Share Program (MACS), Environmental Quality Incentives Program (EQIP), and other programs can provide funding for both local governments and agricultural sources. Details of these programs and additional funding sources can be found at http://www.dnr.state.md.us/bay/services/summaries.html.

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) Potomac River Montgomery County watershed (basin number 02140202) (2008 *Integrated Report of Surface Water Quality in Maryland* Assessment Unit ID: MD-02140202). 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 State's Integrated Report, taking into account seasonal variations, critical conditions, and a protective margin of safety (MOS) to account for uncertainty (CFR 2010b). 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 Potomac River Montgomery County watershed on the State's 2008 Integrated Report as impaired by nutrients – phosphorus (1996), sediments (1996), bacteria - mainstem only (2002), impacts to biological communities (2006), and polychlorinated biphenyls (PCBs) in fish tissue (2008) (MDE 2008). The designated use of the MD 8-digit Potomac River Montgomery County mainstem and its tributaries is Use I-P (Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply) (COMAR 2010a,b).

The TMDL established herein by MDE will address the 1996 sediments listing, for which a data solicitation was conducted, and all readily available data from the past five years have been considered. The MD 8-digit watershed was delisted for bacteria in 2004, and a Water Quality Analysis (WQA) for eutrophication to address the nutrients/phosphorus listing is scheduled to be submitted to the EPA in 2011. In the 2012 Integrated Report, the listing for impacts to biological communities will include the results of a stressor identification analysis, and the PCBs in fish tissue listing will be addressed at a future date.

The objective of the TMDL established herein is to ensure that watershed sediment loads are at a level to support the Use I-P designation for the MD 8-digit Potomac River Montgomery County watershed, and more specifically, at a level to support aquatic life. However, further reductions may be required in order to meet downstream water quality goals quantified in the Chesapeake Bay Nutrient and Sediment TMDLs established by EPA on December 29, 2010, specifically the allocations assigned to the Potomac River

Tidal Fresh Chesapeake Bay Water Quality Segment. Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic life of nontidal stream systems. Therefore, to determine whether aquatic life is impacted by elevated sediment loads, MDE's *Biological Stressor Identification* (BSID) methodology was applied.

The BSID identifies the most probable cause(s) for observed biological impairments throughout MD 8-digit watersheds (1st though 4th order streams only) by ranking the likely stressors affecting a watershed using a suite of physical, chemical, and land use data. The ranking of stressors was conducted via a risk-based, systematic, weight-of-evidence approach. The risk-based approach estimates the strength of association between various stressors and an impaired biological community. The BSID analysis then identifies individual stressors (pollutants) as probable or unlikely causes of the poor biological conditions within a given MD 8-digit watershed and subsequently concludes whether or not these individual stressors or groups of stressors are contributing to the impairment (MDE 2009).

In order to quantify the impact of sediment on the aquatic life 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; MDE 2008). This threshold is then used to determine a watershed specific sediment TMDL.

2.0 SETTING AND WATER QUALITY DESCRIPTION

2.1 General Setting

Location

The Potomac River Montgomery County watershed consists of the mainstem Potomac River within Montgomery County, Maryland, and all of the tributaries draining to this stretch of the mainstem Potomac, except for Seneca Creek and Cabin John Creek. The Montgomery County portion of the mainstem Potomac River flows 39 miles from the Frederick/Montgomery County border down to the Montgomery County/Washington DC border. The actual watershed is located predominately in Montgomery County, Maryland, covering 140.0 square miles, but small portions of the watershed also extend into Frederick County, Maryland (0.7 square miles), and Washington, DC (2.1 square miles). The primary tributaries draining to the mainstem Potomac River within the watershed include the Little Monocacy River, Broad Run, Horsepen Branch, Muddy Branch, Watts Branch, Rock Run, and Little Falls Branch. Several areas within the watershed are highly developed and include parts of the towns of Gaithersburg, Rockville, Bethesda, and Chevy Chase (see Figure 1).

The assessment unit identified on the Maryland 2008 Integrated Report, and consequently addressed by this TMDL, consists only of the Maryland portion of the Potomac River Montgomery County watershed, otherwise referred to as the MD 8-Digit Potomac River Montgomery County watershed. This watershed includes the Potomac River mainstem extending from the Frederick/Montgomery County border to the Montgomery County/Washington DC border and those tributary streams within Maryland draining directly to this portion of the mainstem, excluding Seneca and Cabin John Creeks. There are no "high quality," or Tier II, stream segments (Benthic Index of Biotic Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI) aquatic life assessment scores > 4 (scale 1-5)) located within the watershed requiring the implementation of Maryland's anti-degradation policy (COMAR 2010c; MDE 2010a). Approximately 6.8% percent of the watershed area is covered by water (i.e., streams, ponds, etc). The total population in the MD 8-digit Potomac River Montgomery County watershed is approximately 197,894 (US Census Bureau 2000).

Geology/Soils

The Potomac River Montgomery County watershed lies within the Piedmont Plateau physiographic province of Maryland, which is characterized by open rolling terrain with low knobs and ridges, broad-bottom valleys, and abundant, often steeply incised streams. Areas immediately adjacent to the Potomac River Montgomery County mainstem occupy a well-defined floodplain. The Piedmont Plateau Physiographic Province can be subdivided into a smaller eastern lowland section and a larger western upland section (Reger and Cleaves 2008a,b; MGS 2010a,b). Most of the Potomac River Montgomery County watershed is located in the upland section of the Piedmont Plateau province, where differential weathering has produced distinctive ridges, hills, barren areas, and valleys (MGS 2010b). This area is underlain by meta-sedimentary rocks of late

Precambrian origin, including schist, gneiss, and thin beds and lenses of quartzite and marble. A small portion of the watershed lies within the Mesozoic lowland section of the Piedmont Plateau province. This area is characterized by a relatively flat to gently rolling topography, and outcrops of sandstones, siltstones, shales, and various conglomerates of Triassic age have been weathered into distinctive red soils (Reger and Cleaves 2008a,b; MGS 2010a).

Soils in the western part of the Potomac River Montgomery County watershed belong to the Glenning-Gaila-Occoquan series, whereas in the eastern part of the watershed, soils primarily belong to the Penn-Brentsville-Readington series, with a small portion consisting of the Urban land–Wheaton–Glenelg series. All three soil associations are loamy and are primarily located on broad ridge tops and side slopes. Glenning-Gaila-Occoquan soils are primarily located in uplands. These well drained, deep to very deep soils are well suited for cultivated crops, pasture, or hay production. Penn-Brentsville-Readington soils are moderately well drained to well drained and tend to be moderately deep to deep. Soils in this series are suitable for woodland and pasture. Both the Glenning-Gaila-Occoquan and Penn-Brentsville-Readington soil units are somewhat limited for urban development because onsite sewage disposal is affected by restricted permeability, depth to bedrock, and sometimes slope. Of the three major soil associations in the watershed, the soils in the Urban land–Wheaton–Glenelg unit are the best suited for urban development. The only major limitation is restricted permeability; however, these soils are well drained and deep (USDA 1995).

Soil type for the Potomac River Montgomery County watershed is also characterized by the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) into four hydrologic soil groups: Group A soils have high infiltration rates and are typically deep well drained/excessively drained sands or gravels; Group B soils have moderate infiltration rates and consist of moderately deep-to-deep and moderately well-to-well drained soils, with moderately fine/coarse textures; Group C soils have slow infiltration rates with a layer that impedes downward water movement, and they primarily have moderately fine-to-fine textures; Group D soils have very slow infiltration rates consisting of clay soils with a permanently high water table that are often shallow over nearly impervious material. The Potomac River Montgomery County watershed is comprised primarily of Group D soils (57.3%) with smaller portions of Group C and Group B soils (32.2% and 10.5% respectively) (USDA 2006).

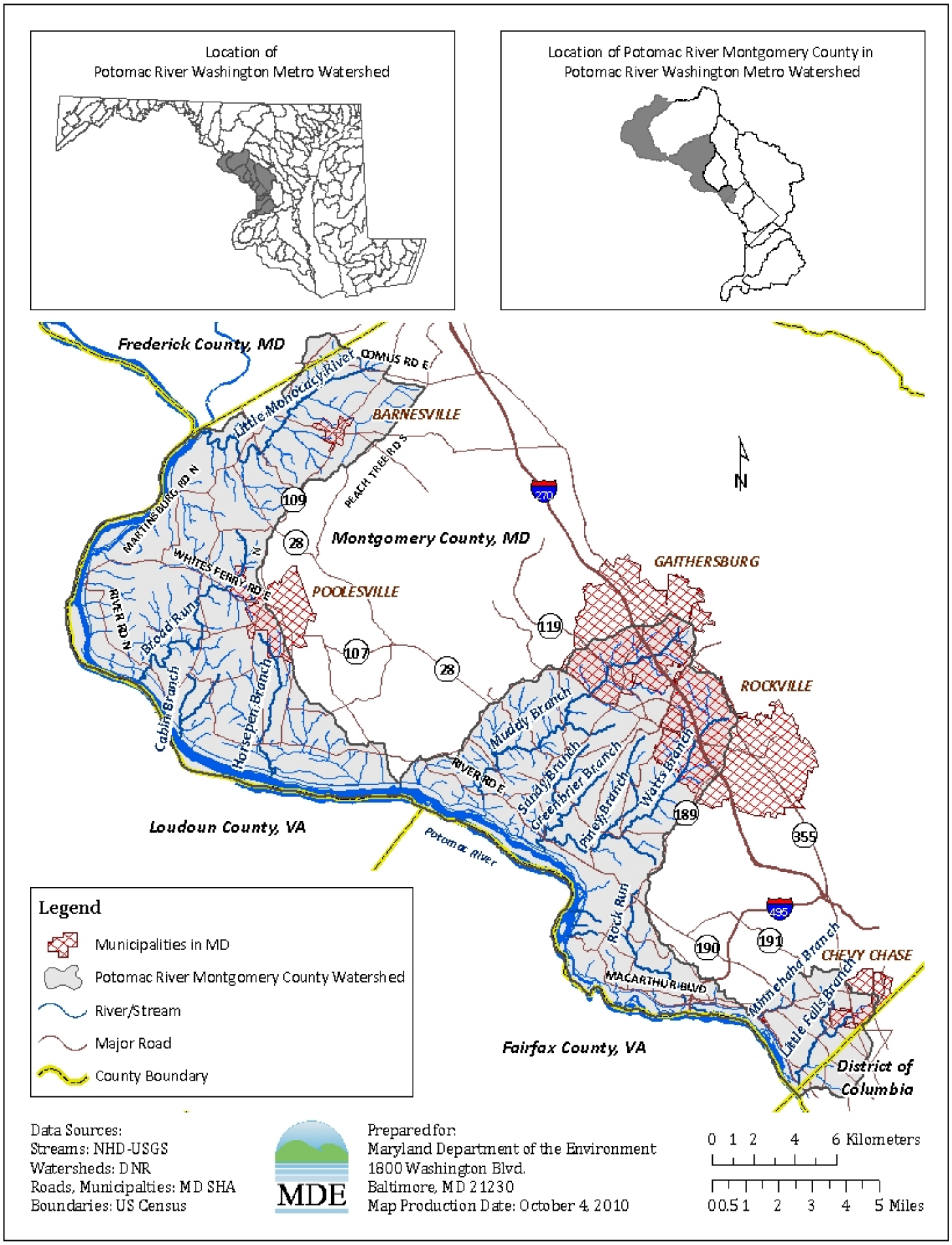

Figure 1: Location Map of the Potomac River Montgomery County Watershed in Montgomery and Frederick Counties, Maryland

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 5.2 (CBP P5.2) watershed model.[1] The CBP P5.2 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 P5.2 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 P5.2 land use does not exist in a single GIS coverage; instead it is only available in a tabular format. The CBP P5.2 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 13 classes with distinct sediment erosion rates. Table 1 lists the CBP P5.2 generalized land uses, detailed land uses, which are classified by their erosion rates, and the acres of each land use in the Potomac River Montgomery County watershed. Details of the land use development

[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.

methodology have been summarized in the report entitled *Chesapeake Bay Phase 5 Community Watershed Model* (US EPA 2008).

<u>Potomac River Montgomery County Watershed Land Use Distribution</u>

The Potomac River Montgomery County watershed land use was evaluated separately for Maryland and the District of Columbia. The land use distribution in Maryland consists primarily of urban land (42%) and forest (38%). There are also smaller amounts of crop land (17%) and pasture (3%). In the District of Columbia, the land use distribution consists solely of urban land (93%) and forest (7%). A detailed summary of the watershed land use areas is presented in Table 1, and a land use map is provided in Figure 2.

Table 1: Land Use Percentage Distribution for the Potomac River Montgomery County Watershed

		Maryland			District of Columbia		
General Land Use	**Detailed Land Use**	**Area** (Acres)	**Percent**	**Grouped Percent of Total**	**Area** (Acres)	**Percent**	**Grouped Percent of Total**
Crop	Animal Feeding Operations	18.3	0.0	17.1	0.0	0.0	0.0
	Hay	4,012.1	4.8		0.0	0.0	
	High Till	1,579.7	1.9		0.0	0.0	
	Low Till	8,686.2	10.4		0.0	0.0	
	Nursery	7.8	0.0		0.0	0.0	
Extractive	Extractive	56.5	0.1	0.1	0.0	0.0	0.0
Forest	Forest	31,509.9	37.6	38.0	91.0	6.7	6.8
	Harvested Forest	318.3	0.4		0.9	0.1	
Pasture	Pasture	2,460.7	2.9	2.9	0.0	0.0	0.0
	Trampled Pasture	0.0	0.0		0.0	0.0	
Urban	Barren	246.0	0.3	42.0	13.2	1.0	93.2
	Impervious	5,795.8	6.9		423.2	31.2	
	Pervious	29,169.2	34.8		828.3	61.1	
Total		**83,860.5**	**100.0**	**100.0**	**1,356.6**	**100.0**	**100.0**

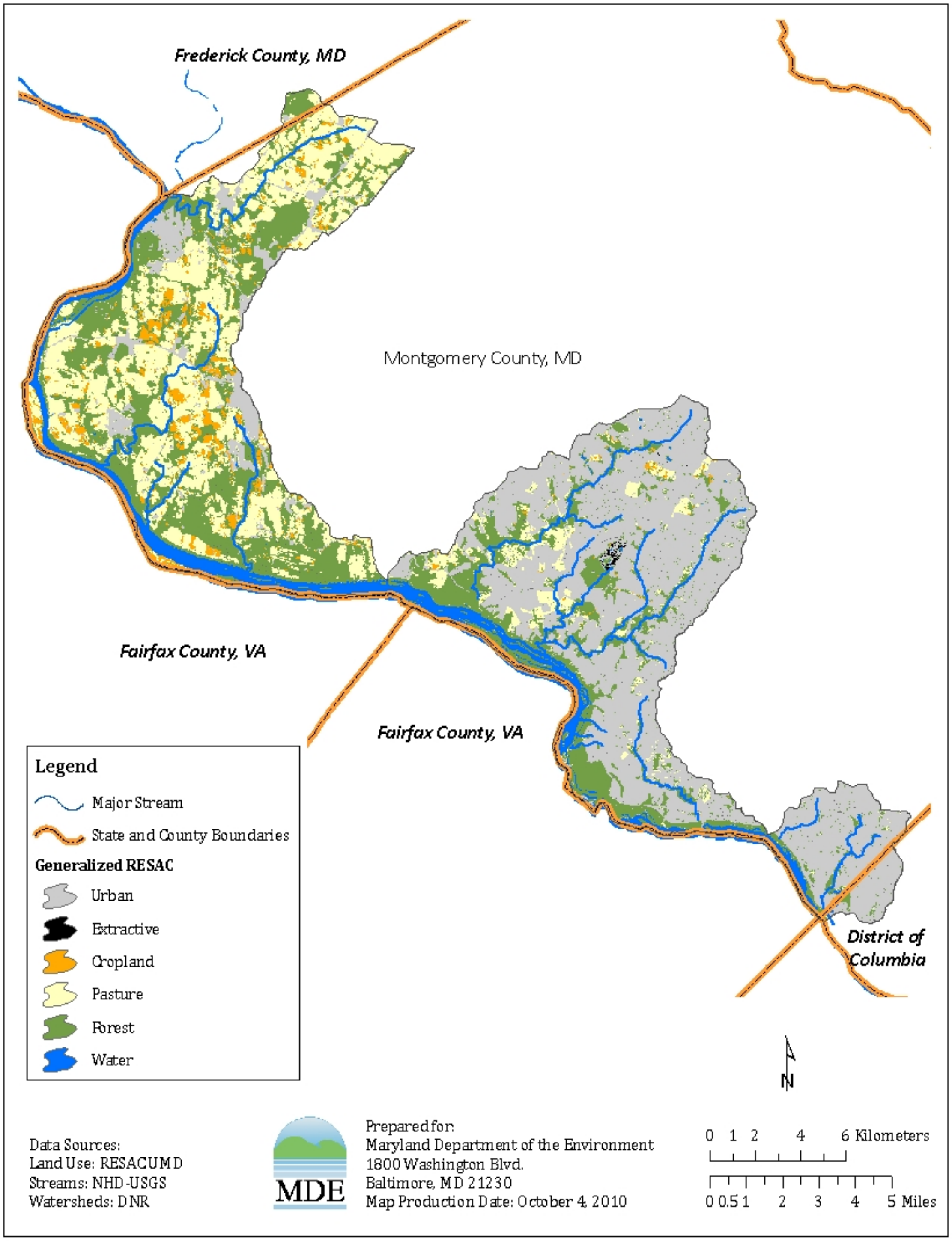

Figure 2: Land Use of the Potomac River Montgomery County Watershed

2.2 Source Assessment

The MD 8-Digit Potomac River Montgomery County Watershed Total Baseline Sediment Load consists of loads generated outside of the assessment unit, referred to as Upstream Baseline Loads, and loads generated within the assessment unit, referred to as the MD 8-Digit Potomac River Montgomery County Baseline Load Contribution. The MD 8-Digit Potomac River Montgomery County Baseline Load Contribution can be 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 stormwater runoff within the MD 8-Digit Potomac River Montgomery County watershed. This section provides the background and methods for determining the nonpoint source baseline loads generated within the MD 8-Digit Potomac River Montgomery County watershed (Nonpoint Source BL_{PR}). This approach was also used to estimate the District of Columbia Upstream Baseline Load.

General Load Estimation Methodology

Nonpoint source sediment loads generated within the MD 8-Digit Potomac River Montgomery County watershed are estimated based on the *edge-of-stream (EOS) calibration target loading rates* from the CBP P5.2 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* (US EPA 2008).

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 Natural Resource Inventory (NRI). NRI is a statistical survey of land use and natural resource conditions conducted by the Natural Resources Conservation Service (NRCS) (USDA 2006). 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 Chesapeake Bay Program Phase 4.3 (CBP P4.3) 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 P5.2 model.

The average value of the 1982 and 1987 surveys was used as the basis for EOF target rates for pasture and cropland. 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 P5.2. For further details regarding EOF Erosion rates, please see Section 9.2.1 of the community model (US EPA 2008).

Rates for urban pervious, urban impervious, extractive, 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 Potomac River Montgomery County watershed.

Table 2: Summary of EOF Erosion Rate Calculations

Land Use	**Data Source**	**Montgomery County (MD)** (tons/acre/year)	**Frederick County (MD)** (tons/acre/year)	**District of Columbia** (tons/acre/year)
Forest	Phase 2 NRI	0.36	0.21	0.33
Harvested Forest[1]	Average Phase 2 NRI (x 10)	3	3	3
Nursery	Pasture NRI (x 9.5)	11.69	14.06	0.29
Pasture	Pasture NRI (1982-1987)	1.23	1.48	0.03
Trampled Pasture[2]	Pasture NRI (x 9.5)	11.69	14.06	0.29
Animal Feeding Operations[2]	Pasture NRI (x 9.5)	11.69	14.06	0.29
Hay[2]	Crop NRI (1982-1987) (x 0.32)	2.8	2.46	0.32
High Till[2]	Crop NRI (1982-1987) (x 1.25)	10.96	9.59	1.26
Low Till[2]	Crop NRI (1982-1987) (x 0.75)	6.57	5.76	0.75
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 P5.2 model is the same as the formula used by the NRCS (USDA 1983).

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

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 P5.2 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;

(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).

Edge-of-Stream Loads

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. The formula for the EOS load calculation is as follows:

$$\sum_{i}^{n} EOS = Acres_i * EOF_i * SDR_i * BMP_i \quad \text{(Equation 2.2)}$$

where:
n = number of land use classifications
i = land use classification
EOS = Edge of stream load, tons/yr
Acres = acreage for land use i
EOF = Edge-of-field erosion rate for land use i, tons/ac/yr
SDR = sediment delivery ratio for land use i, per Equation 2.1
BMP = BMP factor for land use i, as applicable

Streambank Erosion

Many studies have documented the relationship between high amounts of connected impervious surfaces, increases in storm flows, and stream degradation in the form of streambank erosion (Schueler 1994; Arnold and Gibbons 1996). In many urbanized watersheds, small stream channels have been replaced by sewer pipes. As a result, impervious surfaces such as rooftops, parking lots, and road surfaces are now directly connected to the main stream channel via the storm sewer system. During a storm event, this causes a greater amount of precipitation to flow more rapidly into a given stream channel once it reaches the surface. Furthermore, less water soaks into the ground both during and after a storm event, thereby limiting the amount of groundwater recharge to a stream. This altered urban hydrology typically causes abnormally high flows in streams during storms and abnormally low flows during dry periods. The high flows occurring during storm events increase sheer stress and cause excessive erosion of streambanks and streambeds, which leads to degraded stream channel conditions for biological communities (MDE 2007).

Two methods of estimating streambank erosion were presented in the *Total Maximum Daily Loads of Sediment/Total Suspended Solids for the Anacostia River Basin, Montgomery and Prince George's Counties, Maryland and The District of Columbia*. The first estimate uses the Anacostia Hydrological Simulation Program – FORTRAN (HSPF) watershed model in conjunction with the Penn State University streambank erosion equation (Evans et al. 2003). The analysis estimated that approximately 73% of the total annual sediment load within the Anacostia River watershed could be attributed to streambank erosion (MDE 2007).

The second method analyzes the long term relationship between flow and total suspended solids (TSS) concentrations to quantify the effects of an altered urban hydrology on watershed sediment loads. Changes in hydrology in the Anacostia River watershed were characterized using daily flow data from the USGS gage stations. The long-term changes over time in the flow duration curves (FDCs) for each of these stations was quantified using a type of statistical analysis known as "quantile regression." The portion of the FDC representing the highest flows was determined to have increased significantly over time, consistent with hydrologic alteration from increased impervious surfaces. Also, a "sediment rating curve" (i.e., the relationship between suspended sediment concentration and flow) was computed and combined with the FDCs to estimate annual sediment loads before and after increased development (i.e., altered hydrology). The results of the analysis indicate that approximately 75% of the total annual sediment load in the Anacostia River watershed is due to alterations in hydrology (MDE 2007).

Using CBP P5.2 urban sediment EOF target values, MDE developed a formula for estimating the percent of the urban sediment load resultant from streambank erosion (i.e., that portion of the total urban sediment load attributed to stream bank erosion) based on the amount of impervious land within the total urban land use of a watershed. The assumption is that as impervious surfaces increase, the upland sources decrease, flow increases, and the change in sediment load results from increased streambank erosion. This formula recognizes that stream bank erosion can be a significant portion of both the urban sediment load and the total watershed sediment load.

The formula is as follows:

$$\%E = \frac{I * L_I}{I * L_I + (1 - I)L_P} \qquad \text{(Equation 2.3)}$$

Where:
% E = Percent of urban sediment load resultant from streambank erosion
I = Percent impervious of urban land use acreage
L_I = Impervious urban land use EOF load
L_P = Pervious urban land use EOF load

The relationship demonstrated in equation 2.3 is expressed graphically in Figure 3.

While this formula only represents an empirical approximation, it is consistent with results from the Anacostia River Sediment TMDL. Using the equation, the Anacostia River watershed (31% of urban land use covered by impervious surfaces) would equate to approximately a 74% urban sediment load resultant from streambank erosion. This translates to approximately 64% of the total Anacostia River watershed sediment load resulting from streambank erosion, since total urban land use accounts for approximately 86% of the total watershed sediment load. This is slightly less, but still consistent with, the other methods used to estimate the percentage of the total watershed sediment load resultant from streambank erosion within the Anacostia River Sediment TMDL.

Per Table 1, approximately 21% of the Potomac River Montgomery County watershed urban land use is covered by impervious surfaces. This would equate to approximately a 65% urban sediment load resultant from streambank erosion, or 21% of the total watershed sediment load.

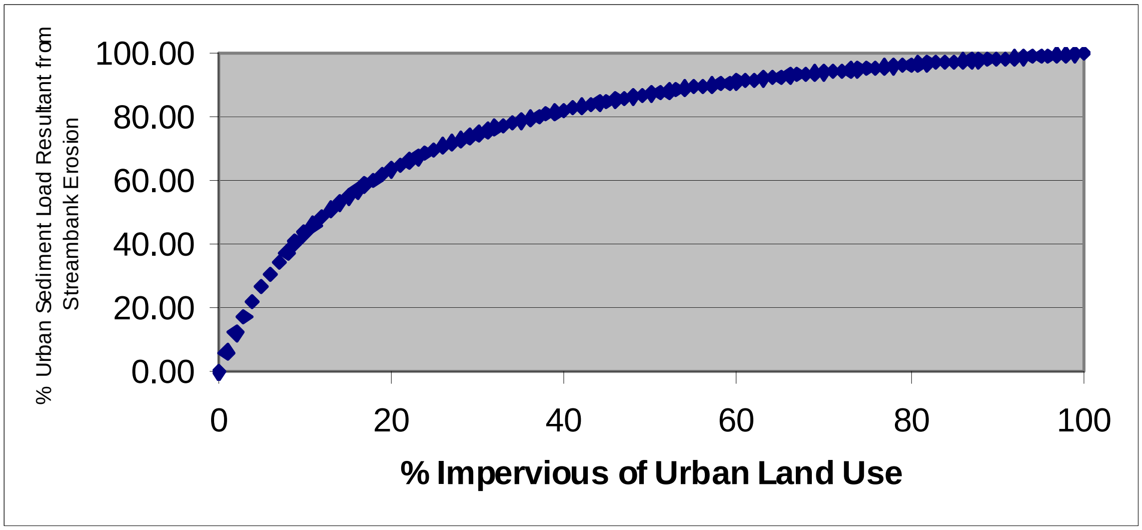

Figure 3: Percent Impervious of Urban Land Use vs. Percent of the Urban Sediment Load Resultant from Streambank Erosion (Based on Equation 2.3)

For this TMDL, the urban sediment resultant from streambank erosion represents an aggregate load within the total urban impervious EOF loads as described in the report *Chesapeake Bay Phase V Community Watershed Model* (US EPA 2008) and is not explicitly reported.

2.2.2 Point Source Assessment

A list of 16 active permitted point sources that contribute to the sediment load in the MD 8-Digit Potomac River Montgomery County watershed was compiled using MDE's Environmental Permit Service Center (EPSC) database. The types of permits identified include individual industrial, individual municipal, individual municipal separate storm sewer systems (MS4s), general mineral mining, general industrial stormwater, and general MS4s. The permits can be grouped into two categories, process water and stormwater. The process water category includes those loads generated by continuous discharge sources whose permits have TSS limits. Other permits that do not meet these conditions are considered *de minimis* in terms of the total sediment load. The stormwater category includes all National Pollutant Discharge Elimination System (NPDES) regulated stormwater discharges.

The sediment loads for the seven process water permits (Process Water BL_{PR}) are calculated based on their permitted TSS limits (average monthly or weekly concentration values) and corresponding flow information. The nine NPDES Phase I or Phase II stormwater permits identified throughout the MD 8-Digit Potomac River Montgomery County 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_{PR}) is calculated using Equation 2.2 and watershed specific urban land use 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 District of Columbia portion of the Potomac River Montgomery County watershed. Subsequently, sediment baseline loads from this watershed will be presented as a District of Columbia Upstream Baseline Load (BL_{DC}). The BL_{DC} is estimated based on the same nonpoint source load estimation methodology described in Section 2.2.1.

2.2.4 Summary of Baseline Loads

Table 3 summarizes the MD 8-Digit Potomac River Montgomery County Baseline Sediment Load, reported in tons per year (ton/yr) and presented in terms of an Upstream Baseline Load and MD 8-Digit Potomac River Montgomery County Watershed Baseline Load Contribution nonpoint and point source loadings.

Table 3: MD 8-Digit Potomac River Montgomery County Baseline Sediment Loads (ton/yr)

Total Baseline Load (ton/yr)		Upstream Baseline Load[1]		MD 8-digit Potomac River Montgomery County Watershed Baseline Load Contribution				
	=	BL_{DC}	+	Nonpoint Source BL_{PR}	+	NPDES Stormwater BL_{PR}	+	Process Water BL_{PR}
24,469.2	=	556.3	+	16,317.6	+	7,499.9	+	95.5

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

Table 4 presents a breakdown of the MD 8-Digit Potomac River Montgomery County Total Baseline Sediment Load, detailing loads per land use. The largest portion of the sediment load in Maryland and the District of Columbia, respectively, is from crop land (55.1%) and urban land (98.6%). In Maryland, the remainder of the sediment load is from urban land (31.4%), forest (9.4%), pasture (3.5%), and extractive (0.3%). In the District of Columbia, the remainder of the sediment load is from forest (1.4%).

Table 4: Detailed Baseline Sediment Budget Loads Within the MD 8-digitPotomac River Montgomery County Watershed

General Land Use	Detailed Land Use	Maryland Load (ton/yr)	Maryland Percent	Maryland Grouped Percent of Total	District of Columbia Load (ton/yr)	District of Columbia Percent	District of Columbia Grouped Percent of Total
Crop	Animal Feeding Operations	33.2	0.1	55.1	0.0	0.0	0.0
	Hay	1,685.8	7.0		0.0	0.0	
	High Till	2,595.3	10.9		0.0	0.0	
	Low Till	8,838.3	37.0		0.0	0.0	
	Nursery	14.4	0.1		0.0	0.0	
Extractive	Extractive	70.1	0.3	0.3	0.0	0.0	0.0
Forest	Forest	2,079.6	8.7	9.4	7.1	1.3	1.4
	Harvested Forest	175.8	0.7		0.6	0.1	
Pasture	Pasture	825.1	3.5	3.5	0.0	0.0	
	Trampled Pasture	0.0	0.0		0.0	0.0	
Urban[1]	Barren	443.4	1.9	31.4	40.9	7.3	98.6
	Impervious	4,121.3	17.2		396.8	71.3	
	Pervious	2,935.2	12.3		110.9	19.9	
	Process Water	95.5	0.4	0.4	0.0	0.0	0.0
	Total	**23,912.9**	**100.0**	**100.0**	**556.3**	**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 Potomac River Montgomery County 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. Therefore, to determine whether aquatic life is impacted by elevated sediment loads, MDE's BSID methodology was applied. The primary goal of the BSID analysis is to identify the most probable cause(s) for observed biological impairments throughout MD's 8-digit watersheds (MDE 2009).

The BSID analysis applies a case-control, risk-based, weight-of-evidence approach to identify potential causes of biological impairment. The risk-based approach estimates the strength of association between various stressors and an impaired biological community. The BSID analysis then identifies individual stressors as probable or unlikely causes of the poor biological conditions within a given MD 8-digit watershed, and subsequently reviews ecological plausibility. Finally, the analysis concludes whether or not these individual stressors or groups of stressors are contributing to the impairment (MDE 2009).

The primary dataset for BSID analysis is Maryland Department of Natural Resources (DNR) Maryland Biological Stream Survey (MBSS) round two data (collected between 2000-2004) because it provides a broad spectrum of paired data variables, which allow for a more comprehensive stressor analysis. The MBSS is a robust statewide probability-based sampling survey for assessing the biological conditions of 1st through 4th order, non-tidal streams (Klauda et al. 1998; Roth et al. 2005). It uses a fixed length (75 meter (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). The random sample design allows for unbiased estimates of overall watershed conditions. Thus, the dataset facilitated case-control analyses because: 1) in-stream biological data are paired with chemical, physical, and land use data variables that could be identified as possible stressors; and 2) it uses a probabilistic statewide monitoring design.

The BSID analysis combines the individual stressors (physical and chemical variables) into three generalized parameter groups in order to assess how the resulting impacts of these stressors can alter the biological community and structure. The three generalized parameter groups include: sediment, habitat, and water chemistry. Identification of a sediment/flow stressor as contributing to the biological impairment is based on the results of the individual stressor associations within both the sediment and habitat parameter groups that reveal the effects of sediment related impacts or an altered hydrologic regime (MDE 2009).

Since it uses MBSS data, the BSID applies only to 1st through 4th order streams in a MD 8-digit watershed. In larger order rivers and streams, DNR CORE/TREND program data is used to assess the support of aquatic life. 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 (DI), the modified Hilsenhoff Biotic Index (HBI), and percent *Ephemeroptera*, *Plecoptera*, and *Trichoptera* (EPT). DNR has extensive benthic macroinvertebrate monitoring data for two stations on the mainstem of the MD 8-Digit Potomac River Montgomery County through the CORE/TREND program. These stations have between 21 and 23 years of benthic macroinvertebrate data (DNR 2009).

MD 8-Digit Potomac River Montgomery County Watershed Monitoring Stations

A total of 44 water quality monitoring stations were used to characterize the MD 8-Digit Potomac River Montgomery County watershed. Forty-two biological/physical habitat monitoring stations from the MBSS program round one and round two data collection were used to describe the MD 8-Digit Potomac River Montgomery County watershed in Maryland's 2008 Integrated Report. The BSID analysis used the 30 biological/physical habitat monitoring stations from the MBSS program round two data collection. Additionally, two monitoring stations from the Maryland CORE/TREND monitoring network were applied within the TMDL analysis. All stations are presented in Figure 3 and listed in Table 5.

Table 5: Monitoring Stations in the MD 8-Digit Potomac River Montgomery County Watershed

Site Number	Sponsor	Site Type	Location	Latitude (decimal degrees)	Longitude (decimal degrees)
POT1183	DNR	CORE/TREND	Potomac River	38.9482	-77.1272
POT1471	DNR	CORE/TREND	Potomac River	39.1546	-77.5214
MO-P-001-214-97	DNR	MBSS Round 1	Watts Branch	39.0902	-77.1721
MO-P-014-107-97	DNR	MBSS Round 1	Potomac River UT6[1]	39.1549	-77.5162
MO-P-016-227-97	DNR	MBSS Round 1	Broad Run UT1	39.1538	-77.4351
MO-P-064-328-97	DNR	MBSS Round 1	Little Monocacy River	39.2148	-77.4379
MO-P-091-204-97	DNR	MBSS Round 1	Muddy Branch	39.1086	-77.2330
MO-P-108-123-97	DNR	MBSS Round 1	Watts Branch UT1	39.0939	-77.1824
MO-P-206-311-97	DNR	MBSS Round 1	Broad Run	39.1289	-77.4671
MO-P-251-115-97	DNR	MBSS Round 1	Little Monocacy River UT1	39.2215	-77.3659
MO-P-436-226-97	DNR	MBSS Round 1	Horsepen Branch UT2 UT1	39.0836	-77.3951
MO-P-481-101-97	DNR	MBSS Round 1	Potomac River UT7	39.1984	-77.4598
MO-P-496-215-97	DNR	MBSS Round 1	Broad Run UT2 UT1	39.1332	-77.4737
MO-P-514-116-97	DNR	MBSS Round 1	Broad Run UT1	39.1568	-77.4328
COCA-102-N-2003	DNR	MBSS Round 2	Potomac River UT19	39.1878	-77.4733
COCA-108-N-2003	DNR	MBSS Round 2	Potomac River UT20	39.1599	-77.5159
COCA-109-N-2003	DNR	MBSS Round 2	Potomac River UT20	39.1589	-77.5168
COCA-111-N-2003	DNR	MBSS Round 2	Potomac River UT20	39.1585	-77.5175
COCA-117-N-2003	DNR	MBSS Round 2	Minnehaha Branch	38.9645	-77.1410
COCA-205-N-2003	DNR	MBSS Round 2	Horsepen Branch UT2	39.0681	-77.3653
COCA-206-N-2003	DNR	MBSS Round 2	Muddy Branch	39.0549	-77.2940
COCA-208-N-2003	DNR	MBSS Round 2	Rock Run	38.9703	-77.1814
COCA-209-N-2003	DNR	MBSS Round 2	Rock Run	38.9717	-77.1820
COCA-210-N-2003	DNR	MBSS Round 2	Muddy Branch	39.0586	-77.2948
COCA-307-N-2003	DNR	MBSS Round 2	Horsepen Branch	39.0723	-77.4131
COCA-308-N-2003	DNR	MBSS Round 2	Watts Branch	39.0429	-77.2651
GWPY-212-N-2004	DNR	MBSS Round 2	Little Falls Branch	38.9383	-77.1178
NCRW-208-N-2004	DNR	MBSS Round 2	Cabin Branch UT1	39.0919	-77.4575
NCRW-309-N-2004	DNR	MBSS Round 2	Muddy Branch	39.0647	-77.2956
PRMO-103-R-2002	DNR	MBSS Round 2	Rock Run	39.0166	-77.2125
PRMO-109-R-2002	DNR	MBSS Round 2	Willett Branch	38.9654	-77.1063
PRMO-110-R-2002	DNR	MBSS Round 2	Broad Run	39.1506	-77.4552
PRMO-112-R-2002	DNR	MBSS Round 2	Greenbriar Branch	39.0544	-77.2479
PRMO-114-R-2002	DNR	MBSS Round 2	Little Monocacy River UT2	39.1969	-77.4221
PRMO-115-R-2002	DNR	MBSS Round 2	Little Monocacy River UT2	39.1968	-77.4235
PRMO-120-R-2002	DNR	MBSS Round 2	Little Monocacy River UT3	39.2145	-77.4472
PRMO-202-R-2002	DNR	MBSS Round 2	Broad Run	39.1270	-77.4580
PRMO-222-R-2002	DNR	MBSS Round 2	Watts Branch	39.0443	-77.2284
PRMO-295-E-2004	DNR	MBSS Round 2	Watts Branch	39.0487	-77.2141
PRMO-304-R-2002	DNR	MBSS Round 2	Little Monocacy River	39.2307	-77.4037
PRMO-307-R-2002	DNR	MBSS Round 2	Little Monocacy River	39.2149	-77.4438

Site Number	Sponsor	Site Type	Location	Latitude (decimal degrees)	Longitude (decimal degrees)
PRMO-311-R-2002	DNR	MBSS Round 2	Little Monocacy River	39.2209	-77.4491
PRMO-313-R-2002	DNR	MBSS Round 2	Horsepen Branch	39.0815	-77.4188
PRMO-323-R-2002	DNR	MBSS Round 2	Little Monocacy River	39.2283	-77.4046

Note: [1]UT = Unnamed Tributary

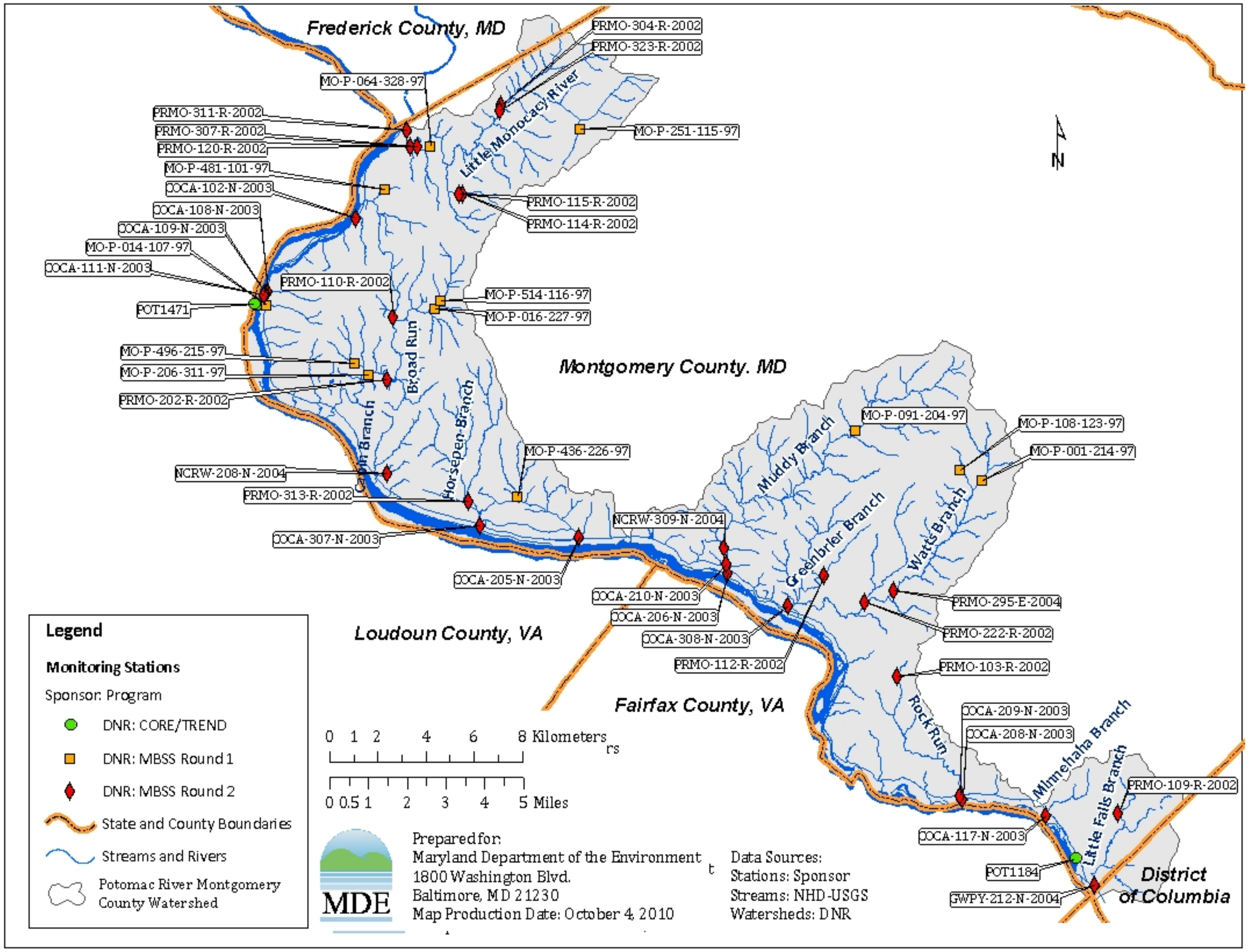

Figure 4: Monitoring Stations in the MD 8-Digit Potomac River Montgomery County Watershed

2.4 Water Quality Impairment

The Maryland water quality standards surface water use designation for the MD 8-Digit Potomac River Montgomery County mainstem and its tributaries is Use I-P (Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply) (COMAR 2010a,b). The water quality impairment of the MD 8-Digit Potomac River Montgomery County watershed addressed by this TMDL is caused by an elevated sediment load beyond a level that the watershed can sustain, thereby causing sediment related impacts that can not support aquatic life. Assessment of aquatic life is based on benthic and fish Index of Biotic Integrity (IBI) scores, as demonstrated via the BSID analysis for the watershed.

The MD 8-Digit Potomac River Montgomery County watershed is listed on Maryland's 2008 Integrated Report as impaired for impacts to biological communities. The biological assessment is based on the combined results of MBSS round one (1995-1997) and round two (2000-2004) data, which includes 42 stations. Twenty-eight of the 42 stations, or 67% of the stream miles in the watershed, are assessed as having BIBI and/or FIBI scores significantly lower than 3.0 (on a scale of 1 to 5) (MDE 2008). As mentioned in Section 2.3, however, only MBSS round two data were used in the BSID analysis. See Figure 3 and Table 5 for station locations and information.

The results of the BSID analysis for the MD 8-Digit Potomac River Montgomery County watershed are presented in a report entitled *Watershed Report for Biological Impairment of the Potomac River Montgomery County Watershed, Montgomery County, Maryland Biological Stressor Identification Analysis Results and Interpretation*. The report states that the degradation of biological communities in the MD 8-Digit Potomac River Montgomery County watershed is strongly associated with various urban land use and its concomitant effects (MDE 2011).

The BSID analysis has determined that the biological impairment in the MD 8-Digit Potomac River Montgomery County watershed is due in part to flow/sediment related stressors. Specifically, the analysis confirmed that individual stressors within the sediment and habitat parameter groupings were contributing to the biological impairment in the watershed. Overall, sediment and flow stressors within the sediment and habitat parameter groupings were identified as having a statistically significant association with impaired biological communities at approximately 85% and 47%, respectively, of the sites with BIBI and/or FIBI scores significantly less than 3.0 throughout the watershed (MDE 2011). Therefore, since sediment is identified as a stressor to the biological communities in the MD 8-Digit Potomac River Montgomery County watershed, the results confirm the 1996 sediment listing, and a TMDL is required.

As discussed in Section 2.3, the BSID applies only to 1st through 4th order streams in a watershed. Therefore, aquatic life in the Potomac River Montgomery County watershed mainstem is assessed using DNR CORE/TREND program data. As shown in Table 6, the biological monitoring results from two DNR CORE/TREND stations data along the

MD 8-Digit Potomac River Montgomery County watershed mainstem indicate that mainstem water quality can be classified "FAIR/GOOD" to "GOOD". Statistical analysis of the long term CORE/TREND data indicates that since 1977, one station has shown improvement and one station has shown no change. These results are based on percent EPT, taxa number, biotic index, and diversity index (DNR 2009).

Generally, a CORE/TREND assessment of "GOOD" or better indicates that the waterbody is supportive of aquatic life, based on previously approved nontidal sediment TMDL analyses. Station POT1183, which is located at Little Falls below the dam, achieved only a "FAIR/GOOD" status, indicating borderline water quality conditions. POT1183 is the only station on the mainstem Potomac River below the confluence of the North and South Branches with an assessment less than "GOOD". An analysis comparing the benthic community metrics for all CORE/TREND stations on the mainstem Potomac River below the confluence of the North and South Branches was performed to further evaluate this "FAIR/GOOD" status (see Appendix D). For the period 2000-2008, the individual benthic community metrics for POT1183 are not significantly different from the other mainstem Potomac River stations that have been assessed as "GOOD" or better. Based on this comparative analysis of benthic community metrics in the mainstem Potomac River, it is concluded that the benthic macroinvertebrate data collected under the CORE/TREND program supports the conclusion that the MD 8-Digit Potomac River Montgomery County watershed mainstem is supportive of aquatic life.

Table 6: MD 8-Digit Potomac River Montgomery County Watershed CORE/TREND Data

Site Number	Current Water Quality Status	Trend Since 1970's
POT1183	FAIR/GOOD	NO CHANGE
POT1471	GOOD	IMPROVEMENT

3.0 TARGETED WATER QUALITY GOAL

The objective of the sediment TMDL established herein is to reduce sediment loads, and subsequent effects on aquatic life in the 1st through 4th order streams in the MD 8-Digit Potomac River Montgomery County watershed, to levels that support the Use I-P designation (Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply) (COMAR 2010a,b). Assessment of aquatic life 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; MDE 2008).

Reductions in 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.

The sediment TMDL, however, will not completely resolve the impairment to biological communities in the 1st through 4th order streams within the watershed. Since the BSID watershed analysis identifies chlorides, sulfates, and high pH as other possible stressors impacting the biological conditions, this impairment remains to be fully addressed through the Integrated Report listing and TMDL development processes. This impairment to aquatic life will only be fully addressed when all impairing substances identified as impacting biological communities in the watershed are reduced to levels that will meet water quality standards, as established in future TMDLs for those substances (MDE 2009, 2011).

Based on the analysis of benthic monitoring results at CORE/TREND stations (see Appendix D), it has been determined that the mainstem of the MD 8-Digit Potomac River Montgomery County watershed is supportive of aquatic life and is therefore not impaired by sediment. The TMDL will be restricted to the 1st through 4th order tributaries within the MD 8-Digit watershed and will exclude the mainstem Potomac River. Hereafter, unless otherwise noted, "MD 8-Digit Potomac River Montgomery County" will only refer to the 1st through 4th order tributaries within Maryland draining to the Potomac River mainstem in Montgomery County, and "Potomac River Montgomery County" will refer to the 1st through 4th order tributaries within both Maryland and the District of Columbia draining to the Potomac River mainstem in Montgomery County. Process water facilities discharging to the mainstem of the MD 8-Digit watershed will receive wasteload allocations (WLAs) and will be included in the overall process water WLA for informational purposes only. The baseline loads described in Section 2.2 are restricted to the loads entering the 1st through 4th order streams in the MD 8-digit watershed. The process water point source facilities discharging directly to the mainstem of the watershed, however, are included in the baseline loads for informational purposes. The baseline loads do not include upstream loads that empty directly into the mainstem.

District of Columbia upstream loads are included though, since they empty into 1st through 4th order tributary streams within Maryland prior to entering the mainstem Potomac River.

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 Potomac River Montgomery County watershed. 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 MOS. Finally, Section 4.8 summarizes the TMDL.

4.2 Analysis Framework

Since there are no specific numeric criteria that quantify the impact of sediment on the aquatic life of nontidal stream systems, a reference watershed approach will be used to establish the TMDL. Furthermore, as the BSID analysis established a link between biological impairment and sediment related stressors, the reference watershed approach will utilize a biological endpoint.

Watershed Model

The watershed model framework chosen for the MD 8-Digit Potomac River Montgomery County watershed TMDL was the CBP P5.2 long-term average annual watershed model EOS loading rates. The spatial domain of the CBP P5.2 watershed model segmentation aggregates to the MD 8-digit watersheds, which is consistent with the impairment listing. The EOS loading rates were used because actual time variable CBP P5.2 calibration and scenario runs were not available upon development of the nontidal sediment TMDL methodology (Currey et al. 2006). These target-loading rates have been used to calibrate the land use EOS loads within the CBP P5.2 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 Potomac River Montgomery County watershed as well as the District of Columbia upstream baseline sediment loads 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 watershed (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 Potomac River Montgomery County watershed was evaluated using one watershed TMDL Segment consisting of eight CBP P5.2 model segments (See Figure 4).

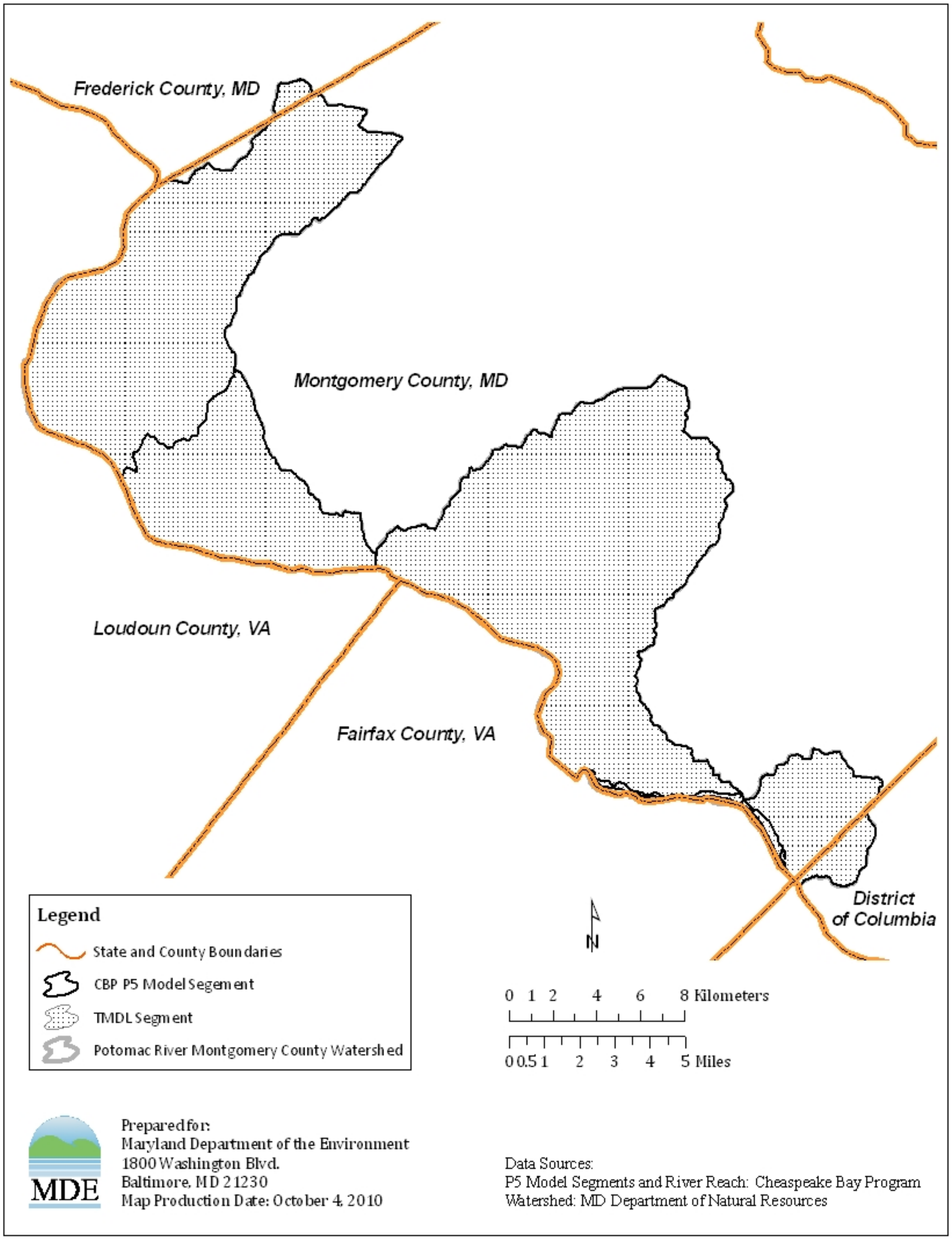

Figure 5: Potomac River Montgomery County Watershed TMDL Segmentation

Reference Watershed Approach

Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic life of non-tidal stream systems. Therefore, in order to quantify the impact of sediment on the aquatic life 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). Reference watersheds were determined based on Maryland's biocriteria methodology. The biocriteria methodology assesses biological impairment at the MD 8-digit watershed scale based on the percentage of MBSS monitoring stations, translated into watershed stream miles, that have BIBI and/or FIBI scores lower than the Minimum Allowable IBI Limit (MAL). The MAL is calculated based on the average annual allowable IBI value of 3.0 (on a scale of 1 to 5). It accounts for annual variability and helps to avoid classification errors (i.e., false positives) when assessing for biological impairments (Roth et al. 1998, 2000; Stribling et al. 1998; MDE 2008).

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 (i.e., soils, slope, etc.), 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 IX 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:

$$Y_n = \frac{y_{ws}}{y_{for}} \qquad \text{(Equation 4.1)}$$

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

Nine reference watersheds were selected from the Highland/Piedmont region. Reference watershed *forest normalized sediment loads* were calculated using CBP P5.2 2000 land use in order to maintain consistency with MBSS sampling years. The median and 75th percentile of the reference watershed *forest normalized sediment loads* were calculated and found to be 3.3 and 4.2 respectively. These values are in close agreement with methods used to determine the *sediment loading threshold* in previous nontidal sediment TMDLs. Therefore, the median value of 3.3 was established as the sediment loading threshold as an environmentally conservative approach to develop this TMDL (see Appendix A for more details).

The *forest normalized sediment load* for the Potomac River Montgomery County watershed (estimated as 4.9) was calculated using CBP P5.2 2005 land use, to best represent current conditions. A comparison of the Potomac River Montgomery County watershed *forest normalized sediment load* to the *forest normalized reference sediment load* (also referred to as the *sediment loading threshold*) demonstrates that the watershed exceeds the *sediment loading threshold*, indicating that it is receiving loads above the maximum allowable load that it can sustain and still meet water quality standards.

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.

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 source loads and upstream loads during the monitoring time frame, as well as estimated point source loads based on discharge data for the same period.

The Potomac River Montgomery County watershed baseline sediment loads are estimated using the CBP P5.2 target EOS land use sediment loading rates with 2005 land use. Watershed loading calculations, based on the CBP P5.2 segmentation scheme, are represented by multiple CBP P5.2 model segments within a TMDL segment. The sediment loads from these segments are combined to represent the baseline condition. The 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 and Appendix B of this report.

TMDL Conditions

This scenario represents the future conditions of maximum allowable sediment loads that will be at a level to support aquatic life. 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 biological community) and the Potomac River Montgomery County *all forested sediment load* (see Section 4.2). The resulting load is considered the maximum allowable load the watershed can sustain and support aquatic life.

The TMDL loading and associated reductions are averaged at the watershed scale; however, 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:

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

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 CBP P5.2 model segment *i* (ton /yr)
i = CBP P5.2 model segment
n = number of CBP P5.2 model segments in watershed

The Potomac River Montgomery County watershed allowable sediment load is estimated using equation 4.2. Also, in accordance with the conclusion drawn in Sections 2.4 and 3.0 that the mainstem of the MD 8-Digit watershed is not impaired by sediment, the four process water point sources discharging to the mainstem Potomac River (see Appendix B for a detailed list of these facilities) and are given WLAs for informational purposes only. Because they do not impact the MD 8-Digit 1st through 4th order streams, their WLAs are added to the forest normalized sediment threshold to make up the TMDL.

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 2010b). 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 reflect the impacts of stressors (i.e., sediment impacts to stream biota) over the course of time and therefore depict an average stream condition (i.e., captures all high and low flow events). Since the TMDL endpoint is based on the median of forest normalized loads from watersheds assessed as having good biological conditions (i.e., passing Maryland's biocriteria), by the nature of the biological data described above, it must inherently include the critical conditions of the reference watersheds. Therefore, since the TMDL reduces the watershed sediment load to a level compatible with that of the reference watersheds, critical conditions are inherently addressed. Seasonality is captured in two components. First, it is implicitly included through the use of the biological monitoring data as biological monitoring data reflect the impacts of stressors over time, as described above. Second, the MBSS dataset included benthic sampling in the spring (March 1 - April 30) and fish sampling in the summer (June 1 - September 30). Benthic sampling in the spring allows for the most accurate assessment of the benthic population, and therefore provides an excellent means of assessing the anthropogenic effects of sediment impacts on the benthic community. Fish sampling is conducted in the summer when low flow conditions significantly limit the physical habitat of the fish community, and it is therefore most reflective of the effects of anthropogenic stressors as well.

4.5 TMDL Loading Caps

This section presents the MD 8-Digit Potomac River Montgomery County watershed average annual sediment TMDL. This load is considered the maximum allowable long-term average annual load the watershed can sustain and support aquatic life. However, further reductions may be required in order to meet downstream water quality goals quantified in the Chesapeake Bay Nutrient and Sediment TMDLs established by EPA on December 29, 2010, specifically the allocations assigned to the Potomac River Tidal Fresh Chesapeake Bay Water Quality Segment.

The long-term average annual TMDL was calculated based on Equation 4.2 and set at a load 3.3 times the all forested condition. In order to attain the TMDL loading cap calculated for the watershed, constant reductions were applied to the predominant controllable sources (i.e., significant contributors of sediment to the stream system), independent of jurisdiction. If only these predominant sources are controlled, the TMDL can be achieved in the most effective, efficient, and equitable manner. Predominant sources typically include urban land, high till crops, low till crops, hay, and pasture, but additional sources could be controlled as well, in order to ensure that the TMDL is attained. Urban land, high till crops, low till crops, hay, and pasture were identified as the predominant controllable sources in the watershed. Thus, constant reductions were applied to these sources. Additionally, all urban land in the Potomac River Montgomery County watershed is considered to represent regulated stormwater sources (i.e., all urban stormwater is regulated via a permit).

In accordance with the conclusion drawn in Sections 2.4 and 3.0, the four process water point sources discharging to the mainstem MD 8-Digit Potomac River Montgomery County are given WLAs for informational purposes only. Table B-2 identifies which point sources discharge directly to the mainstem. Since the estimated sediment loads from these four process water point sources do not impact 1st through 4th order streams, their WLAs are added to the loading calculated based on equation 4.2 after the fact, to produce a final TMDL value.

Relative to the estimated sediment load reductions applied to urban land, which are necessary to achieve the TMDL, the current Montgomery County Phase I MS4 permit requires the jurisdiction to retrofit 20% of their existing impervious area where there is failing, minimal, or no stormwater management (estimated to be areas developed prior to 1985) within a permit cycle (five years) (i.e., the jurisdiction needs to install/institute stormwater management practices to treat runoff from these existing impervious areas) (MDE 2010b). Theoretically, extending these permitting requirements to all urban stormwater sources (i.e., not solely those sources regulated via the Montgomery County Phase I MS4 permit) would require that all impervious areas developed prior to 1985 be retrofit at this pace. Additionally, MDE estimates that future stormwater retrofits will have, on average, a 65% TSS reduction efficiency (Claytor and Schueler 1997; Baldwin et al. 2007; Baish and Caliri 2009). By default, these retrofits will also provide treatment of any adjacent urban pervious runoff within the applicable drainage area.

The MD 8-Digit Potomac River Montgomery County Baseline Load and TMDL are presented in Table 7.

Table 7: MD 8-Digit Potomac River Montgomery County Baseline Load and TMDL

Baseline Load (ton/yr)	**TMDL** (ton/yr)	**Reduction** (%)
24,469.2	16,524.0	32.4

4.6 Load Allocations Between Point and Nonpoint Sources

Per EPA regulation, all TMDLs need to be presented as a sum of WLAs for point sources and load allocations (LAs) for nonpoint source loads generated within the assessment unit, as accounting for natural background, tributary, and adjacent segment loads (CFR - 2010a). In the case of the MD 8-Digit Potomac River Montgomery County watershed, the assessment unit is restricted to the 1st through 4th order streams in the Maryland portion of the watershed draining to the Potomac River mainstem, and not the Potomac River mainstem itself. The only loads from adjacent segments or upstream sources which will be considered are the upstream loads from the District of Columbia, since they empty into 1st through 4th order tributary streams within Maryland prior to entering the mainstem Potomac River. Consequently, the MD 8-Digit Potomac River Montgomery County watershed TMDL allocations are presented in terms of WLAs (i.e., point source loads identified within the MD 8-Digit watershed) and LAs (i.e., the nonpoint source loads within the MD 8-Digit watershed and loads entering the MD 8-Digit watershed from outside of the assessment unit). The State reserves the right to allocate the TMDL among different sources in any manner that protects aquatic life from sediment related impacts.

As described in section 4.5, reductions were applied equally to the predominant controllable sources, which were identified as urban land, high till crops, low till crops, hay, and pasture. Forest is the only non-controllable source, as it represents the most natural condition in the watershed, and no reductions were applied to permitted process load sources, since such controls would produce no discernable water quality benefit when nonpoint sources and regulated stormwater sources comprise greater than 99% of the total watershed sediment load. WLAs for the three process water facilities that discharge into the mainstem Potomac River (see Appendix B for a detailed list of these facilities) have been given informational WLAs based on their design flow and permitted TSS concentrations, and have been included along with the other facilities in the process water WLA.

Based on the current Montgomery County Phase I MS4 permit requirements described in Section 4.5 and the theoretical extension of these requirements to all urban stormwater sources within the watershed, it is anticipated that the urban sediment load reductions necessary to achieve the TMDL will be achieved by retrofitting impervious areas developed prior to 1985 (i.e. approximate areas with failing, minimal, or no stormwater management) (MDE 2010b). Also, it is expected that these future stormwater retrofits will have an estimated 65% TSS reduction efficiency (Claytor and Schueler 1997; Baldwin et al. 2007; Baish and Caliri 2009), and by default, they will provide treatment of any adjacent urban pervious runoff within the applicable drainage area.

Table 8 summarizes the TMDL results derived by applying equal percent reductions to the predominant controllable sediment sources. The TMDL results in a reduction of 32.4% for the MD 8-Digit Potomac River Montgomery County Watershed Contribution, a reduction of 35.3% for the Upstream District of Columbia, and an overall reduction of 32.4%. For more detailed information regarding the MD 8-Digit Potomac River Montgomery County Watershed TMDL nonpoint source LA, please see the technical memorandum to this document entitled "*Significant Sediment Nonpoint Sources in the Potomac River Montgomery County Watershed*". The reductions from the urban sector required to meet this TMDL would entail that at a 65% TSS reduction efficiency, approximately 88% of the urban area (impervious and pervious acres) within the watershed that was developed prior to 1985 will need to be retrofit, or an equivalent reduction in sediment loads from other types of stormwater retrofits is necessary (see Section 5.0 for a detailed description of the other types of stormwater retrofits).

Table 8: MD 8-Digit Potomac River Montgomery County TMDL Reductions by Source Category

<table>
<tr><th></th><th colspan="2">Baseline Load Source Categories</th><th>Baseline Load (ton/yr)</th><th>TMDL Components</th><th>TMDL (ton/yr)</th><th>Reduction (%)</th></tr>
<tr><td rowspan="3">MD 8-digit Potomac River Montgomery County Watershed Contribution</td><td colspan="2">Nonpoint Source</td><td>16,317.6</td><td>LA</td><td>11,286.6</td><td>30.8</td></tr>
<tr><td rowspan="2">Point Source</td><td>Urban</td><td>7,499.9</td><td rowspan="2">WLA</td><td>4,782.0</td><td>36.2</td></tr>
<tr><td>Permits</td><td>95.5</td><td>95.5</td><td>0</td></tr>
<tr><td colspan="3">Subtotal</td><td>23,912.9</td><td></td><td>16,164.1</td><td>32.4</td></tr>
<tr><td>Upstream</td><td colspan="2">District of Columbia</td><td>556.3</td><td>Upstream LA</td><td>359.9</td><td>35.3</td></tr>
<tr><td colspan="3">Total</td><td>24,469.2</td><td></td><td>16,524.0.0</td><td>32.4</td></tr>
</table>

The WLA of the MD 8-Digit Potomac River Montgomery County 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 industrial facilities
- Individual municipal facilities
- General mineral mining facilities

There are seven process water sources with explicit TSS limits in the MD 8-Digit Potomac River Montomgery County watershed that contribute to the watershed sediment load, which include three industrial discharges, three municipal discharges, and one mineral mine discharge. The total estimated TSS load from all of the process water sources, including the three facilities that discharge into the mainstem of the MD 8-Digit

Potomac River Montgomery County, is based on current, average permit limits and is equal to 95.5 ton/yr. As mentioned above, no reductions were applied to these sources, since such controls would produce no discernable water quality benefit when nonpoint sources and regulated stormwater sources comprise greater than 99% of the total watershed sediment load. For a detailed list of the eight process water permits including information on their permit limits, please see Appendix B. Information regarding the allocations to individual process water point sources would normally be included within the technical memorandum to this document entitled "*Significant Sediment Point Sources in the Potomac River Montgomery County Watershed*; however, since all seven process water sources are considered to be "minor facilities" (less than 1.0 Millions of Gallons/Day (MGD) flow), only an aggregate load is reported within the technical memorandum.

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),
- Industrial facilities permitted for stormwater discharges, 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 Potomac River Montgomery County watershed TMDL will be expressed as a single NPDES stormwater WLA. Upon approval of the TMDL, "NPDES-regulated municipal stormwater and small construction storm water discharges effluent limits should be expressed as BMPs or other similar requirements, rather than as numeric effluent limits" (US EPA 2002).

The MD 8-Digit Potomac River Montgomery County NPDES Stormwater WLA is based on reductions applied to the sediment load from the urban land use in 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 MD 8-Digit Potomac River Montgomery County NPDES Stormwater WLA requires an overall reduction of 36.2% (see Table 8).

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 protect aquatic life from sediment related impacts.

For more information on the methods used to calculate the NPDES regulated stormwater baseline sediment load, see Section 2.2.2. For a detailed list of all of the NPDES regulated stormwater discharges within the watershed, please see Appendix B, and for information regarding the NPDES stormwater WLA distribution amongst these discharges, please see the technical memorandum to this document entitled "*Significant Sediment Point Sources in the Potomac River Montgomery County Watershed*".

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 2010b). The MOS shall also account for any rounding errors generated in the various calculations used in the development of the TMDL. 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 4.2. Also, 50% of the reference watersheds have a value less than 3.3. 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 (Currey et al. 2006). This is considered an environmentally conservative estimate, since 50% of the reference watersheds have a load above this value (3.3), which when compared to the 75% value (4.2), results in an implicit MOS of approximately 18%.

4.8 Summary of Total Maximum Daily Loads

The average annual MD 8-Digit Potomac River Montgomery County watershed TMDL is summarized in Table 9. The TMDL is the sum of the LAs, NPDES Stormwater WLA, Process Water WLA, and MOS. The Maximum Daily Load (MDL) is summarized in Table 10 (See Appendix C for more details).

Table 9: MD 8-Digit Potomac River Montgomery County Watershed Average Annual TMDL of Sediment/TSS (ton/yr)

TMDL (ton/yr)	=	**LA**			+	**WLA**			+	**MOS**
		LA_{DC}[1]	+	**LA_{PR}**		**NPDES Stormwater WLA_{PR}**	+	**Process Water WLA_{PR}**		
16,524.0	=	359.9	+	11,286.6	+	4,782.0	+	95.5	+	Implicit

Upstream Load Allocation[2,3] (LA_{DC}); MD 8-Digit Potomac River Montgomery County Watershed TMDL Contribution (LA_{PR} + NPDES Stormwater WLA_{PR} + Process Water WLA_{PR})

Notes: [1] LA_{DC} was determined to be necessary in order to meet Maryland water quality standards within the MD 8-digit Potomac River Montgomery County watershed.
[2] Although for the purposes of this analysis, the upstream load is referred to as an LA, it could include loads from both point and nonpoint sources.
[3] A delivery factor of 1 was used for the Upstream LA.

Table 10: MD 8-Digit Potomac River Montgomery County Maximum Daily Loads of Sediment/TSS (ton/day)

MDL (ton/day)	=	**LA**			+	**WLA**			+	**MOS**
		LA_{DC}[1]	+	**LA_{PR}**		**NPDES Stormwater WLA_{PR}**	+	**Process Water WLA_{PR}**		
44.96	=	0.97	+	30.47	+	12.91	+	0.60	+	Implicit

Upstream Load Allocation[2,3] (LA_{DC}); MD 8-digit Potomac River Montgomery County Watershed MDL Contribution (LA_{PR} + NPDES Stormwater WLA_{PR} + Process Water WLA_{PR})

Notes: [1] LA_{DC} was determined to be necessary in order to meet Maryland water quality standards within the MD 8-digit Potomac River Montgomery County watershed.
[2] Although for the purposes of this analysis, the upstream load is referred to as an LA, it could include loads from both point and nonpoint sources.
[3] A delivery factor of 1 was used for the Upstream LA.

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 WLAs can and will be implemented (CFR 2010b). Maryland has several well-established programs to draw upon, including the Water Quality Improvement Act of 1998 (WQIA) and NPDES programs for both direct and stormwater discharges.

The Federal Nonpoint Source Management Program (§ 319 of the Clean Water Act), Buffer Incentive Program (BIP), State Water Quality Revolving Loan Fund, Bay Restoration Fund, Chesapeake Bay Trust Fund, Maryland Agricultural Cost Share Program (MACS), Environmental Quality Incentives Program (EQIP), and other programs can provide funding for both local governments and agricultural sources. Details of these programs and additional funding sources can be found at http://www.dnr.state.md.us/bay/services/summaries.html.

Potential BMPs for reducing sediment loads and resulting impacts can be grouped into two general categories. The first is directed toward agricultural lands, and the second is directed toward urban (developed) lands.

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). Lastly, riparian buffers can reduce the effect of agricultural sediment sources through trapping and filtering, and reforestation, whether adjacent to part of the watershed stream system or in a watershed's interior, can decrease agricultural sediment sources as well.

Sediment from urban areas can be reduced by stormwater retrofits that address both water quality and flow control. Examples of these retrofits include the modification of existing stormwater structural practices, the construction of new stormwater BMPs in prior development where there is none, a reduction in impervious surfaces, street sweeping, inlet cleaning, increases in the urban tree canopy, stream restoration, and any other management practice that effectively addresses water quality and flow control (i.e., riparian buffers for urban areas and watershed reforestation adjacent to the watershed stream system or within a watershed's interior). A significant portion of the sediment loading from the urban area within the MD 8-Digit Potomac River Montgomery County watershed is attributed to streambank erosion (see Section 2.2.1). Therefore, flow controls must be implemented to reduce sheer stress and limit bank erosion to address this portion of the urban sediment load. Additionally, impervious surface reduction results in a change in hydrology that could also reduce streambank erosion. In terms of upland urban sediment loads, stormwater retrofit reductions range from as low as 10% for dry detention to approximately 80% for wet ponds, wetlands, infiltration practices, and filtering practices (US EPA 2003). It is anticipated that the implementation of the TMDL will include the array of urban BMPs and practices outlined above. Implementation of the required urban sediment load reductions is expected to occur primarily via the Phase I MS4 permitting process for medium and large municipalities, specifically, in this watershed, the current Montgomery County Phase I MS4 permit, which requires the jurisdiction to retrofit 20% of its existing impervious area where there is failing, minimal, or no stormwater management (estimated to be areas developed prior to 1985) every permit cycle, or five years, and develop an implementation plan to meet its assigned regulated stormwater allocation. Since a small portion of the watershed is located in Frederick County as well, implementation of the required urban sediment load reductions is also expected to occur via the Frederick County Phase I MS4 permit which currently requires the jurisdiction to retrofit 10% of its existing impervious area where there is failing, minimal, or no stormwater management every permit cycle (please see the technical memorandum to this document entitled "*Significant Point Sources in the Potomac River Montgomery County Watershed*") (MDE 2010b,c). These Phase I MS4 jurisdictions should work with other regulated stormwater entities in the watershed (see Appendix B, Table B-5) during the implementation process to achieve the necessary reductions.

It has been estimated that the average TSS removal efficiencies for BMPs installed between the years of 1985-2002 and post 2002, which are reflective of the stormwater management regulations in place during these time periods, is 50% and 80%, respectively (Claytor and Schueler 1997; Baldwin et al. 2007; Baish and Caliri 2009). Based on these average TSS reduction efficiencies, BMP specific reduction efficiencies as estimated by CBP, and best professional judgment, MDE estimates that future stormwater retrofits, which are expected to be implemented as part of the retrofit requirement to existing impervious land every five years (MDE 2010b,c), will have approximately a 65% reduction efficiency for TSS. This estimated reduction efficiency is subject to change over time as technology improves and the amount of data gathered from monitoring these retrofits increases. Additionally, any new development in the watershed will be subject to Maryland's Stormwater Management Act of 2007 and will be required to use environmental site design (ESD) to the maximum extent practicable.

While a portion of the sediment loads that contribute to the MD 8-digit Potomac River Montgomery County watershed impairment originate in the District of Columbia portion of the watershed, implementation actions in this area of the watershed are beyond the jurisdictional and regulatory authority of MDE. The Department looks forward to working with the District of Coumbia and the EPA to ensure that the Upstream LAs 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 BMPs, 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	MD 8-digit	Percent Stream Mile BIBI/FIBI < 3.0 (%)[1,2]	Forest Normalized Sediment Load[3]
Deer Creek	02120202	11	3.9
Broad Creek	02120205	12	4.5
Little Gunpowder Falls	02130804	15	3.3
Prettyboy Reservoir	02130806	16	3.7
Middle Patuxent River	02131106	20	3.2
Brighton Dam	02131108	11	4.2
Sideling Creek	02140510	20	1.9
Fifteen Mile Creek	02140511	4	1.6
Savage River	02141006	7	2.5
Median			**3.3**
75th			**4.2**

Notes:
[1] Based on the percentage of MBSS stations with BIBI and/or FIBI scores significantly lower than 3.0 within the MD 8-digit watershed (MDE 2008).
[2] The percent stream miles with BIBI and/or FIBI scores significantly lower than 3.0 threshold to determine if an 8-digit watershed is impaired for impacts to biological communities is based on a comparison to reference conditions (MDE 2008).
[3] Forest normalized sediment loads based on Maryland watershed area only (consistent with MBSS random monitoring data).

APPENDIX B – MDE Permit Information

Table B-1: Permit Summary

NPDES Permit #	MDE Permit #	Facility	County	City	Type	TMDL[1]
MD0057584	91DP1680	MIRANT - WESTLAND FLYASH SITE	MONTGOMERY	DICKERSON	WMA1	Process Water WLA
MD0065447	01DP2844	MONTGOMERY COUNTY RESOURCE RECOVERY FACILITY	MONTGOMERY	DICKERSON	WMA1	Process Water WLA
MD0002640	01DP0048	MIRANT - DICKERSON GENERATING STATION	MONTGOMERY	DICKERSON	WMA1M	Process Water WLA
MD0064777	03DP2754	BRETTON WOODS RECREATION CENTER	MONTGOMERY	GERMANTOWN	WMA2	Process Water WLA
MD0067539	06DP3163	KUNZANG ODSAL PALYUL CHANGCHUB CHOLING	MONTGOMERY	POOLESVILLE	WMA2	Process Water WLA
MD0020931	04DP2529	NIH ANIMAL CENTER	MONTGOMERY	POOLESVILLE	WMA2	Process Water WLA
MDG491365	00MM1365	AGGREGRATE INDUSTRIES - ROCKVILLE QUARRY	MONTGOMERY	ROCKVILLE	WMA5	Process Water WLA
	02SW0856	UNITED PARCEL SERVICE - GAITHERSBURG	MONTGOMERY	GAITHERSBURG	WMA5SW	Stormwater WLA
	02SW0291	MONTGOMERY COLLEGE - ROCKVILLE	MONTGOMERY	ROCKVILLE	WMA5SW	Stormwater WLA
	02SW1309	RICKMAN TRAVILAH, LLC	MONTGOMERY	ROCKVILLE	WMA5SW	Stormwater WLA
MD0068357	01DP3321	FREDERICK COUNTY MS4	FREDERICK	COUNTYWIDE	WMA6	Stormwater WLA
MD0068349	01DP3320	MONTGOMERY COUNTY MS4	MONTGOMERY	COUNTYWIDE	WMA6	Stormwater WLA
MD0068276	99DP3313	STATE HIGHWAY ADMINISTRATION MS4	ALL PHASE I MS4	STATEWIDE	WMA6	Stormwater WLA
MDR05550	03-IM-5500-027	CITY OF ROCKVILLE MS4	MONTGOMERY	ROCKVILLE	WMA6G	Stormwater WLA
MDR05550	03-IM-5500-026	CITY OF GAITHERSBURG MS4	MONTGOMERY	GAITHERSBURG	WMA6G	Stormwater WLA
		MDE GENERAL PERMIT TO CONSTRUCT	ALL	ALL		Stormwater WLA

Note: [1] TMDL column identifies how the permit was considered in the TMDL allocation.

Table B-2: Industrial Permit Data

Discharge[1]	Facility Name	NPDES Permit #	MDE Permit #	Flow (MGD[2])	Permit Avg. Monthly Conc. (mg/l[3])	Permit Daily Max. Conc. (mg/l)
Mainstem	MIRANT - DICKERSON GENERATING STATION (Monitoring Point 101)	MD0002640	01DP0048	0.4	30	100
Mainstem	MIRANT - DICKERSON GENERATING STATION (Monitoring Point 102)	MD0002640	01DP0048	0.006	30	45
Tributaries	MIRANT - WESTLAND FLYASH SITE[4]	MD0057584	91DP1680	0.01	35	70
Tributaries	MONTGOMERY COUNTY RESOURCE RECOVERY FACILITY	MD0065447	01DP2844	0.086	30	60

Notes: 1 This column identifies whether or not the facility discharges to the MD 8-Digit watershed mainstem or 1st through 4th order (tributary) streams. Analysis of DNR CORE/TREND data indicate that the mainstem of the 8-Digit watershed is supporting its aquatic life use. Therefore, the TMDL only applies to the 8-Digit watershed 1st through 4th order streams, and facilities discharging directly to the mainstem will receive an informational allocation only.

2 MGD = Millions of gallons per day.

3 mg/l = Milligram per liter.

4 Average permit concentration for this facility is calculated on a quarterly, not monthly, basis.

Table B-3: Municipal Permit Data

Discharge[1]	Facility Name		NPDES Permit #	MDE Permit #	Flow (MGD)	Permit Avg. Monthly Conc. (mg/l)	Permit Weekly Max. Conc. (mg/l)
Mainstem	KUNZANG ODSAL PALYUL CHANGCHUB CHOLING		MD0067539	06DP3163	0.035	30	45
Mainstem	NIH ANIMAL CENTER:	Oct - Mar	MD0020931	04DP2529	0.1	15	22.5
		Apr - Sep				10	15
Tributaries	BRETTON WOODS RECREATION CENTER		MD0064777	03DP2754	0.015	30	45

Notes: 1 This column identifies whether or not the facility discharges to the MD 8-Digit watershed mainstem or 1st through 4th order (tributary) streams. Analysis of DNR CORE/TREND data indicate that the mainstem of the 8-Digit watershed is supporting its aquatic life use. Therefore, the TMDL only applies to the 8-Digit watershed 1st through 4th order streams, and facilities discharging directly to the mainstem will receive an information allocation only.

4 Maximum permit concentration for this facility is calculated on a daily, not weekly, basis.

5 Washington Suburban Sanitary Commission (WSSC) – Potomac River Water Treatment Plant (NPDES # MD0051586) has not been given an allocation in this TMDL, as they have reported zero net TSS discharge.

Table B-4: General Mine Permit Data

Discharge[1]	Facility Name	NPDES Permit #	MDE Permit #	Flow (MGD)	Permit Avg. Quarterly Conc. (mg/l)	Permit Daily Max. Conc. (mg/l)
Tributaries	AGGREGRATE INDUSTRIES - ROCKVILLE QUARRY	MDG491365	00MM1365	1.5	30	66

Note: [1] This column identifies whether or not the facility discharges to the MD 8-Digit watershed mainstem or 1st through 4th order (tributary) streams. Analysis of DNR CORE/TREND data indicate that the mainstem of the 8-Digit watershed is supportive of aquatic life. Therefore, the TMDL only applies to the 8-Digit watershed 1st through 4th order streams, and facilities discharging directly to the mainstem will receive an information allocation only.

Table B-5: Stormwater Permits[1]

MDE Permit #	Facility Name	NPDES Group
02SW0856	UNITED PARCEL SERVICE - GAITHERSBURG	Phase I
02SW0291	MONTGOMERY COLLEGE - ROCKVILLE	Phase I
02SW1309	RICKMAN TRAVILAH, LLC	Phase I
03-IM-5500-027	CITY OF ROCKVILLE MS4	Phase II
03-IM-5500-026	CITY OF GAITHERSBURG MS4	Phase II
01DP3320	MONTGOMERY COUNTY MS4	Phase I
01DP3321	FREDERICK COUNTY MS4	Phase I
99DP3313	STATE HIGHWAY ADMINISTRATION MS4	Phase I
	MDE GENERAL PERMIT TO CONSTRUCT	Phase I/II

Note: [1] Although not listed in this table, some individual process water permits incorporate stormwater requirements and are accounted for within the NPDES Stormwater WLA (specifically the "Other" Regulated Stormwater Allocation in the Technical Memorandum *Significant Sediment Point Sources in the Potomac River Montgomery County Watershed* accompanying this TMDL report) as well as additional Phase II permitted MS4s, such as military bases, hospitals, etc.

APPENDIX C – Technical Approach Used to Generate Maximum Daily Loads

Summary

This appendix documents the technical approach used to define MDLs of sediment consistent with the average annual TMDL in the MD 8-Digit Potomac River Montgomery County watershed, which is considered the maximum allowable load the watershed can sustain and support aquatic life. The approach builds upon the modeling analysis that was conducted to determine the sediment loadings and can be summarized as follows.

- The approach defines MDLs for each of the source categories.
- The approach builds upon the TMDL modeling analysis that was conducted to ensure that average annual loading targets are at a level that support aquatic life.
- 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 (US EPA 2007).
- 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 MDL values. 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 so as to ensure the support of aquatic life.
- **CBP P5.2 Watershed Model Sediment Loads:** There are two spatial calibration points for sediment within the CBP P5.2 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, as actual CBP P5.2 calibration and scenario runs were not available upon development of the nontidal sediment

TMDL methodology (Currey et al. 2006). Since the EOS target loads applied in the TMDL remain relatively unchanged during the final calibration stages of the CBP P5.2 model, they are consistent with the final CBP P5.2 sediment loading estimates. The CBP P5.2 model river segments were calibrated to daily monitoring information for watersheds with a flow greater that 100 cubic feet per second (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 MDLs when using TMDL approaches that generate daily output (US EPA 2007).

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 MDL – 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 approach that must be adhered to, but rather it contains a range of acceptable options (US EPA 2007). 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 Potomac River Montgomery County Watershed MDLs.

<u>Level of Resolution</u>

The level of resolution pertains to the amount of detail used in specifying the MDL. The draft EPA guidance document on daily loads provides three categories of options for level of resolution, all of which are potentially applicable for the MD 8-Digit Potomac River Montgomery County 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 MDL to vary based upon the observed flow condition.
3. **Temporally-variable daily load:** This option allows the MDL to vary based upon seasons or times of varying source or water body behavior (US EPA 2007).

<u>Probability Level</u>

All TMDLs have some probability of being exceeded, with the specific probability being either 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 MDL should be "based on a representative statistical measure" that is dependent upon the specific TMDL and the best professional judgment of the developers (US EPA 2007). This statistical measure represents how often the MDL 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 MDL 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 MDL 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 MDL based upon a characterization of the variability of daily loads. For example, selection of the 95th percentile value would result in a MDL that would be exceeded 5% of the time.

Selected Approach

The approach selected for defining a MD 8-Digit Potomac River Montgomery County MDL 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 Potomac River Montgomery County watershed
- Approach for Process Water Point Sources within the MD 8-Digit Potomac River Montgomery County watershed
- Approach for upstream sources

Approach for Nonpoint Sources and Stormwater Point Sources within the MD 8-Digit Potomac River Montgomery County Watershed

The level of resolution selected for the MD 8-Digit Potomac River Montgomery County MDL was a representative daily load, expressed as a single daily load for each loading source. This approach was chosen based upon the specific data that exists for nonpoint sources and stormwater point sources within the MD 8-Digit Potomac River Montgomery County watershed. Currently, the best available data is the CBP P5.2 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 these model calibration runs were not available upon the development of the average annual nontidal sediment TMDL methodology (Currey et al. 2006). Therefore, to be consistent with the average annual TMDL, it was concluded that it would not be appropriate to apply the absolute values of the reach simulation model, daily time series results to calculate the MDL. Thus, 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 MDLs.

In the case of the MD 8-Digit Potomac River Montgomery County watershed, however, there is no CBP P5.2 reach which represents the watershed *per se*: EOS loads from the MD 8-Digit Potomac River Montgomery County watershed are input into reaches representing the mainstem Potomac River, and sediment loads in these reaches are dominated by upstream contributions. To develop a time series of daily loads representative of the impaired watershed, a synthetic watershed was constructed using (1) EOS loads from the MD 8-Digit Potomac River Montgomery County watershed, (2) Maryland point sources sediment loads discharging directly to the mainstem Potomac River, and (3) river reach geometry and parameters from a neighboring watershed, Seneca Creek, which is approximately the same size as the MD 8-Digit Potomac River Montgomery County watershed. Using the CBP P5.2 Model, a synthetic time series of daily sediment loads was simulated by routing the MD 8-Digit Potomac River Montgomery County sediment loads through the reach.

The MDL was estimated based on three factors: a specified probability level, the average annual sediment TMDL, and the coefficient of variation (CV) of the CBP P5.2 MD 8-Digit Potomac River Montgomery County synthetic reach simulation of 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 99^{th} percentile of the log-normal probability distribution should be used. The average annual sediment TMDL is estimated from the CBP P5.2 EOS target loads. The calculation of the CV is described below.

The CBP P5.2 MD 8-Digit Potomac River Montgomery County 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 of 0.0013 was calculated using the following equation:

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

Where:

CV = coefficient of variation

$\beta = \alpha\sqrt{e^{\sigma^2} - 1}$

$\alpha = e^{(\mu + 0.5*\sigma^2)}$

α = mean (arithmetic)

β = standard deviation (arithmetic)

μ = mean of logarithms

σ =standard deviation of logarithms

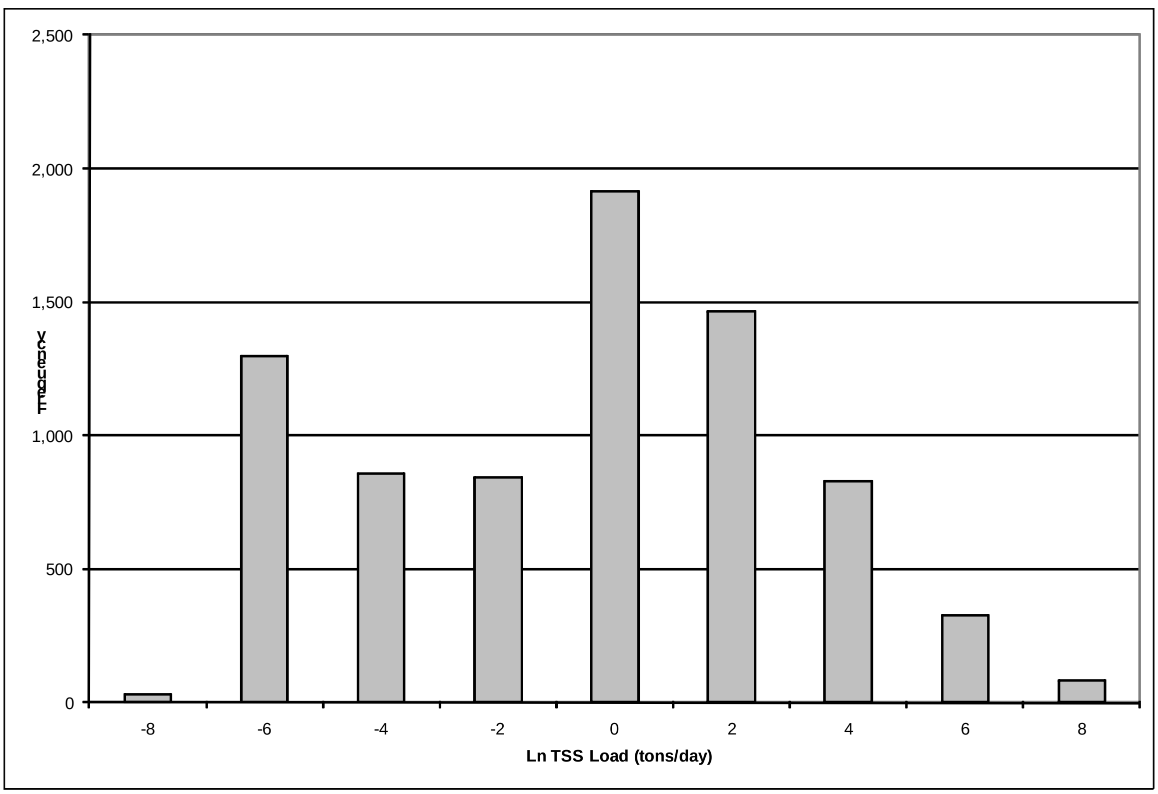

Figure C-1: Histogram of CBP River Segment Daily Simulation Results for the MD 8-Digit Potomac River Montgomery County Watershed

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:

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

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

Using a z-score associated with the 99th percent probability, a CV of 0.0013, and consistent units, the resulting dimensionless conversion factor from long term average annual loads to a MDL is 1.003. The average annual MD 8-Digit Potomac River Montgomery County TMDL of sediment/TSS is reported in ton/yr, and the conversion from ton/yr to a MDL in ton/day is 0.0027 (e.g. 1.003/365).

Approach for Process Water Point Sources within the MD 8-Digit Potomac River Montgomery County Watershed

The TMDL also considers contributions from other point sources (i.e., sources other than stormwater point sources) in the 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 MDLs for these sources was dependent upon whether a maximum daily limit was specified within the permit. If a maximum daily limit was specified, then the reported average flow was multiplied by the daily maximum limit and a conversion factor of 0.0042 to obtain a MDL in ton/day. If a maximum daily limit was not specified, the MDLs were calculated based on the guidance provided 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 99th percentile probability. This results in a dimensionless multiplication factor of 3.11. The average annual MD 8-Digit Potomac River Montgomery County TMDL of sediment/TSS is reported in ton/yr, and the conversion from ton/yr to a MDL in ton/day is 0.0085 (e.g. 3.11/365).

Approach for Upstream Sources

For the purpose of this analysis, only one upstream watershed has been identified: the District of Columbia portion of the Potomac River Montgomery County watershed. District of Columbia MDLs were calculated based on the same approach used for nonpoint sources and stormwater point sources within the MD 8-digit Potomac River Montgomery County watershed.

Results of approach

This section lists the results of the selected approach to define the MD 8-digit Potomac River Montgomery County MDLs.

- Calculation Approach for Nonpoint Sources and Stormwater Point Sources within the MD 8-digit Potomac River Montgomery County Watershed

LA_{PR} (ton/day) = Average Annual TMDL LA_{PR} (ton/yr) * 0.0027

Stormwater WLA_{PR} (ton/day) = Average Annual TMDL Stormwater WLA_{PR} (ton/yr) * 0.0027

- Calculation Approach for Process Water Point Sources within the MD 8-digit Potomac River Montgomery County Watershed
    - For permits with a daily maximum limit:

Process Water WLA_{PR} (ton/day) = Permit flow (mgd) * Daily maximum permit limit (mg/l) * 0.0042, where 0.0042 is a combined factor required to convert units to ton/day

- - For permits without a daily maximum limit:

Process Water WLA_{PR} (ton/day) = Average Annual TMDL Process Water WLA_{PR} Other (ton/yr)* 0.0085, where 0.0085 is the factor required to convert units to ton/day

Table C-1: MD 8-digit Potomac River Montgomery County Maximum Daily Loads of Sediment/TSS (ton/day)

MDL (ton/day)	=	LA			+	WLA			+	MOS
		LA_{DC}[1]	+	LA_{PR}		NPDES Stormwater WLA_{PR}	+	Process Water WLA_{PR}		
44.96	=	0.97	+	30.47	+	12.91	+	0.60	+	Implicit

Upstream Load Allocation[2,3] (applies to LA_{DC})

MD 8-digit Potomac River Montgomery County Watershed MDL Contribution (applies to LA_{PR} through Process Water WLA_{PR})

Notes: [1] LA_{DC} was determined to be necessary in order to meet Maryland water quality standards within the MD 8-digit Potomac River Montgomery County watershed.
[2] Although for the purposes of this analysis, the upstream load is referred to as an LA, it could include loads from both point and nonpoint sources.
[3] A delivery factor of 1 was used for the Upstream LA.

APPENDIX D – Analysis of CORE/TREND Benthic Monitoring Results in the MD 8-Digit Potomac River Montgomery County Watershed Mainstem

The Maryland DNR CORE/TREND program monitors the benthic macroinvertebrate community at 111 fixed locations in Maryland. Biological monitoring has been performed at some of these sites as far back as the 1970's. The information collected is used to assess water quality status and trends, and is intended to complement water quality monitoring data that is also performed under the CORE/TREND program.

Most of the fixed sites are on the larger rivers and streams draining Maryland's 8-digit watersheds. Although there is some overlap, these larger rivers and streams generally fall outside the domain of the MBSS program, which assesses the integrity of fish and macroinvertebrate communities in 1st through 4th order streams. In most cases, the CORE/TREND data represents the only biological data that is available for these larger rivers and streams. Consequently, although it is not formally part of Maryland's assessment methodology, the evaluation of benthic macroinvertebrate data from the CORE/TREND program has played a large role in determining whether aquatic life is supported in larger rivers and streams in TMDLs and WQAs. Generally, a CORE/TREND status assessment of "GOOD" or better indicates that the waterbody is supporting its aquatic life use.

In the MD 8-Digit Potomac River Montgomery County watershed mainstem, there are two fixed stations where the CORE/TREND program assesses water quality based on macroinvertebrate sampling: 1) Station POT1183, at Little Falls below the dam; and 2) POT1471, at White's Ferry. Figure D-1 shows the location of these stations. The CORE/TREND assessed the status of water quality at POT1471 as "GOOD," but rated the water quality status at POT1183 as "FAIR/GOOD," indicating borderline water quality conditions.

POT1183 is the only station on the mainstem Potomac River below the confluence of the North and South Branches with a water quality assessment less than "GOOD." Figure D-1 shows the location of all the CORE/TREND stations in the Potomac River mainstem. Table D-1 describes the location, current water quality status, and trend in water quality since the 1970's of these stations. The goal of this analysis is to compare the assessment of the benthic community at POT1183 with the assessments at other stations in the Potomac River mainstem, to evaluate whether or not the aquatic life use is supported in the MD 8-Digit Potomac River Montgomery County watershed mainstem.

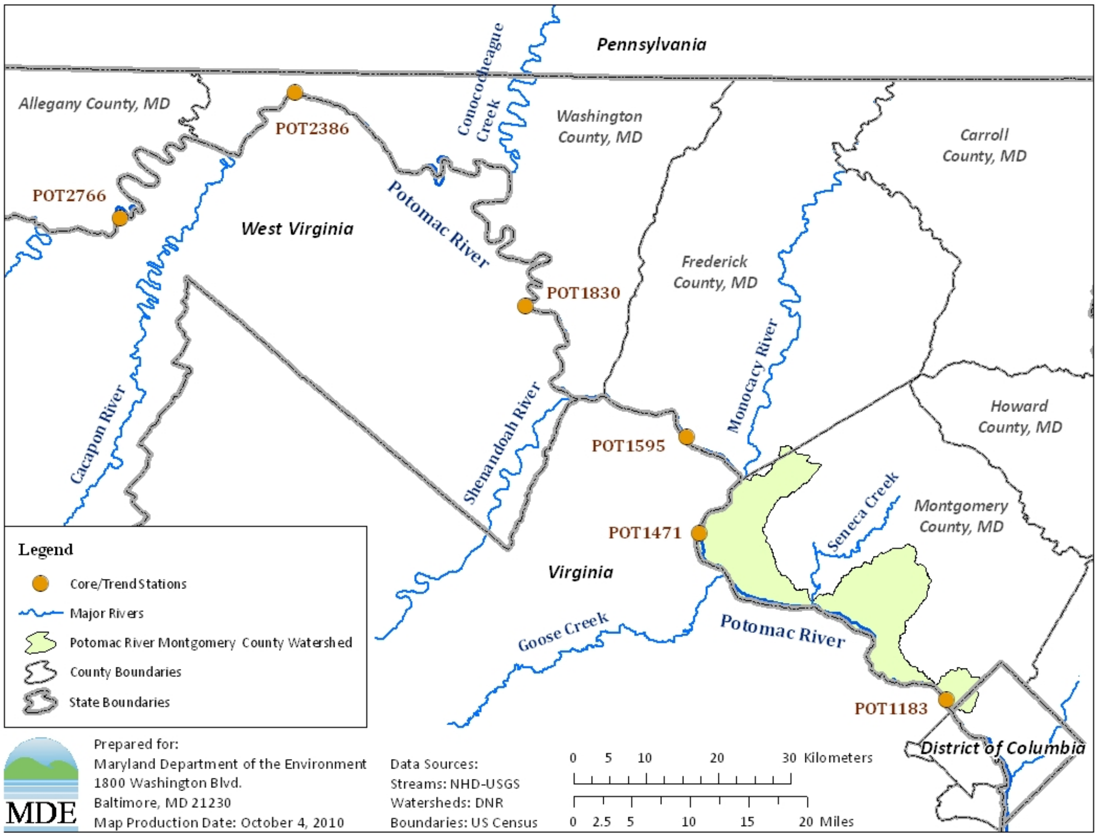

Figure D-1: CORE/TREND Monitoring Stations in the Potomac River Mainstem

Table D-1: CORE/TREND Stations in the Potomac River Mainstem

Station	Location	Current Water Quality Status	Trend Since 1970's
POT1183	Little Falls below dam	FAIR/GOOD	NO CHANGE
POT1471	Whites Ferry	GOOD	IMPROVEMENT
POT1595	Point of Rocks	GOOD	NO CHANGE
POT1830	Shepardstown	GOOD	DEGRADATION
POT2386	Hancock	GOOD	IMPROVEMENT
POT2766	Paw Paw	GOOD/VERY GOOD	IMPROVEMENT

CORE/TREND Assessment Methodology

The CORE/TREND assessment is based on four metrics: 1) total number of taxa; 2) Shannon-Wiener DI; 3) modified HBI; and (4) percent EPT.

Total number of taxa is simply the number of taxa identified in the sample. A larger number of taxa indicates a more diverse benthic community and better water quality. Table D-2 shows the range of values for the total number of taxa for each assessment category.

Table D-2: Assessment Ranges for Total Number of Taxa[1]

Assessment	Range
Excellent	≥28
Very Good	23-28
Good	18-22
Fair	12-17
Poor	6-11
Very Poor	1-5

Note: [1] Source is Friedman (2010a).

The Shannon-Wiener DI measures the relative abundance of taxa, or the degree to which the benthic community is dominated by a small number of taxa. Poor water quality is associated with the greater dominance of a few taxa. Table D-3 shows the range of Shannon-Wiener DI values for each assessment category.

Table D-3: Assessment Ranges for Shannon-Wiener DI[1]

Assessment	Range
Excellent	4-5
Good to Very Good	3-4
Fair to Good	2-3
Poor to Fair	1-2
Very Poor to Poor	0-1

Note: [1] Source is DNR (2009).

The HBI measures the degree to which the taxa present in the benthic community can tolerate organic pollution, such as raw sewage. Individual taxa are classified according to their tolerance, and the overall score is a weighted average of the individual tolerances, weighted of the number of individuals per taxa. The larger the value of the metric is, the greater the overall tolerance of the community to organic pollution, and the greater the likelihood that the community is impacted by poor water quality. Table D-4 shows the range of HBI values for each assessment category.

Table D-4: Assessment Ranges for HBI[1]

Assessment	Range
Excellent	0-1.75
Very Good	1.76-2.25
Good	2.26-2.75
Fair	2.76-3.5
Poor	3.51-4.25
Very Poor	4.26-5

Note: [1] Source is DNR (2009)..

Percent EPT is the percent of individuals belonging to the families Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies) in the sample. Mayflies, stoneflies, and caddisflies are generally intolerant of pollution or habitat impairment. Therefore, their presence is indicative of good water quality. The larger the percentage of individuals from these taxa is, the better the water quality. Table D-5 shows the range of percent EPT values for each assessment category.

Table D-5: Assessment Ranges for Percent EPT[1]

Assessment	Range (%)
Good to Excellent	75-100
Good	50-75
Fair	25-50
Poor	0-25

Note: [1] Source is Friedman (2010a).

The evaluation of the overall status of a station is not based on a strict formula, but involves professional judgment in two respects (Friedman 2010b). First, the overall rating is based on the rating of the four metrics and should be in the assessment range of the metrics; however, it is not a numerical average of the component metrics. Second, the number of data years used to assess the status is a function of the trend at the station. Stations that show a strong trend in metric scores will merely be reflective of having fewer years of data, while stations without strong trends in metrics will be reflective of having more years of data.

Evaluation of the Benthic Community Metrics for the Potomac River Mainstem

Table D-6 provides the benthic community metric scores for stations on the Potomac River mainstem, below the confluence of the North and South Branches, between 2000 and 2007, which is the last year data is available from the CORE/TREND program. Table D-7 provides summary statistics for the metrics from those stations. Figures D-2, D-3, D-4, and D-5 compare the distribution of scores between the stations for the total taxa, HBI, DI, and Percent EPT metrics, respectively, from the stations. Metrics from POT2386 station at Hancock have been omitted from the analysis, since data was only collected in two years, 2004 and 2005.

Table D-6: Potomac River Mainstem CORE/TREND Benthic Community Metrics, 2000-2007

STATION[1]	YEAR	Total Individuals Collected	Benthic Metric			
			TOTAL TAXA (#)	HBI	Shannon-Wiener DI	EPT (%)
POT1183	2000	2562	40	3.25	2.87	55
	2001	828	34	2.77	3.68	66
	2002	286	15	2.45	1.73	4
	2003	1374	42	3.13	3.5	58
	2004	415	27	2.85	3.43	73
	2007	559	23	2.62	3.34	42
POT1471	2000	448	25	2.88	3.35	47
	2001	865	39	2.8	3.59	46
	2003	460	29	3.18	3.32	73
	2004	610	35	2.6	3.07	50
POT1595	2001	783	37	2.94	3.61	47
	2002	1470	32	2.51	2.44	3
	2003	531	43	2.86	4.31	50
	2004	511	33	2.78	3.62	75
	2005	546	22	2.58	2.93	45
	2006	438	28	2.89	3.4	40
POT1830	2000	1538	31	2.63	2.87	12
	2001	491	36	2.9	3.66	24
	2003	1602	42	2.65	3.17	87
	2004	357	34	2.44	3.42	87
	2005	378	38	2.59	4.2	67
	2006	687	35	2.77	3.84	21
POT2766	2000	231	30	2.76	3.92	26
	2001	790	52	2.79	4.14	55
	2002	842	47	2.97	4.52	66
	2003	618	33	2.74	3.56	59
	2004	394	35	2.6	3.95	69
	2005	237	29	2.39	3.5	73
	2006	512	39	2.54	4.06	67
	2007	345	28	2.29	2.88	69

Note: [1] The analysis includes all CORE/TREND stations located on the Potomac River mainstem below the confluence of the North and South Branches. Metrics from the POT2386 station at Hancock, however, are not included in the analysis, since data was only collected at the station during two years, 2004 and 2005.

Table D-7: Potomac River Mainstem CORE/TREND Summary Statistics for Benthic Community Metrics, 2000-2007

HBI							
Station[1]	**N[2]**	**mean**	**minimum**	**25%**	**50%**	**75%**	**maximum**
POT1183	6	2.85	2.45	2.6575	2.81	3.06	3.25
POT1471	4	2.87	2.6	2.75	2.84	2.955	3.18
POT1595	6	2.76	2.51	2.63	2.82	2.8825	2.94
POT1830	6	2.66	2.44	2.6	2.64	2.74	2.9
POT2766	8	2.64	2.29	2.5025	2.67	2.7675	2.97
Shannon-Wiener DI							
Station	**n**	**mean**	**minimum**	**25%**	**50%**	**75%**	**maximum**
POT1183	6	3.09	1.73	2.9875	3.385	3.4825	3.68
POT1471	4	3.33	3.07	3.2575	3.335	3.41	3.59
POT1595	6	3.39	2.44	3.0475	3.505	3.6175	4.31
POT1830	6	3.53	2.87	3.2325	3.54	3.795	4.2
POT2766	8	3.82	2.88	3.545	3.935	4.08	4.52
Percent EPT (%)							
Station	**n**	**mean**	**minimum**	**25%**	**50%**	**75%**	**maximum**
POT1183	6	49.67	4	45.25	56.5	64	73
POT1471	4	54.00	46	46.75	48.5	55.75	73
POT1595	6	43.33	3	41.25	46	49.25	75
POT1830	6	49.67	12	21.75	45.5	82	87
POT2766	8	60.50	26	58	66.5	69	73
Total Taxa (#)							
Station	**n**	**mean**	**minimum**	**25%**	**50%**	**75%**	**maximum**
POT1183	6	30.17	15	24	30.5	38.5	42
POT1471	4	32.00	25	28	32	36	39
POT1595	6	32.50	22	29	32.5	36	43
POT1830	6	36.00	31	34.25	35.5	37.5	42
POT2766	8	36.62	28	29.75	34	41	52

Note: [1] The analysis includes all CORE/TREND stations located on the Potomac River mainstem below the confluence of the North and South Branches. Metrics from the POT2386 station at Hancock, however, are not included in the analysis, since data was only collected at the station during two years, 2004 and 2005.

[2] N = number of samples.

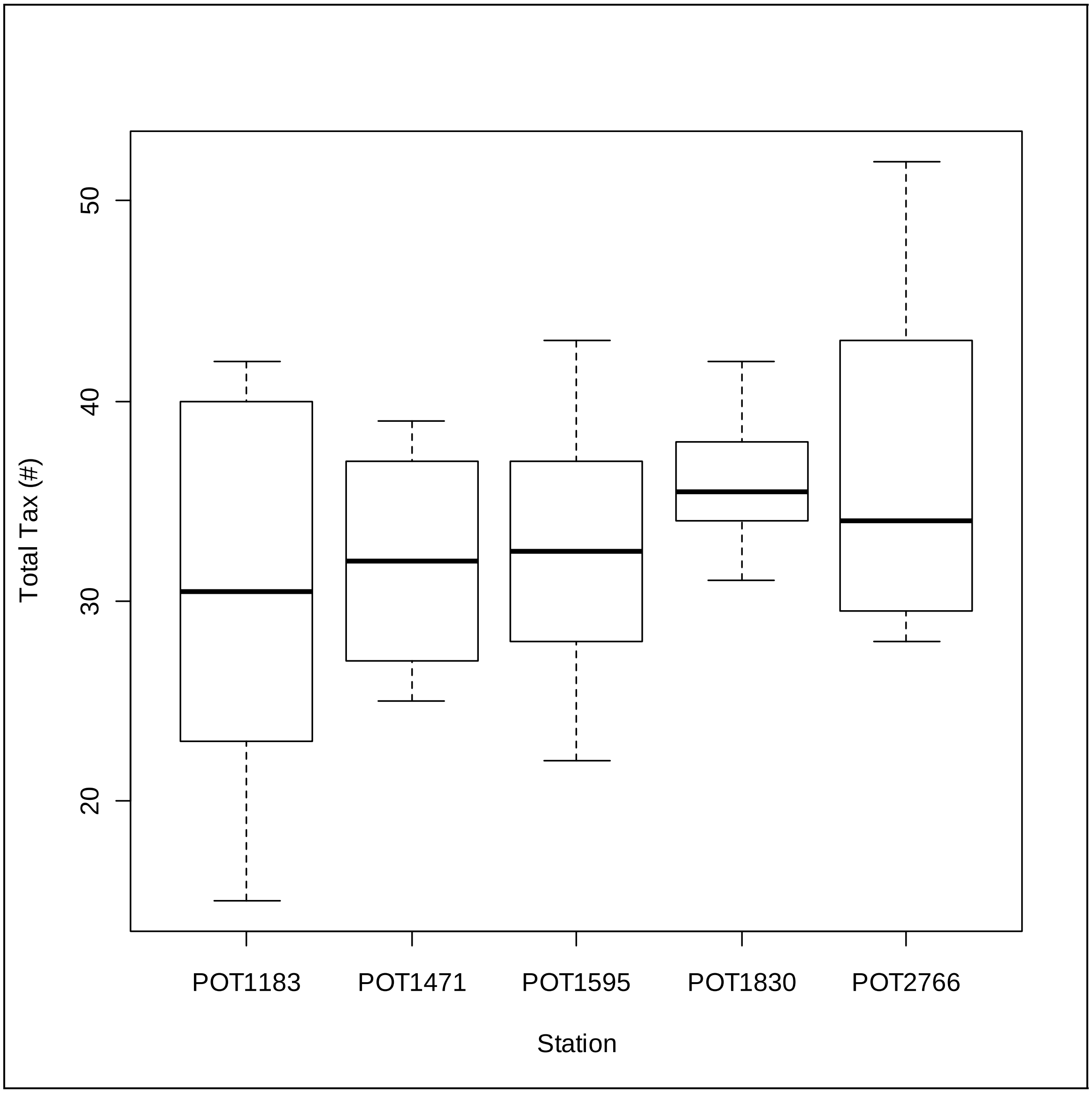

Figure D-2: Potomac River Mainstem CORE/TREND Station Total Number of Taxa Distribution, 2000-2007

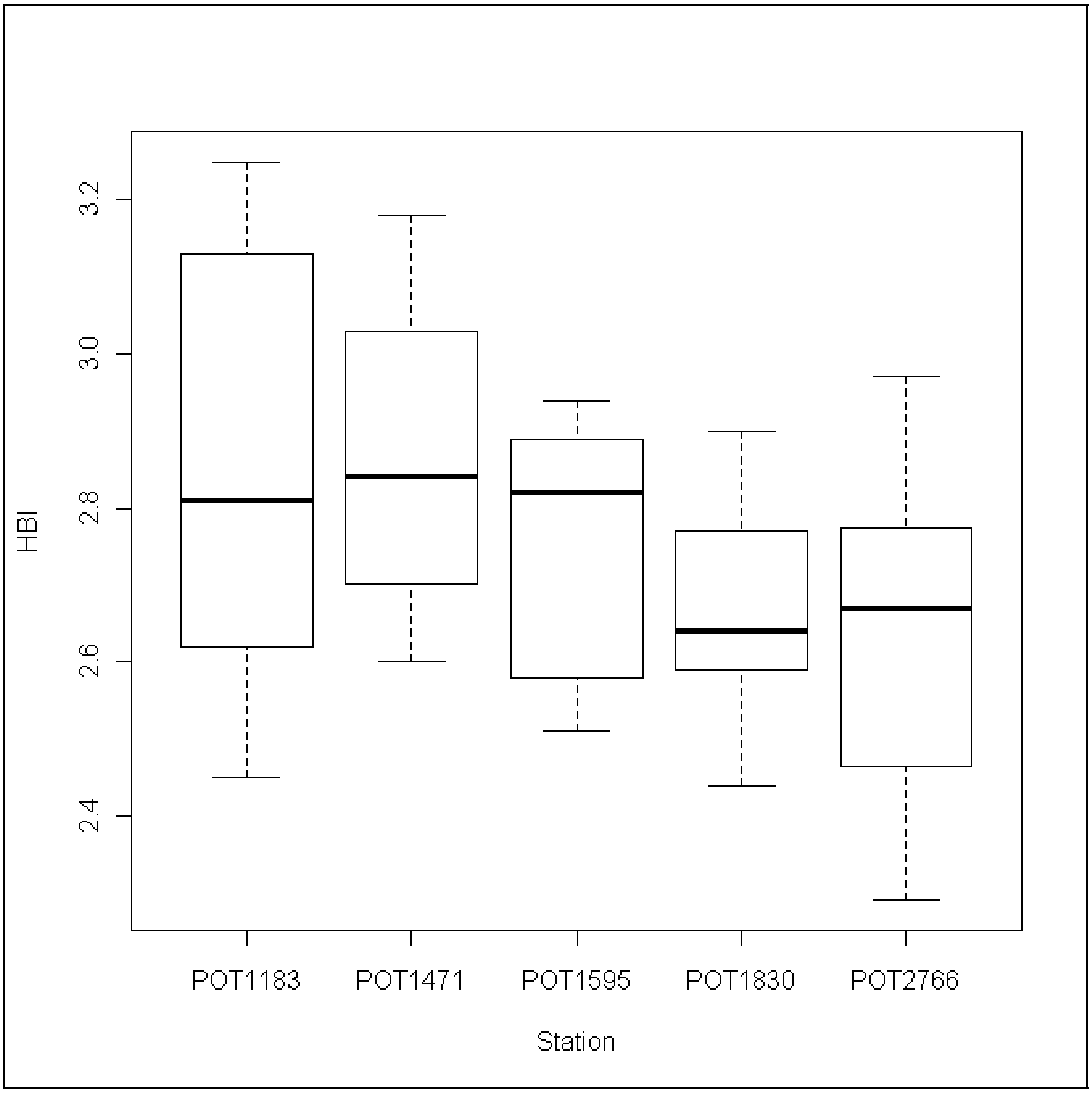

Figure D-3: Potomac River Mainstem CORE/TREND Station HBI Distribution, 2000-2007

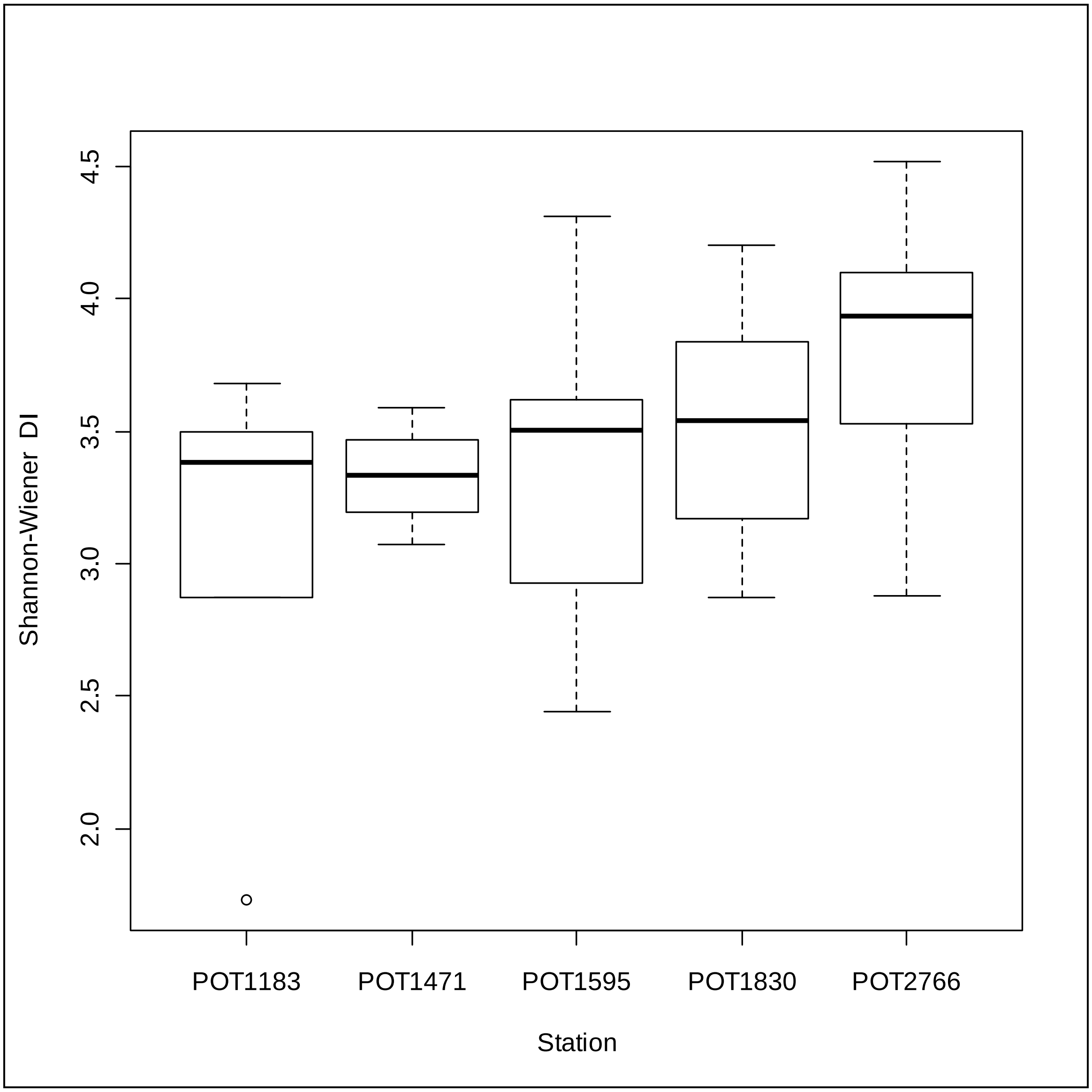

Figure D-4: Potomac River Mainstem CORE/TREND Station Shannon-Wiener DI Distribution, 2000-2007

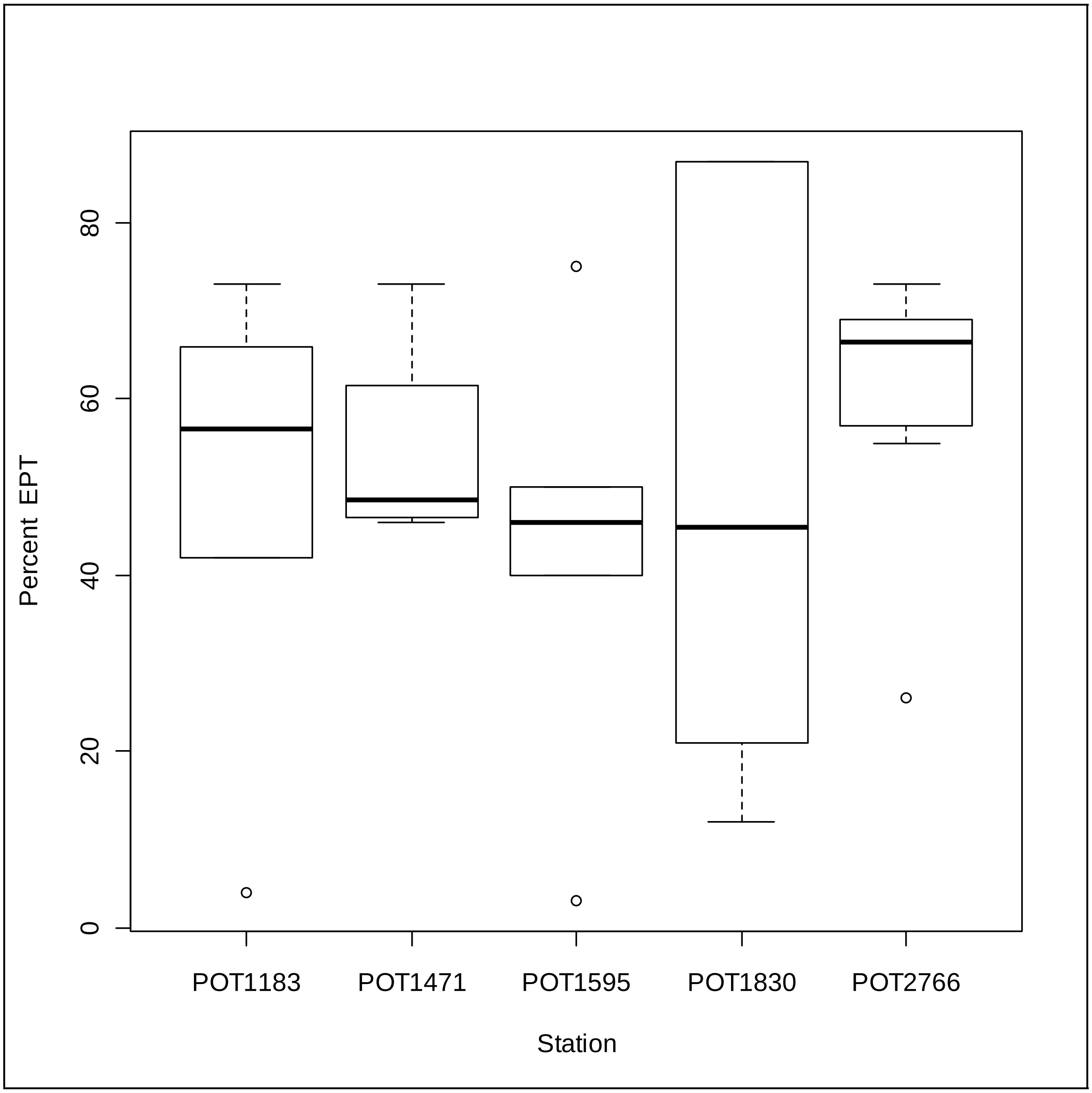

Figure D-5: Potomac River Mainstem CORE/TREND Station Percent EPT Distribution, 2000-2007

Examination of Figures D-1 through D-3 seems to suggest that the total number of taxa, Shannon-Wiener DI, and HBI benthic community metric scores decrease in the downstream direction, indicating a decrease in water quality. Generally, POT1183 has the worst scores among Potomac River mainstem stations for each metric, which is largely the result of poor scores at the station on each metric in 2002. However, Krusal-Wallis tests, performed on all of the benthic community metrics, indicate that there is no difference in the distribution of scores in the benthic community metrics among the Potomac River mainstem CORE/TREND stations. Table D-9 provides the results of these tests.

Table D-8: Kruskal-Wallis Test Results on the Distribution of Potomac River Mainstem CORE/TREND Station Benthic Community Metrics, 2000-2007

Metric	Chi-Square	p-value
Total Number of Taxa	2.2712	0.686
HBI	4.0783	0.3955
Shannon-Wiener DI	5.9219	0.2051
Percent EPT	2.6052	0.6259

The low scores at POT1183 in 2002 seem to be exceptions to the general trend in the distribution of scores at that station. With the exception of 2002, POT1183 tends to have the best Percent EPT scores of any Potomac River station except POT2766 at Paw Paw. Two-thirds of the samples have Percent EPT scores above 50, which is a greater rate than any other station, except POT2766. The metric scores for Total Number Taxa and the Shannon-Wiener DI at POT1183 for 2002 are the only ones below the "Good" range for the period of 2000-2007; otherwise, the metric scores from POT1183 are comparable to the other Potomac River mainstem stations. Two-thirds of the HBI scores at POT1183 are outside the "Good" range; however, this is generally true of the all Potomac River mainstem CORE/TREND stations below the confluence with the Shenandoah River.

Generally, since 2000, POT1183 has acceptable benthic community metric scores comparable to the other CORE/TREND stations in the Potomac River mainstem. During this time period, there is no statistically significant difference in the distribution of metric scores from POT1183 with the other Potomac River mainstem stations. If only the benthic monitoring data from this decade are taken into account, water quality at POT1183 is not statistically different from the other stations on the Potomac River mainstem assessed as having "GOOD" water quality.