APPENDIX C – Technical Approach Used to Generate Maximum Daily Loads

Summary

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

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

Introduction

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

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

Basis for approach

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

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

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

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

Options Considered

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

This section describes the range of options that were considered when developing methods to calculate MD 8-digit Upper Monocacy River Maximum Daily Load.

Level of Resolution

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

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

Probability Level

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

1. Water quality criteria consist of components describing acceptable magnitude, duration, and frequency. The frequency component addresses how often conditions can allowably surpass the combined magnitude and duration components.
2. Pollutant loads, especially from wet weather sources, typically exhibit a large degree of variability over time. It is rarely practical to specify a "never to be exceeded value" for a daily load, as essentially any loading value has some finite probability of being exceeded.

The draft daily load guidance document states that the probability component of the maximum daily load should be "based on a representative statistical measure" that is dependent upon the specific TMDL and best professional judgment of the developers. This statistical measure

represents how often the maximum daily load is expected/allowed to be exceeded. The primary options for selecting this level of protection would be:

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

Selected Approach

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

- Approach for Nonpoint Sources and Stormwater Point Sources within MD 8-digit Upper Monocacy River watershed,
- Approach for Process Water Point Sources within MD 8-digit Upper Monocacy River watershed,
- Approach for upstream sources.

<u>Approach for Nonpoint Sources and Stormwater Point Sources within the MD 8-digit Upper Monocacy River watershed</u>

The level of resolution selected for the MD 8-digit Upper Monocacy River Maximum Daily Load 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 Upper Monocacy River watershed. Currently, the best available data is the CBP P5 model daily time series calibrated to long-term average annual loads (per land use). The CBP reach simulation results are calibrated to daily monitoring information for watershed segments with a flow typically greater that 100 cfs, but they have not been through appropriate peer review. Therefore, it was concluded that it would not be appropriate to apply the absolute values of the reach simulation model results to the TMDL, and the annual loads were used instead. However, it was assumed the distribution of the daily values was correct, in order to calculate a normalized statistical parameter to estimate the maximum daily loads.

The maximum daily load was estimated based on three factors: a specified probability level, the average annual sediment TMDL, and the coefficient of variation (CV) of the CBP P5 MD 8-digit

Upper Monocacy River reach simulation daily loads. The probability level (or exceedance frequency) is based upon guidance from EPA (US EPA 1991) where examples suggest that when converting from a long-term average to a daily value, the z-score corresponding to the 99th percentile of the log-normal probability distribution should be used.

The CBP P5 Upper Monocacy River 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 7.12 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

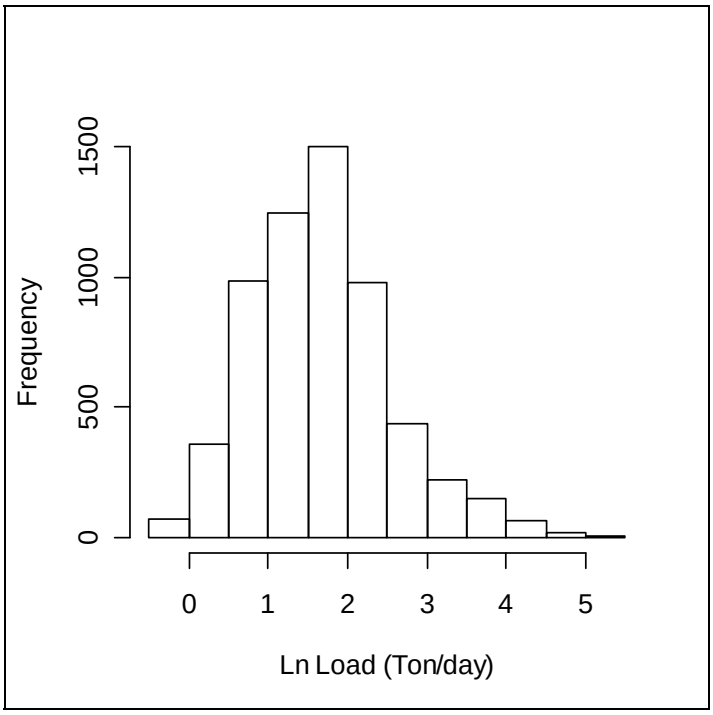

Figure C-1: Histogram of CBP River Segment Daily Simulation Results for the MD 8-digit Upper Monocacy River Watershed

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
$\sigma = \ln(CV^2+1)$
CV = Coefficient of variation based on arithmetic mean and standard deviation

Using a z-score associated with the 99th percent probability, a CV of 7.12, and consistent units, the resulting dimensionless conversion factor from long-term average loads to a maximum daily value is 14.13. The average annual MD 8-digit Upper Monocacy River TMDL of sediment/TSS is reported in ton/year, and the conversion from ton/year to a maximum daily load in ton/day is 0.039 (e.g. 14.13/365).

Approach for Process Water Point Sources within the MD 8-digit Upper Monocacy River 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 maximum daily loads for these sources was dependent upon whether a maximum daily load was specified within the permit. If a maximum daily limit was specified, then the reported average flow was multiplied by the daily maximum limit to obtain a maximum daily load. If a maximum daily limit was not specified, the maximum daily loads were calculated 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 Upper Monocacy River TMDL of sediment/TSS is reported in ton/yr, and the conversion from ton/yr to a maximum daily load in ton/day is 0.0085 (e.g. 3.11/365).

Approach for Upstream Sources

For the purpose of this analysis two upstream watersheds have been identified: (1) the Pennsylvania portion of the Upper Monocacy River watershed and (2) the Double Pipe Creek watershed. The Pennsylvania Maximum Daily Load was calculated based on the same approach as used for nonpoint sources and NPDES regulated stormwater point sources within the MD 8-digit Upper Monocacy River watershed. The Double Pipe Creek Maximum Daily Load is presented in a separate Double Pipe Creek TMDL document (MDE 2008).

Results of Approach

This section lists the results of the selected approach to define the MD 8-digit Upper Monocacy River Maximum Daily Load.

- Calculation Approach for Nonpoint Sources and Stormwater Point Sources within the MD 8-digit Upper Monocacy River watershed

  LA_{UM} (ton/day) = Average Annual TMDL LA_{UM} (ton/yr) * .039

  NPDES Stormwater WLA_{UM} (ton/day) = Average Annual TMDL NPDES Stormwater WLA_{UM} (ton/yr) * .039

- Calculation Approach Process Water Point Sources within the MD 8-digit Upper Monocacy River watershed
  - For permits with a daily maximum limit:

    Process Water WLA_{UM} (ton/day) = Permit flow (mgd) * Daily maximum permit limit(mg/l) * 0.0042
  - For permits without a daily maximum limit:

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

- Calculation Approach for Upstream Sources
  - For Pennsylvania Upstream Sources

    LA_{PA} (ton/day) = Average Annual TMDL LA_{PA} (ton/yr) * .039
  - For Double Pipe Creek Upstream Sources

    For Double Pipe Creek MDL calculation please refer to the "Total Maximum Daily Load of Sediment in the Double Pipe Creek Watershed, Frederick and Carroll Counties, Maryland" (MDE 2008).

Table C-1: MD 8-digit Upper Monocacy River Maximum Daily Load of Sediment/TSS (ton/day)

MDL (ton/day)	=	Max. Daily LA					+	Max. Daily WLA			+	MOS
		LA_{PA}[1]	+	LA_{DP}[2]	+	LA_{UM}		NPDES Stormwater WLA_{UM}	+	Process Water WLA_{UM}		
2,513.2	=	754.7	+	860.8	+	812.3	+	83.8	+	1.4	+	Implicit
		Upstream MDL[3,4]				MD 8-digit Upper Monocacy River Watershed MDL Contribution						

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

[2] For Double Pipe Creek watershed WLA and LA characterization, please refer to the "Total Maximum Daily Load of Sediment in the Double Pipe Creek Watershed, Frederick and Carroll Counties, Maryland" (MDE 2008).

[3] Although for the purpose of this analysis upstream loads are referred to as LAs, they could include loads from point and nonpoint sources.

[4] A delivery factor of 1 was used for all of the Upstream Load Allocations**.**