Appendix F. Technical Approach Used to Generate Maximum Daily Loads (MDLs)

This appendix documents the technical approach used to define Maximum Daily Loads (MDLs) of nitrogen and phosphorus consistent with the average annual TMDLs for Maryland's Coastal Bays. The TMDL reflects the total nitrogen and phosphorus maximum allowable loads, the various waterbodies in the coastal lagoon system can sustain and meet the applicable DO and chlorophyll criteria. The approach builds upon the modeling analysis that was conducted to determine the average annual nitrogen and phosphorus loadings and is described below.

All TMDLs have some probability of being exceeded, with the probability being either explicitly specified or implicitly assumed. This level of probability reflects, either directly or indirectly, 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.

EPA guidance states that the probability component of a calculated MDL should be "based on a representative statistical measure" that is dependent upon the specific TMDL and best professional judgment of the developers (USEPA 2007). This statistical measure represents how often the MDL is expected, or 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.

Because time variable model simulations were conducted, daily loads vary significantly. Daily loading varies both seasonally and annually, with respect to different hydrological years. Therefore, the MDL for this analysis is determined based on a pre-defined probability. The computed MDLs are consistent with achieving the annual cumulative load target. A 95th percentile was selected as the pre-defined probability. Because loading distribution in the Maryland Coastal Bays is better described by a lognormal distribution, the MDLs are computed as follows (USEPA 2007):

$$MDL = LTA \cdot \exp(Z_p \sigma_y - 0.5\sigma_y^2)$$ (Equation F1)

Where Zp is p^{th} percentage point of the standard normal distribution (95_{th} percentile, $Z_p = 1.645$; 99_{th} percentile, $Z_p = 2.326$), LTA is the long-term mean daily loading, and σ_y is computed as:

$$\sigma_y = \sqrt{\ln(CV^2 + 1)}$$ (Equation F2)

where CV is the coefficient of variation of the untransformed data, which equals the standard deviation divided by the mean.

For the simulated forest, urban, and mixed agriculture land uses, *LTAs* for TN and TP were calculated using the 2001-2004 mean daily loadings. Then, the maximum daily loads for TN and TP were calculated using Equation F1 for each TMDL segment. For process water facilities, concentrated animal feeding operations (CAFO) facilities, septics, atmospheric deposition, and shoreline erosion, the total MDL was set equivalent to the LTA, since these loads experience less seasonal variations than observed in the three simulated land uses. The results of the calculated LTAs and MDLs are listed in Tables F1 through F4 for the Maryland portion of each TMDL segment watershed. Tables F5 and F6 provide complete summaries of the MDL equations for each TMDL segment.

Table F1: TN Mean Daily Load (LTA) by TMDL Basin TN - Maryland Watershed Area (lbs/day)

Basin Name	Urban	Mixed Agriculture	Forest/ Barren	Septics	Atmospheric Deposition	Shoreline Erosion	Total
Greys Creek	12	44	3	13	12	14	100
Assawoman Bay[1]	**51**	**45**	**5**	**13**	**117**	**30**	**262**
Bishopville Prong	14	35	3	11	4	2	78
Shingle Landing Prong	29	96	7	11	2	4	152
St. Martin River[1]	64	112	11	30	35	17	280
Herring Creek	14	8	3	4	3	9	39
Turville Creek	21	17	3	15	3	11	72
Manklin Creek	21	3	1	2	5	7	40
Isle of Wight Bay[1]	**148**	**173**	**19**	**52**	**135**	**51**	**592**
Ayer Creek/Kitts Branch	63	75	7	23	13	0	182
Newport Creek	10	31	3	8	2	0	56
Marshall Creek	8	40	4	6	9	3	74
Newport Bay[1]	**101**	**190**	**17**	**46**	**78**	**17**	**459**
Sinepuxent Bay	**60**	**16**	**5**	**19**	**113**	**25**	**237**
Chincoteague Bay	**40**	**336**	**30**	**29**	**867**	**148**	**1,460**

[1] This allocation includes the allocations from other subwatersheds draining to this MD 8-digit watershed.

Table F2: TP Mean Daily Loads (LTA) by TMDL Basin - Maryland Watershed Area (lbs/day)

Basin Name	Urban	Mixed Agriculture	Forest/ Barren	Septics	Atmospheric Deposition	Shoreline Erosion	Total
Greys Creek	1	3	0	0	1	1	7
Assawoman Bay[1]	**5**	**3**	**0**	**0**	**6**	**3**	**18**
Bishopville Prong	1	5	0	0	0	0	7
Shingle Landing Prong	2	11	1	0	0	1	15
St. Martin River[1]	5	14	1	0	2	2	24
Herring Creek	1	1	0	0	0	1	3
Turville Creek	2	1	0	0	0	1	5
Manklin Creek	2	0	0	0	0	1	3
Isle of Wight Bay[1]	**12**	**19**	**2**	**0**	**7**	**6**	**47**
Ayer Creek/Kitts Branch	6	5	1	0	1	0	13
Newport Creek	1	2	0	0	0	0	4
Marshall Creek	1	3	0	0	0	0	5
Newport Bay[1]	**10**	**12**	**1**	**0**	**4**	**2**	**31**
Sinepuxent Bay	**6**	**1**	**0**	**0**	**6**	**4**	**17**
Chincoteague Bay	**4**	**21**	**2**	**0**	**46**	**20**	**95**

[1] This allocation includes the allocations from other subwatersheds draining to this MD 8-digit watershed.

Table F3: TN Maximum Daily Loads by TMDL Basin - Maryland Watershed Area (lbs/day)

Basin Name	Urban	Mixed Agriculture	Forest/ Barren	Septics	Atmospheric Deposition	Shoreline Erosion	Total
Greys Creek	46	169	10	13	12	14	266
Assawoman Bay[1]	**188**	**173**	**16**	**13**	**117**	**30**	**538**
Bishopville Prong	53	134	11	11	4	2	224
Shingle Landing Prong	107	370	23	11	2	4	520
St. Martin River[1]	233	432	40	30	35	17	798
Herring Creek	51	29	9	4	3	9	104
Turville Creek	76	64	10	15	3	11	182
Manklin Creek	78	11	5	2	5	7	109
Isle of Wight Bay[1]	**540**	**666**	**66**	**52**	**135**	**51**	**1,525**
Ayer Creek/Kitts Branch	232	291	23	23	13	0	583
Newport Creek	38	118	9	8	2	0	177
Marshall Creek	30	156	14	6	9	3	221
Newport Bay[1]	**372**	**735**	**58**	**46**	**78**	**17**	**1,315**
Sinepuxent Bay	**220**	**63**	**16**	**19**	**113**	**25**	**455**
Chincoteague Bay	**146**	**1,298**	**104**	**29**	**867**	**148**	**2,602**

[1] This allocation includes the allocations from other subwatersheds draining to this MD 8-digit watershed.

Table F4: TP Maximum Daily Loads by TMDL Basin - Maryland Watershed Area (lbs/day)

Basin Name	Urban	Mixed Agriculture	Forest/ Barren	Septics	Atmospheric Deposition	Shoreline Erosion	Total
Greys Creek	5	12	1	0	1	1	20
Assawoman Bay[1]	**19**	**12**	**1**	**0**	**6**	**3**	**41**
Bishopville Prong	4	18	1	0	0	0	24
Shingle Landing Prong	7	41	2	0	0	1	52
St. Martin River[1]	17	51	4	0	2	2	77
Herring Creek	4	2	1	0	0	1	9
Turville Creek	7	5	1	0	0	1	14
Manklin Creek	7	1	0	0	0	1	10
Isle of Wight Bay[1]	**44**	**72**	**6**	**0**	**7**	**6**	**137**
Ayer Creek/Kitts Branch	23	18	2	0	1	0	45
Newport Creek	4	7	1	0	0	0	12
Marshall Creek	3	10	1	0	0	0	15
Newport Bay[1]	**37**	**46**	**6**	**0**	**4**	**2**	**96**
Sinepuxent Bay	**22**	**4**	**2**	**0**	**6**	**4**	**37**
Chincoteague Bay	**15**	**78**	**9**	**0**	**46**	**20**	**170**

[1] This allocation includes the allocations from other subwatersheds draining to this MD 8-digit watershed.

Table F5: TN Maximum Daily Load Summary by TMDL Basin (lbs/day)

Basin Name	MDL	Upstream Loads[1] (WLA+LA)	WLA (Process Water)	WLA (CAFO)	LA	MOS
Greys Creek	782.1	516.5	0.0	1.9	263.7	Implicit
Assawoman Bay[2]	**2,080.4**	**1,542.2**	**0.5**	**1.9**	**535.8**	**Implicit**
Bishopville Prong	410.1	184.1	1.8	7.7	216.4	Implicit
Shingle Landing Prong	433.1	0.0	41.9	3.7	387.5	Implicit
St. Martin River[2]	1,025.6	184.1	43.7	12.2	785.6	Implicit
Herring Creek	104.2	0.0	0.0	0.0	104.2	Implicit
Turville Creek	182.5	0.0	0.0	2.0	180.4	Implicit
Manklin Creek	108.6	0.0	0.0	0.0	108.6	Implicit
Isle of Wight Bay[2]	**1,710.0**	**184.1**	**131.1**	**14.2**	**1,380.5**	**Implicit**
Ayer Creek/Kitts Branch	621.7	0.0	38.9	1.5	581.3	Implicit
Newport Creek	177.3	0.0	0.0	2.4	174.9	Implicit
Marshall Creek	231.9	0.0	10.5	3.1	218.3	Implicit
Newport Bay[2]	**1,364.7**	**0.0**	**49.5**	**8.4**	**1,306.9**	**Implicit**
Sinepuxent Bay	**465.2**	**0.0**	**10.2**	**0.0**	**454.9**	**Implicit**
Chincoteague Bay	**6,193.6**	**3,591.7**	**0.0**	**11.6**	**2,590.3**	**Implicit**

[1] Upstream Loads denotes loadings from outside Maryland's portion of the watershed. This allocation includes point and nonpoint sources.
[2] This allocation includes the allocations from other subwatersheds draining to this MD 8-digit watershed.

Table F6: TP Maximum Daily Load Summary by TMDL Basin (lbs/day)

Basin Name	MDL	Upstream Loads[1] (WLA+LA)	WLA (Process Water)	WLA (CAFO)	LA	MOS
Greys Creek	53.4	33.8	0.0	0.2	19.4	Implicit
Assawoman Bay[2]	**147.4**	**106.2**	**0.0**	**0.2**	**41.1**	**Implicit**
Bishopville Prong	45.8	21.6	0.0	0.6	23.5	Implicit
Shingle Landing Prong	42.4	0.0	3.3	0.3	38.8	Implicit
St. Martin River[2]	102.0	21.6	3.3	1.0	76.0	Implicit
Herring Creek	8.7	0.0	0.0	0.0	8.7	Implicit
Turville Creek	14.2	0.0	0.0	0.2	14.0	Implicit
Manklin Creek	9.7	0.0	0.0	0.0	9.7	Implicit
Isle of Wight Bay[2]	**161.9**	**21.6**	**15.8**	**1.2**	**123.3**	**Implicit**
Ayer Creek/Kitts Branch	49.0	0.0	4.5	0.1	44.4	Implicit
Newport Creek	12.3	0.0	0.0	0.2	12.1	Implicit
Marshall Creek	16.8	0.0	1.8	0.3	14.8	Implicit
Newport Bay[2]	**101.9**	**0.0**	**6.2**	**0.7**	**95.0**	**Implicit**
Sinepuxent Bay	**37.5**	**0.0**	**0.0**	**0.0**	**37.5**	**Implicit**
Chincoteague Bay	**425.5**	**255.7**	**0.0**	**1.0**	**168.9**	**Implicit**

[1] Upstream Loads denotes loadings from outside Maryland's portion of the watershed. This allocation includes point and nonpoint sources.
[2] This allocation includes the allocations from other subwatersheds draining to this MD 8-digit watershed.

Reference

USEPA. 2007. *Options for expressing daily loads in TMDLs*. U.S. Environmental Protection Agency, Office of Wetland, Ocean &Watersheds.