

**Total Maximum Daily Loads for
Bacteria and Sediment in the
Christina River Basin,
Pennsylvania, Delaware, and Maryland**

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**U.S. Environmental Protection Agency
Region III
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Signed

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Executive Summary

Total Maximum Daily Loads for Bacteria and Sediment in the Christina River Watershed Pennsylvania, Delaware, and Maryland

The Clean Water Act requires a Total Maximum Daily Load (TMDL) be developed for those waterbodies identified as impaired by the state where technology-based and other controls will not provide for attainment of water quality standards. A TMDL is a determination of the amount of a pollutant from point, nonpoint and natural background sources, including a margin of safety (MOS), which may be discharged to a water quality-limited waterbody without violating water quality standards.

This document revises the bacteria TMDLs established by the U.S. Environmental Protection Agency (EPA) on April 8, 2005. Although the sediment TMDLs is not being revised^a, this document supersedes the 2005 document in its entirety.

TMDLs are defined as the summation of the point source wasteload allocations (WLAs) plus the summation of the nonpoint source load allocations (LAs) plus a MOS and are often shown as:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

The TMDL is a written plan and analysis established to ensure that a waterbody will attain and maintain water quality standards. The TMDL is a scientifically-based strategy that considers current and foreseeable conditions, the best available data, and accounts for uncertainty with the inclusion of a MOS value.

The TMDLs are to achieve and maintain the States' existing water quality standards and must meet the following eight regulatory requirements pursuant to 40 CFR Part 130.

1. The TMDLs are designed to implement the applicable water quality standards.
2. The TMDLs include a total allowable load as well as individual WLAs and (LAs).
3. The TMDLs consider the impacts of background pollutant contributions.
4. The TMDLs consider critical environmental conditions.
5. The TMDLs consider seasonal environmental variations.
6. The TMDLs include a MOS.
7. There is reasonable assurance that the proposed TMDLs can be met.
8. The TMDLs have been subject to public participation.

As interstate TMDLs, both Pennsylvania and Maryland have the responsibility of meeting downstream Delaware's water quality standards.

^a Although the sediment TMDLs are not revised, Table 4-7 was corrected.

The Pennsylvania Department of Environment Protection (PADEP) identified waterbodies within Pennsylvania’s portion of the Christina River Watershed as impaired by bacteria and sediment, which are addressed in this TMDL Report. The Delaware Department of Natural Resources and Environmental Control (DNREC) identified waterbodies within Delaware’s portion of the Christina River Basin as impaired by bacteria. Maryland’s Department of the Environment has not identified waterbodies within the Christina River Watershed as impaired.

Both PADEP and DNREC have designated the primary contact recreation (swimming) and protection of aquatic life (fishing) uses for waterbodies in the Christina River Basin. The state agencies use different bacterial indicators in their respective water quality standards for pathogens. Pennsylvania uses fecal coliform bacteria as an indicator of bacteria contamination whereas Delaware uses *enterococcus* bacteria. Maryland uses either *E. coli* or *enterococcus* bacteria. While the states list waterbodies for bacteria impairments, only Pennsylvania and Maryland list waterbodies for sediment, suspended solids, or siltation impairments.

The bacteria TMDL endpoints are identified in Table 1-6 and 1-7. The sediment TMDL endpoint is based on the reference watershed method described in Section 3.2.1.

A customized modeling framework was developed to support determination of bacteria and sediment TMDLs for the Christina River Basin. The modeling framework used in this study consisted of three major components: (1) a watershed loading model Hydrologic Simulation Program Fortran (HSPF) developed for each of the four primary subwatersheds in the Christina River Basin by the U.S. Geological Survey (Senior and Koerke, 2003a, 2003b, 2003c, 2003d), (2) a Combined Sewer Overflow flow model (XP-SWMM) developed by the City of Wilmington, and (3) a hydrodynamic model developed using the computational framework of the Environmental Fluid Dynamics Code (Hamrick, 1992). Development of inputs for these models involved the analyses of historical water quality and streamflow data to estimate point and nonpoint sources of bacteria and sediment.

The pathogen TMDLs are as follows:

Fecal coliform bacteria average annual TMDL allocations for the Christina River Basin

Subbasin	Baseline Load (cfu*/season)			TMDL Allocation (cfu/season)					Percent Reduction
	PS	NPS	Total	WLA	MS4 WLA	LA	MOS	TMDL	
Swimming Season (May 1 - Sep 30)									
Red Clay (R01)	1.872E+12	2.914E+15	2.916E+15	8.734E+10	2.139E+14		1.126E+13	2.252E+14	92.28%
Red Clay (R02)	6.037E+12	1.319E+15	1.325E+15	1.274E+12	1.133E+14		6.031E+12	1.206E+14	90.90%
Red Clay (R03)	1.304E+12	1.435E+15	1.437E+15	1.738E+11	1.206E+14		6.359E+12	1.272E+14	91.15%
White Clay (W04)		1.726E+15	1.726E+15		1.040E+14		5.478E+12	1.095E+14	93.66%
White Clay (W07)	7.529E+10	3.140E+13	3.148E+13	7.529E+10	2.885E+12		1.557E+11	3.115E+12	90.10%
Non-swimming Season (Oct 1 - Apr 30)									
Red Clay (R01)	1.872E+12	6.404E+15	6.406E+15	8.734E+11	2.895E+15		1.524E+14	3.049E+15	52.40%
Red Clay (R02)	6.037E+12	3.406E+15	3.412E+15	1.274E+13	1.571E+15		8.338E+13	1.668E+15	51.12%
Red Clay (R03)	1.304E+12	3.704E+15	3.705E+15	1.738E+12	1.720E+15		9.062E+13	1.812E+15	51.08%

Subbasin	Baseline Load (cfu*/season)			TMDL Allocation (cfu/season)					Percent Reduction
	PS	NPS	Total	WLA	MS4 WLA	LA	MOS	TMDL	
White Clay (W04)		2.499E+15	2.499E+15		2.370E+15		1.249E+14	2.495E+15	0.16%
White Clay (W07)	1.043E+11	6.899E+13	6.910E+13	7.529E+11	6.475E+13		3.450E+12	6.899E+13	0.15%

*Colony forming units

Fecal coliform average annual TMDL allocations for MS4 municipalities

Town	Sub-Watershed	Swimming Season Baseline (cfu/season)	Swimming Season TMDL (cfu/season)	Percent Reduction
East Marlborough TWP	Red Clay	2.61E+15	2.06E+14	92.09%
Kennett Square Boro	Red Clay	2.35E+14	1.88E+13	91.98%
Kennett TWP	Red Clay	1.44E+15	1.24E+14	91.38%
New Garden TWP	Red Clay	1.12E+15	9.38E+13	91.60%
Avondale Boro	White Clay	3.81E+13	2.42E+12	93.64%
London Grove TWP	White Clay	1.54E+15	9.27E+13	93.99%
New Garden TWP	White Clay	3.00E+13	2.76E+12	90.82%
West Grove Boro	White Clay	8.48E+13	5.09E+12	93.99%
Town	Sub-Watershed	Non-Swimming Season Baseline (cfu /season)	Non-Swimming Season TMDL (cfu/season)	Percent Reduction
East Marlborough TWP	Red Clay	5.95E+15	2.85E+15	52.08%
Kennett Square Boro	Red Clay	5.45E+14	2.62E+14	51.95%
Kennett TWP	Red Clay	3.65E+15	1.78E+15	51.26%
New Garden TWP	Red Clay	2.76E+15	1.34E+15	51.52%
Avondale Boro	White Clay	5.83E+13	5.53E+13	5.06%
London Grove TWP	White Clay	2.23E+15	2.12E+15	5.04%
New Garden TWP	White Clay	6.59E+13	6.25E+13	5.15%
West Grove Boro	White Clay	1.23E+14	1.17E+14	5.04%

Average annual state line allocations for Christina River Basin *enterococci* bacteria TMDL

Location	Baseline (cfu/yr)	Allocation (cfu/yr)	Reduction
<i>Allocations at the Pennsylvania-Delaware State Line</i>			
Brandywine Cr. (at PA-DE Line)	3.12E+15	2.01E+14	93.56%
White Clay Cr. (at PA-DE Line)	6.86E+14	2.06E+14	70.03%
Red Clay Cr. (at PA-DE Line)	2.58E+14	1.08E+14	58.05%
Burroughs Run (at PA-DE Line)	1.85E+13	1.30E+13	29.32%
<i>Allocations at the Maryland-Delaware State Line</i>			
Christina River (at MD-DE Line)	1.86E+13	7.73E+12	58.40%

Neither the Pennsylvania nor the Delaware MS4 permits actually identify the extent of the systems. Therefore, the WLAs are for the whole municipal area and by subbasin. Appendix E contains sample calculations for determining WLAs for storm water permits within an MS4 permitted area. The same procedure should be used when converting the TMDL WLA into WLA and LA values when the actual extent of the MS4 system is known.

The non-MS4 point source permittee's allocations for fecal coliform, *enterococci*, and total suspended solids are not reduced from their permitted levels and are shown in Table 2-2.

Permit DE0020320-001, the City of Wilmington, is not shown in Table 2-2 because it discharges to the Delaware River. However, Wilmington has combined sewers with combined sewer overflows (CSOs) discharging to Brandywine Creek, Christina River, and Little Mill Creek. The CSO allocations are shown in the following table.

Table 4-5. Summary of average annual CSO enterococci baseline loads and WLA TMDL

Location	CSO ID Numbers	Baseline (cfu/yr)	WLA (cfu/yr)	Reduction
Little Mill Creek (C05)	27, 28, 29	1.56E+14	3.69E+13	76.32%
Christina River (C09)	5, 6, 7, 9a, 9c, 10, 11, 12, 13, 14, 15, 16, 17, 30	3.54E+14	9.75E+13	72.47%
Brandywine Creek (B34)	3, 4a, 4b, 4c, 4d, 4e, 4f, 18, 19, 20, 21a, 21b, 21c, 22b, 22c, 23, 24, 25, 26, RR	6.89E+14	2.55E+14	63.07%
Total CSO Loads	-	1.20E+15	3.89E+14	67.57%

All of New Castle County is covered by a MS4 permit and the allocations by subbasin are shown in the following table.

Average annual allocations for Christina River Basin enterococci bacteria TMDL

Location	Baseline (cfu/yr)	WLA (cfu/yr)	LA (cfu/yr)	MOS (cfu/yr)	TMDL (cfu/yr)	Reduction
<i>Brandywine Creek in Delaware</i>						
Brandywine Cr. (B18)	1.11E+14	0.00E+00	5.55E+12	2.92E+11	5.85E+12	94.75%
Brandywine Cr. (B19)	5.57E+13	3.45E+10	6.31E+12	3.32E+11	6.68E+12	88.00%
<i>White Clay Creek in Delaware</i>						
White Clay Cr. (W11)	4.07E+13	0.00E+00	9.96E+12	5.24E+11	1.05E+13	74.23%
White Clay Cr. (W12)	1.49E+14	4.15E+10	1.79E+13	9.44E+11	1.89E+13	87.31%
White Clay Cr. (W13)	3.01E+13	0.00E+00	3.91E+12	2.06E+11	4.11E+12	86.34%
White Clay Cr. (W14)	3.82E+13	0.00E+00	3.99E+12	2.10E+11	4.20E+12	89.00%
White Clay Cr. (W15)	2.85E+13	0.00E+00	8.95E+12	4.71E+11	9.42E+12	66.90%
White Clay Cr. (W16)	1.02E+14	0.00E+00	1.32E+13	6.95E+11	1.39E+13	86.41%
White Clay Cr. (W17)	2.41E+14	0.00E+00	3.34E+13	1.76E+12	3.52E+13	85.43%
<i>Red Clay Creek in Delaware</i>						
Red Clay Cr. (R04)	5.89E+13	3.00E+12	8.52E+12	4.48E+11	1.20E+13	79.67%
Red Clay Cr. (R05)	2.25E+13	2.07E+10	7.90E+12	4.16E+11	8.34E+12	63.01%
Red Clay Cr. (R06)	1.51E+13	6.22E+08	1.01E+13	5.34E+11	1.07E+13	29.32%
Red Clay Cr. (R07)	6.05E+12	0.00E+00	1.74E+12	9.16E+10	1.83E+12	69.75%
Red Clay Cr. (R08)	7.61E+13	4.84E+11	7.83E+12	4.12E+11	8.73E+12	88.54%
Red Clay Cr. (R09)	2.88E+13	0.00E+00	2.89E+12	1.52E+11	3.04E+12	89.44%
<i>Christina River and Tidal Brandywine Creek</i>						
Christina River (C01)	3.51E+13	0.00E+00	1.27E+13	6.69E+11	1.34E+13	61.90%
Christina River (C02)	8.16E+13	0.00E+00	2.47E+13	1.30E+12	2.60E+13	68.15%
Christina River (C03)	6.64E+13	0.00E+00	9.35E+12	4.92E+11	9.84E+12	85.18%
Christina River (C04)	8.69E+13	0.00E+00	6.73E+12	3.54E+11	7.09E+12	91.84%
Christina River (C05) *	2.21E+14	3.69E+13	4.84E+12	2.55E+11	4.20E+13	81.01%

Location	Baseline (cfu/yr)	WLA (cfu/yr)	LA (cfu/yr)	MOS (cfu/yr)	TMDL (cfu/yr)	Reduction
Christina River (C06)	7.45E+13	0.00E+00	1.65E+13	8.70E+11	1.74E+13	76.66%
Christina River (C07)	7.16E+13	0.00E+00	1.08E+13	5.70E+11	1.14E+13	84.08%
Christina River (C08)	1.28E+14	0.00E+00	1.67E+13	8.79E+11	1.76E+13	86.29%
Christina River (C09) *	6.84E+14	9.75E+13	3.54E+13	1.87E+12	1.35E+14	80.30%
Tidal Brandywine Cr. (B34) *	8.23E+14	2.55E+14	1.33E+13	6.98E+11	2.68E+14	67.38%
Sunset Lake	6.39E+13	0.00E+00	1.41E+13	7.46E+11	1.49E+13	76.66%
Beck's Pond	6.27E+13	0.00E+00	9.45E+12	4.99E+11	9.98E+12	84.08%
Smalley's Pond	1.28E+14	0.00E+00	1.67E+13	8.79E+11	1.76E+13	86.29%
* CSO loads are included in the Baseline and WLA in these subbasins.						

For more detailed information, see the appendices.