August, 2009 Report #: DEPLW-1005

Mass per Unit Time TMDLs

The State of Maine prefers to express bacteria TMDLs as concentrations (counts of bacteria/100mL), as explained in Section 4 (TMDL Calculations) of the report. Equivalent expressions of the bacteria TMDLs in terms of mass per unit time are provided below for those who are interested in that particular format. Although this mass per unit time method is more indicative of a "load", it is not the most useful measure for bacteria TMDLs.

The mass per unit time bacteria TMDLs are expressed in terms of number of billions of bacteria per day as a function of flow (e.g., streamflow for freshwater, volume of water for coastal embayments). The TMDL calculation uses the applicable concentration bacteria criterion.

In contrast to the concentration bacteria TMDLs, the MOS in the mass per unit time TMDL is explicit because flow estimation introduces additional potential uncertainty. A discrete portion of the loading capacity is reserved to ensure that water quality standards will be attained. In these mass per unit time bacteria TMDLs, 10% of the loading capacity is reserved as the MOS, leaving 90% of the TMDL available for allocation among existing and future sources.

In the mass per unit time bacteria TMDLs, WLAs for continuous discharges (WLA_C), such as wastewater treatment plants, are the appropriate bacteria criteria multiplied by each facility's daily effluent flow and a conversion factor. All stormwater sources and natural background (WLA and LA) are included in one aggregate allocation per impaired stream segment, so the basic TMDL formula is revised as follows:

$$\text{TMDL} = \text{Loading Capacity} = \Sigma WLA_C + [\text{stormwater WLA, LA}] + \text{MOS}$$

The aggregate stormwater WLA, LA is the allocation left after the sum of each continuous discharge allocation (ΣWLA_C) and the MOS are subtracted from the loading capacity or TMDL.
Given the lack of necessary data and difficulty of separating out bacteria associated with different stormwater sources (point and nonpoint, regulated and non-regulated), assigning one aggregate or gross allocation for all sources of stormwater is reasonable.

Load or mass per unit time for the stormwater discharges to rivers is calculated by multiplying river or stream flow at a given point in time by the allowable bacteria concentration and a conversion factor. If stream-flow data are not available, a range of flows can be assumed based on drainage area. Flows within this range are multiplied by the WQS (both instantaneous and geometric mean concentrations) to obtain the loading capacity or TMDL for the stream segment or watershed. For lakes or estuarine and marine segments, the volume of the lake or embayment area is multiplied by the WQS concentration and a conversion factor.

Since there are two freshwater bacteria criteria for class B rivers and streams in Maine, for example, two mass per unit time bacteria TMDLs are presented in the following tables and figures. Table 1and Figure 1 show the TMDL based on the single sample criterion of 236 *E.coli* per 100mL and Table 2 and Figure 2 show the TMDL based on the geometric mean criterion of 64 *E.coli* per 100mL. Tables 3 and 4 and Figures 3, 4, 5 and 6 provide similar information for lake, ponds, estuarine and marine segment based on water volume (for non-flowing segments). In each case, the TMDLs are a function of streamflow. At any particular flow (within an expected range for the given waterbody), the sum of all allocations is set equal to 90% of the value of the bacteria criterion multiplied by that flow and a conversion factor. This subtraction of 10% from the applicable bacteria criterion when calculating the "load" provides an explicit margin of safety (MOS).

Formulas, tables, and graphs for calculating the TMDL for any flow are provided in Figures 1 through 6. Since TMDLs are provided for all flows that could occur under any condition, the TMDLs are protective of water quality under all conditions.

Table 1. River and Stream Mass per Unit Time TMDL based on Single Sample Water Quality Standard.

Flow (Q) (ft^3/sec)	SS WQS (#/100mL)	SS TMDL	MOS	LA and WLA
		billions of *E. coli*/day		
0.5	236	2.9	0.3	2.6
1	236	5.8	0.6	5.2
2	236	11.5	1.2	10.4
3	236	17.3	1.7	15.6
4	236	23.1	2.3	20.8
5	236	28.9	2.9	26.0
10	236	57.7	5.8	52.0
20	236	115	12	104
50	236	289	29	260
75	236	433	43	390
100	236	577	58	520

Abbreviations:

SS WQS = Single Sample Water Quality Standard; SS TMDL = Single Sample Total Maximum Daily Load

WLA_C = Waste Load Allocations for continuous point source discharges;
Stormwater WLA = Waste Load Allocations for NPDES-regulated stormwater;
LA = Load Allocations for nonpoint sources, non-NPDES-regulated stormwater, and natural background;
[Stormwater WLA, LA] = aggregate or gross allocation of all stormwater and natural background;
MOS = Margin of Safety - set equal to 10% of single sample WQS.

Formula:

For Q > 7Q10 (cfs),

TMDL (billions of *E. coli* per day) = WQS (#/100mL) x 1000mL/L x Q (ft^3/sec) x 86400 (sec/day) x 28.32 (L/ft3) /10^9

Where: WQS = 236/100mL *E. coli*

Q = Flow in cubic feet/second (ft^3/sec)

mL = milliliter; L = Liter

Figure 1. River and Stream Mass per Unit Time TMDL based on Single Sample Water Quality Standard.

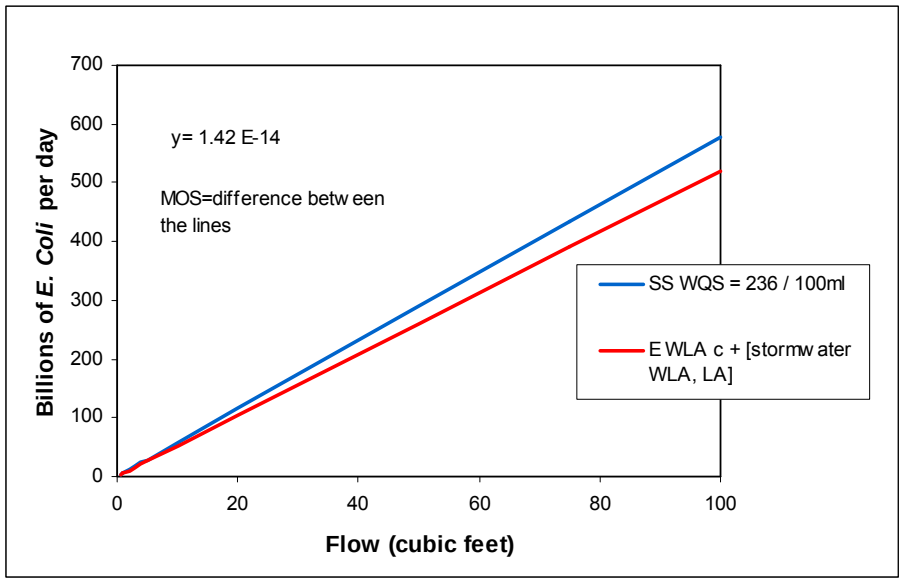

Table 2. River and Stream Mass per Unit Time TMDL based on Geometric Mean Water Quality Standard.

Flow (Q) (ft^3/sec)	GM WQS (#/100mL)	GM TMDL	MOS	LA and WLA
		billions of *E. coli*/day		
0.5	64	0.8	0.1	0.7
1	64	1.6	0.2	1.4
2	64	3.1	0.3	2.8
3	64	4.7	0.5	4.2
4	64	6.3	0.6	5.6
5	64	7.8	0.8	7.0
10	64	15.7	1.6	14.1
20	64	31.3	3.1	28.2
50	64	78.3	7.8	70.5
75	64	117	12	106
100	64	157	16	141

Abbreviations:

GM WQS = Geometric Mean Water Quality Standard; GM TMDL = Geometric Mean Total Maximum Daily Load

WLA_C = Waste Load Allocations for continuous point source discharges;
Stormwater WLA = Waste Load Allocations for NPDES-regulated stormwater;
LA = Load Allocations for nonpoint sources, non-NPDES-regulated stormwater, and natural background;
[Stormwater WLA, LA] = aggregate or gross allocation of all stormwater and natural background;
MOS = Margin of Safety - set equal to 10% of geometric mean WQS

Formula:
For Q > 7Q10 (cfs),
TMDL (billions of E. coli per day) = WQS (#/100mL) x 1000mL/L x Q (ft^3/sec) x 86400 (sec/day) x 28.32 (L/ft3) /10^9

Where: WQS = 64/100mL *E. coli*
Q = Flow in cubic feet/second (ft^3/sec)
mL = milliliter; L = Liter

Figure 2. River and Stream Mass per Unit Time TMDL based on Geometric Mean Water Quality Standard.

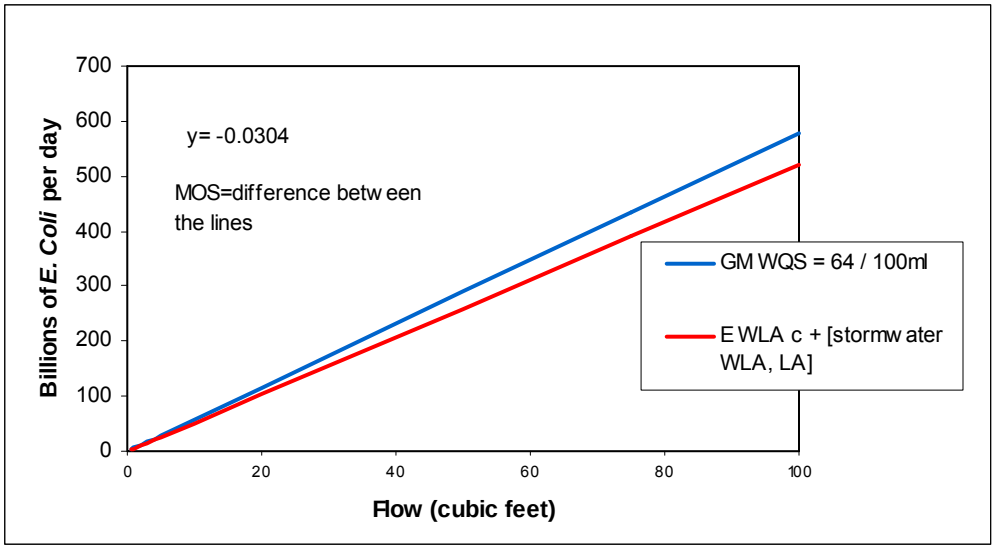

Table 3. Lake and Pond Mass per Unit Time TMDL based on Single Sample Water Quality Standard.

Volume (ft^3)	SS WQS (#/100mL)	SS TMDL	MOS	LA and WLA
		billions of *E. coli*/day		
1000	194	0.05	0.005	0.049
5000	194	0.27	0.03	0.25
10000	194	0.55	0.05	0.49
50000	194	2.7	0.27	2.5
100000	194	5.5	0.55	4.9
500000	194	27.5	2.75	24.7
1000000	194	54.9	5.49	49.4

Abbreviations:

SS WQS = Single Sample Water Quality Standard; SS TMDL = Single Sample Total Maximum Daily Load

WLA_C = Waste Load Allocations for continuous point source discharges;
Stormwater WLA = Waste Load Allocations for NPDES-regulated stormwater;
LA = Load Allocations for nonpoint sources, non-NPDES-regulated stormwater, and natural background;
[Stormwater WLA, LA] = aggregate or gross allocation of all stormwater and natural background;
MOS = Margin of Safety - set equal to 10% of single sample WQS.

Formula:

For Q = 0 cfs,

TMDL (billions of *E. coli* per day) = WQS (#/100mL) x Volume (ft3) x 1000 (mL/L) x 28.32 (L/ft3) /10^9

Where: WQS = 194/100mL *E. coli*

V = Water Volume in cubic feet (ft^3)

mL = milliliter; L = Liter

Figure 3. Lake and Pond Mass per Unit Time TMDL based on Single Sample Water Quality Standard.

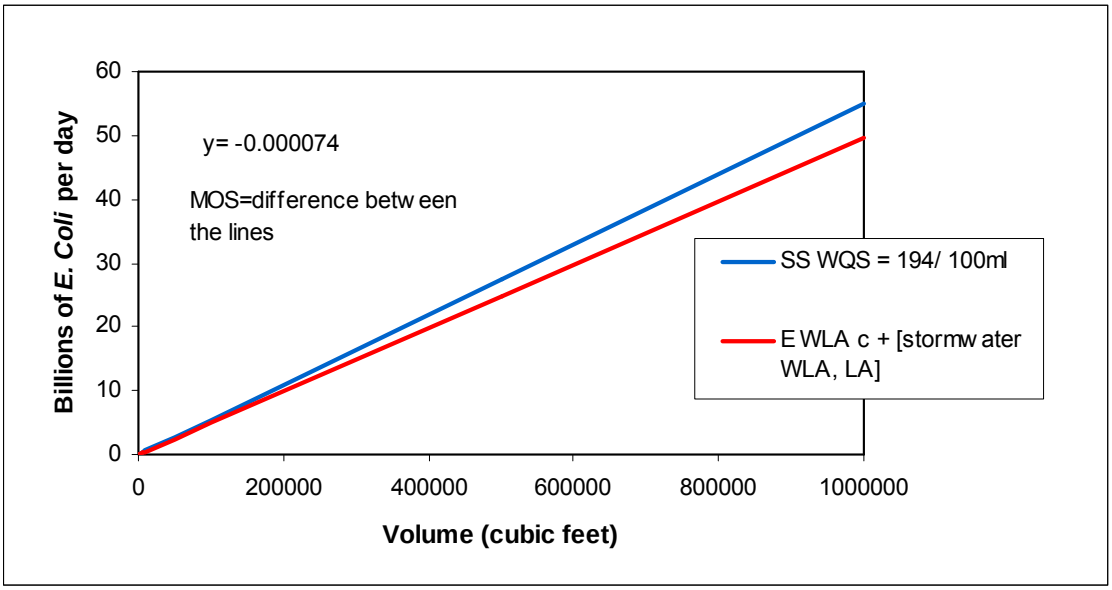

Table 4. Lake and Pond Mass per Unit Time TMDL based on Geometric Mean Water Quality Standard.

Volume (ft^3)	GM WQS (#/100mL)	GM TMDL	MOS	LA and WLA
		billions of *E. coli*/day		
1000	29	0.01	0.001	0.007
5000	29	0.04	0.004	0.037
10000	29	0.08	0.01	0.07
50000	29	0.41	0.04	0.37
100000	29	0.8	0.08	0.74
500000	29	4.1	0.41	3.7
1000000	29	8.2	0.82	7.4

Abbreviations:

GM WQS = Geometric Mean Water Quality Standard; SS TMDL = Single Sample Total Maximum Daily Load

WLA_C = Waste Load Allocations for continuous point source discharges;
Stormwater WLA = Waste Load Allocations for NPDES-regulated stormwater;
LA = Load Allocations for nonpoint sources, non-NPDES-regulated stormwater, and natural background;
[Stormwater WLA, LA] = aggregate or gross allocation of all stormwater and natural background;
MOS = Margin of Safety - set equal to 10% of geometric mean WQS.

Formula:

For Q = 0 cfs,

TMDL (billions of *E. coli* per day) = WQS (#/100mL) x Volume (ft3) x 1000 (mL/L) x 28.32 (L/ft3) /10^9

Where: WQS = 29/100mL *E. coli*

V = Water Volume in cubic feet (ft^3)

mL = milliliter; L = Liter

Figure 4. Lake and Pond Mass per Unit Time TMDL based on Geometric Mean Water Quality Standard.

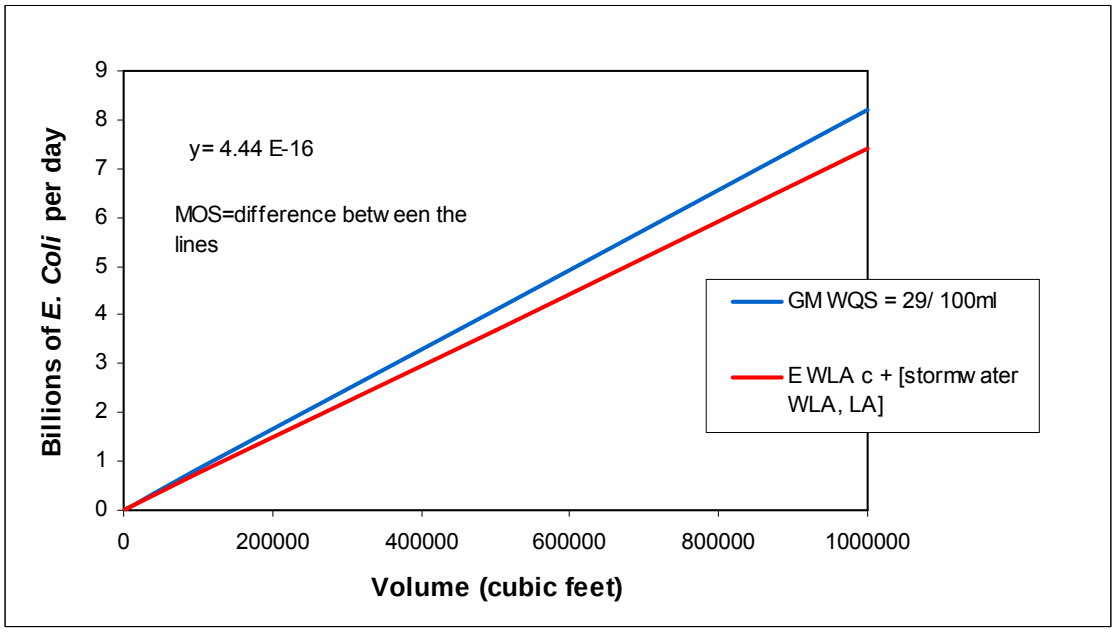

Table 5. Marine and Estuarine Mass per Unit Time TMDL based on 90th Percentile Water Quality Standard.

Volume (ft^3)	SS WQS (#/100mL)	SS TMDL	MOS	LA and WLA
		billions of *Fecal Coliform* /day		
1000	31	0.01	0.001	0.008
5000	31	0.04	0.004	0.040
10000	31	0.09	0.01	0.08
50000	31	0.44	0.04	0.40
100000	31	0.88	0.09	0.79
500000	31	4.4	0.44	4.0
1000000	31	8.8	0.88	7.9

Abbreviations:

GM WQS = Geometric Mean Water Quality Standard; SS TMDL = Single Sample Total Maximum Daily Load

WLA_C = Waste Load Allocations for continuous point source discharges;
Stormwater WLA = Waste Load Allocations for NPDES-regulated stormwater;
LA = Load Allocations for nonpoint sources, non-NPDES-regulated stormwater, and natural background;
[Stormwater WLA, LA] = aggregate or gross allocation of all stormwater and natural background;
MOS = Margin of Safety - set equal to 10% of 90th percentile WQS.

Formula:

For Q = 0 cfs,

TMDL (billions of *Fecal Coliform* per day) = WQS (#/100mL) x Volume (ft3) x 1000 (mL/L) x 28.32 (L/ft3) /10^9

Where: WQS = 31/100mL Fecal Coliform
V = Water Volume in cubic feet (ft^3)
mL = milliliter; L = Liter

Figure 5. Marine and Estuarine Mass per Unit Time TMDL based on 90th Percentile Water Quality Standard.

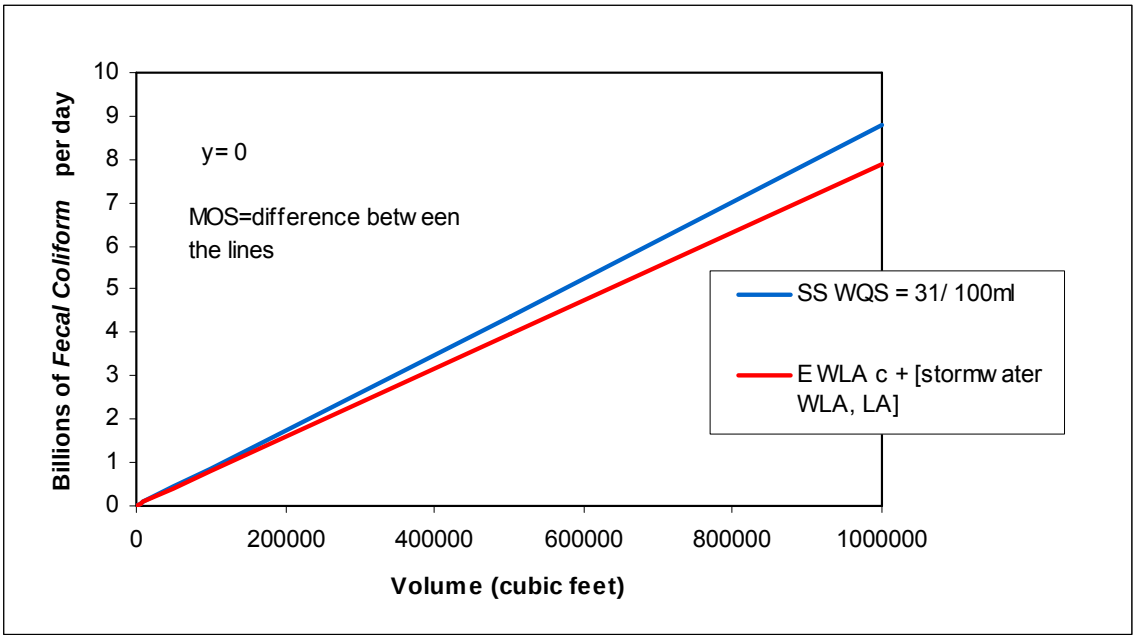

Table 6. Marine and Estuarine Mass per Unit Time TMDL based on Geometric Mean Water Quality Standard.

Volume (ft^3)	GM WQS (#/100mL)	GM TMDL	MOS	LA and WLA
		billions of *Fecal Coliform* /day		
1000	14	0.004	0.0004	0.00
5000	14	0.02	0.002	0.02
10000	14	0.04	0.004	0.04
50000	14	0.20	0.02	0.18
100000	14	0.40	0.04	0.36
500000	14	2.0	0.20	1.8
1000000	14	4.0	0.40	3.6

Abbreviations:

GM WQS = Geometric Mean Water Quality Standard; SS TMDL = Single Sample Total Maximum Daily Load

WLA_C = Waste Load Allocations for continuous point source discharges;
Stormwater WLA = Waste Load Allocations for NPDES-regulated stormwater;
LA = Load Allocations for nonpoint sources, non-NPDES-regulated stormwater, and natural background;
[Stormwater WLA, LA] = aggregate or gross allocation of all stormwater and natural background;
MOS = Margin of Safety - set equal to 10% of geometric mean WQS.

Formula:

For Q = 0 cfs,

TMDL (billions of *Fecal Coliform* per day) = WQS (#/100mL) x Volume (ft3) x 1000 (mL/L) x 28.32 (L/ft3) $/10^9$

Where: WQS = 14/100mL Fecal Coliform
V = Water Volume in cubic feet (ft^3)
mL = milliliter; L = Liter

Figure 6. Marine and Estuarine Mass per Unit Time TMDL based on Geometric Mean Water Quality Standard.