# Appendix B

## *E. coli* Bacteria Allocations and Daily Loads for Oxon Run

## February 2013

## Contents

## Introduction

The purpose of this document is to revise the original 2004 *Final Total Maximum Daily Load for Organics, Metals and Bacteria in Oxon Run* (DDOH 2004). The revision incorporates a new water quality standard (WQS) for *Escherichia coli* (*E.coli*) that the District of Columbia (District) promulgated in October of 2005 after the approval of the original total maximum daily loads (TMDLs). The allocations specified in the original TMDL are still in effect; this revision provides a translation of those loads to *E. coli*, the parameter on which the existing standard is based. The translation was performed using a translator equation developed from analysis of paired fecal coliform/*E.coli* sampling data collected from waters in the District.

In addition, daily loading expressions for the new *E. coli* allocations are also provided. This has been done to comply with the U.S. Environmental Protection Agency (EPA) obligations under the 2006 court case, *Friends of the Earth vs. the Environmental Protection Agency, 446 F.3d 140, 144* (D.C. Cir. 2006), which requires establishment of a daily loading expression in TMDLs in addition to any annual or seasonal loading expressions previously established in the TMDL.

Anacostia Riverkeepers, Friends of the Earth, and Potomac Riverkeepers filed a complaint (Case No.: 1:09-cv-00098-JDB) on January 15, 2009, because certain District TMDLs did not have a daily load expression established. EPA settled the complaint by agreeing to an established schedule that both the court and the plaintiffs to the case approved. The settlement agreement requires establishment of daily loads in District Bacteria TMDLs referenced in Paragraphs 24a, 24c, 24g, 24i, 24j, and 24l of the plaintiffs' complaint by December 2014. This TMDL revision satisfies that requirement for the 2004 *Final Total Maximum Daily Load for Organics, Metals and Bacteria in Oxon Run* (Paragraph 24k of the complaint).

## Applicable Water Quality Standards

Oxon Run was on the District's 1998 303(d) list in part because of excessive counts of fecal coliform bacteria that exceeded the District's WQS. Oxon Run was also listed as impaired by metals and organics, although these contaminants are not addressed by this revision. The District WQS, Title 21 of the District of Columbia Municipal Regulations (DCMR) Chapter 11, 49 D.C. Reg. 3012 and D.C. Reg.4854, specifies the categories of beneficial uses as

1. Class A. primary contact recreation
2. Class B. secondary contact recreation
3. Class C. protection and propagation of fish, shellfish, and wildlife
4. Class D. protection of human health related to consumption of fish and shellfish
5. Class E. navigation

WQS are derived from EPA recommendations on the basis of risk levels associated with swimming. Under the WQS that were in place at the time of the original TMDL, Class A and Class B waters were required to achieve or exceed the WQS for bacteria as measured by fecal coliform as the indicator organism. Fecal coliforms are microbes that live in the intestinal tracts of warm-blooded animals, whose presence indicates the potential for pathogens in the water.

When the original 2004 fecal coliform bacteria TMDL was developed for Oxon River, the standard for Class A waters was a maximum 30-day geometric mean of 200 MPN, where *MPN* is a statistically derived estimate of the Most Probable Number of bacteria colonies in a 100 milliliter sample. This statistical estimate is often called a *count*, although it is represented as a concentration. The geometric mean is based on a minimum of five samples within the 30-day period. The standard for Class B waters was a 30-day geometric mean of 1,000 MPN. Because Oxon Run is designated as a Class A water, the more restrictive limit of 200 MPN was used as the not-to-exceed criterion in the original 2004 TMDL.

Effective January 1, 2008, the District bacteriological WQS changed from fecal coliform to *E. coli*. The current Class A water standards are a geometric mean of 126 MPN and 410 MPN for a single-sample value. The geometric mean is based on a minimum of five samples within the 30-day period and is used in both water quality trend assessments and permits. The single-sample value is only valid for use only in assessing water quality trends. Class B and Class C waters do not have an *E. coli* standard. Oxon Run is used for Class B, C, and D purposes, but it is designated as a Class A, B, C, and D waterbody (DCMR, WQS, 21-1101.2). Therefore, the Class A *E. coli* standard must be met.

## Translation of Fecal Coliform Values to *E. coli*

A *translator* is a mathematical equation that allows one parameter to be translated into another consistently and in a scientifically defensible manner. To support the TMDL revision, EPA and the District of Columbia Department of the Environment developed a District-specific translator using the statistical relationship between paired fecal coliform and *E. coli* data collected in the District's waters (LimnoTech 2011 and 2012).[1] The data used to develop the DC translator was composed of paired fecal coliform and E. coli instream monitoring measurements for DC and adjacent waters collected by three agencies: DDOE, the Virginia Department of Environmental Quality (VDEQ), and the Maryland Department of the Environment (MDE). The dataset includes contains ambient instream water quality monitoring data as well as end-of-pipe data collected by DC Water at separate storm water system (SSWS) outfalls. CSO data was excluded from the dataset and was not used in the development of the translator. E.coli levels for CSO's were not calculated using the translator. (See Section CSO section below) The translator is representative of ambient and stormwater bacteria concentrations and was used to convert the original fecal coliform TMDL allocations into *E. coli* values. The District-specific translator equation is shown in Equation 1 below.

$$\text{Log2}(E.\ coli) = 0.9377[\text{Log2}(\text{fecal coliform})] - 0.4614 \qquad [1]$$

Use of the translator allowed for converting original fecal coliform annual load allocations to the current WQS for *E. coli,* while still relying on the original modeling and analysis.

[1] Documentation related to development of the translator is in LimnoTech's 2011 Memorandum, *Final Memo Summarizing DC Bacteria Data and Recommending a DC Bacteria Translator (Task 2)* and Limno Tech's 2012 Memorandum, *Update on Development of DC Bacteria Translators*.

## Compliance with Revised WQS

Using the District-specific translator, a fecal coliform value of 200 MPN (the original District standard for bacteria) is associated with an *E. coli* value of approximately 104 MPN, which is below the 126 MPN *E. coli* criteria.

It is important to consider that under the original modeling analysis, reductions to sources of fecal bacteria were made until the waterbodies met the fecal coliform geometric mean standard of 200 MPN at all times. Therefore, under the original modeling analysis, fecal coliform loads translated to *E. coli* loads will result in loads that are more protective than WQS. The *E. coli* reductions in this TMDL meet approximately a geometric mean of 104 MPN, while the current bacteria standard is 126 MPN.

## Existing Loads, Allocations and Percent Reductions

This TMDL revision translates the annual fecal coliform loads presented in the original 2004 report into equivalent annual *E. coli* loads. The 2004 TMDL used a revised version of the District's Small Tributaries TMDL model, developed by the Interstate Commission on the Potomac River Basin (ICPRB) and the Watts branch Hydrologic Simulation Program – FORTRAN (HSPF) model, to estimate the existing loads and allocations required to meet WQS. The existing loads were divided into Maryland and District pollutant sources on the basis of the watershed land area and the corresponding land use distribution.

In calculating the original fecal coliform allocations, WQS were considered to be met if no model segment in the District had a fecal coliform maximum 30 day geometric mean exceeding the 200 MPN Class A standards. Exceedance is expressed in the number of months exceeding the geometric mean. However, this revised TMDL considers standards to be met when all portions of the waterbody do not exceed the *E. coli* maximum 30-day geometric mean of 126 MPN Class A standard. Because the bacteria translator provides a calculation of the equivalent *E. coli* load, under a given scenario that meets the fecal coliform standard, the equivalent *E. coli* standard will also be met with an additional MOS.

The approach used to convert the District's TMDL to the new E. coli standards is described below; calculations are presented as a spreadsheet in Appendix C. Table 1 shows the original fecal coliform allocations from the 2004 TMDL.

**Table 1. Original TMDL fecal coliform TMDL components (MPN/year)**

| TMDL | MOS (1%) | WLA | LA | % reduction |
|---|---|---|---|---|
| 1.10E+14 | 1.10E+12 | 9.82E+13 | 1.03E+13 | 90% |

First, the proportion of the District's wasteload allocation (WLA) and LA to the total allocation (total allocation = TMDL - MOS) were found to be 0.902 and 0.095, respectively. See Equations 2 and 3 and the associated calculations.

**Equation 1. Proportionality of the WLA in the original report**

$$\frac{WLA}{TMDL - MOS} = 0.902$$

from: $TMDL - MOS = 1.10\ E\ 14 - 1.10\ E\ 12 = 1.089\ E\ 14$

and: $\frac{WLA}{TMDL-MOS} = \frac{9.82\ E\ 13}{1.089\ E\ 14} = 0.9017 = 0.902$ (rounded result)

**Equation 2. Proportionality of the LA in the original report**

$$\frac{LA}{TMDL - MOS} = 0.095$$

from: $TMDL - MOS = 1.10\ E\ 14 - 1.10\ E\ 12 = 1.089\ E\ 14$ (same as above)

and: $\frac{LA}{TMDL-MOS} = \frac{1.03\ E\ 13}{1.089\ E\ 14} = 0.0946 = 0.095$ (rounded result)

Because the conversion Equation 1 is not linear, it could not be applied to the original MOS, WLA, and LA directly without the three components summing to more than the converted TMDL value. Therefore, the revised District WLA and LA were determined by first converting the fecal coliform TMDL value to *E. coli*, and then calculating the remaining TMDL equation components via Equations 4 and 5, assuming a 1 percent MOS:

**Equation 3. Calculation of the revised WLA**

$$WLA = 0.902 \times (TMDL - MOS)$$

**Equation 4. Calculation of the revised LA**

$$LA = 0.095 \times (TMDL - MOS)$$

When the revised WLA, LA, and 1 percent MOS are added together, the sum is less than the converted TMDL value. The remainder was added to the 1 percent MOS to create a 1.3 percent MOS. The resulting conversion is shown in Table 2.

**Table 2. District *E. coli* average existing loads and TMDL for Oxon Run (MPN/year)**

| TMDL | MOS | WLA | LA | % reduction |
|---|---|---|---|---|
| 1.07E+13 | 1.38E+11 | 9.52E+12 | 1.00E+12 | 90 |

An irregularity was found when converting the Maryland TMDL to the new *E. coli* standards. In the original report, it seems that the 1 percent MOS was incorrectly calculated as 1 percent of the Maryland allocated load. The MOS should be a percentage of the TMDL, and allocated loads should be the difference between the TMDL and the MOS. If the original TMDL intended a 90

percent reduction from the existing load as stated in the original report, the original Maryland TMDL should reflect the values presented in Table 3.

**Table 3. Maryland corrected fecal coliform existing and allocated loads and necessary percent reduction for Oxon Run (MPN/year)**

| TMDL | MOS (1%) | Oxon Run MD allocated load | % reduction |
|---|---|---|---|
| 7.87E+13 | 7.87E+11 | 7.79E+13 | 90% |

The corrected TMDL was converted to the new *E. coli* standards by applying Equation 1 to the existing load, to the TMDL, and to the MOS. Because of the non-linearity of Equation 1, the revised MOS is about 1.3 percent of the revised TMDL. The allocated load is the difference between the TMDL and the MOS. See Table 4.

**Table 4. Maryland *E. coli* existing and allocated loads and necessary percent reduction for Oxon Run (MPN/year)**

| TMDL | MOS | Oxon Run MD allocated load | % Reduction |
|---|---|---|---|
| 7.79E+12 | 1.04E+11 | 7.68E+12 | 88% |

The only point source in the watershed is the District's Municipal Separate Storm Sewer System, so only the District was designated a WLA. LAs, representing the total pollutant loadings attributed to nonpoint sources, were designated to both Maryland and the District.

## Daily Loads

In November 2006, EPA issued the memorandum *Establishing TMDL Daily Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA et al., No. 05-5015 (April 25, 2006) and Implications for NPDES permits*, which recommends that all TMDLs and associated LAs and WLAs include a daily time increment in conjunction with other appropriate temporal expressions that might be necessary to implement the relevant WQS. In compliance with that recommendation, this section presents corresponding daily load expressions for the long-term LAs for Oxon Run described in Tables 1 and 3 above. These daily loads were developed in a manner consistent with the following assumptions in EPA's *Draft Options for Expressions of Daily Loads in TMDLs* (USEPA 2007):

1. Methods and information used to develop the daily load should be consistent with the approach used to develop the loading analysis.
2. The analysis should avoid added analytical burden without providing added benefit.
3. The daily load expression should incorporate terms that address acceptable variability in loading under the long-term loading allocation. Because many TMDLs are developed for precipitation-driven parameters, one number will often not represent an adequate daily load value. Rather, a range of values might need to be presented to account for allowable differences in loading because of seasonal or flow-related conditions (e.g., daily maximum and daily median).

4. The methodologies are applicable to a wide variety of TMDL situations; however, the specific application (e.g., data used, values selected) should be based on knowledge and consideration of site-specific characteristics and priorities.
5. The TMDL analysis on which the daily load expression is based fully meets the EPA requirements for approval, is appropriate for the specific pollutant and waterbody type, and results in attainment of water quality criteria in a manner that is consistent with the underlying analysis that was used to develop the original TMDLs.

Input files to the original model were not available for Oxon Run; therefore, an alternative approach had to be used to determine maximum daily loads. EPA's draft guidance document, *Options for Expressing Daily Loads in TMDLs* (USEPA 2007), recommends a statistical approach as another appropriate way to develop daily maximum load values, specifically when long periods of continuous simulation data are not available. EPA's *Technical Support Document for Water Quality-based Toxics Control* (TSD)(USEPA 1991) describes a statistical approach to identifying a maximum daily load in such circumstances. The statistical daily load expression incorporates acceptable variability in loading under the long-term loading allocation.

The equation below relates the maximum daily load (*MDL*) to the long-term average (*LTA*) as

$$MDL = LTA \cdot \exp\left(Z_p \sigma_y - 0.5\sigma_y^2\right),$$

where

$Z_p$ = *p*th percentage point of the standard normal distribution, as above

*CV* = coefficient of variation of the untransformed data

$$\sigma_y = \sqrt{\ln\left(CV^2 + 1\right)}.$$

Table 5-2 of the TSD provides precalculated multipliers for the LTA depending on coefficient of variation and the Z-statistic used. The 99th percentile was used, and the default coefficient of variation of 0.6 was assumed on the basis of recommendations in the TSD.

For Oxon Run, the LTA is the sum of the annual *E. coli* TMDLs from the District and Maryland divided by 365. The MDL is the product of the LTA and the multiplier found in Table 5-2 of the TSD based on using the 99th percentile z-statistic and a CV of 0.6. The specific steps are summarized below:

1. Summed the *E. coli* TMDLs from the District and Maryland to find the LTA
2. Divided the annual *E. coli* LTA by 365 (average daily load)
3. Multiplied the average daily load by 3.11 (the 99th percentile Z-statistic from Table 5-2 in the TSD) to derive the corresponding maximum daily load

### *E. coli* Daily Loads

The maximum and average daily loads for Oxon Run in terms of *E. coli* are presented in Table 4.

Table 4. Maximum and average daily *E. coli* loads for Oxon Run

| LTA (MPN/year) | Avg daily load (MPN) | Max daily load (MPN) |
|---|---|---|
| 1.84E+13 | 5.05E+10 | 1.57E+11 |

## Other Sources

The December 2004 TMDL does not account for illegal cross connections between storm and sanitary sewers. Although they might exist in the watershed, the District' Water and Sewer Authority actively seeks to prevent and remove them. This TMDL revision likewise does not address illegal connections.

## Assurance of Implementation—Daily Loads

The approach used to calculate daily loads in this TMDL identifies a representative maximum daily or average daily load for the annual TMDL. The approach does not presume that the maximum daily load provided could be discharged every day and still meet the in-stream WQS. While expressions of daily loading values are useful in illustrating the variability in loading that can occur under a TMDL scenario, the annual load must also be met to comply with the TMDL.

Note that federal regulations at Title 40 of the *Code of Federal Regulations* section 122.44(d)(1)(vii)(B) require that, for a National Pollutant Discharge Elimination System permit for an individual point source, the effluent limitations must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the jurisdiction and approved by EPA. There is no express or implied statutory requirement that effluent limitations in National Pollutant Discharge Elimination System permits be expressed in daily terms. The Clean Water Act definition of *effluent limitation* is quite broad (effluent limitation is "any restriction on quantities, rates, and concentrations of chemical, physical, biological, and other constituents which are discharged from point sources …"), see Clean Water Act section 502(11). Unlike the Clean Water Act's definition of TMDL, the Clean Water Act definition of *effluent limitation* does not contain a *daily* temporal restriction. National Pollutant Discharge Elimination System permit regulations do not require that effluent limits in permits be expressed as maximum daily limits or even as numeric limitations in all circumstances, and such discretion exists regardless of the time increment chosen to express the TMDL. For further guidance, see Benjamin H. Grumbles' memo of November 15, 2006, titled *Establishing TMDL Daily Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015 (April 25, 2006) and implications for NPDES Permits.*

## References

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