ESCHERICHIA COLI TOTAL MAXIMUM DAILY LOADS (TMDLs) CONVERSION WITH EXISTING FECAL COLIFORM TMDLs FOR IMPAIRED STREAMS DESIGNATED RECREATION USES IN SOUTH DAKOTA

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Erratum Sheet for: The November 2020 Submitted "*Escherichia Coli* Total Maximum Daily Loads (TMDLs) Conversion with Existing Fecal Coliform TMDLs for Impaired Streams Designated Recreation Uses in South Dakota"

This translation document was approved by the EPA in November of 2020. After EPA approval, an error was found, and a minor change was made to the document. This change can be seen in the table below. All values calculated in the translation document followed the corrected text. The final document with these changes incorporated is dated June 6, 2022.

Location in TMDL	Original Text	Corrected Text
Page 4, Statewide Equation	[*E. coli* Y= (-0.535 + 1.4036)* Fecal coliform X]	[*E. coli* Y= (-0.535 + 1.0436)* Fecal coliform X]

INTRODUCTION

South Dakota adopted EPA recommended national standards and criteria for *Escherichia coli* (*E. coli*) into state water quality standards in 2009 (Administrative Rules of South Dakota 74:51:01: 50:51). *E. coli* eventually replaced Fecal coliform as the primary indicator to protect waters designated immersion and limited contact recreation uses. Fecal coliform initially remained in state water quality standards to allow NPDES permits to transition to *E. coli* during the permit renewal process. This allowed DENR time to build *E. coli* datasets through various monitoring networks. The transition was complete in 2015 when Fecal coliform was officially removed from state water quality standards. Several Fecal coliform TMDLs were developed and approved by EPA prior to South Dakota's transition to *E. coli*.

South Dakota's current Long Term 303(d) Vision Strategy includes a systematic process for prioritizing TMDL development (https://denr.sd.gov/dfta/wp/tmdl/tmdlvision2020.pdf). TMDL prioritization is significantly focused on waters impaired for immersion and limited contact recreation due to *E. coli*. The TMDL priority list contains four stream segments impaired for *E. coli* with EPA approved Fecal coliform TMDLs (Table 1). Considerable time and resources were spent on developing independent Fecal coliform TMDLs for the impaired segments. Converting existing Fecal coliform TMDLs and allocations to *E. coli* would eliminate the need to duplicate resource intensive TMDL development efforts. The relationship between both bacteria has been used for *E. coli* TMDL development with translators as the foundation (Limno Tech, 2011, Dila and McLellan, 2016).

The intent of this document is to convert existing Fecal coliform TMDLs and allocations for four stream segments to *E. coli* using defensible methods to satisfy 303(d) requirements. The following stream segments (Assessment Units) were considered impaired for designated recreation uses due to *E. coli* in South Dakota's most recent 2020 Integrated Report (IR) for Surface Water Quality Assessment https://denr.sd.gov/documents/SD_2020_IR_approved.pdf (Table 1).

Table 1. Fecal coliform TMDL information and references for stream segments impaired for E. coli.

East Fork Vermillion River_01: EAST FORK VERMILLION RIVER FROM MCCOOK/LAKE COUNTY LINE TO ITS CONFLUENCE WITH LITTLE VERMILLION RIVER AUID: SD-VM-R-VERMILLION_E_FORK_01 (formerly SD-VM-R-VERMILLION_EAST_FORK_01) EPA TMDL Approval Date: September 26, 2012 Attains TMDL ID: 42525 http://denr.sd.gov/dfta/wp/tmdl/tmdl_vermillioneastforkfecal0512.pdf
Brule Creek_01: BRULE CREEK FROM THE CONFLUENCE OF EAST AND WEST BRULE CREEK TO THE CONFLUENCE WITH THE BIG SIOUX RIVER AUID: SD-BS-R-BRULE_01 EPA TMDL Approval Date: June 2, 2011 Attains TMDL ID: 40438 http://denr.sd.gov/dfta/wp/tmdl/tmdl_brulecreekfecal0611.pdf
Beaver Creek_02: BEAVER CREEK - SPLIT ROCK CREEK TO SD-MN BORDER (CENTRAL BIG SIOUX RIVER TMDLS) AUID: SD-BS-R-BEAVER_02 EPA TMDL Approval Date: May 28, 2008 Attains TMDL ID: 34499 https://denr.sd.gov/dfta/wp/tmdl/tmdl_bigsiouxcentral.pdf
Lower Rapid Creek_04: LOWER RAPID CREEK - FROM RC WWTF TO ABOVE FARMINGDALE AUID: SD-CH-R-RAPID_04 EPA TMDL Approval Date: September 28, 2010 Attains TMDL ID: 39427 https://denr.sd.gov/dfta/wp/tmdl/tmdl_rapidcreeklowerfecal.pdf

WATER QUALITY STANDARDS AND TMDL TARGETS

South Dakota *E. coli* standards and criteria for immersion (ARSD 74:51:01:50) and limited contact recreation (ARSD 74:51:01:51) consist of a single sample maximum (SSM) and a monthly geometric mean (GM). Criteria for the SSM requires that no single daily sample exceed the standard. The GM is also considered a "must not exceed" criteria, calculated based on a minimum of 5 samples collected during separate 24-hr periods over a 30-day period. The standards structure and criteria for Fecal coliform was identical to *E. coli* for both recreation uses, respectively. However, actual numeric standard limits for *E. coli* are considerably lower than former limits for Fecal coliform (Table 2).

Water quality standards and criteria, while explicit, are used by states as benchmarks to make impairment decisions in accordance with 303(d) listing methods (SD DENR 2020 IR). When two standards exist for the same use (i.e. SSM and GM) an impairment assessment is performed on both standards depending on data availability. Impaired waters require TMDL development based on the most protective standard regardless of the assessment result. Selecting the most protective numeric target for TMDL development ensures attainment with both standards. With regards to Fecal coliform and *E. coli* the GM standards are considerably lower than the SSM standards for both recreation uses, respectively. Therefore, it was common practice for many years to use the GM as the numeric target for TMDL development.

Fecal coliform TMDLs for the four stream segments generally used the GM as the TMDL target (Table 2). The exception was Beaver Creek_02 which used the SSM as the TMDL target. In order to convert the Fecal coliform TMDLs to *E. coli*, it is necessary to establish that the TMDL target will be protective of both standards. An investigation into the development of the *E. coli* standards revealed a statistical linkage between GM and SSM *E. coli* criteria. It was concluded that the GM and SSM *E. coli* standards assigned to both recreation uses are equally protective (Appendix A). As a result, *E. coli* TMDL development was based on the same target used to development the Fecal coliform TMDLs.

Table 2. Designated recreation uses and bacteria standards for the impaired stream segments.

Impaired Stream Segment AUID	Designated Recreation Use	Fecal Coliform Geomean CFU/100mL	Fecal Coliform SSM CFU/100mL	*E. coli* Geomean CFU/100mL	*E. coli* SSM CFU/100 mL
SD-VM-R-VERMILLION_E_FORK_01	Limited Contact	*≤ 1,000	≤ 2,000	*≤ 630	≤ 1,178
SD-BS-R-BRULE_01	Limited Contact	*≤ 1,000	≤ 2,000	*≤ 630	≤ 1,178
SD-BS-R-BEAVER_02	Limited Contact	≤ 1,000	*≤ 2,000	≤ 630	*≤ 1,178
SD-CH-R-Rapid_04	Immersion	*≤ 200	*≤ 400	*≤ 126	*≤ 235

*Refers to numeric standard used for TMDL development.

BACTERIA TMDL CONVERSION APPROACH

E. coli is a Fecal coliform bacteria and both indicators originate from common sources in relatively consistent proportions. The inherent similarity in both bacteria can be exploited for a variety of water quality based applications. SD DENR developed regional relationships to support the addition of Fecal coliform data in *E. coli* TMDL development (SD DENR, 2010). Some states have developed bacteria translator equations to convert Fecal coliform TMDLs and load allocations to *E. coli* (Limno Tech, 2011). The translator approach was explored as a potential option for converting the bacteria TMDLs.

A statewide translator equation was developed from 10,686 paired bacteria samples collected from rivers and streams across South Dakota. All applicable bacteria data were logarithmically transformed (LOG_{10}), and *E. coli* was plotted as a function of Fecal coliform using simple linear regression. The analysis yielded a significant ($p=<0.05$) positive linear relationship and log-normal bacteria concentrations were highly correlated ($r^2 = 0.68$). The following equation was derived from the analysis:

**Statewide Equation: [*E. coli* Y= (-0.535 + 1.0436)* Fecal coliform X]

Fecal coliform standards for immersion and limited contact recreation were used to test the utility of the statewide translator equation. Predicted *E. coli* concentrations are slightly higher than Fecal coliform for all standards with an EC/FC ratio of 1.04, respectively (Table 3). Dila and McLellan (2016), recommend that translator ratios range from 0.5875 (low end) and 0.65 (high end) to be consistent with ratios between the bacteria standards. This ratio range accounts for variability in bacteria datasets and ensures confidence in meeting standards. A 1:1 ratio is considered optimal though unreliable for standards protection and TMDL development due to variability in bacteria datasets.

Table 3. Bacteria translation results from South Dakota's statewide equation

South Dakota Statewide Translator		
Fecal coliform X	**Predicted E. coli Y**	**EC/FC Ratio**
200	208	1.04
400	417	1.04
1,000	1043	1.04
2,000	2087	1.04

Ohio, Virginia and Oregon have developed comprehensive translator methods and equations for use in bacteria TMDL development (Limno Tech, 2011). These states' translator equations were used to predict *E. coli* concentrations and examine EC/FC ratios against South Dakota's former immersion and limited contact Fecal coliform standards. The translator equations yielded ratios that range from 0.47 to 0.84 (Tables 4). Predicted *E. coli* concentrations result in clear protection of the standards at ratios under 0.6 in all cases. Oregon's translator would result in *E. coli* concentrations that exceed standards for all criteria.

Table 4. EC/FC ratios applied to SD bacteria standards using Ohio, Virginia and Oregon bacteria translator equations.

Ohio Bacteria Translator (Statewide excluding NE region)		
Fecal coliform X	**Predicted *E. coli* Y**	**EC/FC Ratio**
200	93	0.47
400	191	0.48
1,000	489	0.49
2,000	997	0.50
Virginia Statewide Bacteria Translator		
Fecal coliform X	**Predicted *E. coli* Y**	**EC/FC Ratio**
200	129	0.64
400	243	0.61
1,000	564	0.56
2,000	1,068	0.53
Oregon Statewide Bacteria Translator		
Fecal coliform X	**Predicted *E. coli* Y**	**EC/FC Ratio**
200	146	0.73
400	304	0.76
1,000	804	0.80
2,000	1,676	0.84

Virginia considered using bacteria standards as the basis for developing a translator equation (Limno Tech, 2011). This approach involves using the ratio between *E. coli* and Fecal coliform standards to predict *E. coli*. For example, the GM for Fecal coliform and *E. coli* is 200 (CFU/100mL) and 126 (CFU/100mL), respectively. The resultant EC/FC ratio is calculated at 0.63. The following equation would be used to predict *E. coli* concentrations using the Fecal coliform GM standard for immersion recreation.

[*E. coli* (Y) = EC/FC ratio* FC (X)] (FC (X)=200; *E. coli* (Y)=126)

As expected, *E. coli* equates to 126 (CFU/100mL) consistent with the GM standard for immersion recreation. Virginia decided to use actual paired bacteria data to develop the translator versus the standards ratio approach.

South Dakota's statewide bacteria relationship is robust with regards to the total number of paired observations and high correlation. The near 1:1 ratio is impressive considering paired samples were collected over a large temporal and spatial scale from many diverse systems. The statewide translator equation would result in *E. coli* TMDLs and load allocations that are slightly over the TMDL targets. It is possible to improve the equation to achieve desired ratios by screening the data and exploring different regression analysis techniques (Limno Tech, 2011). This was not considered due to limitations with obtaining conditional information and potential risk of making biased decisions from such a large dataset that encompasses a wide range of environmental controls. A decision was made to use the standards ratio approach to convert Fecal coliform TMDLs to *E. coli*. This approach ensures that *E. coli*

TMDLs and load allocations are protective of the standards despite variability in bacteria data. The process is documented in the TMDL and Load Allocation section.

NONPOINT SOURCES

The level of information provided in the nonpoint source assessments varies among the different Fecal Coliform TMDL documents. In general, the predominate land use in the watersheds of the impaired stream segments residing in eastern South Dakota was documented as cropland and pasture. Lower Rapid Creek _04 is the only segment located in western South Dakota. This segment begins at the edge of Rapid City though a fair portion of the watershed is rangeland. The largest source of bacteria production documented in the impaired watersheds was from livestock (beef, dairy, and hogs) on grass and in feedlots. Bacteria source estimates are based on literature values for Fecal coliform, which are considered synonymous with *E. coli* based on the statewide bacteria relationship. Land use and bacteria production characteristics in the impaired watersheds are expected to be vastly similar to that documented during the respective Fecal Coliform TMDL assessments.

POINT SOURCES

There are several documented point source discharges within the watersheds of three out of the four impaired stream segments. This includes five permitted National Pollutant Discharge Elimination Systems (NPDES) that may directly contribute *E. coli* bacteria. These potential sources of *E. coli* bacteria are documented here to provide a watershed scale account of the systems operational characteristics (discharge permits etc.), potential impact and Waste Load Allocation consideration.

SD-BS-R-BEAVER_02

The city of Valley Springs Wastewater Treatment Facility consists of a 3 cell pond system and is authorized (NPDES permit SD0020923) to periodically discharge directly to the impaired segment of Beaver Creek. Discharge from the facility must comply with effluent limits established for various pollutants. *E. coli* concentrations must not exceed the SSM and GM *E. coli* criteria for limited contact recreation waters which is consistent with the TMDL target. The *E. coli* TMDL would not add new requirements or implementation expectations to the permit. The permit also demonstrates that *E. coli* limits meet Fecal coliform TMDL goals.

The Fecal coliform TMDL included a Waste Load Allocation (WLA) for the City of Valley Springs. A Waste Load Allocation of $4.01X10^{10}$ CFU/day was assigned to the Fecal coliform TMDL. The WLA was based on the average design flow (0.82) multiplied by the SSM Fecal coliform standard (2,000 CFU/100mL) for limited contact waters, times a unit conversion factor (24465715). The *E. coli* WLA was derived from the same calculation substituting the SSM *E. coli* standard (1,178 CFU/100mL), resulting in a WLA of $2.36EX10^{10}$. This facility has only discharged once for a brief period since 2000. The actual *E. coli* waste load to Beaver Creek_02 is considered negligible and as long as future discharges from this facility do not exceed permit effluent limits for *E. coli*, impact to the TMDL is considered minimal.

SD-CH-R-RAPID_04

The Rapid City Water Reclamation Facility is a mechanical system and is authorized to discharge (NPDES permit SD0023574) to Rapid Creek Segment 04. Continuous discharge from the facility must comply with effluent limits established for various pollutants. *E. coli* concentrations must not exceed the SSM and GM *E. coli* criteria for immersion recreation waters which is consistent with the most stringent TMDL target. The *E. coli* TMDL would not add new requirements or implementation expectations to the permit. The permit also demonstrates that *E. coli* limits meet Fecal coliform TMDL goals.

The Fecal coliform TMDL included WLAs for the Rapid City Water Reclamation facility. The WLAs were based on the average design flow (23.2 cfs) multiplied by the SSM and GM standards (400 CFU/100mL and 200 CFU/100mL) for immersion recreation waters, times a unit conversion factor (24465715). The *E. coli* WLA was derived from the same calculation substituting the SSM (235 CFU/100mL) and GM (126 CFU/100mL) *E. coli* standards resulting in a WLA of $1.30EX10^{11}$ and $7.18EX10^{11}$, respectively.

Rapid City Regional Airport Wastewater Facility is permitted (NPDES permit SD0028638) to discharge wastewater in the event of an emergency, otherwise it is a no discharge system in accordance with provisions of the permit. Emergency wastewater discharges are conveyed to an unnamed tributary approximately 2.1 miles upstream of the impaired segment (04) of Rapid Creek. The permit contains *E. coli* monitoring provisions for emergency discharges. As long as this system complies with the requirements of the "no discharge" permit ensuring discharges are unlikely and indirect loading events, the TMDL assumes *E. coli* contribution is minimal. A WLA for this facility was not provided in the TMDL.

Rapid Valley Sanitary District is a rural drinking water system covered under a minor water treatment and distribution general permit (permit SDG86007). This system was not identified as a source of E. coli bacteria for the impaired segment of Rapid Creek. A Waste Load Allocation (WLA) was not provided for this system in the TMDL.

SD-BS-R-BRULE_01

L.G. Everist. Inc.-NWIA is permitted (NPDES permit SD0027928) to discharge outfall from the Spink Gravel Pit (Outfall 001) to the impaired segment of Brule Creek only under emergency conditions. Discharges from this operation have been infrequent (13 days out of 193) according to recent monitoring reports. TMDL considerations from the permit suggest this operation is not expected to be a contributor of *E. coli.* As a result, a WLA was not provided for this operation in the TMDL. The WLA for SD-BS-R-BRULE_01 is considered zero.

There were no Concentrated Animal Feeding Operations (CAFOs) identified in the Fecal Coliform TMDL documents of the four impaired segments. A recent search found that two CAFOs have since been established in the East Fork Vermillion River_01 watershed (Table 5). Both facilities have permit coverage under South Dakota's 2017 general permit. For more information about South Dakota's CAFO requirements and general permits visit: http://denr.sd.gov/des/fp/cafo.aspx. As long as these facilities comply with the general CAFO permit requirements ensuring their discharges are unlikely and indirect loading events, the TMDL assumes their *E. coli* contribution is minimal. As a result, the Waste Load Allocation (WLA) for this segment remains zero. There are no CAFOs in the other impaired watersheds at this time.

Table 5. CAFOs identified in the East Fork Vermillion River Segment 01 watershed.

Name of Facility	Type of Operations	SD General Permit #
Christopher Katzer Swine Facility	swine (housed lot)	SDG-100150
Orland Hutterian Brethren, Inc.	multiple animals (housed lots)	SDG-109100

TMDL AND ALLOCATIONS

A load duration curve framework was used to develop the existing Fecal coliform TMDLs for the impaired stream segments. A standards ratio approach was used to convert existing Fecal coliform TMDLs to *E. coli* TMDLs for each flow zone. *E. coli* TMDLs were calculated by multiplying the existing Fecal coliform TMDLs by the ratio (EC:FC) between the applicable bacteria standards (Table 6). The *E. coli* TMDL allocations (TMDL=WLA+LA=MOS) were based on the same percent contribution as established for the Fecal coliform TMDL allocations in each flow zone.

The Fecal coliform current load in each flow zone was used to calculate the percent reduction required to meet the *E. coli* TMDLs. The *E. coli* percent reduction was calculated as the current Fecal coliform load minus the *E. coli* TMDL divided by the current Fecal coliform load. Using the current Fecal coliform load to determine the required *E. coli* load reductions is considered conservative.

Table 6. Bacteria standards and ratio for immersion and limited contact recreation uses.

Fecal coliform standards	E. coli standards	EC/FC ratio
200	126	0.63
400	235	0.5875
1,000	630	0.63
2,000	1,178	0.589

The *E. coli* TMDLs are protective of applicable standards assigned to designated recreation uses of the impaired stream segments. The existing Fecal coliform TMDL documents contain supporting information for implementing the *E. coli* TMDLs in accordance with 303(d) requirements. The original Fecal coliform and converted *E. coli* TMDLs, allocations and reductions are provided by stream segment in Tables 7 through 16.

SD-VM-R-VERMILLION_E_FORK_01

Table 7. Existing Fecal coliform TMDL and allocations for the East Fork Vermillion River-Segment 01 based on GM standard (1000 CFU/100 mL) for limited contact recreation.

Flow Zone	Fecal TMDL (CFU/day)	WLA (CFU/day)	LA (CFU/day)	MOS (CFU/day)	% Reduction
High	5.55E+13	0.00E+00	5.00E+13	5.55E+12	0.0%
Moist	5.23E+12	0.00E+00	4.71E+12	5.23E+11	0.0%
Mid-Range	8.75E+11	0.00E+00	7.88E+11	8.75E+10	93.8%
Dry	3.03E+11	0.00E+00	2.73E+11	3.03E+10	98.7%
Low	6.71E+10	0.00E+00	6.04E+10	6.71E+09	67.43%

Table 8. E. coli TMDL and Load allocations for the East Fork Vermillion River-Segment 01 based on GM standard (630 CFU/100 mL) for limited contact recreation.

Flow Zone	E. coli TMDL (CFU/day)	WLA (CFU/day)	LA (CFU/Day)	MOS (CFU/day)	% Reduction
High	3.50E+13	0.00E+00	3.15E+13	3.50E+12	0.0%
Moist	3.29E+12	0.00E+00	2.97E+12	3.29E+11	0.0%
Mid-Range	5.51E+11	0.00E+00	4.96E+11	5.51E+10	96.1%
Dry	1.91E+11	0.00E+00	1.72E+11	1.91E+10	99.2%
Low	4.23E+10	0.00E+00	3.80E+10	4.23E+09	79.5%

SD-BS-R-BRULE_01

Table 9. Existing Fecal coliform TMDL and Load allocations for Brule Creek-Segment 01 based on GM standard (1000 CFU/100 mL) for limited contact recreation.

Flow Zone	Fecal TMDL (CFU/day)	WLA (CFU/day)	LA (CFU/Day)	MOS (CFU/day)	% Reduction
High	3.10E+16	0.00E+00	3.10E+16	2.80E+12	99.9%
Moist	3.10E+14	0.00E+00	3.10E+14	5.40E+11	98%
Mid-Range	2.20E+13	0.00E+00	2.20E+13	1.70E+11	99%
Dry	4.80E+12	0.00E+00	4.70E+12	1.30E+11	7.6%
Low	3.90E+11	0.00E+00	3.40E+11	5.10E+10	79%

Table 10. E. coli TMDL and Load allocations for Brule Creek-Segment 01 based on GM standard (630 CFU/100 mL) for limited contact recreation.

Flow Zone	E. coli TMDL (CFU/day)	WLA (CFU/day)	LA (CFU/Day)	MOS (CFU/day)	% Reduction
High	1.95E+16	0.00E+00	1.95E+16	1.76E+12	99.9%
Moist	1.95E+14	0.00E+00	1.95E+14	3.40E+11	98.7%
Mid-Range	1.39E+13	0.00E+00	1.38E+13	1.07E+11	0.0%
Dry	3.02E+12	0.00E+00	2.94E+12	8.19E+10	0.0%
Low	2.46E+11	0.00E+00	2.14E+11	3.21E+10	0.0%

SD-BS-R-BEAVER_02

Table 11. Existing Fecal coliform TMDL and Load allocations for Beaver Creek-Segment 01 based on SSM standard (2000 CFU/100 mL) for limited contact recreation.

Flow Zone	Fecal TMDL (CFU/day)	WLA (CFU/day)	LA (CFU/Day)	MOS (CFU/day)	% Reduction
High/Moist	5.65E+12	4.01E+10	5.04E+12	5.65E+11	84.7%
Mid-Range	1.24E+12	4.01E+10	1.08E+12	1.24E+11	0.0%
Dry/Low	2.96E+11	4.01E+10	2.26E+11	2.96E+10	0.0%

Table 12. E. coli TMDL and Load allocations for Beaver Creek-Segment 01 based on SSM standard (1,178 CFU/100 mL) for limited contact recreation.

Flow Zone	E. coli TMDL (CFU/day)	WLA (CFU/day)	LA (CFU/Day)	MOS (CFU/day)	% Reduction
High/Moist	3.33E+12	2.36E+10	2.97E+12	3.33E+11	91%
Mid-Range	7.29E+11	2.36E+10	6.33E+11	7.29E+10	0.0%
Dry/Low	1.74E+11	2.36E+10	1.33E+11	1.74E+10	0.0%

SD-CH-R-RAPID_04

Table 13. Existing Fecal coliform TMDL and Load allocations for Rapid Creek-Segment 04 based on SSM standard (400 CFU/100 mL) for immersion recreation.

Flow Zone	Fecal TMDL (CFU/day)	WLA (CFU/day)	LA (CFU/Day)	MOS (CFU/day)	% Reduction
High	6.47E+12	2.27E+11	4.24E+12	2.00E+12	94.7%
Moist	2.15E+12	2.27E+11	1.23E+12	6.95E+11	84.4%
Mid-Range	7.99E+11	2.27E+11	4.45E+11	1.27E+11	0.0%
Dry	5.38E+11	2.27E+11	1.84E+11	1.27E+11	0.0%
Low	3.13E+11	2.27E+11	4.70E+10	3.90E+10	0.0%

Table 14. E. coli TMDL and Load allocations for Rapid Creek-Segment 04 based on SSM standard (235 CFU/100 mL) for immersion recreation.

Flow Zone	E. coli TMDL (CFU/day)	WLA (CFU/day)	LA (CFU/Day)	MOS (CFU/day)	% Reduction
High	3.80E+12	1.33E+11	2.49E+12	1.17E+12	96.9%
Moist	1.27E+12	1.33E+11	7.24E+11	4.08E+11	90.8%
Mid-Range	4.69E+11	1.33E+11	2.61E+11	7.46E+10	37.2%
Dry	3.16E+11	1.33E+11	1.08E+11	7.46E+10	29.1%
Low	1.84E+11	1.33E+11	2.76E+10	2.29E+10	0.0%

Table 15. Existing Fecal coliform TMDL and Load allocations for Rapid Creek-Segment 04 based on GM standard (200 CFU/100 mL) for immersion recreation.

Flow Zone	Fecal TMDL (CFU/day)	WLA (CFU/day)	LA (CFU/Day)	MOS (CFU/day)	% Reduction
High	3.23E+12	1.14E+11	2.12E+12	9.98E+11	55.9%
Moist	1.08E+12	1.14E+11	6.16E+11	3.47E+11	0.0%
Mid-Range	3.99E+11	1.14E+11	2.21E+11	6.40E+10	0.0%
Dry	2.69E+11	1.14E+11	9.10E+10	6.40E+10	0.0%
Low	1.57E+11	1.14E+11	2.30E+10	2.00E+10	0.0%

Table 16. E. coli TMDL and Load allocations for Rapid Creek-Segment 04 based on GM standard (126 CFU/100 mL) for immersion recreation.

Flow Zone	E. coli TMDL (CFU/day)	WLA (CFU/day)	LA (CFU/Day)	MOS (CFU/day)	% Reduction
High	2.04E+12	7.18E+10	1.34E+12	6.29E+11	72.2%
Moist	6.79E+11	7.18E+10	3.88E+11	2.19E+11	27.4%
Mid-Range	2.52E+11	7.18E+10	1.40E+11	4.03E+10	0.0%
Dry	1.69E+11	7.18E+10	5.73E+10	4.03E+10	0.0%
Low	9.86E+10	7.18E+10	1.42E+10	1.26E+10	23%

SUMMARY AND FUTURE CONSIDERATIONS

This document provides a framework to convert Fecal coliform TMDLs and allocations to *E. coli* to address impaired streams designated recreation uses in South Dakota. A statewide translator equation was developed from over 10,000 paired bacteria samples. The resulting equation indicates a clear similarity in both bacteria with a near 1:1 ratio. The statewide equation was not considered a viable translator option as ratios should range between 0.5875 to 0.63 to be consistent with the ratio between standards to account for variability in bacteria data. A standards ratio approach was used to convert existing Fecal coliform TMDLs to *E. coli* within each of the established flow zones. This approach accounts for variability in bacteria data and provides assurance that *E. coli* TMDLs are protective of applicable standards.

This TMDL conversion process only applies to impaired waters where conditions present during Fecal coliform TMDL development have remained static. The process should not be followed in instances where significant changes have occurred in the watershed (source assessments) or new NPDES permits have been issued requiring a WLA. The translation process and resulting *E. coli* TMDLs and allocations were subject to public comment prior to submittal to EPA for review and approval consideration in accordance with 303(d) requirements. Once approved, the standards ratio approach will be used, when relevant, to convert Fecal coliform TMDLs to *E. coli* following an addendum process.

**Statewide equation on page 4 was corrected via an errata on June 6, 2022.

PUBLIC COMMENT

A public notice letter was published in several local newspapers within the watersheds of the four impaired stream segments to announce the availability of this bacteria TMDL conversion document for review and comment. The document and comment process was made available on the South Dakota Department of Environment and Natural Resources One Stop Public Notice webpage at: https://denr.sd.gov/public/default.aspx. The public comment period began September 4, 2020 and ended on October 8, 2020. No public comments were received during this period.

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Appendix A: E. coli Numeric TMDL Target Selection Rationale

TMDLs are required to identify a numeric target to measure whether or not the applicable water quality standard is attained. A maximum allowable load, or TMDL, is ultimately calculated by multiplying this target with a flow value and a unit conversion factor. Generally, the pollutant causing the impairment and the parameter expressed as a numeric water quality criterion are the same. In these cases, selecting a TMDL target is as simple as applying the numeric criteria. Occasionally, an impairment is caused by narrative water quality criteria violations or by parameters that cannot be easily expressed as a load. When this occurs, the narrative criteria must be translated into a numeric TMDL target (e.g., nuisance aquatic life translated into a total phosphorus target) or a surrogate target established (e.g., a pH cause addressed through a total nitrogen target) and a demonstration should show how the chosen target is protective of water quality standards.

As seen from Table 2 there are two numeric *E. coli* criteria for TMDL target consideration. When multiple numeric criteria exist for a single parameter, the most stringent criterion is selected as the TMDL target. To judge whether one is more protective of the beneficial use, it is necessary to further elaborate how the criteria were derived.

South Dakota's *E. coli* criteria are based on EPA recommendations originally published in 1986 (USEPA, 1986). EPA issued slightly modified recommendations in 2012 that did not substantially change the underlying analysis or criteria values in South Dakota (USEPA, 2012). As recommended, SDDENR adopted *E. coli* criteria that contain two components: a geometric mean (GM) and a single sample maximum (SSM). The GM was established from epidemiological studies by comparing average summer exposure to an illness rate of 8:1,000. The SSM component was computed using the GM value and the corresponding variance observed in the epidemiological study dataset (i.e., log-standard deviation of 0.4). EPA provided four different SSM values corresponding to the 75^{th}, 82^{nd}, 90^{th}, and 95^{th} percentiles of the expected water quality sampling distribution around the GM to account for different recreational use intensities (Figure 2). South Dakota adopted the most stringent recommendation, the 75^{th} percentile, into state water quality standard regulations as the SSM protective of designated beaches.

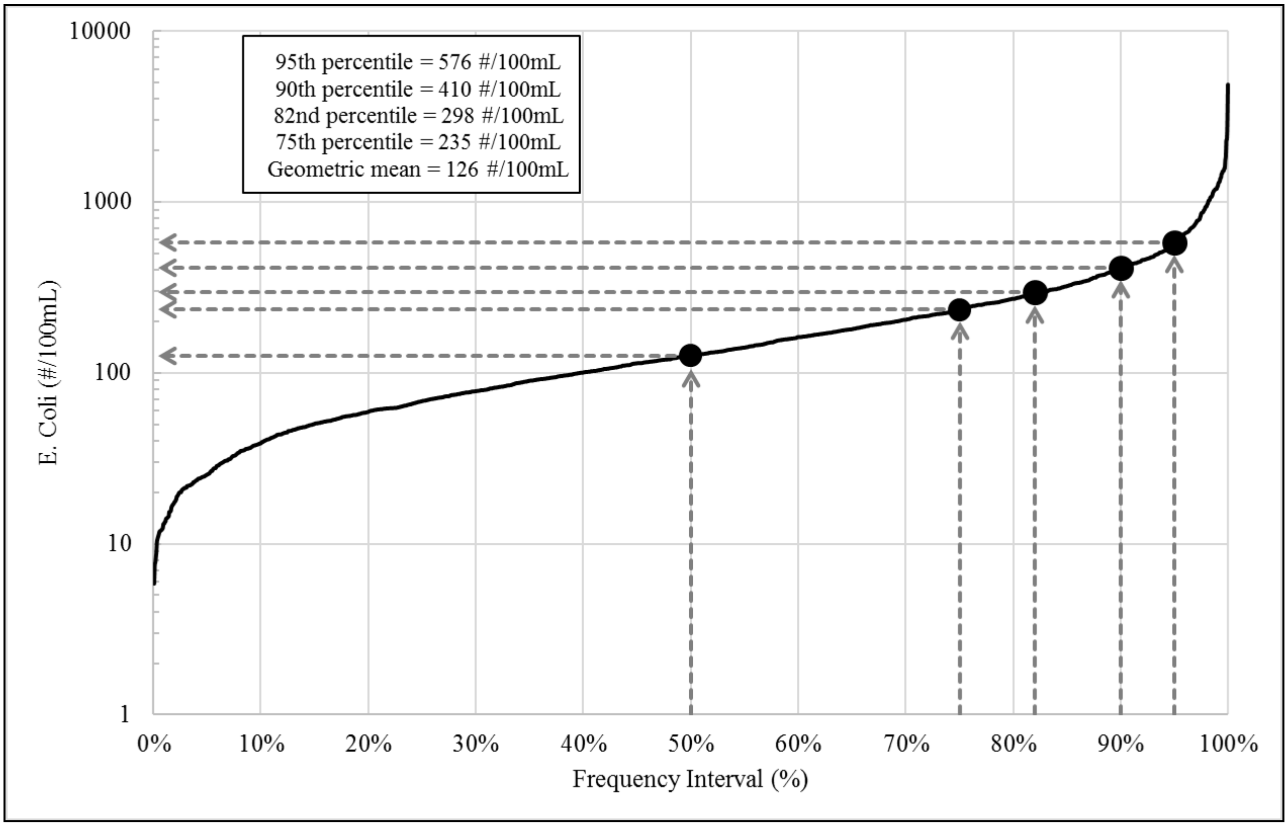

Figure 2. Log-Normal Frequency Distribution Used to Establish South Dakota's Immersion Recreation *E. coli* Criteria of 126 (GM) and 235 (SSM) #/100mL (EPA, 1986).

Dual criteria were established to balance the inherent variability of bacteria data and provide flexibility for handling different sampling routines. Together, the GM and SSM describe a water quality distribution expected to be protective of immersion contact recreation. The GM and SSM are equally protective of the beneficial use because they are based on the same illness rate and differ simply representing different statistical values and sampling timeframes. While this investigation has revealed the GM and SSM *E. coli* criteria to be equally protective of the immersion recreation use, a likewise conclusion can be made for the GM and SSM criteria associated with the limited contact recreation use since those values were simply derived as five times the immersion values.

As described in EPA's *Protocol for Developing Pathogen TMDLs*, the availability of data may dictate which criterion should be used as the TMDL target (EPA, 2001). When a geometric mean of the sampling dataset can be calculated as defined by South Dakota Administrative Rules (i.e., at least five samples separated by a minimum of 24-hours over a 30-day period) and compared to the GM criterion, SDDENR uses the GM criterion as the TMDL target. This establishes a smaller overall loading capacity and is considered a conservative approach to setting the TMDL.

When a proper GM cannot be calculated SDDENR uses the SSM as the TMDL target. This is permissible because the SSM is equally protective of the beneficial use as discussed above. Although this target selection leads to the establishment of a larger allowable load, in some respects it is more appropriate because timeframes align better (i.e., the SSM is associated with a single day and TMDLs establish daily loads, versus the 30-day GM). Additionally, certain aspects of

SDDENR's *E. coli* assessment method, when combined with a SSM TMDL target, result in an expected dataset GM more protective than the GM criterion. SDDENR uses assessment methods to define how to interpret and apply water quality standards to 303(d) impairment decisions. These methods are further discussed in Section 3.4, however for this discussion, it is important to note that SDDENR allows a 10% exceedance frequency of both the SSM and GM. In other words, as long as the *E. coli* dataset meets other age and size requirements, a waterbody is considered impaired (i.e., not meeting water quality standards) when greater than 10% of samples exceed either the SSM or GM. Water quality standards are met if the exceedance frequency is 10% or less.

Returning to the original distribution used to establish South Dakota's Immersion Recreation *E. coli* criteria in Figure 2 remember that SDDENR chose to adopt a SSM concentration based on the most stringent recommendation (75th percentile). According to assessment methods in South Dakota, however, the SSM concentration is treated as a 90th percentile (i.e., 10% exceedance frequency). Step #1 in Figure 3 shows how doing so effectively moves the SSM point to the right. If the original log-normal frequency distribution with a log-standard deviation of 0.4 is subsequently re-fitted to this new 90th percentile point at 235 #/100mL (red dotted line), the corresponding 50th percentile (GM) is 72 #/100mL as shown in Step #2 of Figure 3.

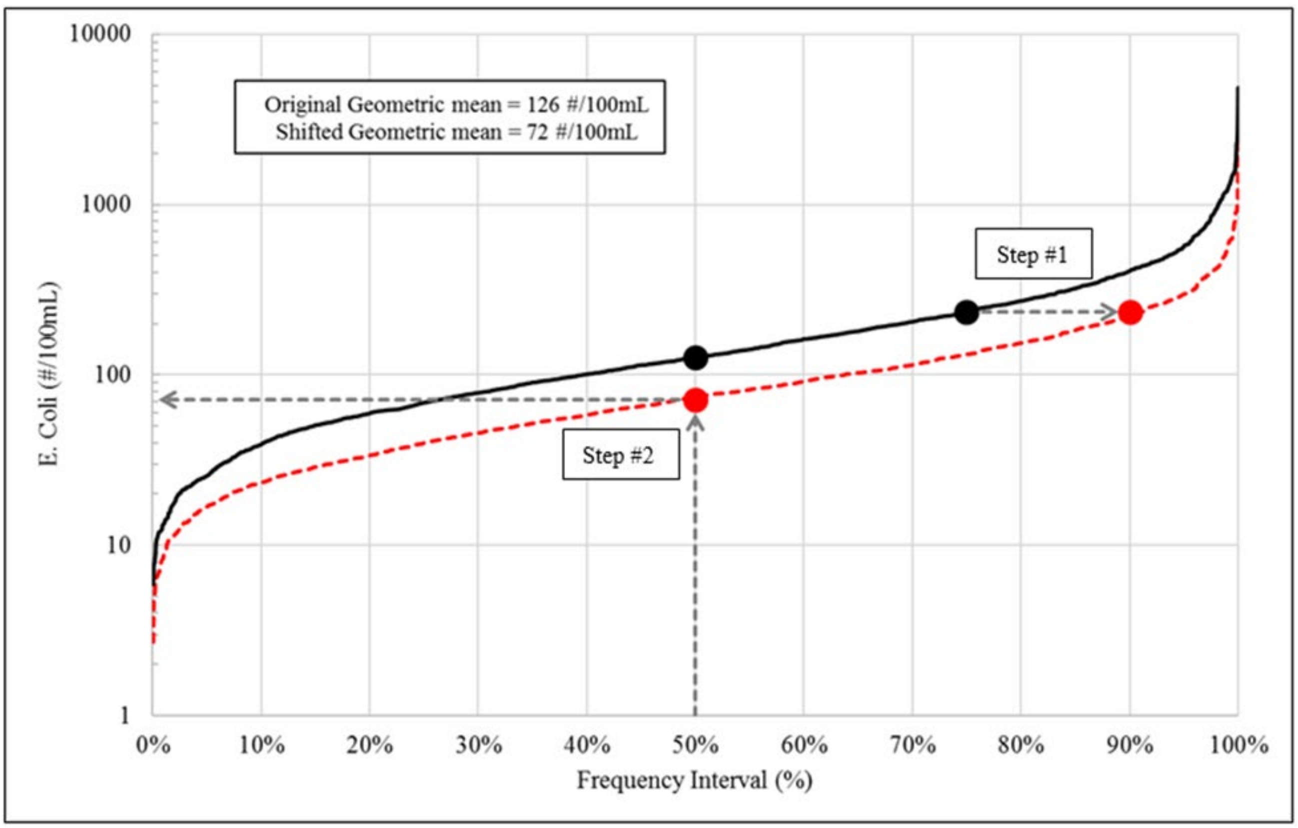

Figure 3. **The Effective Impact of South Dakota's *E. coli* Assessment Method on the Criteria's Original Log-Normal Frequency Distribution (Black line = original; red dotted line = shifted)**

The GM associated with this shifted distribution is more stringent than the GM of the original distribution (126 #/100mL), thus this demonstrates that attaining a maximum daily SSM target in a TMDL will also achieve the 30-day GM criterion when following South Dakota's assessment method. A similar conclusion was determined by EPA in *An Approach for Using Load Duration Curves in the Development of TMDLs* (USEPA, 2007) using Michigan criteria as an example. Once again, this outcome holds true for South Dakota's limited contact recreation *E. coli* criteria since they were simply derived as five times the immersion values.

Finally, while the SSM is associated with a single day of sampling and the GM is associated with 30 days of sampling, it is not technically appropriate to refer to them as "acute" and "chronic" criteria. Those terms distinguish timeframes over which harm-to-use impacts develop, not the sampling or averaging timeframe as with the SSM and GM. Acute refers to an effect that comes about rapidly over short periods of time. Chronic refers to an effect that can build up over longer periods, sometimes as long as the lifetime of a subject. In the case of *E. coli*, gastrointestinal illness develops within a matter of hours to days. Both the SSM and GM are derived from this same timeframe and based on the same underlying illness rate, thus treating the SSM as an acute criterion and assuming it to be less stringent is incorrect. EPA recommends states use the GM and SSM together, rather than just the GM or just the SSM, to judge whether water quality is protective of recreational uses. SDDENR follows these guidelines and only relies on one criterion when forced by data availability.

Appendix B

EPA Approval Letter and Decision Document