UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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Decision Rationale for the

Total Maximum Daily Load for the Primary Contact Use (Bacteriological) Impairment on Beaverdam Creek, Bedford County, Virginia

Signed

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I. Introduction

The Clean Water Act (CWA) requires a Total Maximum Daily Load (TMDL) be developed for those water bodies identified as impaired by a 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), that may be discharged to a water quality-limited water body.

This document will set forth the U. S. Environmental Protection Agency's (EPA) rationale for approving the TMDL for the primary contact use (bacteriological) impairment on the Beaverdam Creek Watershed. EPA's rationale is based on the determination that the TMDL meets the following eight regulatory conditions pursuant to 40 CFR §130.

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

II. Background

The Beaverdam Creek Watershed is located in Bedford County, Virginia. The watershed is 17,400-acres in size. The impaired segment for Beaverdam Creek is 5.58 miles in length. Forested lands account for 67 percent of the watershed area, while agricultural lands compose another 30 percent of the total land-use in the watershed. Residential lands and open water make up the remaining lands within the watershed.

In response to Section 303(d) of the CWA, the Virginia Department of Environmental Quality (VADEQ) listed Beaverdam Creek on Virginia's Section 303(d) lists as being unable to attain its primary contact use due to violations of the bacteriological criteria.

Table 1 - Impaired Stream Segment

Stream	Segment	List	Description
Beaverdam Creek	VAW-L07R	1998	Begins 0.5 miles above Route 24 on Beaverdam Creek and terminates at the impoundment on Beaverdam Creek. (5.58 miles)

Beaverdam Creek was listed for violations of Virginia's fecal coliform water quality criteria. Fecal coliform is a bacterium which can be found within the intestinal tract of all warm blooded animals. Fecal coliform in itself is not a pathogenic organism. However, fecal coliform indicates the presence of fecal wastes and the potential for the existence of other pathogenic bacteria. The higher concentrations of fecal coliform indicate the elevated likelihood of increased pathogenic organisms.

EPA encouraged the states to use e-coli and enterococci as the indicator species instead of fecal coliform. A better correlation was drawn between the concentrations of e-coli and enterococci, and the incidence of gastrointestinal illness. The Commonwealth adopted e-coli and enterococci criteria in January 2003. Streams are evaluated against the e-coli and enterococci criteria after 12 samples have been collected using these indicator species. Since 12 e-coli samples have been collected from Beaverdam Creek, compliance is based upon the e-coli criteria.

As Virginia designates all of its waters for primary contact, all waters must meet the current bacteriological criteria for primary contact. Virginia's criteria apply to all streams designated for primary contact for all flows. The e-coli criteria requires a geometric mean concentration of 126 colony forming units (cfu)/100ml of water with no sample exceeding 235 cfu/100ml of water. Although, the TMDL and criteria require the e-coli concentration not to exceed 235 cfu/100ml of water, waters are not placed on the Section 303(d) list if their violation rate does not exceed 10 percent.

The TMDL submitted by Virginia is designed to determine the acceptable load of e-coli which can be delivered to the impaired water, as demonstrated by the load-duration approach. The load-duration approach is considered an appropriate method to analyze the impaired waters through its analysis and comparison of observed flows, in-stream bacteria concentrations, and the numeric water quality criteria.

The load-duration approach analyzes the stream's entire flow record to find a correlation between flow regimes and bacteriological concentrations. Since there was no flow gage on Beaverdam Creek, a simulated flow record was developed. The TMDL modelers located flow gages on several similar near by waters including Kerrs Creek, Battle Run and Catawba Creek. Eighteen flow measurements were collected from Beaverdam Creek to run a correlation analysis between the flows on Beaverdam Creek and the gaged streams.

The flow data from the impaired segments were entered into Excel spreadsheets along

with daily mean flow data from nearby, long term, continuous record gaging stations.[1] Using the Excel data analysis tools, the impaired watershed's flows were correlated to the observed data from the United States Geological Survey (USGS) gages. The gage on Kerrs Creek was selected and used to predict the flow patterns for Beaverdam Creek, since its data produced the highest correlation with the impaired water. The flow data from the impaired water were plotted against the daily mean flow data from the USGS gage. Excel plotted a best fit line through the data and developed a regression equation for the impaired water. Once the regression equation was developed, a simulated flow could be ascertained for the impaired water based on the observed flows on Kerrs Creek.

Through the use of the regression equation a flow record could be formed for the impaired water. A flow record is essential to the load duration approach, as the flow determines the allowable loading (load that will allow the stream to attain criteria) and the observed loading. For each flow along the load-duration curve the allowable load can be determined by multiplying the numeric criteria (235 cfu/100ml) by the flow. The observed loads were determined by multiplying the observed concentrations by the simulated flow for that time. In order to insure that the TMDL was protective of all flow conditions, it was developed to the instance when the difference between the observed and allowable loadings was greatest. This process describes the first step in the development of the TMDL. The load duration approach was not developed for the geometric mean criteria as it is not a dynamic model that can predict the flow and load conditions associated with multiple monitoring events. However, the reductions were based on the largest exceedance of the instantaneous criteria and are to be applied to all flows. The reductions required to bring the largest violation into compliance are being applied to flows that are already in compliance and those which are not as severely impaired as well. There is uncertainty in this model, but it is hoped that by modeling to the greatest observed violation the TMDL will attain all criteria.

The next step of the TMDL was to determine what organisms or sources are responsible for the pollutant loading to the stream. Since e-coli, like fecal coliform, is associated with warm blooded animals as mentioned above, it was necessary to determine which animals were providing the bacteria loadings to the impaired water. Through a process known as bacterial source tracking (BST), VADEQ was able to break down the source of bacteria into four categories. The four categories were human, pets, livestock, and wildlife. Three of these four sources are anthropogenic in origin and can be controlled via a variety of techniques. Wildlife, which may be attracted to certain areas due to anthropogenic modifications to the watershed, is considered a natural source of bacteria.

The BST approach used by VADEQ is known as the Antibiotic Resistance Approach

[1]VADEQ, March 2004, "Bacteria TMDLs for Sepulcher Creek, Toms Creek, Little Toms Creek and Crab Orchard Branch

(ARA). ARA measures the bacteria's resistance to a suite of antibiotics. The assumption is that bacteria associated with humans will have the highest resistance to antibiotics due to previous exposures to antibiotics. Livestock and pets would have the next highest resistance, while wildlife would exhibit the least resistance. In order to conduct this work, waste samples from known sources had to have their resistance measured. This data was placed into a library. The resistance of the bacteria collected in water samples was compared to the data in the library to determine its source. For additional information on the ARA please refer to Appendix B of the TMDL.

The data collected in steps one and two were then combined to determine the impact of the sources to water quality in the impaired waters. VADEQ collected one year of BST samples from the impaired waters, for each sample VADEQ determined the bacterial concentration and the percent loading derived from each source. The percent loading for each source category was averaged over the annual period and this average percent loading was used to determine the loading for each source.

In the Beaverdam Creek TMDL, the highest bacteria violation occurred during a flow of approximately 10 cubic feet per second (cfs). This is not a very high flow in the watershed and based on the available data is exceeded half of the time. The e-coli load for this flow event was 3.56E+14 cfu/year. The allowable load at this same flow was 2.19E+13 cfu/year. This represents a 94 percent reduction in loadings. Next the average annual flow was determined for Beaverdam Creek and the same magnitude violation was applied to that flow. Under these conditions, the existing annual bacteria load was 7.24E+14 cfu/year. A 94 percent load reduction, percent reduction based on largest violation, was then applied to this e-coli load to yield an annual allowable load of 4.46+13 cfu/year. The BST data demonstrated that livestock, pets, humans and wildlife represented 27, 21, 15 and 37 percent of the load respectively. Therefore, it was determined that all sources must be reduced.

Through the development of this and other similar TMDLs, it was discovered that natural conditions (wildlife contributions to the streams) could cause or contribute to violations of the bacteria criteria. BST sampling data collected on the impaired stream indicated that bacteria from wildlife represent approximately 37 percent of the load. Many of Virginia's TMDLs, including the TMDL for Beaverdam Creek, have called for some reduction in the amount of wildlife contributions to the affected streams. EPA believes that a reduction in wildlife is not practical and will not be necessary due to the implementation plan discussed below.

A phased implementation plan will be developed for all streams in which the TMDL calls for reductions in wildlife. In Phase 1 of the implementation, the Commonwealth will begin implementing the reductions (other than wildlife) called for in the TMDL. In Phase 2, which can occur concurrently to Phase 1, the Commonwealth will consider addressing its standards to accommodate this natural loading condition. The Commonwealth has indicated that during Phase 2, it may develop a Use Attainability Analysis (UAA) for streams with wildlife reductions which are not used for frequent bathing. Depending upon the result of the UAA, it is possible that these streams could be designated for secondary contact.

After the completion of Phase 1 of the implementation plan, the Commonwealth will monitor the streams to determine if the wildlife reductions are actually necessary, as the violation level associated with the wildlife loading may be smaller than the percent error of the model. In Phase 3, the Commonwealth will investigate the sampling data to determine if further load reductions are needed in order for these waters to attain standards. If the load reductions and/or the new application of standards allow the stream to attain standards, then no additional work is warranted. However, if standards are still not being attained after the implementation of Phases 1 and 2, further work and reductions will be warranted. Table 1 documents the TMDL equation for each of the impaired segment.

Table 1 - Summarizes the Specific Elements of the TMDL.

Segment	Parameter	TMDL (cfu/yr)	WLA (cfu/yr)	LA (cfu/yr)	MOS
Beaverdam Creek	E-coli	4.46E+13	1.39E+10	4.46E+14	Implicit

The United States Fish and Wildlife Service have been provided with a copy of the TMDL.

III. Discussion of Regulatory Conditions

EPA finds that Virginia has provided sufficient information to meet all of the eight basic requirements for establishing primary contact (bacteriological) impairment TMDL for Beaverdam Creek. EPA is therefore approving the TMDL. EPA's approval is outlined according to the regulatory requirements listed below.

1) The TMDL is designed to meet the applicable water quality standards.

Virginia has indicated that excessive levels of bacteria from both anthropogenic and natural sources have caused violations of the water quality criteria and designated uses in the Beaverdam Creek Watershed. The new e-coli criteria require a geometric mean of 126 cfu/100ml of water with no sample exceeding 235 cfu/100 ml.

The load-duration approach, described above was used by the Commonwealth for the development of the Beaverdam Creek TMDL. This approach uses the flow data from a USGS gage, in-stream water quality data, a regression equation, and BST data to quantify the bacteria loading and the sources responsible for that loading. The load-duration approach in this instance developed a flow record for the impaired reach based on observed flow data from the Kerrs Creek USGS gage and Beaverdam Creek. For each flow along the load-duration curve the allowable load can be determined by multiplying the numeric criteria by the flow. The observed loads were determined by multiplying the observed concentrations by the simulated flow at that time. In order to insure that the TMDL was protective of all flow conditions, it was developed for the flow that exhibited the greatest difference between the observed and allowable loadings.

Through the use of BST, VADEQ was able to break down the sources of bacteria into four categories. The four categories of bacteria sources were human, pets, livestock, and wildlife. VADEQ collected one year of BST samples from Beaverdam Creek. VADEQ determined the bacterial concentration and the percent loading derived from each source for each sample. The percent loading for each source category was averaged over the year. This average percent loading was used to determine the loading for each source.

2) The TMDL includes a total allowable load as well as individual waste load allocations and load allocations.

Total Allowable Loads

Virginia indicates that the total allowable loading is the sum of the loads allocated to land based precipitation driven nonpoint source areas (forest and agricultural land segments) and point sources. Activities that increase the levels of bacteria to the land surface or their availability to runoff are considered flux sources. The actual values for total loadings can be found in Table 1 of this document. The total allowable loads were calculated on an annual basis.

Waste Load Allocations

There are three point sources discharging to Beaverdam Creek. Two of the facilities are single family units permitted to discharge 1,000 gallons of effluent per day with a bacteria concentration of 126 cfu/100ml. The Stewartsville Elementary School is the other facility in the watershed and is permitted to discharge 6,000 gallons of effluent per day with a total residual chlorine requirement. Chlorine is used to remove e-coli from the effluent. The WLA for these facilities can be determined by multiplying the permitted flow by the permitted bacteria concentration by 365 days after the appropriate unit conversions. Table 2 documents the WLA in the TMDL. The point sources were not required to reduce their WLA because they are discharging at or below the water quality criteria.

EPA regulations require that an approvable TMDL include individual WLAs for each point source. According to 40 CFR 122.44(d)(1)(vii)(B), "Effluent limits developed to protect a narrative water quality criterion, a numeric water quality criterion, or both, are consistent with assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA pursuant to 40 CFR 130.7." Furthermore, EPA has authority to object to the issuance of any National Pollutant Discharge Elimination System (NPDES) permit that is inconsistent with the WLAs established for that point source.

Table 2 - Bacteriological (E-Coli) WLAs for Beaverdam Creek

Stream	Facility Name	Permit Number	Allocated Load (cfu/yr)
Beaverdam Creek	Single Family Residence	VAG402101	1.74E+09
Beaverdam Creek	Single Family Residence	VAG402030	1.74E+09
Beaverdam Creek	Stewartsville Elementary	VA0020842	1.04E+10

Load Allocations

According to Federal regulations at 40 CFR 130.2(g), LAs are best estimates of the loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting loading. Wherever possible, natural and nonpoint source loads should be distinguished. The load-duration approach used BST data to determine the bacteria load from each source. In order to meet a violation rate of around 10 percent, a 70 percent total load reduction is required in Beaverdam Creek. In order for the criteria to not be violated, a 94 percent reduction in total loading is required. Table 3 identifies the LAs for Beaverdam Creek.

Table 3 - LA for Bacteria (E-Coli) for Beaverdam Creek

Source Category	Existing Load (cfu/yr)	Allocated Load (cfu/yr)
Livestock	1.95E+14	1.95E+12
Pets	1.52E+14	1.52E+12
Human	1.09E+14	1.09E+12
Wildlife	2.68E+14	3.88E+13

3) The TMDL considers the impacts of background pollution.

The TMDL considers the impact of background pollutants by considering the bacterial load from natural sources such as wildlife.

4) The TMDL considers critical environmental conditions.

According to EPA's regulation 40 CFR 130.7 (c)(1), TMDLs are required to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of the impaired creek is protected during times when it is most vulnerable.

Critical conditions are important because they describe the factors that combine to cause

a violation of water quality standards and will help in identifying the actions that may have to be undertaken to meet water quality standards[2]. Critical conditions are a combination of environmental factors (e.g., flow, temperature, etc.), which have an acceptably low frequency of occurrence. In specifying critical conditions in the waterbody, an attempt is made to use a reasonable "worst-case" scenario condition. This was addressed in the Beaverdam Creek TMDL by modeling the reductions to the flow that exhibited the greatest disparity between observed and allowable concentrations.

5) The TMDL considers seasonal environmental variations.

Seasonal variations involve changes in stream flow and loadings as a result of hydrologic and climatological patterns. The loadings to Beaverdam Creek were investigated on a monthly basis to determine if seasonality existed between the sources. Based on the BST results it was determined that there were minimal seasonal impacts to loading and the source loads were averaged on an annual basis.

6) The TMDL includes a margin of safety.

This requirement is intended to add a level of safety to the modeling process to account for any uncertainty. The MOS may be implicit, built into the modeling process by using conservative modeling assumptions, or explicit, taken as a percentage of the WLA, LA, or TMDL. Virginia included an implicit MOS in the TMDLs through the use of conservative modeling assumptions. The TMDL was modeled to the single-most extreme water quality violation event and applied the percent reduction necessary during that event to all conditions.

7) There is a reasonable assurance that the TMDL can be met.

EPA requires that there be a reasonable assurance that a TMDL can be implemented. WLAs will be implemented through the NPDES permit process. According to 40 CFR 122.44(d)(1)(vii)(B), the effluent limitations for an NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source.

Nonpoint source controls to achieve LAs can be implemented through a number of existing programs such as Section 319 of the CWA, commonly referred to as the Nonpoint

[2]EPA memorandum regarding EPA Actions to Support High Quality TMDLs from Robert H. Wayland III, Director, Office of Wetlands, Oceans, and Watersheds to the Regional Management Division Directors, August 9, 1999.

Source Program.

8) The TMDL has been subject to public participation.

The TMDL for Beaverdam Creek was subject to the Commonwealth's public participation process. The meeting and comment period was noticed in the Virginia Register. The public meeting for the TMDL was held on March 14, 2006 in Moneta, Virginia; nine people attended. No written comments were received.