

Listing Methodology for Identifying Waters Impaired by Bacteria in Maryland's Integrated Report

**Water & Science Administration
Maryland Department of the Environment**

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Introduction

The Maryland Department of the Environment (MDE) routinely monitors shellfish harvesting waters for fecal coliform bacteria and conducts pollution source surveys to ensure that shellfish harvested in Maryland are safe for human consumption. In addition, MDE coordinates the State's Beach bacteria monitoring program. Beach sample collection and notification of advisories is delegated to the Counties in order to protect public health at Maryland's designated bathing beaches.

Fecal indicator bacteria are used in these programs since monitoring for actual pathogens is not feasible. It is assumed that if fecal indicator bacteria are present, then human pathogens may also be present. Since the primary goal of both the Shellfish and Beach programs is to ensure that public health concerns are addressed in a timely fashion, ongoing day-to-day management decisions by these programs are designed to be necessarily conservative. One such example is that beach advisories may be based on a single sampling event which shows a high level of indicator bacteria. However, bacteriological indicators are known to be variable in the environment and a single high measurement does not always coincide with fecal contamination. For this reason, this assessment methodology, developed for conducting Integrated Report (IR) assessments, will make use of larger longer-term sample sizes before making impairment determinations that could result in a Total Maximum Daily Load (TMDL). Doing this allows MDE to continue to protect public health in a timely fashion (by both the Shellfish and Beach programs) but also allows for a higher level of confidence to be used prior to initiating potentially costly TMDL development and implementation efforts. This helps to enhance the accuracy with which impairment determinations are made and enables the Department to focus on the highest priority impairments first.

Due to the complexities of collecting and assessing bacteriological indicator data, MDE strongly encourages groups to contact Heather Merritt (MDE) at Heather.Merritt@maryland.gov or (410) 537-3618 both when designing a sampling program and prior to submitting bacteria data for the Integrated Report. Ms. Merritt can provide guidance to groups interested in collected bacteria data so that this data is useful for the intended purposes.

For additional detail regarding monitoring and notification for Maryland's Shellfish Harvesting waters and Beaches Program please visit MDE's webpages at:

Shellfish Harvesting Areas:

<https://mde.maryland.gov/programs/Marylander/fishandshellfish/Pages/index.aspx>

Beaches Program:

<https://mde.maryland.gov/programs/Water/Beaches/Pages/index.aspx>.

Rules used by MDE to interpret bacteria data and apply the water quality standards are discussed below in the first three sections. The first section generally describes the protocols that MDE

uses. The second and third sections describe how bacteria monitoring data is assessed to determine support of the shellfish harvesting designated use and the water contact recreation use, respectively. The fourth section describes previous changes to the methodology and how MDE will provide information to the public on sewage overflows.

I. Protocols

Data are collected and analyzed using National Shellfish Sanitation Program with oversight from United States Food and Drug Administration (FDA) (for shellfish harvesting areas) or Environmental Protection Agency (EPA) (for recreational waters) approved methods, which include strict quality assurance and quality control (QA/QC) guidelines. Only Level 3 data¹ may be utilized for decision-making with respect to designated use support status. All other available data will be considered but may be used for prioritization, additional study, or revised monitoring. In all cases, it is critical that bacteria sampling be carried out in a way that is representative of conditions in time and space. High spatial and temporal variability suggest that infrequent or moderately elevated bacteriological levels alone do not necessarily represent a human health risk or impairment. The bacteriological standard is numeric but also includes a narrative component that permits the use of sanitary surveys and epidemiological studies. The methodology recognizes the inherent variability of the bacterial measurement and recognizes the inadequacies of indicator organisms. Most Probable Number (MPN) or Colonies Forming Units (CFU), reported as results used to express the level of bacteria, is not a direct count but a statistical estimation subject to a high degree of variability.

The current analytical methods used for bacteria sample analysis are specific to the use being evaluated (e.g. shellfish harvest vs. water contact). For the shellfish harvesting use, the Multiple Tube Fermentation method is used to measure fecal coliform (expressed as MPN/100 ml). For evaluating the recreational use the most commonly used tests for recreational waters are both MPN methods; the ONPG-MUG (Colilert) test measures *E. coli* and the MUG media (Enterolert) test measures enterococci.

II. Interpretation of Fecal Coliform Data for Assessing Use II Shellfish Harvesting Areas

The indicator and criteria used for shellfish (bivalve molluscan shellfish only) harvesting waters is established by the National Shellfish Sanitation Program (NSSP) and is promulgated in Code of Maryland Regulations (COMAR) 26.08.02.03-3 (COMAR 2019; NSSP 2017). In order to demonstrate support of the shellfish harvesting designated use, the measured level of fecal coliform in water must have a median of less than 14 MPN/100 ml and a 90th percentile of less than 49 MPN/100 ml, calculated from a minimum of 30 samples usually taken over a three-year

¹ For Maryland's Integrated Report, MDE evaluates submitted data according to data quality levels. The levels are based upon both the level of data quality and the authorized uses of the data provided to the agency, where Level 1 has the lowest and Level 3 has the highest data quality requirements. Level 3 datasets are used for regulatory decision-making purposes and are therefore legally defensible data. The data must be accompanied by a Quality Assurance Project Plan, and documentation of field sampling and/or laboratory testing protocols.

period. MDE conducts routine bacteria water quality sampling and pollution source surveys to assess shellfish harvesting areas so that waters can be assigned to one of three classifications used for protecting shellfish consumers. The following sections describe the different shellfish area classifications and how these classifications relate² to assessment categories on the IR.

A. Restricted and Prohibited (closed safety zone): A restricted classification for shellfish waters means that no direct shellfish harvesting is permitted in those waters. This classification is used in the following three scenarios:

1. Shellfish harvesting areas that do not meet the NSSP bacteria water quality standard for an approved classification (a fecal coliform median of 14 MPN/100 ml and a 90th percentile of <49 MPN/100 ml) are classified as restricted and listed as impaired in Category 4 or 5 (depending on whether a TMDL was completed or not) of the IR.
2. Shellfish harvesting waters located in the vicinity of wastewater treatment plant (WWTP) outfalls are classified as prohibited and a closed safety zone is established at the discharge point. This is a preventative public health protection measure and is required under the NSSP. However, these waters typically meet the standard for an approved classification under the NSSP because the discharge limit is less than 14 MPN/100 ml fecal coliform. If bacteria data shows violations with State standards it will be listed appropriately on the impaired (Category 4 or 5) part of the IR.
3. The upper Chesapeake Bay³ typically meets the standard for an approved classification but is restricted to shellfish harvesting for administrative reasons which are not based on water quality data. Water quality is routinely monitored in this area for fecal coliform. If bacteria data demonstrates that State standards are not being met, this area will be listed as impaired (Category 4 or 5) on the IR

B. Conditionally Approved Waters: Certain shellfish harvesting areas are classified as conditionally approved and are closed to harvesting for three days following a rainfall event of greater than or equal to one-inch in twenty-four hours. Conditionally approved harvesting areas generally meet the bacteriological water quality criteria for an approved classification (median of 14 MPN/100ml and 90th percentile <49MPN/100ml) at all other times and shellfish can be harvested from these areas when in the open status. When the water quality criteria for using a conditionally approved classification are not met, this area will be listed as impaired.

² Please note that shellfish area classifications do not directly relate to bacteria water quality. In some cases, certain shellfish area classifications are made based on administrative protection measures and not water quality data. In all cases, shellfish areas are assigned to categories on the IR based on water quality data alone.

³ The upper Chesapeake Bay, only as it's referred to in this paragraph, is defined as all of the area north of a line running in a southeasterly direction from the Robin's Point Tower to the Pooles Island Range Light, then easterly to the Worton Point Tower.

- C. **Approved Waters:** Waters classified as approved for shellfish harvesting meet the water quality standards for shellfish harvesting waters and are placed in Category 1 or 2 (meeting water quality standards) of the IR.
- D. **Shellfish Waters — Geographic Scale of Assessment**
For the purposes of the IR, MDE will georeference shellfish harvesting impairments as polygonal bodies of water within the larger estuarine waters (i.e. Chesapeake Bay segments, Coastal Bays, etc.). The shape of these ‘polygonal’ areas of estuarine water will be determined by the spatial arrangement of monitoring stations and by nearby shoreline features.

III. Interpretation of Bacteria Data for Water Contact Recreation Use

Maryland has implemented the EPA recommended enterococcus (marine or freshwater) and *E. coli* (freshwater only) standards for all recreational waters. According to EPA’s *Ambient Water Quality Criteria for Bacteria -1986*, the indicators *E. coli* and enterococcus have been found through epidemiological studies to have the best quantifiable relationship between the density of an indicator in the water and the potential human health risks associated with swimming in sewage-contaminated waters. “Indicator organisms are a fundamental monitoring tool used to measure both changes in environmental (water) quality or conditions and the potential presence of hard-to-detect pathogenic organisms. An indicator organism provides evidence of the potential presence or absence of a pathogenic organism that survives under similar physical, chemical, and nutrient conditions.” (EPA 2002).

These criteria are used during the beach season by beach managers to issue advisories and to notify the public. A few high values of the indicators may or may not be indicative of impairment. Therefore, it is necessary to evaluate the results from multiple sampling events over time to adequately quantify water quality conditions. EPA’s recreational criteria were developed for waters where primary contact recreation was designated and therefore apply to those activities. For water bodies where primary contact is not possible or permitted, MDE will prioritize these waters for sampling based on available resources. Please see Appendix A. for further considerations for bacteria sampling at non beach areas.

Assessing Support of Water Contact Recreation Use

In 2012, the EPA issued the updated *Recreational Water Quality Criteria* (RWQC) document (EPA 2012) which includes recommendations for magnitude, duration, and frequency. The 2012 RWQC magnitude is expressed as two numeric concentration thresholds consisting of a geometric mean (GM) and a statistical threshold value (STV), which are presented in Table 1. Both of these numeric thresholds are used in Maryland’s bacteria assessments and were adopted into Maryland’s water quality standards. These criteria correspond to a level of water quality that is associated with an estimated illness rate of 36 per 1,000 primary contact recreators (EPA 2012). The listing methodology for water contact recreation use applies to all Maryland waters. The 2012 RWQC also provides optional Beach Action Values that are for use in the beaches

notification programs. These values are not used in determining use attainment, i.e., IR impairment listings.

Table 1. EPA Recreational Water Quality Criteria (EPA 2012).

Designated Use	Bacteria Indicator	GM (cfu/100ml)	STV (cfu/100ml)
Marine & Tidal, or Freshwaters Contact Recreation	Enterococci	≤ 35	No more than 10% > 130
Freshwater Contact Recreation	E. coli	≤ 126	No more than 10% > 410
Duration and Frequency: The waterbody GM should not be greater than the selected GM magnitude in any 90-day period. There should not be greater than a ten percent excursion frequency of the STV magnitude in the same 90-day period.			

Water bodies should be monitored at least weekly to evaluate the GM and STV during an annual 90-day assessment period. For each year or 90 day period, data are evaluated independently as either meeting or not meeting the criteria⁴. In a given year, if both the resulting GM and associated STV do not exceed the bacteria indicator criteria noted in Table 1, then the waterbody meets water quality criteria for that year. If either the resulting GM or the associated STV exceeds their respective bacteria indicator criteria then the waterbody does not meet water quality criteria for that year. The waterbody assessments for the Integrated Report are assessed using the most recent and consecutive two years of data. If both years meet water quality criteria, then the waterbody is listed on Category 2 as meeting some water quality standards. If both years do not meet the water quality criteria, then the waterbody is listed on Category 5 as impaired. If one year meets the water quality criteria and one year does not, then the waterbody is listed on Category 3 for insufficient information. Because of the variable nature of bacteria data, only data from the most recent ten-year period will be considered. If there aren't two consecutive years' worth of data in the most recent ten-year period, then the waterbody is listed on Category 3 for insufficient information. Listings can change each Integrated Reporting cycle based on a new year or multiple years' worth of data.

Geographic Scale of Assessment

Beaches - For the purposes of the Integrated Report, waters identified and assessed as beaches will be georeferenced as linear stretches of water, having only the dimension of length. As a

⁴ State biologists reserve the right to use best professional judgment in the use of data collected during or after rain events. Rain and the subsequent stormwater runoff has been known to sometimes elevate levels of the bacteriological indicators without a source of fecal contamination. In other locales, rain events are known to cause sewage overflows and therefore samples collected in these locations are representative of the actual risk to public health.

result, the water body size reported for beaches will be expressed in miles. Since bathing beaches are typically narrow bands of water where water contact recreation occurs, this will help focus the georeferencing process to those areas of shoreline where beach access occurs.

Recreational Waters (not beaches) - Recreational waters, as the term is used here, generally refers to non-tidal flowing waters that may, from time to time, be used for full body contact recreation. For the purposes of the Integrated Report, when a bacterial monitoring station is assessed on non-tidal flowing waters, all upstream waters within the Maryland 8-digit watershed will be georeferenced as having the same assessment result. The only exception to this rule will be when there is an in-stream impoundment that significantly alters flow up and downstream of the dam. Recreational waters can also include tidal waters that may have had special assessments completed outside of the normal beach monitoring program. Assessments for these waters will be based on the spatial arrangement of monitoring stations and any nearby shoreline features. As a result, the geographic depiction of these assessments will show a polygonal body of water.

IV. Sewage Releases

In previous iterations of the Bacteria Assessment Methodology, there was a section that discussed sewage releases and how information on combined sewage overflows (CSOs) and sanitary sewage overflows (SSOs) was used in relation to water quality data on bacteria levels. However, after further consideration, the Department determined that this part of the methodology is not appropriate for 303(d) assessment purposes since there is insufficient scientific basis for determining that an overflow of 30,000 gallons was significant in a wide range of waterbody types, nor are there any federal regulatory requirements to list waters solely based on overflows. Such waters will not be listed in Category 5 of the IR so as to avoid overstating the potential water quality impairment where bacterial water quality data do not exist or do not support impairment. This will not impact the Department's ability to protect public health or to remedy faulty infrastructure.

References

COMAR (Code of Maryland Regulations). 2019. Water Quality Criteria Specific to Designated Uses. Accessed April 2019. Available at:

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_____. 2012. Recreational Water Quality Criteria. Office of Water 820-F-12-058. Washington, DC 20460. Accessed April 2019. Available at

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<https://mde.maryland.gov/programs/Water/Beaches/Documents/MDBEACHrev2016.pdf>

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<https://www.fda.gov/media/98328/download>

Appendix A. Considerations for Bacteria Sampling at Non-Beach Areas

Development and Purpose of the *Enterococcus spp.* and *E. Coli* Indicators in Recreational Water (assessing risk of accidental ingestion/head immersion)

The criteria were designed to protect human health in locations where people are swimming and recreating. The 1986 and 2012 Criteria were developed by EPA and used by Maryland for primary contact recreation, which typically includes activities where immersion and ingestion are likely and there is a high degree of bodily contact with the water, such as swimming, bathing, surfing, water skiing, tubing, skin diving, water play by children, or similar water-contact activities (EPA, 820-F-12-058, p. 3).

Source and Relative Risk

The source of the bacteria matters. Microbial Risk Assessment studies have shown that the potential human health risks from feces could be different due to the nature of the source (human versus wildlife), the type (different kinds of harmful pathogens), and number of pathogens from any given source (EPA, 820-F-12-058, p. 51). Because of this, finding out the sources of bacteria pollution is critical. Source surveys are a component of Maryland's Beaches and Shellfish Program so that any human sources of pollution can be stopped as soon as possible. Fecal indicator bacteria sample results are most useful when used in combination with other source data such as pollution source surveys. Without pollution source data, bacteria data only tell resource managers a small part of the story.

Sample Depth

EPA recommends that samples be collected from at least knee depth, unless it is unsafe to go that deep in the water. There is evidence that under specific conditions, fecal indicator organisms can colonize and multiply in ambient waters and associated sand and sediment (EPA, 4305T, p. 14). Although fecal indicator organisms can indicate pollution, they may at times simply be from stirred up sediments. If samples are collected from very shallow water, re-suspended indicators may not indicate fresh fecal pollution, and therefore samples with a high number of re-suspended organisms might not provide a good means to assess water quality (EPA, EPA-823-B-14-001, p. 53). The criteria were developed in studies where there was a correlation between illness and indicator concentrations for samples collected at knee depth. Application of the criteria in other conditions may not be as meaningful.

Seasonality

Bacteria sampling is most useful in warmer months. Both the 1986 and 2012 criteria were developed for the swimming season, when primary contact recreation activities were occurring (EPA, EPA440/5-84-002 and 820-F-12-058). The datasets do not include cold weather data as it is unlikely to find many people swimming. Although a bacteria sample collected during cold weather months may indicate the presence of pathogens, there have not been primary contact recreational studies to understand the impacts to human health.

Sampling Frequency

Bacteria sampling should occur at least weekly. Bacteria concentrations are naturally variable in the water column, regardless of the pollution source. Typically, a larger dataset will more accurately characterize the water quality in a waterbody over time, which may result in more meaningful attainment determinations. EPA also recommends frequent sampling to adequately evaluate the geometric mean and statistical threshold value of the criteria (EPA, 820-F-12-058, p. 42).

Bacteria Data for use in the Integrated Report

Bacteria data submitted for use in the Integrated Report of Surface Water Quality should be sampled weekly during the summer swimming season for locations where many people are recreating and/or there is a high risk to human health. Since the studies for the development of the criteria were conducted at beaches, during the summer swimming season, where many people were recreating, and where there were known human pollution sources, MDE will use best professional judgement and apply the bacteria criteria to the sampling data as appropriate.

References

- EPA, Office of Water. EPA440/5-84-002, Ambient Water Quality Criteria for Bacteria – 1986, January 1986, Washington D.C.
- EPA, Office of Water. 4305T, Assessment of the Extra-Enteric Behavior of Fecal Indicator Organisms in Ambient Waters, December 2010.
- EPA. 2010. Sampling and Consideration of Variability (Temporal and Spatial) for Monitoring of Recreational Waters. EPA-823-R-10-005. U.S. Environmental Protection Agency, Office of Water, Washington, DC.
- EPA, Office of Water. 820-F-12-058, Recreational Water Quality Criteria, 2012.
- EPA. EPA-823-B-14-001, National Beach Guidance and Required Performance Criteria for Grants, July 2014.