

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 assesses bacteria data for both the Shellfish Harvesting Designated Use and the Water Contact Recreation Designated Use. MDE 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 which monitors beaches for *E. coli* or *Enterococcus* bacteria. 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 where the beach action value threshold is exceeded. These data, although collected for the Shellfish or Beaches programs, are considered readily available data and information and should be used, along with other data, for use in the Integrated Report (IR) assessments.

However, bacteriological indicators are known to be variable in the environment and a single high measurement does not always indicate a water quality impairment. For this reason, this assessment methodology for conducting Integrated Report (IR) assessments, is designed to determine which Maryland waters require restoration and will make use of larger longer-term sample sizes before making impairment determinations. Doing this allows MDE to make general bacteria impairment determinations for the Integrated Report, while the Shellfish and Beaches programs use the data to make prompt public health decisions. **Bacteria assessments for the Integrated Report do not provide a real-time indication of swimming or shellfish harvesting conditions for the public.**

For additional detail regarding monitoring and public health notifications 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>.

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

For the shellfish (bivalve molluscan shellfish only) harvesting use, the Multiple Tube Fermentation method is used to measure fecal coliform (expressed as MPN/100 ml). The indicator and criteria used for harvesting waters is established by the National Shellfish Sanitation Program (NSSP) with oversight from the United States Food and Drug Administration and is promulgated in Code of Maryland Regulations (COMAR) 26.08.02.03-3 (NSSP 2019). All fecal coliform data used for shellfish harvesting decisions or in support of the shellfish harvesting designated use must be collected following the NSSP methods and processed by a certified lab.

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 shellfish harvesting status classifications used for protecting shellfish consumers. For shellfish harvesting status classifications, 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 typically calculated from the Shellfish Harvesting Program monitoring data of 30 samples taken over a three-year period. Please note that shellfish area classifications do not always 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.

For the IR, all shellfish areas are assigned to report categories based on water quality data alone. Assessments for the shellfish harvesting designated use will typically be conducted using data from the Shellfish Harvesting Program monitoring data over the most recent five-year period. A minimum of 30 samples are required for assessment over the five-year period. A median fecal coliform level and a percentage of fecal coliform data greater than 49 MPN/100ml will be calculated for all data within the most recent five-year period. In order to demonstrate support of the shellfish harvesting designated use for the IR, 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.

For the Integrated Report assessments, a waterbody will be listed in Category 2 (waters attaining some standards) if the median level of fecal coliform in water is less than 14 MPN/100 ml and if less than 10% the data is greater than 49 MPN/10 ml, thereby achieving the 90th percentile of less than 49 MPN/100 ml. Both the median and 90th percentile must be achieved to be considered attaining (Category 2).

A waterbody will be listed in Category 5 (impaired waters for which a TMDL is required) when the median level of fecal coliform in water is greater than or equal to 14 MPN/100 ml or 10% or more of the data are greater than 49 MPN, thereby exceeding the 90th percentile of less than 49 MPN/100 ml. If either the median or the 90th percentile are exceeded, the waterbody will be considered impaired. Listings can change each Integrated Reporting cycle based on a new year or multiple years' worth of data. **Bacteria assessments for the Integrated Report do not provide a real-time indication of shellfish harvesting conditions for the public. For current**

conditions, please see MDE's shellfish harvesting webpage here:

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

MDE will use its best professional judgment to evaluate data with overwhelming evidence of impairment or attainment but less than 30 samples over the five-year period. Those stations may also be placed in Category 3 (waters with insufficient information) and prioritized for follow-up monitoring to determine attainment status.

Geographic Scale of Assessment

For the purposes of the IR, MDE will geo-reference 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.

II. Interpretation of Bacteria Data for Water Contact Recreation Use

Introduction:

For evaluating the recreational use the most commonly used tests are both MPN methods; the ONPG-MUG (Colilert®-IDEXX) test measures *E. coli* and the MUG media (Enterolert®-IDEXX) test measures enterococci. All data collected must follow Environmental Protection Agency (EPA) (for recreational waters) approved methods, which include strict quality assurance and quality control (QA/QC) guidelines. Tier III data¹ will be utilized for decision making with respect to designated use support status. All other available data will be evaluated and considered and if technical/quality concerns are identified, these data may not be used to make IR assessment decisions, but instead 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 sampling may not be sufficient to adequately characterize a waterbody, and/or moderately elevated bacteriological levels alone do not necessarily represent a human health risk or water quality 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.

There are two different analysis methods and reporting units for bacterial measurements. Colony Forming Units (CFU) is a unit of measurement from a direct count of bacteria. Most Probable Number (MPN) reported as a measurement unit used to express the level of bacteria. This equivalent unit is associated with a statistical estimation for bacteria concentration instead of a direct count. MDE accepts both analysis methods and units for assessment purposes as measures of the estimated number of bacteria in a water sample.

Maryland has implemented the EPA recommended enterococcus (marine or freshwater) and *E. coli* (freshwater only) standards for all recreational waters. According to EPA's *Recreational Water Quality Criteria- 2012*, 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).

¹ For Maryland's Integrated Report, MDE evaluates submitted data according to data quality tiers. The tiers are based upon both the level of data quality and the authorized uses of the data provided to the agency, where Tier I has the lowest and Tier III has the highest data quality requirements. Tier III 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.

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. **Bacteria assessments for the Integrated Report do not provide a real-time indication of swimming conditions for the public. For current conditions, please see MDE's Beaches webpage here:** <https://mde.maryland.gov/programs/Water/Beaches/Pages/index.aspx>.

Assessing Support of Water Contact Recreation Use:

In 2012, EPA issued the updated *Recreational Water Quality Criteria* (RWQC) document (EPA 2012) which provides recommendations for protecting human health in any waters designated for primary contact recreation use. The 2012 RWQC offers two sets of numeric concentration thresholds which protect the Water Contact Recreation Use and, therefore, the public from exposure to harmful levels of pathogens. The listing methodology for water contact recreation use applies to all Maryland waters. The 2012 RWQC consists of three components: magnitude, duration, and frequency. The 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 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). For 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. Maryland also has narrative criteria stating that when a sanitary survey and an epidemiological study approved by the Department disclose no significant health hazard, the criteria in Table 1 do not apply. The 2012 RWQC also provides optional Beach Action Values that are not water quality criteria but, a precautionary tool used by the Beach Program to provide an early alert to beach goers. 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.			

Assessments for the water contact recreation use will be conducted using data from the most recent 5-year IR data window. That data will be assessed in 90-day periods as either attaining or not attaining the recreational criteria shown in Table 1 above. The minimum sample size for the 90-day period is 10 sampling events which typically equates to weekly sampling over the 90-day period. This high frequency monitoring is necessary to evaluate both the GM and STV during the 90-day assessment period and captures short-term fluctuations in bacteria concentrations, which better reflect impacts to recreation.

The GM and the STV will be assessed to determine if a waterbody is meeting water quality standards for the recreational designated use. Data will be assessed in discrete 90 day periods, to determine if the waterbody is attaining or not attaining the criteria. In a given 90 day period, if both the resulting GM and associated STV meet the bacteria indicator criteria noted in Table 1, then the waterbody is in attainment for that 90 day period. For the Integrated Report assessments, a waterbody will be listed in Category 2 (waters attaining some standards) if all 90-day windows for which there are data, are attaining water quality criteria.

In each 90-day period, if the resulting GM exceeds the bacteria indicator criteria, then the waterbody is not attaining water quality criteria for that 90-day window. A waterbody will be listed in Category 5 (impaired waters for which a TMDL is required) when there are one or more 90-day periods not attaining the GM criteria. The geomean will typically be used for listing purposes since it is more reflective of longer-term water quality issues. However, where no geomean exceedances occur and STV excursions are greater than 10% for a 90-day period, MDE will evaluate the magnitude and timing of the STV excursions to determine if they constitute impairment. Listings can change each Integrated Reporting cycle based on a new year or multiple years' worth of data.

MDE will use its best professional judgment to evaluate data with overwhelming evidence of impairment or attainment but fewer than 10 sampling events. If data document consistently low bacteria levels within sparsely populated watersheds, MDE will consider attainment of the criterion if no likely sources of bacteria are present in the watershed. Conversely, for incomplete data sets that consistently document high bacteria counts (e.g., E. coli >410 CFU/100 ml), MDE will consider whether the waterbody is impaired for the Water Contact Recreational Use. Tier

III data with less than 10 sampling events may also be placed in Category 3 (waters with insufficient information) and prioritized for follow-up monitoring to determine attainment status.

Geographic Scale of Assessment

Beaches – For the purposes of the Integrated Report, waters identified and assessed as beaches will be geo-referenced as linear stretches of water, having only the dimension of length. As a 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. Recreational Waters can also include tidal waters that may have had special assessments completed outside of the normal beach monitoring program. For the purposes of the Integrated Report, waters identified and assessed as Recreational Waters will be assessed on a reasonable and flexible scale. Assessments for these waters will be based on the spatial arrangement of monitoring stations and any nearby shoreline features. In some cases, only a single location may have been sampled, while in others, multiple samples may have been collected over a larger area. In either case, MDE will exercise best professional judgement in applying assessment results to a particular geographic area. Unique geographic and/or data scenarios require maximum flexibility to ensure that assessments are representative of a particular waterbody.

References

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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). 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.

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