United States
Environmental Protection
Agency

Implementation Guidance for Ambient Water Quality Criteria for Bacteria

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U.S. Environmental Protection Agency
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Washington, DC 20460

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Foreword

We use water for swimming, drinking. white water rafting, surfing, kayaking, and simply for enjoying its aesthetic qualities while hiking or birdwatching. Protection of waterbodies begins with states, territories, and authorized tribes adopting appropriate water quality standards. The *Implementation Guidance for Ambient Water Quality Criteria for Bacteria* provides guidance to state, territorial, and authorized tribal water quality programs on the adoption and implementation of bacteriological water quality criteria to protect waters designated for recreation. This document may also serve as a useful resource for beach program managers and interested members of the public.

This guidance reflects valuable comments the Agency received on previous drafts and subsequent interactions with interested stakeholders. I believe you will find this document a useful resource. Should you have any questions or concerns, please do not hesitate to contact me (202-566-0430) or Denise Keehner, Director of the Standards and Health Protection Division (202- 566-0400).

Geoffrey H. Grubbs, Director
Office of Science and Technology

NOTICE

The *Implementation Guidance for Ambient Water Quality Criteria for Bacteria* is designed to address questions on implementing EPA's recommended water quality criteria for bacteria within state, territory, and authorized tribal water quality programs. It provides guidance to EPA Regions, States, Territories, and Tribes and the general public on how EPA intends to exercise its discretion in implementing the statutory and regulatory provisions that concern water quality criteria and standards for bacteria. The guidance is designed to implement national policy on these issues.

The statutory provisions and EPA regulations described in this document contain legally binding requirements. This document does not substitute for those provisions or regulations, nor is it a regulation itself. Thus, it does not impose legally binding requirements on EPA, States, Territories, or Tribes, and may not apply to a particular situation based upon the circumstances. EPA, State, Territory, and Tribal decisionmakers retain the discretion to adopt approaches on a case-by-case basis that differ from this guidance where appropriate. Any decisions regarding a particular facility will be made based on the statute and regulations. Therefore, interested parties are free to raise questions and objections about the substance of this guidance and the appropriateness of the application of this guidance to a particular situation. EPA will, and States, Territories, and Tribes should, consider whether or not the recommendations or interpretations in the guidance are appropriate in that situation. This guidance is a living document and may be revised periodically without public notice. EPA welcomes public comments on this document at any time and will consider those comments in any future revision of this guidance document.

Acknowledgments

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Executive Summary

The purpose of this document is to provide guidance for the implementation of water quality criteria for bacteria once adopted into state and tribal water quality standards. EPA is encouraging all states and authorized tribes to use *E. coli* or enterococci as the basis of their water quality criteria for bacteria to protect recreational waters. *E. coli* and/or enterococci are the indicators best suited for use in determining the potential risk of contracting acute gastrointestinal illness from incidental ingestion of fecally contaminated water during recreational activities. For coastal recreational waters (i.e., marine waters, coastal estuaries, and the Great Lakes that are designated for swimming and similar water contact activities), states are required to adopt by April 2004 criteria for *E. coli* or enterococci as protective of human health as EPA's Clean Water Act §304(a) criteria recommendations.

This document provides a summary of EPA's existing recommended water quality criteria for bacteria that it published in 1986 as well as recommendations on the implementation of bacteriological criteria for the protection of recreational uses once they have been adopted into a state or authorized tribe's water quality standards. The use of water quality standards to protect recreational waters encompasses a broad spectrum of waterbody types, from heavily-used oceanfront beach areas to remote mountain streams. This document attempts to acknowledge these different types of recreational uses and the different management choices that are available to states and tribes in managing these water resources.

States and authorized tribes must provide protection for recreation in and on the water wherever attainable for all surface waters within their jurisdiction. States and authorized tribes typically accomplish this by designating waters for primary contact recreation (i.e., activities that could be expected to result in ingestion of water or immersion) within their water quality standards. Once assigned as a designated use, states and authorized tribes must establish protective water quality criteria. In assigning designated uses for recreation to provide protection of human health, states and tribes should consider the use of the waterbody by children and other susceptible groups and conduct surveys to identify sources of fecal pollution when high levels of bacteria are observed. In many circumstances, waterbodies are impacted by not only human sources of fecal contamination, but also domesticated animals and wildlife. Although there have been few studies investigating the impact of fecal contamination from animal source, it is inappropriate to conclude that these sources present no risk to human health from waterborne pathogens, particularly when the animals in question are likely to have had frequent contact with humans and may harbor and shed human pathogens. Thus, EPA's bacteria criteria should apply to measures of human and domesticated animal fecal contamination, but may exclude the component from wildlife. As explained in detail in sections 3.2 and 3.4.2, this may be reflected in the expression of the criteria or in the assignment of the designated use.

States and authorized tribes have flexibility to tailor and refine recreational designated uses. In some instances, particularly in cold northern climates, states and authorized tribes may choose to adopt seasonal contact recreation uses to protect primary contact recreation during the time of year it occurs and to prevent excessive disinfection by dischargers during the winter months. For

example, in those climates residual chlorine in effluents can result in the formation of disinfection byproducts such as trihalomethanes in surface waters, which can have an adverse effect on human health and aquatic life. In other circumstances where a state or authorized tribe has determined that primary contact recreation is not an existing use as defined by federal and state (or tribal) regulations, nor attainable for one of the reasons identified in the federal and state (or tribal) regulations, states and authorized tribes may adopt other categories of recreation such as intermittent primary contact recreation, wildlife impacted recreation, or secondary contact recreation.

States and authorized tribes have discretion in how they apply EPA's bacteria criteria. EPA's bacteria criteria represent a distribution of values over a recreation season that collectively are associated with a specific illness rate. That distribution is characterized by a geometric mean and a series of upper percentile values, based on the standard deviation of values around the mean. States and authorized tribes may choose from a range of risk levels and corresponding geometric means to characterize long term water quality. They may also choose from a range of upper percentile values for day-to-day management of a waterbody.

In addition to providing recommendations on the adoption of recreational uses and protective water quality criteria into water quality standards, this document also provides explanations of how standards should be used to form the basis for water quality-based national pollutant discharge elimination system permits, assess and determine attainment of water quality standards, and develop subsequent total maximum daily loads and wasteload allocations. While this document is focused primarily on the adoption and implementation of water quality criteria for bacteria as part of water quality standards, the relationships between standards and drinking water programs, shellfishing programs, and beach management activities are also briefly addressed. Where available, this document provides references where more information may be obtained.

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1. Background and Introduction

Water quality standards consist of designated uses, criteria necessary to protect those uses, and an antidegradation policy. Water quality standards establish the "goals" for a waterbody. Designated uses determine what criteria apply to the water body. Clean Water Act (CWA) §101(a)(2) set the national goal of achieving water quality which provides for the "protection and propagation of fish, shellfish, and wildlife" and "recreation in and on the water" wherever attainable. These national goals are commonly referred to as the "fishable/swimmable" goals of the Clean Water Act. CWA §303(c)(2)(A) requires water quality standards to "protect the public health and welfare, enhance the quality of water, and serve the purposes of this Act." EPA's regulations at 40 CFR Part 131 interpret and implement these provisions through a requirement that water quality standards provide for fishable/swimmable uses unless those uses have been shown to be unattainable. States have generally provided for the "swimmable" goal by designating "primary contact recreation" for their waters. Primary contact recreation encompasses activities that could be expected to result in ingestion of water or immersion. These activities logically include swimming, water skiing, surfing, kayaking, and any other activity where contact and immersion in the water are likely.

In 1986, the U.S. Environmental Protection Agency (EPA) published *Ambient Water Quality Criteria for Bacteria*–1986. That document contained EPA's recommended water quality criteria for bacteria to protect bathers from gastrointestinal illness in recreational waters. The water quality criteria are based on levels of indicator bacteria, namely *Escherichia coli* (*E. coli*) and enterococci, that demonstrate the presence of fecal pollution. EPA identified levels of these indicators which protect bathers in fresh and marine recreational waters. Indicator organisms such as these have long been used to protect bathers from illnesses that may be contracted from recreational activities in surface waters contaminated by fecal pollution. These organisms generally do not cause illness directly, but have demonstrated characteristics that make them good indicators of harmful pathogens in waterbodies. Prior to its 1986 recommendations, EPA recommended the use of fecal coliforms as an indicator organism to protect bathers from gastrointestinal illness in recreational waters. However, EPA conducted epidemiological studies and evaluated the use of several organisms as indicators, including fecal coliforms, *E. coli*, and enterococci, and subsequently recommended in 1986 the use of *E. coli* for fresh recreational waters and enterococci for fresh and marine recreational waters because they were better predictors of acute gastrointestinal illness than fecal coliforms. Some states and authorized tribes have replaced their fecal coliform criteria with water quality criteria for *E. coli* and/or enterococci; however, many other states and authorized tribes have not yet made this transition.

The main route of exposure to illness-causing organisms in recreational beach waters is through direct contact with polluted water while swimming, most commonly through accidental ingestion of contaminated water. In waters containing fecal contamination, many types of waterborne diseases that are spread through fecal contamination and subsequent ingestion (the "fecal-oral route") may affect bathers. These illnesses result from the following general categories of infection:

- Bacterial infection (such as cholera, salmonellosis, shigellosis, and gastroenteritis).

- Viral infection (such as infectious hepatitis, gastroenteritis, and intestinal diseases caused by enteroviruses).
- Protozoan infections (such as cryptosporidiosis, amoebic dysentery, and giardiasis).

Although the most common effects of bathing in contaminated water are illnesses affecting the gastrointestinal tract, other illnesses and conditions affecting the eye, ear, skin, and upper respiratory tract can be contracted as well. With these conditions, infection may occur when pathogenic microorganisms come into contact with small breaks and tears in the skin or ruptures in delicate membranes in the eye, ear or nose resulting during recreation in the water. These illnesses are not likely to be life-threatening for the majority of the population.

Microorganisms are ubiquitous in all terrestrial and aquatic ecosystems. Many types are beneficial, functioning as agents for chemical decomposition, food sources for larger animals, and essential components of the nitrogen cycle and other biogeochemical cycles. Some microorganisms reside in the bodies of animals and aid in the digestion of food; others are used for medical purposes such as providing antibiotics. Of the vast number of species of microorganisms present in the environment, only a small subset are human pathogens (i.e., capable of causing varying degrees of illness in humans). While some human pathogens are naturally occurring in the environment (e.g., Naeglaria or *Vibrio cholera*), the source of these microorganisms is usually the feces or other wastes of humans and various other warm-blooded animals.

Bacteria are unicellular organisms that lack an organized nucleus and contain no chlorophyll. Waste from warm-blooded animals is a source of many types of bacteria found in waterbodies, including the coliform group and streptococcus, lactobacillus, staphylococcus, and clostridia. However, most types of bacteria are not pathogenic.

Viruses are a group of infectious agents that are obligate intracellular parasites (i.e., require a host in which to live). The most significant virus group affecting water quality and human health originates in the gastrointestinal tract of infected animals. These enteric viruses are excreted in feces and include hepatitis A, rotaviruses, Norwalk-type viruses, adenoviruses, enteroviruses, and reoviruses.

Protozoa are unicellular organisms occurring primarily in the aquatic environment. Pathogenic protozoa constitute almost 30 percent of the 35,000 known species of protozoans. Pathogenic protozoa exist in the environment as cysts that hatch, releasing infective forms that attach to or invade cells, and then grow and multiply, causing associated illness. Encystation of protozoa facilitates their survival, protecting them from harsh conditions such as high temperature and salinity. Two protozoa of major concern as waterborne pathogens are *Giardia lamblia* and *Cryptosporidium parvum*.

The detection and enumeration of all pathogens of concern are impractical in most circumstances due to the potential for many different pathogens to reside in a single waterbody; lack of readily available and affordable methods; and the variation in likely pathogen concentrations. The use of fecal indicators provides regulators and water quality managers with a means to ascertain the likelihood that human pathogens may be present in recreational waters. Specifically, the criteria published by EPA are intended, once adopted by states and authorized tribes, to control pathogens by keeping concentrations of indicator organisms at a level that corresponds with low levels of risk of acute gastrointestinal illness to recreational water users.

Of the different illnesses that may be contracted during recreational activities, gastrointestinal illness occurs most frequently (CDC 2000; CDC 1998). Gastroenteritis is a term for a variety of diseases that affect the gastrointestinal tract and are rarely life-threatening. Symptoms of the illness include nausea, vomiting, stomachache, diarrhea, headache, and fever. While other illnesses may be contracted from recreational activities, they are not specifically addressed by EPA's criteria recommendations. People who become ill as a result of bathing in contaminated water often do not associate their illness symptoms with swimming because symptoms often appear several days after exposure and are often not severe enough to cause individuals to go to the hospital or see a doctor. Most people afflicted by gastroenteritis will experience flu-like symptoms several days after exposure, rarely suspecting that ingestion of water while recreating is the cause of their illness and often assuming that the symptoms are a result of the flu or food poisoning. Consequently, disease outbreaks often are inconsistently detected and reported, leading to difficulty in ascertaining the total incidences of illness resulting from contact with recreational waters.

1.1 What is the purpose of this guidance?

This guidance provides recommendations to help states[1] and authorized tribes[2] implement EPA's recommended water quality criteria for bacteria for the protection of recreational waters. EPA strongly encourages states and authorized tribes that have not already done so to adopt the recommendations set forth in *Ambient Water Quality Criteria for Bacteria* – 1986 or to adopt other scientifically defensible water quality criteria for bacteria into their recreational water quality standards to replace fecal or total coliform criteria.

EPA's *Ambient Water Quality Criteria for Bacteria*–1986 was developed for the protection of waters designated for recreational uses. Under section 304(a) of the Clean Water Act (CWA), EPA is required to publish water quality criteria accurately reflecting the latest scientific knowledge for the protection of human health and aquatic life. The scientific foundation of the criteria is based on studies conducted by EPA demonstrating that for fresh water, *E. coli* and enterococci are best suited for predicting the presence of gastrointestinal illness-causing pathogens, and for marine waters, enterococci is most appropriate. *E. coli* and enterococci indicators provide a much better means of protecting recreators from contracting gastrointestinal illness than the use of fecal

[1] Note: The term "states" will be used to denote states and U.S. territories.

[2] Pursuant to section 518(e) of the CWA, EPA is authorized to treat an Indian tribe in the same manner as a state for the purposes of administering a water quality standards program. 40 CFR 131.8 establishes the criteria by which the Agency makes such a determination. At this time, 26 tribes have requested and been granted program authorization, and 22 tribes have adopted, and EPA has approved, water quality standards pursuant to section 303(c) of the Act, and the implementing federal regulations at 40 CFR 131.

coliforms. The transition to *E. coli* and enterococci bacterial indicators continues to be an Agency priority for states' and authorized tribes' triennial reviews of water quality standards. Further, the Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act of 2000) requires coastal and Great Lakes states, by April 2004, to adopt water quality criteria and standards for those pathogens and pathogen indicators for which the [EPA] Administrator has published criteria under §304(a) of the CWA. The pathogen indicator criteria and standards adopted by states must be as protective as EPA's criteria. The BEACH Act of 2000 further directs EPA to propose and promulgate such standards for states that fail to do so. Appendix A contains the full text of the Beach Act of 2000.

1.2 Why is EPA publishing this guidance?

Despite the studies (see Appendix B) demonstrating much better correlation between swimming-associated illnesses and concentrations of *E. coli* and enterococci, many states and authorized tribes continue to use either fecal or total coliform criteria to protect and maintain waterbodies designated for recreation. EPA recognizes there has been some uncertainty among states and authorized tribes with regard to how EPA's recommended 1986 bacteriological water quality criteria should be implemented and how the transition from fecal coliforms to *E. coli* and enterococci should be made. This guidance addresses those issues identified by states and authorized tribes as impeding their progress toward adopting and implementing EPA's current recommended water quality criteria for bacteria. This document includes the following parts:

- Section 2 contains an explanation of the relationship among state and tribal water quality standards, the requirements of the BEACH Act of 2000, and state and authorized tribal beach monitoring and advisory programs;

- Section 3 contains recommendations on the application of EPA's recommended water quality criteria to waters contaminated by non-human sources; provides recommendations for appropriate approaches for monitoring the safety of recreational waters in those tropical climates where *E. coli* and enterococci may exist naturally in the soil environment, possibly complicating the use of those organisms as indicators; and provides recommendations for appropriate approaches for managing risk in waters that are not designated for primary contact recreation, including waters impacted by high levels of indicator organisms during wet weather events or wildlife sources of fecal pollution;

- Section 4 contains recommendations for making the transition from fecal coliforms to EPA's recommended water quality criteria, including the use of multiple indicators during a transition period; contains recommendations on the development of wasteload allocations for the purpose of calculating total maximum daily loads; provides recommendations for the use of detection and enumeration methods in monitoring ambient and effluent water quality; and discusses the relationship of recommendations contained in this document to the protection of drinking water sources and shellfishing waters.

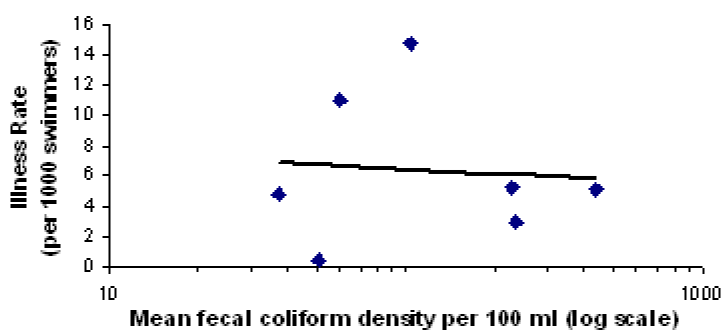
1.3 Who should use this guidance?

This guidance should be used by state and authorized tribal environmental agencies administering a water quality standards program. This guidance may also provide useful information for state, tribal, and local beach program managers and interested members of the public.

1.4 What is the basis for EPA's 1986 water quality criteria for bacteria?

Prior to publishing its recommended criteria in 1986, EPA conducted a series of epidemiological studies that examined the relationship between swimming-associated illness (namely, acute gastrointestinal illness) and the microbiological quality of the waters used by recreational bathers. The results of those studies did not demonstrate that fecal coliforms (the indicator originally recommended in 1968 by the Federal Water Pollution Control Administration of the Department of the Interior) correlated with swimming-associated gastroenteritis, as shown in Figure 1.1. However, two indicator organisms, *E. coli* and enterococci, exhibited a strong correlation to swimming-associated gastroenteritis, the former in fresh waters only and the latter in both fresh and marine waters (USEPA, 1986; USEPA, 1984; USEPA, 1983). The strong correlation (see Figure 1.3) may be due to the indicator organisms being more similar to the pathogens of concern in their ability to survive within the environment. In some cases, fecal coliforms are routinely detected where fecal contamination is absent, possibly resulting in inaccurate assessments of recreational safety. For example, *Klebsiella* spp., a bacterial organism that is part of the fecal coliform group and is generally not harmful to humans, is often present in pulp and paper and textile mill effluents (Archibald, 2000; Dufour et al., 1973). In contrast, *E. coli* and enterococci are less frequently found in environments where fecal contamination is known to be absent, making them more suitable as indicators of fecal contamination. Enterococci are also resistant to environmental factors, particularly saline environments, enhancing their utility as an indicator in marine waters.

Figure 1.1 Fecal Coliform and Illness Rates



Source: "Health Effects Criteria for Fresh Recreational Waters", EPA 1984

Based on these studies, EPA's *Ambient Water Quality Criteria for Bacteria* - 1986, published under section 304(a) of the CWA, recommended the use of criteria based on the indicator organisms *E. coli* and enterococci rather than fecal coliforms.

1.4.1 How were EPA's epidemiological studies conducted?

The data supporting the water quality criteria were obtained from a series of studies (USEPA, 1984; USEPA, 1983) conducted by EPA examining the relationships between swimming-associated illness and the microbiological quality of waters used by recreational bathers. These studies were conducted at three marine and two freshwater locations over several years. The EPA studies were unique at the time they were initiated because they attempted to relate swimmer illness to water quality at the time of swimming. This was done by approaching individuals as they were leaving the beach and asking if they would volunteer to take part in the recreational water studies. Individuals who had also been swimming during the previous week were excluded from the study. After seven to 10 days, the volunteers were contacted by telephone to determine their health status since the swimming event. Control non-swimmers, usually a member of the volunteer's family, were questioned in a similar manner. Data were collected on the bacteriological water quality and the incidents of gastrointestinal illness among swimmers as compared to non-swimmers. Multiple potential indicators were measured in each beach water sample. Multiple indicators were measured because it was unknown which one would best correlate to swimmer illness. The swimming-associated illness parameter was obtained by subtracting the non-swimmer illness rate from the swimmer illness rate using data collected over a summer trial. Additional study details may be obtained from *Health Effects Criteria for Marine Recreational Waters* (USEPA, 1983), *Health Effects Criteria for Fresh Recreational Waters* (USEPA, 1984), and the subsequent *Ambient Water Quality Criteria for Bacteria*–1986 (USEPA, 1986).

1.4.2 How were the data from EPA's epidemiological studies analyzed to provide EPA's recommended water quality criteria for bacteria?

For the purpose of analysis, the data collected at each of the sites were grouped by location and then by season. Each season at a beach was then averaged into one paired data point consisting of an averaged illness rate and a geometric mean of the observed water quality. These data points were plotted to determine the relationships between illness rates and average water quality (expressed as a geometric mean). The resulting linear regression equations were used to calculate recommended geometric mean values at specific levels of protection (e.g., 8 illnesses per thousand swimmers). Using a standard deviation and the geometric mean of the data collected, various upper percentiles were calculated and presented as "single sample maximum" values.

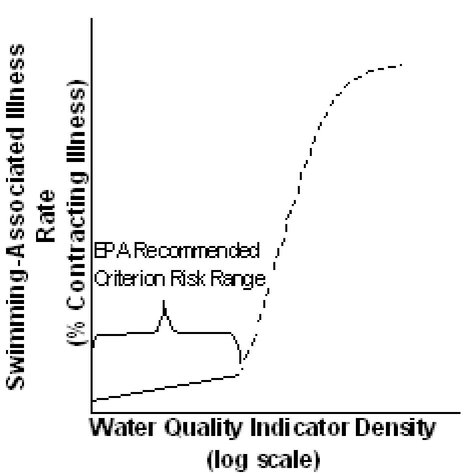
The criteria were developed based on exposures incurred during swimming with head immersion and are thus intended to be adopted by states and authorized tribes to protect their primary contact recreation uses. Other criteria values may be used to protect surface waters designated for recreational uses other than primary contact recreation; however, such a designation must be supported by a use attainability analysis consistent with federal regulations at 40 CFR 131.10(g) where appropriate. See sections 3.4 and 3.5 for further discussion.

1.5 What are EPA's recommended water quality criteria for bacteria?

Tables 1-1 and 1-2 on the following pages contain EPA's recommended water quality criteria for the protection of primary contact recreation. As described in the introduction, primary contact recreation encompasses activities that could be expected to result in ingestion of water or immersion. These activities logically include swimming, water skiing, surfing, kayaking, and any other activity where contact and immersion in the water are likely. EPA's criteria are essentially constructed as a series of frequency distributions of bacteria densities associated with specific risk levels (e.g., illness rates) over the course of a swimming season (i.e., several months). EPA characterizes each distribution (i.e., for a 1% risk level and higher risk levels where possible) using a geometric mean and upper percentile values. When the criteria were published in 1986, EPA recommended use of specific risk levels and associated geometric means for fresh and marine recreational waters. Further, upper percentiles of the associated frequency distribution (referred to as "confidence levels" in EPA's 1986 criteria document) were termed "single sample maximum" values, reflecting one possible way of using the information and applying the criteria. While the risk assessment and scientific basis for EPA's 1986 criteria remain unchanged, this guidance more fully recognizes and describes the risk management considerations in selecting an appropriate risk level and applying both the geometric mean and upper percentile values. The term "upper percentiles" is used in place of "single sample maximum" to more accurately reflect their derivation and more adequately reflect the range of recommended usage of this aspect of EPA's criteria.

In the 1986 criteria document, EPA recommended the use of a risk level associated with 8 illnesses per 1000 swimmers in fresh waters and 19 illnesses per 1000 in marine waters. This represents approximately a 1-2% risk that recreators will suffer from gastrointestinal illness from swimming in ambient recreational waters. These risk levels were identified based on the concentrations of *E. coli* and enterococci that roughly correlated to the previous fecal coliform criterion (a more complete discussion of the derivation of EPA's recommended criteria is contained in *Ambient Water Quality Criteria for Bacteria*-1986). However, it is appropriate for states and authorized tribes to exercise their risk management discretion when protecting recreational waters. Based on a review of the studies used in the derivation of EPA's §304(a) criteria for bacteria, EPA recommends states and authorized tribes select a risk level from the ranges displayed in tables 1-1 (for fresh waters) and 1-2 (for marine waters).

Figure 1.2 Exposure - Response



The conceptual relationship between pathogen density (as measured by the indicator organisms density on log scale) and illness rate is an "S" shaped curve as depicted in Figure 1.2. At relatively low pathogen densities, illness rates rise relatively slowly but constantly (i.e., a linear "straight line"); this observed relationship is shown in more detail in Figure 1.3. At some point as pathogen density reaches relatively high levels, the relationship intensifies and the corresponding illness rate rises sharply. At extremely high pathogen densities, the illness rate would again increase slowly, as it has already reached an acute epidemic level. The data supporting EPA's bacteria criteria fit linear regression models well, and

Table 1-1 Water Quality Criteria for Bacteria for Fresh Recreational Waters

Enterococci Criteria

Risk Level (% of swimmers)	Geometric Mean Density (per 100 ml)	Upper Percentile Value Allowable Density (per 100 ml)			
		75th Percentile	82nd Percentile	90th Percentile	95th Percentile
0.8	**33**	62	79	107	151
0.9	**42**	79	100	137	193
1.0	**54**	101	128	175	247

***E. coli* Criteria**

Risk Level (% of swimmers)	Geometric Mean Density (per 100 ml)	Upper Percentile Value Allowable Density (per 100 ml)			
		75th Percentile	82nd Percentile	90th Percentile	95th Percentile
0.8	**126**	236	299	409	576
0.9	**161**	301	382	523	736
1.0	**206**	385	489	668	940

are considered to characterize the initial "flat" portion of the conceptual dose-response relationship described above, where illness rates are relatively low (e.g., at the 1%-2% risk level range). While EPA recognizes that this range has generally represented an acceptable risk level for protection of recreational waters, it is important to ensure that the selected criteria do not extend beyond the demonstrated range of the linear dose-response relationship to avoid the potential of incurring risk well beyond this range (i.e., extending into the range where illness rate rises sharply).

The relationship between risk levels and fresh water bacteria densities is based on observed epidemiological data. The data points and the resultant regression line derived from the *E. coli* data are displayed in Figure 1.3. For *E. coli*, the maximum observed bacterial density was 236/100ml (this density corresponded to an illness rate of 14.7/1000 swimmers). Figure 1.3 clearly shows that, based on the regression line, any risk level chosen above 1.0% (e.g., 10 illnesses per 1000 swimmers) would result in a bacteria density greater than the observed data range.

Figure 1.3 *E. coli* and Illness Rates

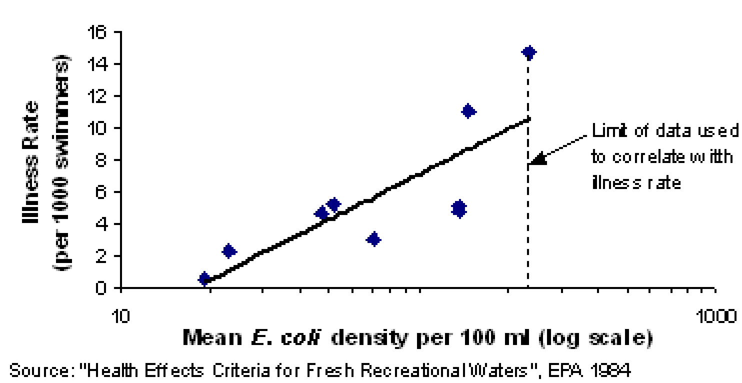
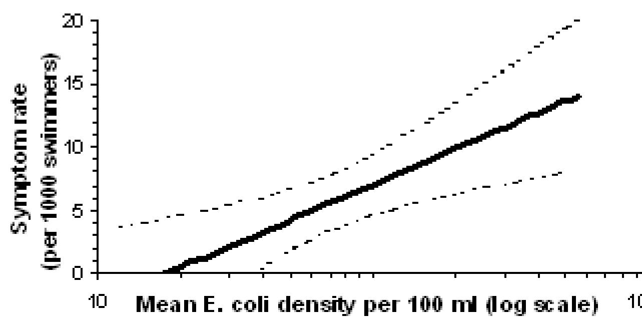


Table 1-2 Water Quality Criteria for Bacteria for Marine Recreational Waters

Enterococci **Criteria**

Risk Level (% of swimmers)	Geometric Mean Density (per 100 ml)	Upper Percentile Value Allowable Density (per 100 ml)			
		75th Percentile	82nd Percentile	90th Percentile	95th Percentile
0.8	**4**	13	20	35	63
0.9	**5**	16	24	42	76
1.0	**6**	19	29	50	91
1.1	**8**	23	35	61	110
1.2	**9**	28	42	73	133
1.3	**11**	34	51	89	161
1.4	**14**	41	62	107	195
1.5	**17**	49	75	130	235
1.6	**20**	60	91	157	284
1.7	**24**	72	109	189	344
1.8	**29**	87	132	229	415
1.9	**35**	104	158	276	501

Figure 1.4 Confidence Limits



Source: "Health Effects Criteria for Fresh Recreational Waters", EPA 1984

Another way of conveying the limits of extrapolating the data is by showing the associated statistical confidence limits around the linear relationship. For any given density the risk level falls within the range characterized by the confidence limits. Consequently, the precise risk level resulting from a specific density is somewhat unknown. However, as indicator densities increase beyond the densities observed in the studies the confidence that those densities correspond to a risk level along the regression line decreases (this is shown in Figure 1.4). In other words, selecting a risk level greater than 1.0% could potentially result in many more illnesses occurring than the regression line relationship would imply. Figure 1.4 also demonstrates that the difference among illness rates in the "flat" portion of the curve is actually much smaller than is often perceived. In general, any given indicator density is associated with a specific illness rate plus or minus approximately 3 illnesses per 1000 swimmers.

While EPA acknowledges that states and authorized tribes may wish to adopt criteria for both fresh and marine recreational waters associated with risk levels of up to 1.9% of swimmers to protect their waters designated for primary contact recreation (consistent with EPA's 1986 recommendations for marine waters), for the reasons described above EPA recommends that states and authorized tribes adopt fresh water criteria based on risk levels at or below 1.0%. Further discussion on this topic is contained in section 3.1.1.

There has been confusion surrounding the use of several terms related to EPA's 1986 bacteria criteria. First, the use of the term 'illness rate' implied a precision in predicting risk that current data do not support. There is a certain degree of uncertainty and variability associated with illness rates and indicator densities (as shown in Figure 1.4), and the term 'risk level' better captures the true meaning of the concept. In addition, the term 'single sample maximum' was named with its primary use in mind, i.e., beach monitoring. In those situations, an unacceptably high value for any given individual sample may trigger a beach advisory or closing. The 'single sample maximum' values allow beach managers to quantitatively determine when water quality at a particular site is likely not associated with long-term protective conditions (i.e., they are less likely to be associated with the protective central tendency). Implementation of this 'single sample maximum' is not limited to its use as a 'value not to be exceeded' when referring to attainment decisions and national pollutant discharge elimination system (NPDES) permitting under the Clean Water Act. A number of states and authorized tribes have incorporated the value in their attainment decisions and permitting. This is one acceptable approach to implementing bacteria criteria. Because 'single sample maximum' has led to confusion, EPA is dropping the use of the term in favor of the more statistically correct term "upper percentile value."

In terms of criteria setting, the targeted level of protection is the risk level, and the most direct relationship between measurements of bacteria levels and risk level is the geometric mean of measurements taken over the course of a recreation season. The best way to interpret a series of bacterial measurements taken over a period of time is in comparison to the geometric mean, and the best way to interpret any single measurement (or small number of measurements) is in comparison to the upper percentile value associated with the distribution around the geometric mean. For each geometric mean value, four different upper percentile values were identified based on the distribution of the observed data. These range from the 75th to the 95th percentiles (see appendix C for more discussion of this topic).

Percentiles describe the relative position of values in a distribution. For example, the upper 95th percentile represents the point where only 5 percent of the samples exceed, while 95 percent of the samples fall below this value. EPA recommends that states and authorized tribes acquire enough sample data to calculate site-specific upper percentile values to best characterize water quality for waters where greater precision in assessing risk and responding appropriately is particularly important (e.g., frequently used bathing beaches). Doing so would mean that local and state authorities do not have to rely on the assumption that the frequency distributions observed in EPA's epidemiological studies are representative of a particular waterbody. If a state or authorized tribe chooses not to calculate site-specific upper percentile values (or if the dataset is not robust enough) the upper percentiles derived by EPA should be used. Calculations and procedures for generating waterbody-specific upper percentile values are described in Appendix C.

1.6 Is EPA planning on conducting additional epidemiological studies in the future?

The BEACH Act of 2000 requires EPA to perform an assessment of potential human health risks resulting from exposure to pathogens in coastal recreation waters. To meet this requirement, EPA is conducting additional epidemiological studies that may be used to revise and develop new water quality criteria for pathogens and pathogen indicators (See CWA §§104, 304(a) (33 U.S.C. 1254; 33 U.S.C. 1314); Section 2 contains more information on the BEACH Act of 2000 and EPA's BEACH program. Appendix A contains the full text of the BEACH Act of 2000). Future epidemiological studies and evaluation of new indicators and methods may provide new information to support the protection of recreation waters. EPA is conducting epidemiological studies to support the development of new water quality indicators and associated water quality criteria guidelines for recreational waters. The epidemiological studies will examine the illness rates in families with children as they relate to microbial contaminant levels in fresh and marine recreational waters. The studies will evaluate exposure to and effects of illness from microbial pathogens in recreational waters. A range of water quality indicators will be monitored in fresh and marine recreational waters. Recreational waters included in the study have been selected based on potential number of beach-goers, water quality, and sources of microbial pathogens to the water (domestic sewage versus animals). Pilot studies were conducted in summer 2002 and full-scale studies began in 2003 with completion scheduled for the end of the 2006 fiscal year. Pending their results, new criteria for the protection of recreation waters may be developed following the completion of these studies.

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2. Relationship Between Water Quality Standards and Beach Monitoring and Advisory Programs

CWA §303 requires states and authorized tribes to adopt water quality standards for waters of the United States within their jurisdiction sufficient to "protect the public health or welfare, enhance the quality of water and serve the purposes of [the CWA]." Further, §303(c) specifies that water quality standards shall include the designated use or uses to be made of the water and water quality criteria necessary to protect those uses. EPA has an oversight role in this process. EPA's implementing regulations at 40 CFR 131.11 require water quality criteria to be based on sound scientific rationale and to contain sufficient parameters to protect designated uses. States and authorized tribes may adopt water quality criteria based on EPA's recommended water quality criteria developed under §304(a) of the CWA or those based on other scientifically defensible methods.

EPA's current §304(a) criteria are used as the basis for Agency decisions, both regulatory and nonregulatory, until EPA revises and reissues pollutant-specific §304(a) criteria. EPA's §304(a) criteria serve two distinct purposes: (1) as guidance to states and authorized tribes in the development and adoption of water quality criteria which will protect designated uses, and (2) as the basis for promulgation of a superseding federal rule when such action is necessary. Once adopted by a state or authorized tribe into their water quality standards, or promulgated by EPA for a state or authorized tribe, the water quality criteria are used to establish national pollutant discharge elimination system (NPDES) water quality-based permit limits, to assess the attainment of water quality, and to provide the basis upon which total maximum daily loads (TMDLs) are developed.[3]

In addition to the purposes served by the state or tribal-adopted water quality criteria for bacteria listed above, some beach monitoring and advisory programs have used the state or authorized tribe's bacteriological criteria adopted into the state's or authorized tribe's water quality standards to issue beach advisories and make opening and closure decisions for identified beach areas. In general, waters designated for primary contact recreation within a state or authorized tribe's water quality standards comprise a much larger group of waterbodies than those falling under the purview of a state or tribal beach monitoring program. While waters designated for primary contact recreation may consist of a majority of a state or tribe's waters and may vary in type from remote streams to well-known and highly managed beach areas, beach programs generally focus on the latter subset.

EPA recommends beach programs use the state or tribal adopted water quality standards for beach advisories. EPA encourages coordination between state and tribal water quality standards programs and beach monitoring and advisory programs. For states and authorized tribes with coastal recreation waters, use of water quality standards that can be approved by EPA under CWA §303(c) for beach monitoring and notification is a requirement for receiving a grant under CWA §406.

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[3]After a waterbody has been placed on a list by a state or authorized tribe for not attaining its water quality standards, a TMDL, which is an analysis apportioning pollutant loads to sources of the pollutant causing the impairment, is usually developed.

Although these relationships exist between water quality standards and beach monitoring and advisory programs, the use of bacterial water quality monitoring data as part of beach monitoring and advisory programs may differ slightly to account for some of the inherent differences between the two programs. For example, because a beach manager must make decisions based on water quality on a given day or weekend, he or she should focus more on recently collected data to determine whether a swimming advisory should be issued. Further, for beach programs, beach managers may wish to consider other types of data in addition to water quality data. This may include considering rainfall data when notifying the public that the standards have been exceeded or are expected to be exceeded. A recent EPA-funded study in Massachusetts at Boston Harbor beaches found that because the time necessary to obtain water quality monitoring results is at least 24 hours, levels of enterococci measured on the previous day were not always predictive of the water quality that existed when the monitoring results became available. The study found that using water quality data in conjunction with rainfall data as the basis for posting swimming advisories resulted in more accurate postings (MWRA, 2001).

The Environmental Monitoring for Public Access and Community Tracking (EMPACT) Program was established by EPA with the goal of helping communities bring to citizens up-to-date local environmental information they can understand and use in making daily decisions about protecting their health and environment. EPA's Office of Water and Office of Research & Development jointly conducted a study under the EMPACT program in 2002 to provide information on the various monitoring and sampling factors at beaches that were seen to have some association with indicator density. Five beaches participated in the study, including two freshwater, two marine, and one estuarine beach. The freshwater samples were analyzed for *E. coli*, while the marine and estuarine water samples were analyzed for enterococci. This project examined several beach environments to determine the factors that most influence the measurement of beach water quality and to define which characteristics are most significant with regard to monitoring approaches and protecting human health. Preliminary results from the study show little correlation between the 30 day rolling geometric mean and individual water quality measurements on subsequent days. The study showed that, given current analytical method procedures, the best predictor of tomorrow's condition would be today's measurement alone, and that the greater the period of time between measurements, the less their predictive value (USEPA, 2003).

The authority for administering beach programs varies among states and tribes and may rest with state, tribal, county, or municipal government. When the governmental body with the responsibility and authority for a beach monitoring and advisory program differs from the state or tribal water quality standards program, EPA encourages coordination of these programs to ensure the greatest efficiency and consistency in monitoring and data collection. Additional information on the use of EPA's recommended criteria for bacteria in beach monitoring and notification programs can be found in EPA's *National Beach Guidance and Required Performance Criteria for Grants* (EPA 823-B-02-004).

2.1 What is the BEACH Act of 2000 and how does it apply to waters designated for recreation under a state or tribe's water quality standards?

On October 10, 2000, the Beaches Environmental Assessment and Coastal Health Act (BEACH Act of 2000) was passed, amending the Clean Water Act to provide for monitoring of coastal recreation waters and public notification when the applicable water quality standards are not met or are not expected to be met. As defined by the Act, coastal recreation waters are the Great Lakes and marine coastal waters (including coastal estuaries) that are designated under CWA §303(c) by a state for use for swimming, bathing, surfing, or similar water contact activities. The BEACH Act of 2000 contains three significant provisions, summarized as follows:

1. The BEACH Act of 2000 amended the CWA to include §303(i), which requires states that have coastal recreation waters to adopt new or revised water quality standards by April 10, 2004, for those pathogens and pathogen indicators for which the [EPA] Administrator has published criteria under CWA §304(a). Criteria using those indicators must be as protective as the criteria published by EPA under CWA §304(a). See CWA §303(i)(1)(A). The BEACH Act of 2000 further directs EPA to promulgate such standards for states that fail to do so. See CWA §303(i)(2)(A).

2. The BEACH Act of 2000 amended the CWA to require EPA to study issues associated with pathogens and human health and, by October 10, 2005, to publish new or revised CWA §304(a) criteria for pathogens and pathogen indicators based on these studies. See CWA §104(v). Within 3 years after EPA's publication of the new or revised §304(a) criteria, states that have coastal recreation waters must then adopt new or revised water quality standards for all pathogens and pathogen indicators to which EPA's new or revised §304(a) criteria apply. See CWA §303(i)(1)(B).

3. The BEACH Act of 2000 amended the CWA to include a new section, §406, which authorizes EPA to award grants to states and authorized tribes for the purpose of developing and implementing a program to monitor for pathogens and pathogen indicators in coastal recreation waters adjacent to beaches that are used by the public, and to notify the public if water quality standards for pathogens and pathogen indicators are exceeded or likely to be exceeded. To be eligible for the implementation grants, states and authorized tribes must develop monitoring and notification programs that are consistent with performance criteria published by EPA under the Act. These performance criteria are contained in EPA's *National Beach Guidance and Required Performance Criteria for Grants*. Development grants were made available to all eligible states in 2001 and 2002. The first implementation grants were awarded in 2003. The BEACH Act of 2000 also requires EPA to perform monitoring and notification activities for waters in states that do not have a program consistent with EPA's performance criteria, using grants funds that would otherwise have been available to those states. See CWA §406(h). For the full text of the BEACH Act of 2000, see Appendix A.

2.2 How will EPA determine if a state's water quality standards for coastal recreation waters are as protective of human health as EPA's 1986 water quality criteria for bacteria for purposes of §303(i)?

As described in section 2.1, the BEACH Act of 2000 requires states with coastal recreation waters to adopt water quality criteria for bacteria as protective of human health as the criteria published by EPA under §304(a) of the Clean Water Act. This statutory provision refers to EPA's *Ambient Water Quality Criteria for Bacteria*-1986. EPA will assess the protectiveness of a state's water quality standards in light of this requirement codified in CWA §303(i), for state criteria applying to coastal and Great Lakes states. As part of EPA's assessment of a state's water quality standards for pathogens and pathogen indicators, EPA will include consideration of whether a state's standards:

1. Are based on EPA's recommended indicators;
2. Are derived from a scientifically defensible quantitative link to an acceptable risk level (as indicated by *Ambient Water Quality Criteria for Bacteria*-1986), and;
3. Identify and account for the statistical variability in bacterial monitoring (e.g., specify appropriate use of the geometric mean and upper percentile values)

When determining what criteria are appropriate for coastal recreation waters, states and tribes have two major risk management decisions to make: (1) what risk level is acceptable, and (2) how to use the corresponding geometric mean and upper percentile values for assessing monitoring data and establishing source controls. With respect to the first major risk management decision, states retain some flexibility to determine an acceptable risk level within the context of the requirement that states adopt water quality standards "as protective of human health as the criteria for pathogens and pathogen indicators for coastal recreation waters published by the Administrator". That flexibility is constrained by the bounds of acceptable risk levels identified in *Ambient Water Quality Criteria for Bacteria*-1986. Under the heading "Basis of Criteria for Marine and Fresh Recreational Waters", EPA's 1986 bacteria criteria document identifies the definition of "recreational water quality criterion" as a "quantifiable relationship between the density of an indicator in the water and the potential human health risks involved in the water's recreational use". The text further explains that "*from such a definition*, a criterion now can be adopted by a regulatory agency, which establishes upper limits for densities of individual bacteria in waters that are associated with acceptable health risk for swimmers" (emphasis added). In describing monitoring recommendations, the document refers to an assumption that "an acceptable risk level has been determined *from the appropriate criterion*" (emphasis added). Thus, it is clear from the criteria document itself that the published *criteria* is the *relationship* between indicator density and risk, coupled with the choice of an acceptable risk level. This is consistent with EPA's view of human health criteria for toxic effects, where the Agency recommends that states and tribes choose an acceptable cancer risk level (i.e., between 10^{-5} and 10^{-6} as long as no sub-population is exposed to greater than 10^{-4} risk).

With respect to identifying an acceptable risk level, *Ambient Water Quality Criteria for Bacteria* - 1986 includes an estimate of the historically accepted illness rate associated with the previously recommended fecal coliform criterion as a geometric mean value. Based on ratios of *E. coli* and enterococci to fecal coliform densities, the historically accepted risk levels were estimated to be 0.8% of swimmers at fresh water beaches and 1.9% of swimmers at marine beaches. However, the analysis upon which these estimates is based is inherently uncertain because there was not an underlying correlation between illness rate and fecal coliform density. These risk levels were used to calculate the specific bacteria density values presented in tabular form in the 1986 criteria document, with associated text stating: "While this [risk] level was based on the historically accepted risk, it is still arbitrary insofar as the historical risk was itself arbitrary." Given that the intended *target* of the 200 fecal coliforms per 100 ml criterion was no detectable risk (with respect to statistical significance), "arbitrary" may not be the best description of the historical risk. Nonetheless, it is clear that there is a lack of precision and uncertainty around estimating the *actual* historically accepted risk level. Furthermore, it is also clear that the specific values presented in tabular form in the 1986 criteria document represent but one acceptable choice of risk level to apply to the criterion.

In defining the range of acceptable choices of risk level for coastal recreation waters, there are two considerations. The first is consideration of the estimated actual historically accepted risk levels as provided in the 1986 criteria document. Given that the estimates were independent, and that there is no reason to believe that the acceptable risk level should be any different in fresh water beaches than in marine beaches, consideration of the range between 0.8% and 1.9% of swimmers is appropriate for all coastal recreational waters. However, the second, and more important, consideration is assurance that the risk level remains low and represents conditions in the linear "flat" portion of the dose-response curve, as described in Chapter 1 of this guidance. Here, limits of data extrapolation constrain the risk level range to 0.8%-1.0% of swimmers for fresh waters to assure that the risk level remains on the linear portion of the dose-response curve.

In terms of the second major risk management decision for coastal recreation waters, states have the flexibility to choose a specific upper percentile value that corresponds with the selected risk level within the range of values presented in *Ambient Water Quality Criteria for Bacteria*-1986 (i.e., 75^{th} to 95^{th} percentile). Selecting a lower upper percentile (e.g., 75%) for comparison to single measurements will result in a more conservative estimate of whether the measurement is associated with a given distribution around a geometric mean value. This may result in a greater number of "false positive" determinations (i.e., bias toward concluding that criteria are not being met). In contrast, selecting a higher upper percentile (e.g., 95%) for comparison to single measurements will result in a less conservative estimate of whether the measurement is associated with a given distribution around a geometric mean value. This may result in a fewer number of "false positive" determinations. As explained in *Ambient Water Quality Criteria for Bacteria* - 1986, under the heading "Recommendations on Bacterial Criteria Monitoring" EPA considers the range from the 75^{th} to the 95^{th} percentiles to represent an appropriate balance between "false positives" and "false negatives" for determining whether or not bacteria levels represent an unacceptable risk to bathers.

The table of "single sample maximum" values presented in the 1986 criteria document included qualitative descriptors of beach usage associated with different confidence levels (USEPA 1986). This represents one approach to risk management, one that reflects a strong bias toward avoiding the potential for greater numbers of illnesses at more heavily used recreational waters. In practice, the choice of an upper percentile depends on several considerations, including the degree of confidence that the variability associated with the standard deviation accurately reflects the variability at the site [i.e., if the site (or group of recreational waters) exhibits enormous variability in bacteria levels, then a lower upper percentile (e.g., 75%) may be more appropriate, at least until a site-specific standard deviation is determined].

EPA will review state and tribal submissions of section 303(i) standards for coastal recreation waters for the adoption of both a geometric mean and upper percentile value. Because the criteria are used for several purposes under the CWA, adoption of both a geometric mean and an upper percentile value will give states and authorized tribes the necessary components to best implement their adopted criteria for developing water quality-based effluent limits, determining whether a waterbody is attaining its water quality standards, and issuing beach notifications and advisories. Section 3.1 contains a discussion of how water quality standards might be written to accomplish this. In some circumstances, after evaluation of their monitoring data for a particular waterbody, states and authorized tribes may conclude that, while the geometric mean is consistently met, the distribution of water quality data is such that the upper percentile values are routinely exceeded. In this case, as described in *Ambient Water Quality Criteria for Bacteria*–1986, a state or authorized tribe may calculate a standard deviation specific to the waterbody and subsequently adopt upper percentile values based on the observed distribution of data into water quality standards. For any state or authorized tribe choosing this option, data used should be sufficient in number and representative of the waterbody, and should demonstrate that the waterbody is meeting its geometric mean requirement. Additional information on calculating waterbody-specific upper percentile values is contained in Appendix C.

2.2.1 How should the water quality criteria for bacteria be used in beach monitoring and notification programs?

States, authorized tribes, and local governments carrying out beach monitoring and notification programs under CWA §406 monitor certain coastal recreation waters for attainment of applicable water quality standards, and notify the public whenever those standards are exceeded or are likely to be exceeded. EPA recommends that states and tribes use only the upper percentile value as the basis for making public notification decisions. The geometric means expressed in EPA's criteria represent a central tendency over the course of an entire swimming season (e.g., several months). As such, water quality measurements taken on any given day could be above the geometric mean and still represent conditions that are protective of the primary contact designated use over the course of the swimming season, as long as they are balanced with measurements that fall below the geometric mean. Thus, comparing an individual water quality measurement to a long term geometric mean could result in beach closures nearly half the time at a beach which has sufficiently protective conditions over the course of the entire season and where the use would ultimately not be deemed impaired.

Use of collective data from shorter periods of time than an entire season (e.g., 30 day rolling geometric means) may likewise be of limited utility. As mentioned above, preliminary results from the EMPACT study show little correlation between the 30 day rolling geometric mean and individual water quality measurements on subsequent days. The study showed that, given current analytical method procedures, the best predictor of tomorrow's condition would be today's measurement alone, and that the greater the period of time between measurements, the less their predictive value (USEPA, 2003). The most appropriate basis for comparison of individual or one day's measurements is an upper percentile value. Individual measurements on a given day that fall outside the bounds of the expected frequency distribution (or above specified upper percentile values) have a high probability of representing water quality that is not associated with long-term protective conditions (i.e., they are less likely to be associated with the protective central tendency). The geometric mean is most useful in indicating long term water quality conditions, especially chronic pollution. Frequent excursions from the geometric mean will likely indicate that a chronic contamination problem exists and that a sanitary survey should be conducted to determine the cause.

When a bacterial concentration exceeds the appropriate component of a water quality standard, a state, tribe, or local government should immediately either issue a public notification, or resample if there is reason to doubt the accuracy or certainty of the first sample (for more information, refer to the *National Beach Guidance and Required Performance Criteria for Grants* discussion in Section 4.2.1, When to Conduct Additional Sampling).

- If the results of a sampling effort are determined to be accurate and standards are indeed being exceeded, the agency must issue its public notification. Notification should remain in effect until resampling indicates that water quality standards are no longer being exceeded and approved quality control requirements are being met for sample accuracy. When standards are no longer being exceeded the basic sampling approach may be resumed, provided no heavy rainfall or other pollution events have occurred.
- Resampling is acceptable after a state or tribal water quality standard has been exceeded, if there is reason to doubt the accuracy or certainty of the first sample, based on predefined quality assurance measures. EPA recommends that additional samples be taken as soon as possible if the first sample exceeds water quality standards.

Note: The above are requirements for those states receiving grants under the BEACH Act of 2000. EPA recommends that states not receiving beach grants follow the same procedures.

EPA's *National Beach Guidance and Required Performance Criteria for Grants* also contains detailed information and recommendations regarding when and how to provide public notification for beaches covered under the state or authorized tribe's program. EPA recommends a "tiered" beach classification system in which beaches are sorted into various tiers, depending on beach risk and/or amount of use. Further, CWA §406 requires states, authorized tribes, and local governments to prioritize the use of grant funds for monitoring and notification programs based on the use of the waterbody and the risk to human health presented by pathogens or pathogen indicators. Thus, "Tier 1" would include those beaches likely to have the greatest risk and/or highest use. Under this approach, the specific notification actions and sampling frequency may be tailored to each category. In areas where regular monitoring occurs less frequently, monitoring should be conducted as soon as possible after a single, very high sample is detected. If a state, authorized tribe, or local government has developed a good quality assurance/quality control plan, requiring the collection of replicate samples would provide it with further information with which to assess whether the observed high bacteria level is representative of conditions or is an "outlier." In general, EPA recommends that states, tribes, and local governments monitor most often at the Tier 1 and Tier 2 beaches. More information on the prioritization and tiering of beaches is available in the *National Beach Guidance and Required Performance Criteria for Grants*.

In addition to the available EPA-approved methods for enumerating E. coli and enterococci in ambient waters, EPA is investigating several additional ambient water quality monitoring methods for bacteria that are easily portable and relatively inexpensive, which should facilitate states', authorized tribes', and local governments' ability to conduct additional monitoring should the need arise. More discussion on analytical methods is provided in section 4.5.

The approach outlined above will meet the BEACH Act requirement that states adopt water quality standards for their coastal waters "as protective of human health as" EPA's recommendations. In using this approach, states will achieve the protection of recreational waterbodies consistent with EPA's criteria recommendations.

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3. Appropriate Approaches to Managing Risk in Recreational Waters

Recreation occurs in many forms throughout the United States and frequently centers around waterbodies and activities occurring in and on the water. To protect the public while recreating in surface waters, states and authorized tribes have adopted primary contact recreation uses and bacteriological criteria for the majority of waterbodies in the United States. Pursuant to federal regulations, primary contact recreation uses must be adopted for waterbodies unless such uses are shown not to be attainable. Further, primary contact recreation uses must be adopted wherever necessary to protect such uses downstream. See 40 CFR 131.10(b), 40 CFR 131.10(j).

EPA recommends states and authorized tribes help assure protection of recreational waters through:

- frequent monitoring of known recreation areas to establish a more complete database upon which to determine if the waterbody is attaining the water quality criteria;
- assuring that where mixing zones for bacteria are authorized, they do not impinge upon known primary contact recreation areas; and
- conducting a sanitary survey when higher than normal levels of bacteria are measured.

Sanitary surveys are an important element of protecting recreational waters and have long been used as a means to identify potential sources of contamination. A sanitary survey is an examination of a watershed to determine if unauthorized sanitary discharges are occurring from sources such as failed septic tank leach fields or cesspools, sewage leakage from broken pipes, sanitary sewer overflows from hydraulically overloaded sewers, or overflows from storm sewers that may contain illegal sanitary sewer connections. The survey should use available public health and public works department records to identify where such septic tanks and sewer lines exist so that observations are focused in the right places. A sanitary survey might also use dyes or other tracers in both dry and wet weather to see if unauthorized discharges are occurring from septic tanks and sewers. In addition, EPA recommends that sanitary surveys identify other possible sources, including confined animal areas, wildlife watering points, and recreational spots, such as dog running/walking areas, since these are also sources of fecal pollution. Additional guidance for conducting sanitary surveys may be found in several sources: The *National Beach Guidance and Required Performance Criteria for Grants* contains a section discussing the use of sanitary surveys in recreational waters and contains a summary of recent publications on the subject. Additional resources include the *Guidance Manual for Conducting Sanitary Surveys of Public Water System* (USEPA, 1999), the *National Shellfish Sanitation Program Model Ordinance* (NSSP, 1999), and California's *Guidance for Salt Water Beaches* (draft) and *Guidance for Fresh Water Beaches* (draft) (CA DHS, 2000a; CA DHS, 2000b).

Sanitary surveys, in addition to being a tool that can be used to identify sources of contamination, can provide useful data in characterizing a recreational waterbody and determining the relative contributions of fecal pollution sources. This type of information can be useful in deciding how to control sources as well as in providing useful information to a state or authorized tribe that may be contemplating a change to the recreational use. While many waters are suitable for recreation of some sort, there are circumstances where primary contact recreation may not be attainable. This section identifies these situations and provides recommendations to appropriately protect these waters.

3.1 Where should the primary contact recreation use apply?

States and authorized tribes should designate primary contact recreation and adopt water quality criteria to support that use unless it is shown to be unattainable, to reduce the risk of gastrointestinal illness in recreators. In particular, states and authorized tribes should assure that primary contact recreation uses are designated for waterbodies where people engage, or are likely to engage, in activities that could result in ingestion of water or immersion. These activities include swimming, water skiing, kayaking, and any other activity where contact and immersion in the water are likely. Certain conditions, such as the location of a waterbody, high or low flows, safety concerns, or other physical conditions of the waterbody may make it unlikely that these activities would occur. However, states and authorized tribes should take into consideration that there will be individuals, particularly children, who may be more likely to swim or make other use of the waterbody such that ingestion may occur. States and authorized tribes should take those populations into account when making designated use determinations.

3.1.1 What water quality criteria for bacteria should states and authorized tribes adopt to protect waters designated for primary contact recreation?

In adopting criteria to protect primary contact recreation waters, EPA recommends states and authorized tribes use enterococci and/or *E. coli* criteria based on a risk level no greater than 1.0% in fresh waters and no greater than 1.9% for marine waters, based on the limits of available data. These recommendations are described in section 1.5. In adopting water quality criteria for bacteria to protect waters designated for primary contact recreation, states and authorized tribes should adopt both a geometric mean and an upper percentile, using the values or equations described in Appendix C, and further specify which of these components is used for various applications. An example of one approach states and tribes may use to formulate their standards is contained in Figure 3-1. This is just one example of an approach states and authorized tribes can take to specify appropriate usage of the criteria components; EPA encourages states and authorized tribes to work with their EPA Regional offices to develop approaches that best fit specific situations. For recommendations on refining recreation uses for waters where primary contact recreation is not attainable, see section 3.4.

Figure 3-1 Example Water Quality Standards

Primary Contact Recreation

Water Quality Criteria for Fresh Waters

Enterococci	Geometric mean:	33 / 100 ml
	75th percentile	62 / 100 ml
	95th percentile	151 / 100 ml

Water Quality Criteria for Marine Waters

Enterococci	Geometric mean:	35 / 100 ml
	75th percentile	105 / 100 ml
	95th percentile	502 / 100 ml

Assessing ambient water quality

For purposes of assessing ambient water quality of fresh surface waters designated for primary contact recreation under CWA §303(d) and §305(b), the geometric mean and upper percentile values shall be used:

- Frequently used recreational waters (including State parks and lifeguarded beaches) shall be determined to be impaired if the geometric mean is exceeded or if more than five samples exceed the 95th percentile value[1] (based on data compiled during the swimming season). The swimming season is the time from April 15 through September 15.
- All other waters designated for primary contact recreation shall be determined to be impaired if an individual sample or average daily values exceed the 95th percentile on two or more occasions over the course of the swimming season.
- The list of frequently used recreational waters is available on the state website.

Development of water quality-based effluent limits for NPDES permits

For the purposes of developing water quality-based effluent limits for NPDES permits, the geometric mean value shall be used to establish monthly average effluent limits; the upper percentile value shall be used to establish maximum daily limits.

Issuance of beach advisories

For waters of the state where beach advisories may be issued by the state or local departments of health, samples exceeding the 75th percentile value shall result in the issuance of a beach advisory or resampling until subsequent samples indicate enterococci concentrations are below this level.

1. States and authorized Tribes may use descriptive or inferential statistical procedures to make these evaluations. See section 4.3.2 for more information.

States and authorized tribes that opt to protect primary contact recreation waters with criteria associated with risk levels within the ranges outlined in section 1.5 should recognize that this is a risk management decision by the state or authorized tribe similar to the selection of alternate risk levels when adopting human health criteria for carcinogens, and thus would not require a use attainability analysis as described by the federal regulations at 40 CFR 131.10. Exercising such discretion should assure, however, that downstream uses are protected, including downstream uses across state or tribal boundaries. As with any addition or revision to a state or authorized tribe's water quality standards, any changes resulting from these risk management decisions are subject to the public participation requirements at 40 CFR 131.20(b).

In utilizing this risk management discretion, states and authorized tribes may wish to establish more than one category of primary contact recreation use. For example, Colorado has two categories of primary contact recreation use in addition to their secondary contact recreation designated use (CDPHE, 2001). The Recreation Class 1A use is the default use category, and is assigned an *E. coli* criterion of 126 colony forming units (cfu) per 100 milliliters (ml) as a geometric mean, based on a risk level of 8 illnesses per 1000 swimmers. In these waters, primary contact recreation uses have been documented or are presumed to be present. The Recreation 1B use is intended to protect waters with the potential to support primary contact recreation uses and may be assigned only if a reasonable level of inquiry has failed to identify any existing primary contact recreation uses of the waterbody. This use category is assigned an *E. coli* criterion of 206 cfu per 100 ml as a geometric mean, based on a risk level of 10 illnesses per 1000 swimmers. Finally, under Colorado regulation, the secondary contact recreation use (known as Recreation Class 2 in the Colorado water quality standards) may be assigned only where a use attainability analysis has been conducted consistent with 40 CFR 131.10 that further demonstrates there is no reasonable potential for primary contact recreation uses to occur within the next 20-year period. This use category is assigned an *E. coli* geometric mean criterion of 630 cfu per 100 ml.

3.1.2 When is it appropriate to adopt seasonal recreational uses?

A seasonal recreation use may be appropriate for those states and authorized tribes where ambient air and water temperatures cool substantially during the winter months. For example, in many northern areas, primary contact recreation is possible only a few months out of the year. Several states and authorized tribes have adopted, and EPA has approved, primary contact recreation uses and the associated microbiological water quality criteria only for those months when primary contact recreation occurs. Those states and tribes then rely on less stringent secondary contact recreation water quality criteria to protect for incidental exposure in the "non-swimming" season. The federal regulation (40 CFR 131.10(f)) allows for seasonal uses, provided the criteria adopted to protect such uses do not preclude the attainment and maintenance of a more protective use in another season.

This is an appropriate approach, particularly where treatment of discharges sufficient to meet the primary contact recreation use would result in the use of chlorine for disinfection and thus, the release of residual chlorine in the effluent. Total residual chlorine in effluents discharging to surface waters can react with organic compounds to produce disinfection by-products such as trihalomethanes. Trihalomethanes have an adverse impact on human health and aquatic life, and are consequently of particular concern in waterbodies used for drinking water and areas where aquatic life may be adversely impacted. Thus, in some cases states and authorized tribes have adopted seasonal uses to allow for the reduction or suspension of effluent chlorination during the colder months which consequently reduces risk to human health and aquatic life.

The rationale provided by states and authorized tribes to EPA to support a change in water quality standards resulting in adoption of a seasonal recreation use for a waterbody need not be burdensome. EPA's regulations do not require a formal use attainability analysis for the adoption of seasonal recreation uses. Generally, for a state or authorized tribe contemplating such a revision to its recreational water quality standards, EPA would expect that the state or authorized tribe provide information on why the particular season is being chosen. This information may include information relating to the times of year when the ambient air and water temperatures support primary contact recreation, activities in and use (or lack thereof) of the waterbody during the proposed non-recreation months, and other relevant information.

3.2 What is EPA's policy regarding high levels of indicator organisms from animal sources?

In the 1994 *Water Quality Standards Handbook*, EPA established a policy that states and authorized tribes may apply water quality criteria for bacteria to waterbodies designated for recreation with the rebuttable presumption that the indicators show the presence of human fecal contamination. This 1994 policy stated:

> States may apply bacteriological criteria sufficient to support primary contact recreation with a rebuttable presumption that the indicators show the presence of human fecal pollution. Rebuttal of this presumption, however, must be based on a sanitary survey that demonstrates a lack of contamination from human sources. The basis for this option is the absence of data demonstrating a relationship between high densities of bacteriological water quality indicators and increased risk of swimming-associated illness in animal-contaminated waters.

In short, under this policy a state or authorized tribe could justify a decision not to apply the criteria to a particular waterbody when bacterial indicators were found to be of animal origin. This policy was based on the absence of data correlating non-human sources of fecal contamination and human illness and on the belief that pathogens originating from animal sources present an insignificant risk of acute gastrointestinal illness in humans.

The position taken in the 1994 Water Quality Standards Handbook is no longer supported by the available scientific data. The available data suggest there is some risk posed to humans as a result of exposure to microorganisms resulting from non-human fecal contamination, particularly those animal sources with which humans regularly come into contact, i.e., livestock and other domestic animals. As a result, states and authorized tribes should not use broad exemptions from the bacteriological criteria for waters designated for primary contact recreation based on the presumption that high levels of bacteria resulting from non-human fecal contamination present no risk to human health.

Recent evidence indicates that warm-blooded animals other than humans may be responsible for transmitting pathogens capable of causing illness in humans. Examples include outbreaks of enterohemorrhagic *E. coli* O157:H7, *Salmonella, Giardia*, and *Cryptosporidium*, all of which are frequently of animal origin. Livestock, domestic pets, and wildlife are carriers of human pathogens and can transmit these pathogens to surface waters as well as contribute significant numbers of indicator bacteria to waterbodies.

Incidents where these pathogens have been spread to humans through water have been documented in recent years. In the case of *E. coli* O157:H7, several cases have been cited in which fecal contamination from animals was the probable source of the pathogen. The most prominent examples have included contamination of water supplies, including an outbreak in Alpine, Wyoming, in June 1998, affecting 157 people, and a major outbreak in Walkerton, Ontario, in May and June of 2000 causing more than 2,300 people to become ill and causing seven deaths (CDC, 2002; CDC, 2000; Ontario's Ministry of the Attorney General, 2000). In the former case, contamination by wildlife of the community water supply is the suspected source, and in Walkerton, Ontario, heavy rains causing agricultural runoff to leak into city wells is suspected. The 1993 Milwaukee *Cryptosporidium* outbreak is a well-known example of water supply contamination that resulted in 403,000 illnesses and approximately 100 deaths. The source of the oocysts was not identified, but suspected sources include agricultural runoff from dairies in the region, wastewater from a slaughterhouse and meat packing plant, and municipal wastewater treatment plant effluent (Casman, 1996; USDA, 1993). In addition, *Cryptosporidium* was the known cause of 15 other outbreaks associated with drinking and recreational water affecting 5,040 individuals in the U.S. between 1991 and 1994 (Gibson et al., 1998). While many of the reported outbreaks have occurred through the consumption of contaminated drinking water, other incidences of *E. coli* O157:H7 infection from exposure to surface waters have been documented. **[For example, in the summer of 1991, 21 *E. coli* O157:H7 infections were traced to fecal contamination of a lake where people swam in Portland, Oregon (Keene et al., 1994)]**

The relative health risk from waters contaminated by human sources versus non-human sources has been the subject of recent debate, particularly related to the application and implementation of EPA's recommended water quality criteria for bacteria. While **[EPA believes] that]** non-human sources are capable of transmitting pathogens that can cause the specific kinds of gastrointestinal illness identified in EPA's original epidemiological studies, the specific risk from these sources has not been fully determined. The risk presented by fecal contamination of waters by non-human sources is possibly less significant; however, the increasing number of cases described above in which animals are the likely cause of the contamination and resulting illness present a compelling case to protect waters where human contact or consumption are likely to occur. In addition, because the presence of bacterial indicators provides evidence of fecal pollution, high levels of these indicator organisms originating from animal sources may also indicate the presence of pathogens capable of causing other human illnesses in addition to acute gastroenteritis.

Animals are more likely to carry or be infected with human pathogens when those animals are in close proximity to humans and their waste. The closer the association between animals and humans, the more likely it is that human pathogens will pass back and forth between humans and animals. The more crowded an animal herd, the more likely it is that human pathogens will be shared between animals of the herd. These pathogens are transmitted to others in the herd because of the direct contact between animals and their fecal matter. Fecal contamination from these infected herds, unless sufficiently treated or contained, can find its way into surface or ground waters and present a potential exposure route for people using the contaminated waters for recreation or drinking. This scenario potentially applies not only to animal feeding operations but also to herds of wildlife (deer, for example). However, the threat from livestock herds is likely to be greater given the typical herd size and the resultant quantity of fecal wastes. Wild herds are typically more dispersed and smaller and therefore likely represent a smaller risk to watersheds. In addition, wildlife are not typically in routine daily contact with humans, as may be the case for livestock and other domestic animals.

It is essential that states and authorized tribes provide recreators with an appropriate level of protection in their water designated for recreational uses. Based on increased knowledge of the potential hazards associated with animal wastes, fecal contamination from all sources should be considered and evaluated for their relative risk contribution. The current state of knowledge regarding risk from wildlife sources is limited: it is apparent there is some risk, but that risk has not been quantified adequately. However, **[EPA believes that]** livestock and other domestic animals have the potential to pose a more substantial risk to humans than wildlife. This is based partly on the quantities of waste generated by herds of livestock, but also on the knowledge that domestic animals are more likely to carry human pathogens in general and carry a larger number of human pathogens than most species of wildlife. Therefore, at a minimum, it is appropriate to account for bacteria from all non-wildlife sources in state and authorized tribal water quality standards. Alternatively, states and authorized tribes may choose to provide their designated bathing areas with a more protective approach which accounts for all sources of bacteria, including wildlife. Such an approach may be appropriate in special cases where states and authorized tribes believe wildlife may contribute to disease in humans because of unique circumstances associated with, for example, their number, species, and/or proximity to human populations.

There are several ways to accomplish this. The option that takes full advantage of the public participation process would be to create a subcategory of primary contact recreation that accounts for the potential impact of fecal contamination from wildlife sources (i.e., create a separate "wildlife impacted recreation use" with a less stringent criterion). This option would allow states and authorized tribes to refine uses only where necessary. A complete discussion of this option is in section 3.4.2.

[Another way would be to simply express the criteria as "non-wildlife enterococci" or "non-wildlife *E. coli*".] The presumption for interpreting any measurement or permitting any source would be that the enterococci or *E. coli* is non-wildlife. However, if it is strongly suspected that the bacteria are solely or primarily from wildlife, then the responsible authority may conduct analysis (i.e., sanitary survey, source tracking, etc.) to determine the percent contribution of the bacteria measurement that represent wildlife bacteria (in situations where there are no human or domesticated animal sources of fecal pollution, the responsible authority could conclude that wildlife is the source of the measured bacteria). The relative contribution provided by wildlife can then be applied to the measurement prior to comparison with the protective criterion so that wildlife contributions are discounted. This approach has at least two advantages. First, with proper application, it is unnecessary to change the underlying designated use. Second, it allows continued appropriate permitting of unquestioned sources of non-wildlife bacteria, such as sewage treatment plants separate and apart from relying on antidegradation provisions. Section 3.4.2 provides more information on source tracking techniques.

Other approaches may also be appropriate, in addition to the approaches described here. EPA will work with states and authorized tribes interested in developing such approaches to assure they meet the requirements of the Clean Water Act and federal regulations. In conjunction with the non-wildlife criteria and/or reference waterbody approaches, a state or tribe may issue precautionary bathing advisories in waters where wildlife bacteria exceed the non-wildlife bacteria criteria to warn would-be recreators of the unknown and uncertain risks of exposure to human pathogens that could be associated with wildlife.

3.3 What is EPA's policy regarding high levels of indicator organisms originating from environmental sources in tropical climates?

Recent research has raised the possibility that EPA's recommended bacterial indicators, *E. coli* and enterococci, may not be appropriate for assessing the risk of gastrointestinal illness in tropical recreational waters. *E. coli* and enterococci have been found to persist in soils and waterbodies (Fujioka et al., 1999; Fujioka and Byappanahalli, 1998; Lopez-Torres et al., 1987). Some researchers have hypothesized that these bacteria have developed mechanisms to maintain viable cell populations for significant periods of time under uniform tropical conditions (Fujioka, 1998). Because of these observations, some states have expressed a concern that the use of EPA's recommended indicator organisms will result in high observed concentrations of these bacteria that are not indicative of human health risks.

3.3.1 Does EPA recommend a different indicator for tropical climates?

At this time, EPA does not recommend that states and authorized tribes use different bacterial indicators for recreational waters in tropical climates. EPA's continued recommendation to apply *E. coli* and/or enterococci criteria for the protection of recreational waters in tropical climates is consistent with existing EPA policy and has not been altered by an expert workshop held on this issue and the scientific information available to date.

In March 2001, the University of Hawaii conducted a Tropical Water Quality Indicator Workshop; EPA provided funds, assisted with planning and participated in the workshop. The workshop, which was held in Hawaii, was designed to evaluate the existing scientific body of information on the adequacy of current indicators for tropical waters. International experts who either have conducted studies or who were otherwise very familiar with the scientific database regarding *E. coli* or enterococci indicator persistence and growth in tropical environments were tasked to determine if these indicators remained appropriate for determining water quality and associated exposure risks for gastrointestinal disease in recreational waters. Participants were asked to:

- critically evaluate published findings and monitoring data related to sources, persistence, and multiplication of EPA-approved fecal indicators in tropical locations and the impact of such findings on the suitability of existing water quality criteria for these locations.

- critically evaluated published reports and other kinds of monitoring data related to the use of alternative water quality indicators in tropical locations, and
- reach conclusions on the identified problems and to provide suitable recommendations to address these problems.

The workshop resulted in four "consensus statements" (although not all were unanimous):

- Consensus Statement One: Soil, sediments, water, and plants may be significant indigenous sources of indicator bacteria in tropical waters.

- Consensus Statement Two: The inherent environmental characteristics of the tropics affect the relationships between indicators of fecal contamination (*E. coli*, fecal coliforms, enterococci) and health effects observed in bathers, which may compromise the efficacy of EPA guidelines.

- Consensus Statement Three: Fecal indicators of bacteria (fecal coliforms, *E. coli*, enterococci) can multiply and persist in soil, sediment, and water in some tropical/subtropical environments (Hawaii, Guam, Puerto Rico, south Florida).

- Consensus Statement Four (the preferred alternative): Recreational water quality guidelines for the tropics/subtropics should be supplemented with additional alternative indicators *C. perfringens*, coliphages) for watershed assessment (or sanitary survey).

- Consensus Statement Four (the alternate version): In the absence of a predominant point source pollution, recreational water quality guidelines for the tropics/subtropics should be supplemented with additional alternative indicators *C. perfringens*, coliphages) for watershed assessment (or sanitary survey).

In addition, the workshop concluded by identifying overall recommendations and research needs. The final report from this expert workshop, *Proceedings and Report, Tropical Water Quality Indicator Workshop*, was published in 2003. For additional information, go to the University of Hawaii at Manoa website at http://www.wrrc.hawaii.edu/tropindworkshop.html.

Based on EPA's participation in the workshop and review of the final report, the evidence is still not sufficiently compelling to change EPA's recommendation for states and authorized tribes to use *E. coli* or enterococci criteria to ensure protection of their tropical recreational waters. The Agency believes there currently are insufficient data and information concerning possible adverse health implications to support a recommendation for the use of different tropical indicators. EPA will consider further research to determine whether or not environmental mechanisms favoring the persistence or growth of *E. coli* and enterococci indicators impact upon correctly determining the safety of tropical recreational waters. Also, EPA is reviewing the research needs identified in the tropical indicators workshop report to decide upon an approach to pursue future research on alternative indicators that may be better suited for characterizing tropical recreational water quality.

3.3.2 What options are available to states and authorized tribes to address the applicability of EPA's recommended water quality criteria for bacteria in tropical climates?

States and authorized tribes have several options to modify their water quality standards and/or implementation procedures to address the potential for bacterial indicators to persist in tropical climates. First, a state or authorized tribe may develop water quality criteria applicable to recreational waters in tropical climates using alternative indicators. If a state or authorized tribe wishes to pursue this approach, they should apply a risk-based methodology to the development of the water quality criteria to establish a correlation between alternative indicator organism concentrations and gastrointestinal illness. This approach would be consistent with EPA's requirements for the development of scientifically defensible criteria. See 40 C.F.R. §131.11(b)(1)(iii). In addition to demonstrating a statistically significant relationship to gastrointestinal illness, an alternative indicator should be indicative of recent contamination and be detectable and quantifiable using acceptable peer-reviewed analytical methods.

Clostridium perfringens has been identified as a candidate organism having potential as a bacteriological indicator of fecal pollution. However, studies have yet to be conducted demonstrating a correlation between *C. perfringens* and the incidence of gastrointestinal illness. In addition, because *C. perfringens* forms spores that can survive for extended periods of time, EPA continues to have concerns regarding the ability of *C. perfringens* to indicate recent fecal contamination. However, for states and authorized tribes that do not wish to undertake resource-intensive epidemiological studies, *C. perfringens,* or another microorganism associated with fecal pollution may be adopted as a supplemental indicator of fecal pollution. EPA recommends the use of enterococci (expressed both as a geometric mean and upper percentile value) as the primary bacteriological indicator for marine and fresh waters (or *E. coli* for fresh waters), with a supplemental indicator of human fecal contamination if desired. For a state or authorized tribe with tropical waters that chooses this approach, the use of EPA's recommended criteria and a supplemental indicator of fecal contamination, in conjunction with site surveys, should be adequate to protect primary contact recreation. EPA will work with states and authorized tribes concerned about the applicability of EPA's recommended criteria in tropical waters on developing appropriate implementation procedures that take into account the behavior of indicator organisms in tropical climates.

Another option is the adoption of a subcategory of recreation use with appropriate criteria reflecting these natural conditions similar to the process described in section 3.4.2 for waterbodies impacted by high levels of wildlife fecal pollution. An approach such as this would be appropriate if it can be shown that primary contact recreation is not an existing use, the source of pollution is not from anthropogenic sources, and that the primary contact designated use cannot be attained due to naturally-occurring pollutant concentrations preventing the attainment of the use. (See section 3.4.2 for additional details.)

Other approaches may also be appropriate, in addition to the approaches described here. EPA will work with states and authorized tribes interested in developing such approaches to assure they meet the requirements of the Clean Water Act and federal regulations. In general, the above approaches are applicable to any tropical area with high background concentrations of indicator bacteria. However, prior to any change to water quality standards or implementation procedures, EPA strongly recommends conducting sanitary surveys in addition to bacterial indicator monitoring, especially in areas where higher than normal bacteria densities are observed during monitoring. A discussion of sanitary surveys and additional related resources is provided at the beginning of this chapter.

3.4 What options exist for adopting subcategories of recreation uses?

States and authorized tribes may adopt subcategories of recreational uses. More choices in subcategories of recreational uses allow states and authorized tribes to better tailor the level of protection to the waterbody where it is most needed, while maintaining appropriate protection for unanticipated recreation in waters where primary contact recreation is unattainable. Examples of such categories are: (1) primary contact recreation uses modified to reflect high flow situations or (2) waterbodies significantly impacted by wildlife sources of fecal contamination, where states or authorized tribes choose to take a more cautious approach in terms of expected risk to humans from wildlife sources of fecal contamination. In determining the appropriate recreational use for a waterbody, states and authorized tribes should consider that, in certain circumstances, people will use whatever waterbodies are available for recreation, regardless of the physical conditions, and that adopting a recreational use subcategory may necessitate a concurrent plan or action by the state or authorized tribe to communicate to the public the potential risks or hazards associated with recreating in certain waterbodies.

In adopting recreational subcategories with criteria less stringent than those associated with primary contact recreation, some analysis is expected. States and authorized tribes have in many circumstances designated primary contact recreation broadly for waters without conducting waterbody-specific analyses. In some instances, states may find that recreation is not an existing use.[4] In addition, if one of the six factors in 40 CFR 131.10(g) is met, recreation uses may be removed altogether. The level of analysis required will vary depending upon the type of recreation use being designated. These uses can include the designation of intermittent, secondary, or seasonal recreation uses. Subject to the provisions of 40 CFR 131.10, recreational uses other than primary contact recreation may be applicable to waters where, for example, human caused conditions combined with wet weather events cannot be remedied, or where meeting the primary contact recreation use at all times would result in substantial and widespread social and economic impact. Where states and authorized tribes have adopted uses less than primary contact recreation, federal

[4] 40 CFR 131.3(e) defines existing uses as "those uses actually attained in the waterbody on or after November 28, 1975, whether or not they are included in the water quality standards."

regulations require a re-examination every three years to determine if any new information has become available to support the designation of a primary contact recreation use. See 40 CFR 131.20.

3.4.1 When is it appropriate to modify primary contact recreation uses to reflect extreme wet weather situations?

An intermittent recreation use may be appropriate when the water quality criteria associated with primary contact recreation are not attainable due to wet weather events. The water quality criteria associated with primary contact recreation may be suspended during defined periods of time, usually after a specified infrequent hydrologic or climatic event. EPA intends this intermittent primary contact recreation use to be adopted for waterbodies in a limited number of circumstances, contingent upon a state or authorized tribe demonstrating that the primary contact recreation use is not attainable through effluent limitations under CWA §301(b)(1)(A) and (B) and §306 or through cost effective and reasonable best management practices, and meets one of the six reasons listed under 40 CFR 131.10(g).[5] The length of time the water quality criteria (and, thus, the recreation uses) should be suspended during these events should be determined on a waterbody-by-waterbody basis, taking into account the proximity of outfalls to sensitive areas, the amount of rainfall, time of year, etc.

EPA anticipates that the use of extreme wet weather exclusions associated with an intermittent recreation use will be primarily applicable to flowing waterbodies and still waters impacted by flowing waterbodies, where high flows are accompanied by high indicator levels that cannot be remedied. For example, in an urbanized watershed there may be specific times after rainfall events where bacteria criteria cannot be met even after implementation of an appropriate storm water management plan. When considering whether an extreme wet weather exclusion may be appropriate for a particular waterbody, states and authorized tribes should evaluate the effects of the wet weather events on the recreation use. For example, in some waterbodies, high flows routinely provide a highly attractive recreation environment (e.g., for kayakers), making such waters

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[5] One of the six conditions listed under 40 CFR 131.10(g) must be met in order to remove a designated use which is not an existing use, or to establish sub-categories of a use:

(1) Naturally occurring pollutant concentrations prevent the attainment of the use; or

(2) Natural, ephemeral, intermittent or low flow conditions or water levels prevent the atttainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or

(3) Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or

(4) Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasibile to restore the waterbody to its original condition or to operate such modification in a way that would result in the attainment of the use; or

(5) Physical conditions related to the natural features of the waterbody, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or

(6) Controls more stringent than those required by sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.

poor candidates for such an exclusion. In other circumstances, high wet weather flows result in dangerous conditions physically precluding recreation (e.g., arroyo washes in the arid west), thus indicating that primary contact recreation is not or should not be occurring. Waterbody flow and velocity vary greatly among waterbodies depending on a combination of many factors (such as the amount of impervious surface, slope, soil texture, vegetative cover, soil compaction, and soil moisture). The conditions affecting velocity also vary with the depth and width of the waterbody's channel. These variables affect the relationship between wet weather events and the resulting indicator levels.

Swift water conditions created by engineered flood control channels (which are constructed to reduce the incidence of flooding in urbanized areas by rapidly conveying storm water runoff to the ocean or other discharge points as efficiently as possible) provide an example of a hydrologic condition that precludes primary contact recreation. In Los Angeles county, the inherent danger of recreating in engineered flood channels during and immediately following storm events is widely recognized. Protocols have been set for locking access gates to flood control channels and preparing for possible swift-water rescues in these channels during defined, forecasted storm events. In response, a categorical UAA for all engineered flood control channels during defined storm events was developed, and the primary contact recreational use designations for engineered channels are temporarily suspended during and for 24 hours following a storm event of ½-inch per day or greater. Further, it is not feasible to restore the water body to its original condition or operate the modifications in such a way as to attain the use during the defined storm conditions.

Adoption of an extreme wet weather exclusion should be based on scientific assessment and should reflect public input. If the waterbody is impacted by combined sewer overflows, the supporting analysis for any water quality standards revision should be consistent with, or reflected in, the Long Term Control Plan (LTCP). Additionally, such an exemption should apply on a case-by-case basis (rather than state-wide, for example), should be tailored to the waterbody (rivers, as distinct from lakes), and should clearly identify the situation where it applies. For flowing waters, one approach is to specify the flow conditions when an exceedance may be allowed. Alternatively, for either flowing or still waters, a state or authorized tribe may identify specific rainfall events, after which the bacteriological criteria may be exceeded for a limited time. In general, flow itself may not correspond well to increases in bacterial density associated with storm runoff. Typically, the highest spike will occur early in the hydrograph (i.e., at the "first flush") prior to peak storm flow.

If a state or authorized tribe adopts an intermittent recreation use with an extreme wet weather exclusion, it should address several questions:

- Will other uses of the waterbody continue to be protected even when the exclusion is triggered?
- Would the conditions during these events attract recreational uses (including kayaking) that typically occur during high velocity flows?
- What triggers the exclusion and for how long would the exclusion apply and how was the length of time determined?
- Will the state or authorized tribe adopt the exclusion as a condition/ criteria,

or create a recreational subcategory that correlates to the exclusion?

- Has there been a demonstration that one of the factors relating to establishing a subcategory of use (40 CFR 131.10(g)) has been met?
- Have cost-effective and reasonable best management practices been considered?

States and authorized tribes designating a waterbody with an intermittent recreation use, or some other subcategory of primary contact recreation (such as an extreme wet weather exclusion), should include provisions for maintaining and protecting the primary contact recreational use when normal conditions prevail and for protecting downstream uses. EPA envisions that states and authorized tribes could apply a methodology on a site-specific basis using the waterbody channel and landscape characteristics. States and authorized tribes could also create a subcategory of the recreational uses to which the exclusion would apply. As with other changes in designated uses, the public must have an opportunity to comment on the proposed revision to the water quality standard before a state or authorized tribe adopts and submits it to EPA for approval or disapproval under CWA §303(c).

For states and authorized tribes using this approach, EPA encourages the development of a plan to communicate to the public the conditions under which recreation should not occur. For waterbodies that are known to be beaches or heavily used recreation areas, EPA encourages caution in adopting intermittent suspensions of the primary contact recreation use. If the state or authorized tribe finds after public comment that such a revision to water quality standards for a beach area is supported, EPA encourages beach managers to issue advisories during the exclusion conditions unless monitoring data are collected indicating it is safe to recreate. This is the most appropriate implementation measure for those waters heavily used for recreation since the adoption of such an exclusion presumes that, under the conditions specified by the state or authorized tribe, the bacteriological criteria will be exceeded and, thus, may present a hazard to swimmers.

Further guidance on refining water quality standards specifically for combined sewer overflow receiving waterbodies is contained in the *Coordinating CSO Long-Term Planning With Water Quality Standards Reviews* (USEPA, 2001).

3.4.2 When is it appropriate to adopt wildlife impacted recreation uses?

In addition to the option outlined in section 3.2, states and authorized tribes may refine designated uses if it can be demonstrated that primary contact recreation is not an existing use and natural sources preclude the attainment of water quality criteria related to that use. Prior to exercising this option, a state or authorized tribe should gather data to address the following questions:

- Is the waterbody publicly identified, advertised, or otherwise regularly used or known by the public as a beach or swimming area where primary contact recreation activities are encouraged to occur?

- What is the existing water quality? If it is not currently meeting the applicable recreational water quality standards, do the exceedances occur on a seasonal basis, in response to rainfall events, or at other times due to other conditions or weather-related events?
- Is the primary contact recreation use attainable through the application of effluent limitations under CWA §301(b)(1)(A) and (B) and §306 or through cost effective and reasonable best management practices?
- What are the sources of fecal pollution within the waterbody? What are the relative contributions of these sources?

The first two questions will assist the state or authorized tribe in determining whether or not primary contact recreation is an existing use. In answering these questions, both water quality and the actual use that has occurred since November 28, 1975 should be considered. See 40 CFR 131.3(e). Information provided by the public should be considered by the state or authorized tribe in making this determination. The state or authorized tribe should provide documentation of the waterbody's historical water quality, if available, and the use of the waterbody for recreation in support of its conclusion that primary contact recreation is not an existing use.

Secondly, the state or authorized tribe should determine that natural sources, and not leaking septic tanks or other anthropogenic sources, prevent attainment of water quality standards. To ascertain whether natural sources are the cause of impairment, several tools are available. Sanitary surveys may be conducted to identify the sources contributing to a waterbody. Recommendations on conducting sanitary surveys and additional references are contained at the beginning of section 3. Detection of detergents, dyes, or caffeine may indicate human sewage as the source of fecal pollution. Knowledge of land use patterns within a watershed may also assist states and authorized tribes in determining the relative contribution sources of fecal contamination within a watershed. In addition, other analytical tools are becoming more common in identifying the sources of fecal contamination. While Bacterial Source Tracking methods such as ribotyping and Antibiotic Resistance Analysis are becoming more common, such methods may be cost prohibitive for many states and authorized tribes to use on a large scale (See, for example, Dombeck et al., 2000; Harwood et al., 2000, Wiggins et al., 1999).

The results of the sanitary survey or other methods demonstrating that natural sources preclude attainment of primary contact recreation should be sufficient to conclude that primary contact recreation is not attainable under 40 CFR 131.10(g)(1), on the grounds that naturally-occurring pollutant concentrations prevent the attainment of the use. When removing a CWA §101(a) goal use or adopting subcategories of those uses, under 40 CFR 131.10(g), states and authorized tribes are required to submit an analysis demonstrating that the use is not an existing use and justifying the removal of that use based on one of the six reasons listed in that section. When contemplating revisions to water quality standards based upon impacts from natural sources, EPA encourages states and authorized tribes to use scientifically defensible methods in their supporting analyses. EPA will review this information as part of its review and action on any revised water quality standards. Answering the questions identified above should assist the state or authorized tribe in making a scientifically defensible determination that natural sources preclude attainment of the primary contact recreation use.

Once the initial analysis has been completed, states and authorized tribes have several options for revising their recreational water quality standards. A state or authorized tribe could pursue adopting a wildlife impacted recreation use as a recreational use subcategory, or, for waterbodies where water quality sufficient to support primary contact recreation is unattainable and location or barriers make recreation unlikely to occur, consider adopting a secondary contact recreation use or removal of recreation uses. Establishing a wildlife impacted recreation use would be appropriate for waters where limited recreational activities may still occur. EPA recommends that states and authorized tribes wishing to adopt a wildlife impacted recreation use adopt a criterion reflecting the natural levels of bacteria and, because the specific risk to people recreating in these waters is unknown, develop a plan to communicate to the public the potential risk of recreating in waters designated with this use. This communication could include public announcements or sign posting along the waterbody. Ideally, the state or authorized tribe should have monitoring and/or modeling data that would assist in identifying the natural levels of indicator organisms. Because such contributions are often correlated with rainfall events, the state or authorized tribe should consider the level of bacterial indicators present during dry and wet weather as well as any other spatial or temporal variability to assist in the establishment of an appropriate criterion. EPA envisions that a wildlife impacted recreation use category would provide greater protection than a secondary contact recreation use. However, wildlife sources of fecal contamination may still present some additional risk to recreators. Therefore, if the state or authorized tribe is adopting a less stringent criterion, the increment of change should correspond only to the estimated amount of the bacteria that is present due to natural sources.

Where it is shown that primary contact recreation is not an existing use and that the waterbody is significantly impacted by wildlife contamination, states and authorized tribes may adopt a secondary contact recreation use or remove the recreation use altogether. In determining whether recreation is an existing use, states and authorized tribes should consider the location of the waterbody and any barriers that may exist that would preclude the use of the waterbody for primary contact recreation. See Section 3.5 for a discussion of secondary contact recreation uses and criteria.

Other water quality standards approaches beyond those described here may also be appropriate. EPA will work with states and authorized tribes interested in developing such approaches to assure they meet the requirements of the Clean Water Act and federal regulations. Regardless of the option a state or authorized tribe pursues, EPA emphasizes the importance of public participation in revising its water quality standards.

Use of this approach can provide states and authorized tribes with the means to acknowledge the source(s) of fecal pollution that exists and its potential risk to recreators. Concern has been expressed that the use of this approach may provide existing NPDES permitted dischargers with relaxed effluent limitations. In the case where a discharger has a water quality based effluent limitation (WQBEL) for bacteriological criteria, it would not be eligible for less stringent effluent limitations unless an antidegradation analysis was performed consistent with the federal and state (or tribal) regulations. See 40 CFR 131.12. In addition, an analysis should be performed as part of the development of the WQBEL that considers the receiving waterbody's water quality and to determine whether the discharge has the reasonable potential to cause or contribute to the exceedance of applicable water quality standards. See 40 CFR 122.44(d).

3.5 What is EPA's policy regarding secondary contact recreation uses?

EPA defines secondary contact uses as including recreational activities where most participants have very little direct contact with the water and where ingestion of water is unlikely. States and authorized tribes may be able to justify the adoption of a secondary contact use, in lieu of a primary contact use, by completing a use attainability analysis. Subject to the provisions of 40 CFR 131.10, a secondary contact recreation use may be appropriate for waters that are, for example, impacted by human caused conditions that cannot be remedied, or where meeting the criteria associated with the primary contact recreation use would result in substantial and widespread social and economic impact.

3.5.1 When is it appropriate to designate a secondary recreation use?

EPA considers waters designated for primary contact recreation and waters designated for secondary contact recreation -- but with criteria sufficient to support primary contact recreation -- to have "swimmable" standards consistent with the CWA §101(a) goal[6]. States and authorized tribes may assign less than "swimmable" standards where adoption of such a standard is adequately justified by a use attainability analysis (UAA). A UAA is a structured scientific assessment of the factors affecting the attainment of the use which may include physical, chemical, biological, and economic factors. See 40 CFR 131.3(g), 131.10(g), and 131.10(j). Removing a "swimmable" standard and replacing it with a less than "swimmable" standard (or no recreation standard at all) is acceptable only where the revision is adequately justified by a UAA. It is also important to remember that all waters where less than "swimmable" standards have been assigned must be re-examined by the state or authorized tribe every three years to determine if new information has become available. If such new information indicates that "swimmable" standards are attainable, the standards are to be revised accordingly. See 40 CFR 131.20.

Where a UAA demonstrates that a "swimmable" standard is not attainable, the state or authorized tribe should evaluate whether a subcategory of recreation use with less stringent criteria is appropriate. States may elect to establish several categories of recreation uses, and perhaps even several categories of secondary contact uses, and assign criteria which are appropriate to the types of activities to be protected. However, any decision to assign a less than "swimmable" standard to

[6] For purposes of this discussion, waters with "swimmable" standards consistent with the CWA § 101(a)(2) goal are defined as including waters with a primary contact use and criterion, and waters with a secondary contact (or other) recreation use, but criteria sufficient to protect primary contact uses.

a particular segment must be adequately supported by a UAA. Less than "swimmable" standards may be considered, for example, where flowing or pooled water is not present within a waterbody during the months when primary contact recreation would otherwise take place and the waterbody is not in close proximity to residential areas, thereby indicating that primary contact uses are not likely to occur. Also, if a state or authorized tribe can demonstrate that natural, ephemeral, intermittent, or low flow conditions or water levels prevent attainment of the primary contact recreation use, a secondary contact recreation use may be appropriate. Another example would be a discharger that is not able to meet the limits necessary to protect the primary contact recreation use without causing substantial and widespread social and economic impact, but can meet limits that would assure protection of a secondary contact recreation use. In addition, as discussed in section 3.4.2, designating a secondary contact recreation use may be appropriate where primary contact recreation is not an existing use and high levels of natural or uncontrollable fecal pollution exist. These demonstrations would fulfill the requirements of and address one of the six conditions contained in 40 CFR 131.10(g) supporting the removal of a designated use.

3.5.2 What information should be contained in a use attainability analysis to identify the appropriate recreation use?

A recreational use attainability analysis (UAA) should be an objective collection of site-specific facts that are relevant to deciding what designated use is most appropriate. Not all recreation UAAs will support a conclusion that a "swimmable" standard is not attainable. The water quality standards coordinators in EPA's Regional offices should be consulted when developing UAA methods/guidance or specific workplans for individual UAAs. Consultation with appropriate EPA staff regarding the study objectives and methods, prior to any field work, is recommended.

Although each situation is different and may require a UAA workplan with special provisions to address unique circumstances, the information included in a use attainability analysis for recreation uses may need to include the following:

- information concerning any existing recreational activities that occur in the waterbody, by type of activity, and including frequency information (e.g., gathered from surveys or interviews with knowledgeable individuals, entities, or organizations);
- information that is useful in assessing the potential for various types of recreational uses to occur in the waterbody, which may include:
    - physical analyses addressing: features that facilitate public access to the waterbody (e.g., road crossings, trails), facilities promoting recreation (e.g., rope swings, docks, picnic tables), features limiting access to the waterbody or that discourage recreation uses (e.g., fences, signs), location of the waterbody including proximity to residential areas, schools, or parks, projections of population growth/development in the area, safety considerations, water temperatures, flows, velocity, depth, and width, and other physical

attributes of the waterbody such as substrate characteristics;

- chemical analyses of existing water quality for key parameters (bacteria, nutrients), including a comparison of available representative data for indicator bacteria to the criteria adopted by the state or authorized tribe (which may include both geometric mean and upper percentile values);
- identification of sources of fecal pollution, and an assessment of the potential for reduced loadings of bacterial indicators; and
- economic/affordability analyses.

(See also sections 3.4.1 for changes to recreation uses for waterbodies impacted by bacteria associated with high flow conditions and 3.4.2 for waterbodies impacted by non-human sources.)

On the subject of physical analyses, EPA has previously stated that, "Physical factors, which are important in determining attainability of aquatic life uses, may not be used as the basis for not designating a recreational use consistent with the CWA section 101(a)(2) goal" (USEPA, 1994). In fact, 40 CFR 131.10(g)(5), which refers to physical conditions as a factor to consider when determining whether or not to remove a designated use, applies only to aquatic life uses. Therefore, physical factors alone are not sufficient justification for removing or failing to designate a primary contact recreation use.

Likewise, the general Agency policy is to place emphasis on the potential uses of a waterbody and to do as much as possible to protect the health of the public (see the preamble to the amendments to the water quality standards regulation, 48 FR 51401, November 8, 1983, and Section 2.1.3 of the Water Quality Standards Handbook). In certain instances, the public will use whatever waterbodies are available for recreation, regardless of the flow or other physical conditions. Accordingly, EPA encourages States to designate primary contact recreation uses, or at least to require a level of water quality necessary to support primary contact recreation, for all waterbodies with the potential to support primary contact recreation.

EPA's suggested approach to the physical factors issue is for states and authorized tribes to look at a suite of factors such as whether the waterbody is actually being used (or has been used) for primary contact recreation; existing water quality; water quality potential; access; recreational facilities; location (i.e., proximity to recreational facilities); safety considerations, and; physical attributes of the waterbody in making any use attainability decision. Any one of these factors, alone, may not be sufficient to conclude that a "swimmable" standard is not warranted.

In general, adoption of "swimmable" standards is appropriate wherever it is feasible to achieve water quality levels necessary for the protection of primary contact uses. However, there are a few instances where physical considerations may play an important role in informing a state or authorized tribe's decision regarding what recreation use is most appropriate. This may include a waterbody where access is prevented by fencing or in an urban waterbody that also serves as a shipping port or has close proximity to shipping lanes. A physical analysis may lead to a conclusion that flowing or pooled water is not present during certain times of the year, or that the waterbody is not in proximity to residential areas. In instances such as these, an analysis of the physical attributes may help determine when and where primary contact recreation occurs in waterbodies where another §131.10(g) factor already prevents attainment.

Some types of primary contact activities require more substantial flows and/or depths, while others can and do occur when water flows and depths are quite low. For example, whereas white water rafting may not be possible in a certain water body when flows are low, that same water body might have sufficient flow to support a variety of summertime activities by children that may involve ingestion of water. As such, it is not appropriate to establish broad methods that result in assignment of less than "swimmable" standards where flows or water depths are below a certain fixed level. Rather, UAA methods should address a suite of factors. Regarding water flows and depths, UAA determinations should consider the particular recreational activities that are likely to occur. In particular, flows and depths should be evaluated differently in areas where children have easy access to the water body.

EPA understands that substantial and widespread social and economic impacts are often determining factors in assessing whether or not "swimmable" standards can be attained. EPA has published guidance to assist states and authorized tribes in considering economic impacts when adopting water quality standards (USEPA, 1995). The cost of placing additional control measures on sources of fecal contamination are often cited as the reason a water cannot attain the primary contact recreation use and the associated water quality criteria in all waters at all times. In the use attainability analysis process, the federal regulation at 40 CFR 131.10(g) lists the factors that may be used to demonstrate that a primary contact recreation use cannot be met; these factors include substantial and widespread social and economic impact, and natural conditions. Water quality criteria are derived to address the effects of pollution on the environment and human health, while under the federal regulation, the setting of designated uses may take into account social and economic considerations. See 40 CFR 131.10(g).

3.5.3 What water quality criteria should be applied to waters designated for secondary contact recreation?

For waterbodies where a state or authorized tribe demonstrates through a use attainability analysis that "swimmable" standards are not attainable, adoption of secondary contact uses and the associated water quality criteria may be appropriate. EPA defines secondary contact uses as including activities where most participants would have very little direct contact with the water and where ingestion of water is unlikely. Secondary contact activities may include wading, canoeing, motor boating, fishing, etc. Many states and authorized tribes have adopted secondary contact recreation uses for waterbodies. States and authorized tribes with fecal coliform criteria generally have adopted a secondary contact water quality criterion of 1000 cfu/100ml geometric mean, which is five times the geometric mean value typically used to protect primary contact recreation. This water quality criterion has been applied to secondary contact uses and to seasonal recreation uses during the months of the year not associated with primary recreation. The *Ambient Water Quality*

Criteria for Bacteria –1986, which recommended *E. coli* and enterococci as indicators, did not provide criteria recommendations for recreation uses other than primary contact recreation. States and authorized tribes have cited this as one reason why they have not adopted EPA's recommended water quality criteria.

EPA is unable to derive a national criterion for secondary contact recreation based upon existing data, because secondary contact activities involve far less contact with water than primary contact activities. During the development of this guidance document, EPA explored the feasibility of deriving criteria for secondary contact waters and found it infeasible for several reasons. In reviewing the data generated in the epidemiological studies conducted by EPA that formed the basis for its 1986 criteria recommendations, EPA found that the data would be unsuitable for the development of a secondary contact criterion. The data collected were associated with swimming-related activities involving immersion. Secondary contact recreation activities generally do not involve immersion in the water, unless it is incidental (e.g., slipping and falling into the water or water being inadvertently splashed in the face).

Despite the lack of epidemiological studies/data necessary to develop a risk-based secondary contact recreation criterion, waters designated for secondary contact recreation should have an accompanying numeric criterion. Adopting a numeric criterion for the secondary contact recreation use provides the basis for the development of effluent limitations and, where applicable, the implementation of best management practices. Such an approach provides a mechanism to assure that downstream uses are protected and, where adopted as part of a seasonal recreation use, helps to assure that the primary contact recreation use is not precluded during the recreation season. Adoption of a secondary contact criterion is also consistent with historical practices for most states and authorized tribes. Accordingly, states and authorized tribes may wish to adopt a secondary contact criterion which is five times their primary contact criterion. EPA recommends that secondary contact criteria be geometric mean values using a 30 day, seasonal, or annual averaging period. Clearly identifying the averaging period is very important to support attainment and permitting decisions. Another approach would be the adoption of a secondary contact criterion as a maximum, not to be exceeded value. This would also be an appropriate approach, particularly for states and authorized tribes that are unable to collect sufficient monitoring data to calculate a geometric mean value. States and authorized tribes may also pursue other approaches for secondary contact waters, and EPA will work with the state or authorized tribe to ensure the approach is protective of the designated use and meets the above objectives.

3.5.4 Will EPA publish risk-based water quality criteria to protect for "secondary contact" uses?

EPA's *Ambient Water Quality Criteria for Bacteria* – 1986 are designed to protect the public from gastrointestinal illnesses associated with accidental ingestion of water. EPA has not developed any water quality criteria for secondary contact recreation uses. As part of EPA's requirements under the BEACH Act amendments, EPA intends to gather additional data and investigate the development of water quality criteria for transmission of organisms that cause skin, eye, ear, nose, respiratory illness, or throat infections. Some elements of such future water quality criteria may potentially be applicable to secondary contact uses.

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4. Implementation of EPA's *Ambient Water Quality Criteria for Bacteria* – 1986 in State and Authorized Tribal Water Quality Programs

4.1 What is EPA's recommended approach for states and authorized tribes making the transition from fecal coliforms to *E. coli* and/or enterococci?

EPA recognizes that states and authorized tribes that have yet to adopt EPA's recommended 1986 water quality criteria for bacteria may be concerned about how to ensure consistency and continuity within their regulatory programs. Specifically, states and authorized tribes may have concerns about making regulatory decisions during this transition period while an adequate monitoring database is being established. To facilitate this period of transition, states and authorized tribes may include both fecal coliforms and *E. coli*/enterococci in their water quality standards for the protection of designated recreational waters for a limited period of time, generally one triennial review cycle. The dual sets of applicable criteria will enable regulatory decisions and actions to continue while collecting data for the newly adopted *E. coli* or enterococci criteria. For states and authorized tribes choosing this approach, EPA expects that during this limited period of time, states and authorized tribes will be actively collecting data on *E. coli* and/or enterococci and be working to incorporate *E. coli* and/or enterococci water quality criteria into their water quality programs, e.g., national pollutant discharge elimination system (NPDES), 305(b), and 303(d) programs. Alternatively, states and authorized tribes may elect to concurrently adopt a delayed effective date to allow for time in which to collect data on the newly adopted criteria. With these options available, lack of data should not delay states' and authorized tribes' adoption of *E. coli* and/or enterococci. Once *E. coli* and/or enterococci are adopted into state or tribal water quality standards, EPA encourages states and authorized tribes to remove the fecal coliform criterion as it applies to recreational waters during its next triennial review, since retaining the fecal coliform criterion for recreational waters may result in additional permitting and monitoring requirements.

Once adopted as water quality standards by states, authorized tribes, or EPA, these water quality criteria form the basis for water quality program actions, both regulatory and non-regulatory. For example, water quality criteria are used in establishing NPDES water quality-based effluent limitations (WQBELs), listing impaired waters under section 303(d), and beach monitoring and advisory programs. How the adopted criteria will be used in these different programs should be clearly explained in states' and authorized tribes' water quality standards or supporting implementation documents.

EPA recommends that states and authorized tribes adopt water quality criteria for bacteria containing both the geometric mean and upper percentile value components. This allows states and authorized tribes the flexibility to utilize the appropriate criteria component based on the situation. EPA recommends the use of the geometric mean when assessing and determining attainment of waters designated for primary contact recreation, provided a sufficient number of samples has been taken over the course of the recreation season. In situations where sampling is infrequent it is appropriate to use the upper percentile value in determining attainment.

With regard to interpreting the geometric mean component of the criteria, there has been a common misconception of how water quality data should be used to determine whether or not a waterbody has attained the applicable geometric mean value. Some states and authorized tribes have mistakenly interpreted the water quality criteria as requiring a minimum number of samples in order to determine the attainment of the geometric mean component of the water quality criteria. The confusion may have arisen because the water quality criteria recommend a monitoring frequency of five samples taken over a 30-day period. The recommendation does not intend to imply that five samples are needed before a geometric mean can be calculated. The minimum number of samples used in the 1986 water quality criteria for bacteria is for accuracy purposes only; clearly, more frequent sampling yields more confidence when determining whether or not a waterbody is meeting its geometric mean. Further, in some instances averaging periods greater than 30 days may be appropriate (e.g., data collected over a recreation season). Unless specified otherwise in a state or authorized tribe's water quality standards or assessment methodology, the geometric mean should be calculated based on the *total number of samples collected* over the specified monitoring period, and used in conjunction with an upper percentile value to determine attainment of the numeric water quality criteria (e.g., CWA §303(d) listing for fresh and marine waters). This interpretation encourages the collection and use of data and is what has always been intended. EPA notes that this interpretation was used by the Agency when promulgating water quality standards for the Colville Confederated Tribes (40 CFR 131.35).

4.2 How should states and authorized tribes implement water quality criteria for bacteria in their NPDES permitting programs[7]?

States and authorized tribes have discretion in how NPDES water quality-based effluent limits for bacteria are specified. The following sections describe how limits may be established by the permitting authority for different discharge types and be consistent with the applicable federal requirements. Two scenarios are discussed: first, the period of time during which states and authorized tribes are making the transition from fecal coliform criteria to *E. coli* or enterococci criteria, and second, developing limits once the *E. coli*/enterococci criteria have been established in state and tribal water quality standards.

4.2.1 While transitioning from fecal coliforms to *E. coli* and/or enterococci, how should states and authorized tribes implement water quality criteria for bacteria in their NPDES permitting programs?

If a state or authorized tribe chooses to retain its fecal coliform criterion during a transition period after adoption of *E. coli* and/or enterococci as water quality criteria, any new or reissued permits would need to contain water quality-based effluent limits, reflecting both criteria unless

[7]Pursuant to section 518(e) of the CWA, EPA is authorized to treat an Indian tribe in the same manner as a state for the purposes of administering a NPDES program. 40 CFR 123.31-121.34 establishes the procedures and criteria by which the Agency makes such a determination. At this time, several tribes are in the process of requesting program authorization; however, to date no tribe has been granted authorization to administer an NPDES program.

specified otherwise in a state or authorized tribe's water quality standards, to be consistent with the federal requirement at 40 CFR 122.44(d)(1)(i). This provision requires water quality-based permits containing limits for those pollutants (including all bacterial pollutants) the permitting authority determines are or may be discharged at a level which will cause, have reasonable potential to cause, or contribute to an exceedance of any applicable water quality standard. In this case, the existence of "reasonable potential" for fecal coliforms would also indicate the existence of reasonable potential for any other criterion for bacteria adopted by the state or authorized tribe. In most cases, wastewater treatment plants that have used secondary and tertiary treatment for fecal coliforms should find that this treatment also adequately addresses *E. coli* and enterococci (Miescier and Cabelli, 1982). However, wastewater treatment plants chlorinating their effluent may find enterococci more resistant to chlorination than fecal coliforms or *E. coli* (Oregon Association of Clean Water Agencies, 1993; Miescier and Cabelli, 1982).

4.2.2 Once *E. coli* and/or enterococci have been adopted by states and authorized tribes, how should the water quality criteria for bacteria be implemented in NPDES permits ?

Many states and authorized tribes have raised concerns regarding how state and tribal water quality standards based on EPA's 1986 water quality criteria for bacteria should be implemented through NPDES permits. Under the Clean Water Act and the implementing federal regulations, states and authorized tribes have flexibility in how they translate water quality standards into NPDES permit limits to ensure attainment of designated uses. In implementing state and tribal water quality standards that include both the geometric mean and upper percentile value components, there are multiple acceptable approaches. Because effluent limits are generally based on monthly averages, EPA recommends that states and authorized tribes use the geometric mean component for NPDES water quality-based effluent limits. For those permits that include maximum daily limits, the upper percentile value should be used. Alternatively, states and authorized tribes could use *both* the geometric mean and upper percentile value in the development of NPDES water quality-based effluent limits. EPA is aware that states have taken different approaches in deriving WQBELs for bacteria to ensure the ambient water quality criteria are met. For example, many states apply the ambient water quality criteria for bacteria directly to the discharge with no allowance for in-stream mixing (often referred to as "criteria end-of-pipe"). Alternatively, some states provide mixing zones for bacteria and derive permit limits that account for in-stream dilution. EPA has also stated that for certain types of regulated discharges (e.g., municipal separate storm sewer systems [MS4s] and concentrated animal feeding operations [CAFOs]), the most appropriate permit requirements may be non-numeric effluent limitations expressed in the form of best management practices (BMPs). The underlying principle, however, is that whichever approach is selected, the permitting authority must determine that permit limits and requirements derive from and comply with applicable water quality standards. See 40 CFR 122.44(d)(1)(vii)(A).

In determining a discharger's compliance with any effluent limitation, the federal regulation requires that discharge monitoring for any pollutant should never occur less than once per year. Further, monitoring requirements should be established case-by-case based on the nature of the effluent. See 40 CFR 122.44(i)(2). More frequent sampling may be appropriate if the discharge is in close proximity to beach areas or known recreation areas.

With respect to determining whether WQBELs for bacteria are needed for a specific discharge, the Agency expects permitting authorities to use the same approach that applies to other pollutants. Thus, the permitting authority must include a WQBEL in the NPDES permit for a discharger if it determines that a pollutant (including all bacteria pollutants) is or may be discharged at a level which will cause, have reasonable potential to cause, or contribute to an exceedance of any state or tribal water quality standard. See 40 CFR 122.44(d)(1)(i). When a state or authorized tribe adopts, and EPA approves, new water quality criteria for *E. coli* and/or enterococci, the permitting authority (in most cases, the state) must immediately begin implementing these criteria through limits incorporated into any new or reissued NPDES permit, unless the state or tribal water quality standards authorize another approach. Additionally, if the state or authorized tribe chooses to retain an existing water quality criterion for fecal coliforms, the permitting authority must continue to implement this criterion in the form of a WQBEL as well, unless otherwise specified in the state or tribal water quality standards. In some cases where a discharge is released into a waterbody designated for both recreation and shellfishing, even after removal of the fecal coliform criterion for recreation, the permit will likely continue to contain effluent limitations for both parameters since the fecal coliform criterion will continue to apply to waters designated for shellfishing.

Following state or tribal adoption and EPA approval of water quality criteria for *E. coli* and/or enterococci, permitting authorities will typically not need to reopen existing permits prior to their expiration dates to incorporate WQBELs based on the newly-adopted water quality criteria. Instead the Agency expects that existing WQBELs for fecal coliforms will continue to be enforced through the existing permit's term, and that permitting authorities will incorporate WQBELs based on newly adopted water quality criteria (as needed) at the time of permit reissuance.

4.2.3 How do the antibacksliding requirements apply to NPDES permits with effluent limits for bacteria?

Dischargers that previously had NPDES water quality-based effluent limits for fecal coliforms, and subsequently have water quality-based effluent limits based on a state or authorized tribe's newly adopted *E. coli* and/or enterococci criteria should also be aware of federal NPDES "antibacksliding" provisions. The CWA and implementing NPDES federal regulations contain specific restrictions on when an existing WQBEL may be removed or replaced with a less stringent effluent limitation in a reissued NPDES permit. See CWA section 402(o); 40 CFR 122.44(l). When a state or authorized tribe replaces a fecal coliform criterion with water quality criteria for *E. coli* and/or enterococci, that replacement will not generally result in less stringent effluent limits in the permit (i.e., replacing a 200 cfu/100 ml fecal coliform criterion with an *E. coli* criterion of 126 cfu/100 ml or an enterococci criterion of 33 cfu/100 ml for fresh water or 35 cfu/100 ml enterococci criterion for marine water). In other words, if all other factors are unchanged, EPA expects that the WQBEL(s) based on the newly adopted water quality criteria for bacteria (for *E. coli* and/or enterococci), while perhaps expressed in a different form, will not be less stringent than the previous

WQBEL (for fecal coliform) and that, therefore, the backsliding prohibitions in section 402 of the CWA and its implementing regulations will not apply.

If a state or authorized tribe chooses to adopt *E. coli* or enterococci water quality criteria greater than, for fresh waters, an *E. coli* criterion of 206 cfu/100 ml or an enterococci criterion of 54 cfu/100 ml or, for marine waters, an enterococci criterion of 35 cfu/100 ml (generally occurring through the adoption of a subcategory of primary contact recreation use, other recreational subcategories, or secondary contact recreation use), the antibacksliding elements of the CWA and federal regulations would apply. In these instances, the CWA and federal regulations would allow for backsliding in some circumstances as described below. EPA has consistently interpreted section 402(o)(1) of the CWA to allow relaxation of WQBELs if the requirements of CWA section 303(d)(4) are met. (While CWA §402(o)(2) allows for backsliding to occur when new information is present, revised water quality standards regulations do not constitute "new information" under this provision.)

Section 303(d)(4) has two parts: paragraph (A) which applies to "non-attainment waters" and paragraph (B) which applies to "attainment waters."

- **Non-attainment water**–Section 303(d)(4)(A) allows the establishment of less stringent WQBELs for waters identified under CWA §303(d)(1)(A) as not meeting applicable water quality standards (i.e., a "nonattainment water"), if two conditions are met. First, the existing WQBEL must be based on a total maximum daily load (TMDL) or other wasteload allocation. Second, relaxation of a WQBEL is only allowed if attainment of water quality standards will be assured.
- **Attainment water**–Section 303(d)(4)(B) applies to waters where the water quality equals or exceeds levels necessary to protect the designated use, or to otherwise meet applicable water quality standards (i.e., an "attainment water"). Under section 303(d)(4)(B), WQBELs may only be relaxed where the action is consistent with the state or authorized tribe's antidegradation policy.

It is important to note that these exceptions to the prohibition on antibacksliding as a result of a change to water quality standards are only applicable to permits with water quality-based effluent limitations. They are not applicable to relax limitations based on technology-based treatment standards for the pollutants at issue.

4.3 How should state and tribal water quality programs monitor and make attainment decisions for the water quality criteria for bacteria in recreational waters?

Monitoring protocols and assessment methodologies for recreational waters may differ depending upon the location of the waterbody, level of use, and program resources. The following sections describe appropriate approaches in the development and implementation of state and tribal monitoring and assessment programs for bacteria. Specifically, section 4.3.1 provides recommendations applicable to the period during which a state or authorized tribe may be transitioning from fecal coliforms to *E. coli* or enterococci. Section 4.3.2 focuses on general recommendations and examples for evaluating monitoring data, assessing water quality, and determining attainment of water quality standards.

4.3.1 While transitioning from fecal coliforms to *E. coli* and/or enterococci, how should states and authorized tribes monitor and make attainment decisions for their water quality criteria for bacteria?

Once a state or authorized tribe has adopted *E. coli* and/or enterococci into its water quality standards and EPA has approved the new standards, states and authorized tribes should not delay listing waterbodies for exceedances of water quality criteria for bacteria where historical data (whether for fecal coliforms or for the newly adopted criteria) indicate an impairment. Further, current Agency guidance and policy reject the notion that states and authorized tribes can avoid listing waters in anticipation of a change to a state or authorized tribe's water quality standards. Thus, if a state or authorized tribe has fecal coliform data that indicate a particular waterbody is not attaining the applicable water quality standards, the waterbody should still be listed even if the state or authorized tribe anticipates replacing its fecal coliform criteria with *E. coli* or enterococci in the near future.

For waterbodies previously listed under section 303(d) for not attaining water quality standards for fecal coliforms, EPA recommends that the waterbody continue to be included in the state or authorized tribe's 303(d) impaired waters list for bacteria until sufficient *E. coli*/enterococci data are collected to either develop a total daily maximum load (TMDL) for bacteria or support a de-listing decision. Where possible, states and authorized tribes may wish to assign these waterbodies a lower priority ranking for development of TMDLs to accommodate the collection of data on *E. coli* and/or enterococci. This would allow a waterbody listed for fecal coliforms to have additional data collected for *E. coli* and/or enterococci and, if needed, a TMDL written based on these newer criteria. In some instances states and authorized tribes may find that a waterbody not meeting its previous fecal coliform criterion will meet the newer *E. coli* or enterococci criterion. In a recent EPA-funded study conducted at Boston Harbor beaches in Massachusetts, it was found that the enterococci criterion was met more often than the fecal coliform criterion (MWRA, 2001). Proceeding in this manner to accommodate the collection of additional data would also preclude the need for a future TMDL revision if it had initially been written based on fecal coliforms.

Where there is an immediate threat to public health or where a waterbody has been listed under 303(d) on the basis of fecal coliform exceedances, and the waterbody is a priority due to court order or state (or tribal) statute or regulations, states and authorized tribes should not delay developing a TMDL. In these situations, the state or authorized tribe should develop the TMDL using the fecal coliform criterion, and monitor progress toward meeting all bacterial water quality standards, including the fecal coliform criterion (if it has been retained in the state or authorized tribe's water quality standards during a transition period) and *E. coli* and/or enterococci. Because data may not yet exist on the newly-adopted criteria, this would be one approach to meeting the requirement that TMDLs be based on the water quality criterion in effect at the time of development. If data collected over time indicate that the waterbody is meeting the *E. coli*/enterococci criteria, this would constitute an acceptable measure of attainment of the TMDL. Alternatively, if later data show a continuing problem under the *E. coli*/enterococci criterion that has not been adequately addressed under the fecal coliform TMDL, revisions to the TMDL may be necessary once data on *E. coli*/enterococci are collected.

After a state or authorized tribe adopts criteria for *E. coli* and/or enterococci, the amount of data necessary to support a listing or de-listing decision will vary among states' and authorized tribes' monitoring programs. This information should be contained either in states' and authorized tribes' assessment and listing methodologies or in their water quality standards. The design of the state or authorized tribe's monitoring program and the conclusiveness of the data collected will affect the length of time before a state or authorized tribe is able to make regulatory decisions and take appropriate actions. For example, if a state or authorized tribe routinely collects monitoring data and finds within a relatively short period of time that the data collected indicate an exceedance of the water quality criteria, EPA expects the state or authorized tribe to conclude that the waterbody is impaired. Further, monitoring designs should reflect the way in which the state or authorized tribe's water quality standards are expressed.

4.3.2 Once *E. coli* and/or enterococci have been adopted, how should recreational waters be assessed and attainment determined for waters where the bacteriological criteria apply?

Implementing water quality criteria for bacteria within a state or authorized tribe's monitoring and listing program is a recurring topic within the ongoing dialogue EPA has with states, authorized tribes, and other stakeholders, particularly during the recent development of the *Consolidated Assessment and Listing Methodology* (USEPA, 2002a). Version 1 of the Methodology addresses water quality monitoring strategies, data quality and data quantity needs, and data interpretation methodologies. This effort is focused on helping states and authorized tribes improve the accuracy and completeness of their CWA §303(d) lists and §305(b) reports as well as streamlining these two reporting requirements. In addition, this document provides recommendations for the listing and assessment of waters designated for primary contact recreation and specifically refines previous recommendations on assessing attainment of the water quality criteria for bacteria.

States and authorized tribes have questioned how the criteria should be interpreted when assessing waterbodies under CWA §305(b) and determining attainment under CWA §303(d). As discussed earlier, EPA recommends states and authorized tribes adopt both a geometric mean and an upper percentile value. Although the upper percentile value is intended primarily for beach monitoring and notification programs, including it in water quality standards provides states and authorized tribes the flexibility to determine the circumstances where the geometric mean and the upper percentile value would be most appropriate for determining attainment.

Historically, states and authorized tribes have used simple descriptive statistics to determine attainment consistent with these recommendations. Using this approach, the geometric mean of the total number of samples taken over a certain period of time is calculated and the results compared to the geometric mean component of the criterion. For situations where only a few (or even individual) samples have been taken, the monitoring data are compared to the upper percentile value (historically referred to as a single sample maximum value) to assure that no sample has exceeded the upper percentile value. Using simple descriptive statistics such as this, while acceptable to EPA, has several drawbacks. Most notably, use of this approach assumes that the entire population was representatively sampled, i.e., that the samples fully captured the range and variability of the ambient concentrations existing over the period of time in which the samples were taken.

States and authorized tribes may also use what is known as inferential statistics (e.g., Students t-test, binomial and chi-square tests). The primary difference between the descriptive statistical approach described above and inferential statistics is how they handle uncertainty (i.e., decision error) and the likelihood that the sample data represent the population they are used to characterize. While descriptive statistics do not address uncertainty in the statistics used to describe the population of interest, inferential statistics assume a potential for error in using sample data to characterize the population and specifically address the likelihood that the sample data represent the population by setting targets for reasonable decision error. States and authorized tribes that define acceptable decision error have taken on a greater responsibility for monitoring programs, because these states and authorized tribes are systematically defining—and, it is hoped, committing the resources to collect—sufficient samples to support the tests.

Of these two general approaches, EPA prefers that, if sufficient data are collected, states and authorized tribes use inferential statistical models due to the ability of these models to provide the greatest certainty in making attainment decisions. Recommendations and discussions of the use of different statistical approaches are provided in EPA's *Consolidated Assessment and Listing Methodology* (USEPA, 2002a) and are also contained in EPA's *Guidance for Choosing a Sampling Design for Environmental Data Collection* (USEPA, 2000). Using statistical approaches enables the assessor to estimate, based on the samples taken and a specified confidence level and statistical power, whether or not the criterion is being attained. In order for these approaches to provide reliable results, a certain amount of data must be collected as determined by data quality objectives, which in turn reflect individual state or tribal standards. Alternatively, states and authorized tribes have employed other statistical approaches. For example, some states and authorized tribes calculate confidence intervals, the upper limits of which are compared to the upper percentile value to determine compliance with that component of the criterion. Additional guidance on the use of alternate assessment approaches is provided in the *Consolidated Assessment and Listing Guidance*.

In addition to these two approaches, states and authorized tribes may develop their own approaches; however, any monitoring and/or assessment protocol developed by the state or authorized tribe should be consistent with the relevant water quality standards. If the state or tribal water quality standards define how the standards are to be interpreted, the state or authorized tribe must follow its prescribed approach when assessing attainment. If the state or authorized tribe's standards are silent on how to interpret data to make ambient attainment decisions, the state or authorized tribe should describe its process. The state or authorized tribe may either follow EPA recommendations or develop implementation procedures that are consistent with its water quality standards. For example, if a state or authorized tribe's water quality criteria for bacteria consist of a geometric mean and an upper percentile and specify that the geometric mean is to be calculated based on five samples taken over a thirty day period and that no sample may exceed the upper percentile value, the state or authorized tribe's monitoring and assessment protocol should be consistent with these water quality standards provisions. In some circumstances, states and authorized tribes may find that revisions need to be made to their water quality standards to clarify how the water quality standards will be interpreted for assessment and attainment determinations.

Many states and authorized tribes use information on bathing area advisories and closures to determine attainment with recreation-based water quality standards. This information often comes from state, tribal, or local health departments and may be based on water quality monitoring, calibrated rainfall alert curves, or precautionary information. Before using this information on use restrictions and closures, it is important to document the basis for them. For example, the water quality agency may want to verify that the health department uses indicators and thresholds that are consistent with the state or authorized tribe's water quality standards.

In general, water quality-based bathing closures or advisories that are consistent with the state or authorized tribe's water quality standards and assessment methodology and are in effect during the reporting period should be considered as an indicator of water quality standards attainment. There are some exceptions, however. Bathing areas subject to precautionary administrative closures such as automatic closures after storm events of a certain intensity may not trigger an impairment decision if monitoring data show an exceedance of applicable water quality standards has not occurred. Similarly, closures or restrictions based on other conditions like rip-tides or sharks should not trigger a nonattainment decision (USEPA, 2002a). It is also acceptable to base day-to-day beach closure decisions on an upper percentile value, while using the geometric mean as the basis for long-term attainment over an assessment period (see Chapter 3).

Regardless of the monitoring protocol used by a state or tribe, EPA recommends, at a minimum, that primary contact recreation waters be monitored throughout the swimming season, ideally on a weekly basis, to ensure human health is adequately protected, particularly waters that are beach areas. EPA has prepared additional guidance contained in chapter 4 of the *National Beach Guidance and Required Performance Criteria for Grants* recommending monitoring approaches for identified beach areas, as well as recommendations on how to use the data in making beach closures and advisories. This document is available through EPA's Beach Watch web site at http://www.epa.gov/waterscience/beaches.

EPA recognizes that there may be some waterbodies that merit less frequent monitoring. These waterbodies may include those where public access is purposely restricted or limited by location and other waterbodies that are not likely to be used for primary contact recreation. Due to resource or other constraints, states and authorized tribes may not be able to collect sufficient samples for these waterbodies to perform a robust statistical analysis or to collect sufficient samples within a specified period of time to perform the recommended mathematical analysis. In these cases of small sample size (e.g., less than 5 samples), EPA recommends that measured values be compared to an upper percentile value to either assess attainment or trigger additional monitoring. Examples of two types of assessment approaches that may be applied to infrequently used recreational waters are described in Table 4-1.

Limited state or tribal resources may result in a state or tribe not being able to collect sufficient samples to calculate a meaningful geometric mean for comparison with the criterion. While EPA continues to encourage frequent monitoring of beaches and heavily-used recreation areas, for those waterbodies that are remote or, for other reasons, rarely used, EPA recommends states and authorized tribes develop alternative monitoring protocols that describe how these waterbodies will be monitored. States and authorized tribes should assure that any alternate monitoring protocols developed are consistent with its water quality standards (an example of how a set of water quality standards might look is at Figure 3.1). In some cases, states and authorized tribes may wish to revise their water quality standards to clarify these approaches. Alternatively, states and authorized tribes may choose to specify their monitoring procedures in their CWA §303(d) listing methodology. Regardless of where this information is contained, states and authorized tribes should assure that their monitoring protocols and interpretation of the monitoring data are consistent with the expression of the applicable water quality standards.

Table 4-1. Assessment approaches for less frequently used primary contact recreation waters

Example #1
Samples for remote waters not identified as public or high use beaches are compared to the upper percentile value, serving as a trigger for collecting additional data. If routine monitoring finds an exceedance (or certain number of exceedances) of an upper percentile value, then the state or tribe collects additional samples to calculate the geometric mean. The state or tribe then uses the geometric mean to make an attainment/nonattainment decision (i.e., both the geometric mean and the upper percentile value need to exceed the state or tribal standards for the waterbody to be identified as impaired under CWA §§305(b) and 303(d)). This approach differs from Example #2 in that the assessment decision is made only after additional data are collected.
Example #2
Samples for remote waters not identified as public or high use beaches are compared to the upper percentile value to determine attainment status. If the specified number of samples (individual or multiple samples, based on the adopted methodology) exceeds the upper percentile value, the waterbody is determined to be impaired. This approach differs from Example #1 in that the assessment decision is made after comparison only with the upper percentile value. An exceedance results in a nonattainment decision by the state or tribe as opposed to triggering more monitoring.

When considering the spectrum of different types of waterbodies designated for recreation, approaches states and authorized tribes take to monitor their waterbodies may vary with the uses assigned, since prioritization of monitoring resources may be directed more toward the heavily used recreation areas. For example, a state or authorized tribe may choose an inferential statistical approach for the monitoring and evaluation of data for high use or identified bathing areas since more data are likely to be collected in these areas. Alternatively, states and authorized tribes may choose an approach that relies on fewer data for other waterbodies that are primary contact recreation waters, but are not heavily used. (See section 3.1.1 for a discussion of how states and authorized tribes may bifurcate their primary contact recreation use designations.) Regardless of the approach used, states and authorized tribes should specify which monitoring approaches they will be using. Additionally, states and authorized tribes may find it useful to identify and provide to the public a list of recreation waters and the frequency with which they will be monitored.

4.4 How should a state or authorized tribe's water quality program calculate allowable loadings for TMDLs?

If a state or authorized tribe finds that its bacteriological criteria are not being attained on a particular waterbody, the state or authorized tribe will need to develop a TMDL consistent with CWA §303(d). A TMDL establishes the allowable loadings for specific pollutants that a waterbody can receive without exceeding water quality standards, thereby providing the basis for states and authorized tribes to establish water quality-based pollution controls. A TMDL identifies the loading capacity for a pollutant in a waterbody, the allocation of that pollutant to point and nonpoint sources contributing the pollutant, and the seasonal variation and margin of safety so that the TMDL will result in attaining the water quality standard.

For states and authorized tribes that have adopted *E. coli* and/or enterococci into their water quality standards, state and authorized tribe's water quality programs need to keep in mind the basis and assumptions inherent in the development of the applicable water quality standard when calculating a waterbody's total allowable load of the impairment-causing pollutant. EPA's recommended *E. coli* and enterococci criteria are generally expressed both as a geometric mean and as an upper percentile value. The geometric mean is based on a comparison of the average summer exposure to the risk level; the upper percentile value is a calculation of a daily exposure that is statistically related to the geometric mean. The calculated allowable load will need to reflect these: that is, the allowable load is a seasonal or 30-day average load (depending on how the criterion is expressed in the water quality standards) if based on the geometric mean, and a single day load if based on the upper percentile value.

EPA has published guidance on how to calculate loadings that attain water quality standards for pathogens and fecal indicators (USEPA, 2001a). This guidance identifies analytical tools that are appropriate to calculate these loads:

- **Empirical approaches** – Empirical approaches use existing data to determine the linkage between sources and water quality targets. In cases where there are sufficient observations to characterize the relationship between loading and exposure concentration across a range of loads, this information could be used to establish the linkage directly, using, for example, a regression approach.

- **Simple approaches** – Where the sole source of indicator bacteria are NPDES permitted sources, these sources should always be required to meet water quality standards for indicator bacteria at the point of discharge or edge of the mixing zone, as specified in the state or tribal water quality standard. Simple dilution calculations and/or compliance monitoring (for existing discharges) are often adequate for this task.

- **Detailed modeling** – In cases where sources of bacteria are complex and subject to influences from physical processes, a water quality modeling approach is typically used to incorporate analysis of fate and transport issues. Modeling techniques vary in complexity, using one of two basic approaches: steady-state or dynamic modeling. Steady-state models use constant inputs for effluent flow, effluent concentration, receiving water flow, and meteorological conditions. Generally, steady-state models provide very conservative results when applied to wet weather sources. Dynamic models consider time-dependent variation of inputs. Dynamic models apply to the entire record of flows and loadings; thus the state or tribal water quality program does not need to specify a design or critical flow for use in the model. A daily averaging time is suggested for bacteria.

When detailed modeling is used, different types of models are required for accurate simulation for rivers and streams as compared to lakes and estuaries because the response is specific to the waterbody:

- **Rivers and Streams**. Prediction of bacteria concentrations in rivers and streams is dominated by the processes of advection and dispersion and the bacteria indicator degradation. One-, two-, and three-dimensional models have been developed to describe these processes. Waterbody type and data availability are the two most important factors that determine model applicability. For most small and shallow rivers, one-dimensional models are sufficient to simulate the waterbody's response to indicator bacteria loading. For large and deep rivers and streams, however, the one-dimensional approach falls short of describing the processes of advection and dispersion. Assumptions that the bacteria concentration is uniform both vertically and laterally are not valid. In such cases two- or three-dimensional models that include a description of the hydrodynamics are used.

- **Lakes and Estuaries.** Predicting the response of lakes and estuaries to bacteria loading requires an understanding of the hydrodynamic processes. Shallow lakes can be simulated as a simplified, completely mixed system with an inflow stream and outflow stream. However, simulating deep lakes with multiple inflows and outflows that are affected by tidal cycles is not a simple task. Bacteria concentration prediction is dominated by the processes of advection and dispersion, and these processes are affected by the tidal flow. The size of the lake or the estuary, the net freshwater flow, and wind conditions are some of the factors that determine the applicability of the models.

Given that most sources of bacteria are related to rainfall and higher river flow events, and that water quality standards apply over a wide range of flows, states and authorized tribes will most likely find that they need to calculate allowable loads for a wide variety of river flows. For this reason, EPA recommends that states and authorized tribes use dynamic modeling to calculate these loads. EPA recommends three dynamic modeling techniques to be used when an accurate estimate of the frequency distribution of projected receiving water quality is required: continuous simulation, Monte Carlo simulation, and log-normal probability modeling. These methods are described in detail in EPA's guidance (USEPA, 2001; USEPA, 1991b). Models capable of simulating bacterial concentrations are also described in EPA's guidance (USEPA, 2002b; USEPA, 1997).

In using dynamic modeling techniques, the state or authorized tribe will first develop, calibrate, and verify a water quality model for existing loads, and then will try different scenarios of load reductions until the water quality standards are attained. The wasteload allocations are then directly calculated from the dynamic model using the permit derivation techniques described in the *Technical Support Document for Water Quality-based Toxics Control* (USEPA, 1991b). The load allocations are calculated from the percent reduction or pounds reduction used to attain the water quality standard. Because the comparison of bacteriological indicator concentrations to illnesses was conducted on a daily basis, EPA recommends using the daily average effluent flow for calculating loads based on the upper percentile value.

If a state or authorized tribe elects not to use a dynamic model, generally because there are not sufficient data to develop such a model, then the program will need to use a steady state model approach. This entails specifying a design flow for riverine systems to apply to the water quality criterion in the standards. As discussed above, this flow will need to reflect the basis and assumptions inherent in the development of the water quality criterion. Specifying the flow will also be a challenge because the water quality standards must be attained over a range of flows, and where the loadings are rainfall related, a critical drought flow approach will generally not be representative of the conditions when the standards might be exceeded. In lakes and estuaries, the flow is not as responsive to rainfall events, and an average water circulation can be used.

Most TMDLs for bacteria will include intermittent or episodic loading sources (e.g., surface runoff) that are rain-related and thus have serious water quality impacts under various flow conditions. Usually, maximum impacts from rain-related loading occur at high flows instead of at low flows. For example, elevated spring flows associated with snowmelt can contain high concentrations of bacteria, especially when snowmelt originates from agricultural areas where manure is spread in winter or from urban areas where residents practice poor pet curbing. As another example, a small tributary may deliver bacteria to a river. The river's bacteria load is positively, although not linearly, correlated with flow in the higher-order stream. (Both waters respond to regional precipitation patterns.) The in-stream concentration from the tributary load will be affected by the competing influences of increased load and increased dilution capacity, resulting in a peak impact at some flow greater than base flow. If a point source was also present, a dual design condition might be necessary.

For these reasons, if a state or authorized tribe elects to use a steady state model for a riverine system, EPA recommends a dual design approach where the loadings for intermittent or episodic sources are calculated using a flow duration approach and the loadings for continuous sources are calculated based on a low flow statistic. The flow duration approach has been used to establish a number of TMDLs for rivers in Kansas (Stiles, 2001).

The flow duration approach calculates a load duration curve by first calculating the cumulative frequency of the historical daily stream flow data over a period of time and then multiplying that by the water quality criterion. This in essence calculates the allowable load for every flow event, and portrays those loads as the percentage of days that a loading can be exceeded without exceeding the water quality criterion. The geometric mean criterion should be multiplied by the 30-day average stream flow, and the upper percentile value criterion should be multiplied by each daily stream flow. The flows used should reflect the long term history of a river, although those periods may be shortened due to major disruptions to rivers, such as reservoir operations or ground water depletion.

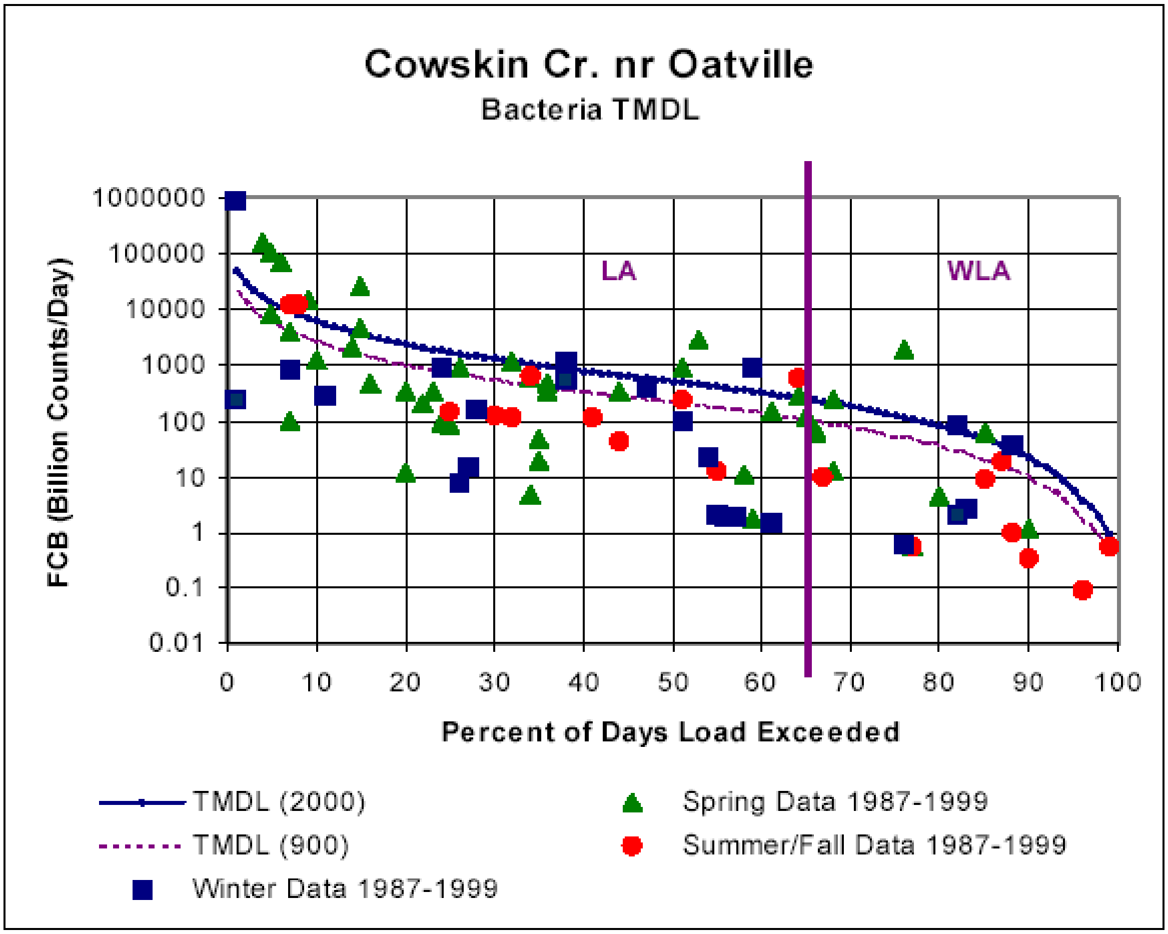
This approach requires the availability of long-term flow data to develop flow duration curves as well as daily flow values associated with dates of sampling. Where there are no gauging stations present at the sampling site, the state or authorized tribe may need to monitor flow itself or rely on USGS-developed methods to estimate flow duration curves from ungauged areas.

The distribution of existing loads is calculated by multiplying the sampled quality data by the daily flow on the date of sample, and plotting these calculations on the load duration curve above. The state or authorized tribe can then compare the actual loadings to what is needed to attain water quality standards. An example of this approach for Cowskin Creek near Oakville, Kansas, is shown in Figure 1 (Stiles, 2001). While this example has used the state's existing fecal coliform criterion, the approach is also applicable to either *E. coli* or enterococci criteria.

The overall reduction in loading necessary to attain the water quality standards is calculated as the reduction from the distribution of the existing loadings to that of the loadings necessary to attain the standards. This reduction also defines the necessary load reduction for nonpoint sources in the Load Allocation as well as continuous and intermittent or episodic point sources in the Wasteload Allocation.

Continuous loadings, that is, sources that discharge at about the same level regardless of the rainfall, often most greatly impact water quality under low-flow, dry-weather conditions, when dilution is minimal (USEPA, 1991a). For these sources, EPA recommends that the allowable loading be calculated for the geometric mean as the product of the geometric mean water quality

FIGURE 1. EXAMPLE OF A TMDL LOAD DURATION CURVE FOR BACTERIA



Source: Stiles, 2001

criterion and the 30Q5 flow statistic (i.e., the highest 30-day flow occurring once every five years), and for the individual sample as the product of the upper percentile value water quality criterion and 1Q10 flow statistic (i.e., the highest one-day flow occurring once every 10 years) or the low flow specified in the state or tribal water quality standards, if one is so specified. These flows reflect the characteristics of the criteria, that is, a 30-day average flow for the 30-day average geometric mean and a one day flow for the upper percentile value. By using extreme flow values, the loading calculation ensures that the criteria are rarely exceeded. The 30Q5 is EPA's recommendation for human health criteria for non-carcinogens and the 1Q10 is EPA's recommendation for calculating loadings for criteria that represent a daily or hourly averaging period (USEPA, 1991b).

4.5 What analytical methods should be used to quantify levels of *E. coli* and enterococci in ambient water and effluents?

The permit writer is responsible for specifying the analytical methods to be used for monitoring in an NPDES permit. Typically, the methods specified are those cited in 40 CFR 136 in the standard conditions of the permit, unless other test procedures have been specified. In the case of the development of permits for *E. coli* and enterococci, for ambient waters, EPA has published final methods in 40 CFR 136, and is planning to publish final methods in 40 CFR 136 for effluent waters in the near future, although methods do not yet exist in 40 CFR 136 for these constituents. Pursuant to 40 CFR 122.41(j)(4), permit writers have the authority to specify methods that are not contained in 40 CFR 136. In addition to commercially available test methods there are several EPA-approved methods permit writers may specify in permits, including the mE and the mEI agar methods for enterococci and the modified mTEC and mTEC agar methods for *E. coli*.

4.6 How do the recommendations contained in this document affect waters designated for drinking water supply?

Waterbodies that are used as drinking water supplies are an important resource that share many of the same human health concerns with recreational waterbodies. Both types of waterbodies have a need to be protected against contamination by sources of fecal pollution. Like recreational waterbodies, the primary route of exposure is through ingestion. However, unlike recreation, consumption and other uses of water are intensive and typically in much larger quantities.

EPA recognizes that programs under the Clean Water Act (CWA) are some of the most important tools in protecting sources of drinking water from contamination. As such, EPA is committed to promoting full utilization of CWA programs to help protect drinking water sources wherever possible. The operating principle of these policy efforts is that, while public water systems are legally accountable for the delivery of safe drinking water to their consumers, no water system should have to provide more treatment than that which is necessary to address naturally occurring pollutant concentrations.

To date, EPA has not developed criteria recommendations under section 304(a) of the CWA specifically aimed at the protection of drinking water sources from microbiological contaminants. Some states and authorized tribes have adopted EPA's recommended water quality criteria for bacteria to protect waters designated for drinking water supplies. In the absence of nationally recommended water quality criteria specifically targeted to the microbiological organisms and exposure routes of concern in drinking water supplies, adoption of the current 304(a) bacteria criteria may afford some additional protection to waters designated as drinking water supplies Even though public water systems are required to remove microbial pathogens to safe levels for consumption, the adoption of EPA's recommended water quality criteria for bacteria to protect drinking water supplies provides an additional and critical measure of public health protection. State and tribal adoption of EPA's bacteriological criteria recommendations into their water quality standards for the protection of drinking water supplies can provide a mechanism by which water quality may be maintained and protected and sources of fecal pollution controlled. EPA is contemplating the development of water quality criteria specifically targeted toward the protection of waters designated for drinking water supplies.

4.7 How do the recommendations contained in this document affect waters designated for shellfishing?

EPA's criteria recommendations for the use of fecal coliform criteria to protect designated shellfishing waters are contained in its *Quality Criteria for Water 1986* (also known as the Gold Book) (USEPA, 1986). While EPA continues to recommend states and authorized tribes use fecal coliform criteria to protect shellfishing waters, EPA's current recommendation that states and authorized tribes use enterococci for marine recreational waters and either enterococci or *E. coli* for fresh recreational waters, are causing states and authorized tribes that have adopted these criteria to now monitor for two different indicators. While EPA realizes that this may cause some inconvenience and additional resources to conduct monitoring, data and information do not yet exist that would support the use of *E. coli* or enterococci as criteria to protect waters designated for shellfishing.

The 1986 *E. coli* and enterococci criteria were developed to protect against human health effects, namely acute gastroenteritis, that may be incurred due to incidental ingestion of water while recreating. These criteria do not account for exposure that may be incurred by the consumption of shellfish, and therefore, are not appropriate for evaluating compliance with the shellfishing designated use. If data and information are compiled that support the use of these indicator organisms in shellfishing waters, EPA will revisit this issue in coordination with the Food and Drug Administration, the National Oceanic and Atmospheric Administration, and the Interstate Shellfishing Sanitation Conference, and consider the development of a revised criterion that appropriately takes into account the exposure pathways associated with the consumption of shellfish. In the meantime, EPA continues to recommend the use of fecal coliforms for the protection of shellfishing waters.

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Appendix A: Beaches Environmental Assessment and Coastal Health Act of 2000

An Act

To amend the Federal Water Pollution Control Act to improve the quality of coastal recreation waters, and for other purposes.
Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Beaches Environmental Assessment and Coastal Health Act of 2000".

SECTION 2. ADOPTION OF COASTAL RECREATION WATER QUALITY CRITERIA AND STANDARDS BY STATES.

Section 303 of the Federal Water Pollution Control Act (33 U.S.C. 1313) is amended by adding at the end the following:

(i) **Coastal Recreation Water Quality Criteria.—**

(1) **Adoption by States.—**

(A) **Initial Criteria and Standards.—**Not later than 42 months after the date of the enactment of this subsection, each State having coastal recreation waters shall adopt and submit to the Administrator water quality criteria and standards for the coastal recreation waters of the State for those pathogens and pathogen indicators for which the Administrator has published criteria under section 304(a).

(B) **New or Revised Criteria and Standards.—**Not later than 36 months after the date of publication by the Administrator of new or revised water quality criteria under section 304(a)(9), each State having coastal recreation waters shall adopt and submit to the Administrator new or revised water quality standards for the coastal recreation waters of the State for all pathogens and pathogen indicators to which the new or revised water quality criteria are applicable.

(2) **Failure of States to Adopt.—**

(A) **In General.—**If a State fails to adopt water quality criteria and standards in accordance with paragraph (1)(A) that are as protective of human health as the criteria for pathogens and pathogen indicators for coastal recreation waters published by the Administrator, the Administrator shall promptly propose regulations for the State setting forth revised or new water quality standards for pathogens and pathogen indicators described in paragraph (1)(A) for coastal recreation waters of the State.

(B) **Exception.—**If the Administrator proposes regulations for a State described in subparagraph (A) under subsection (c)(4)(B), the Administrator shall publish any revised or new standard under this subsection not later than 42 months after the date of the enactment of this subsection.

(3) **Applicability.**—Except as expressly provided by this subsection, the requirements and procedures of subsection (c) apply to this subsection, including the requirement in subsection (c)(2)(A) that the criteria protect public health and welfare.

SECTION 3. REVISIONS TO WATER QUALITY CRITERIA.

(a) **Studies Concerning Pathogen Indicators in Coastal Recreation Waters.**—Section 104 of the Federal Water Pollution Control Act (33 U.S.C. 1254) is amended by adding at the end the following:

(v) **Studies Concerning Pathogen Indicators in Coastal Recreation Waters.**—Not later than 18 months after the date of the enactment of this subsection, after consultation and in cooperation with appropriate Federal, State, tribal, and local officials (including local health officials), the Administrator shall initiate, and, not later than 3 years after the date of the enactment of this subsection, shall complete, in cooperation with the heads of other Federal agencies, studies to provide additional information for use in developing—

(1) an assessment of potential human health risks resulting from exposure to pathogens in coastal recreation waters, including nongastrointestinal effects;

(2) appropriate and effective indicators for improving detection in a timely manner in coastal recreation waters of the presence of pathogens that are harmful to human health;

(3) appropriate, accurate, expeditious, and cost-effective methods (including predictive models) for detecting in a timely manner in coastal recreation waters the presence of pathogens that are harmful to human health; and

(4) guidance for State application of the criteria for pathogens and pathogen indicators to be published under section 304(a)(9) to account for the diversity of geographic and aquatic conditions.

(b) **Revised Criteria.**—Section 304(a) of the Federal Water Pollution Control Act (33 U.S.C. 1314(a)) is amended by adding at the end the following:

(9) **Revised Criteria for Coastal Recreation Waters.**—

(A) **In General.**—Not later than 5 years after the date of the enactment of this paragraph, after consultation and in cooperation with appropriate Federal, State, tribal, and local officials (including local health officials), the Administrator shall publish new or revised water quality criteria for pathogens and pathogen indicators (including a revised list of testing methods, as appropriate), based on the results of the studies conducted under section 104(v), for the purpose of protecting human health in coastal recreation waters.

(B) **Reviews.**—Not later than the date that is 5 years after the date of publication of water quality criteria under this paragraph, and at least once every 5 years thereafter, the Administrator shall review and, as necessary, revise the water quality criteria.

SECTION 4. COASTAL RECREATION WATER QUALITY MONITORING AND NOTIFICATION.

Title IV of the Federal Water Pollution Control Act (33 U.S.C. 1341 et seq.) is amended by adding at the end the following:

SEC. 406. COASTAL RECREATION WATER QUALITY MONITORING AND NOTIFICATION.

(a) **Monitoring and Notification.**—

(1) **In General.**—Not later than 18 months after the date of the enactment of this section, after consultation and in cooperation with appropriate Federal, State, tribal, and local officials (including local health officials), and after providing public notice and an opportunity for comment, the Administrator shall publish performance criteria for—

(A) monitoring and assessment (including specifying available methods for monitoring) of coastal recreation waters adjacent to beaches or similar points of access that are used by the public for attainment of applicable water quality standards for pathogens and pathogen indicators; and

(B) the prompt notification of the public, local governments, and the Administrator of any exceeding of or likelihood of exceeding applicable water quality standards for coastal recreation waters described in subparagraph (A).

(2) **Level of Protection.**—The performance criteria referred to in paragraph (1) shall provide that the activities described in subparagraphs (A) and (B) of that paragraph shall be carried out as necessary for the protection of public health and safety.

(b) **Program Development and Implementation Grants.**—

(1) **In General.**—The Administrator may make grants to States and local governments to develop and implement programs for monitoring and notification for coastal recreation waters adjacent to beaches or similar points of access that are used by the public.

(2) **Limitations.**—

(A) **In General.**—The Administrator may award a grant to a State or a local government to implement a monitoring and notification program if—

(i) the program is consistent with the performance criteria published by the Administrator under subsection (a);

(ii) the State or local government prioritizes the use of grant funds for particular coastal recreation waters based on the use of the water and the risk to human health presented by pathogens or pathogen indicators;

(iii) the State or local government makes available to the Administrator the factors used to prioritize the use of funds under clause (ii);

(iv) the State or local government provides a list of discrete areas of coastal recreation waters that are subject to the program for monitoring and notification for which the grant is provided that specifies any coastal recreation waters for which fiscal constraints will prevent consistency with the performance criteria under subsection (a); and

(v) the public is provided an opportunity to review the program through a process that provides for public notice and an opportunity for comment.

(B) **Grants to Local Governments.**—The Administrator may make a grant to a local government under this subsection for implementation of a monitoring and notification program only if, after the 1year period beginning on the date of publication of performance criteria under subsection (a)(1), the Administrator determines that the State is not implementing a program that meets the requirements of this subsection, regardless of whether the State has received a grant under this subsection.

(3) **Other Requirements.**—

(A) **Report.**—A State recipient of a grant under this subsection shall submit to the Administrator, in such format and at such intervals as the Administrator determines to be appropriate, a report that describes—

(i) data collected as part of the program for monitoring and notification as described in subsection (c); and

(ii) actions taken to notify the public when water quality standards are exceeded.

(B) **Delegation.**—A State recipient of a grant under this subsection shall identify each local government to which the State has delegated or intends to delegate responsibility for implementing a monitoring and notification program consistent with the performance criteria published under subsection (a) (including any coastal recreation waters for which the authority to implement a monitoring and notification program would be subject to the delegation).

(4) **Federal Share.**—

(A) **In General.**—The Administrator, through grants awarded under this section, may pay up to 100 percent of the costs of developing and implementing a program for monitoring and notification under this subsection.

(B) **Nonfederal Share.**—The non-Federal share of the costs of developing and implementing a monitoring and notification program may be—

(i) in an amount not to exceed 50 percent, as determined by the

Administrator in consultation with State, tribal, and local government representatives; and

(ii) provided in cash or in kind.

(c) **Content of State and Local Government Programs.**—As a condition of receipt of a grant under subsection (b), a State or local government program for monitoring and notification under this section shall identify—

(1) lists of coastal recreation waters in the State, including coastal recreation waters adjacent to beaches or similar points of access that are used by the public;

(2) in the case of a State program for monitoring and notification, the process by which the State may delegate to local governments responsibility for implementing the monitoring and notification program;

(3) the frequency and location of monitoring and assessment of coastal recreation waters based on—

(A) the periods of recreational use of the waters;

(B) the nature and extent of use during certain periods;

(C) the proximity of the waters to known point sources and nonpoint sources of pollution; and

(D) any effect of storm events on the waters;

(4) (A) the methods to be used for detecting levels of pathogens and pathogen indicators that are harmful to human health; and

(B) the assessment procedures for identifying short-term increases in pathogens and pathogen indicators that are harmful to human health in coastal recreation waters (including increases in relation to storm events);

(5) measures for prompt communication of the occurrence, nature, location, pollutants involved, and extent of any exceeding of, or likelihood of exceeding, applicable water quality standards for pathogens and pathogen indicators to—

(A) the Administrator, in such form as the Administrator determines to be appropriate; and

(B) a designated official of a local government having jurisdiction over land adjoining the coastal recreation waters for which the failure to meet applicable standards is identified;

(6) measures for the posting of signs at beaches or similar points of access, or functionally equivalent communication measures that are sufficient to give notice to the public that the coastal recreation waters are not meeting or are not expected to meet applicable water quality standards for pathogens and pathogen indicators; and

(7) measures that inform the public of the potential risks associated with water contact activities in the coastal recreation waters that do not meet applicable water quality standards.

(d) **Federal Agency Programs.**—Not later than 3 years after the date of the enactment of this section, each Federal agency that has jurisdiction over coastal recreation waters adjacent to beaches or similar points of access that are used by the public shall develop and implement, through a process that provides for public notice and an opportunity for comment, a monitoring and notification program for the coastal recreation waters that—

(1) protects the public health and safety;

(2) is consistent with the performance criteria published under subsection (a);

(3) includes a completed report on the information specified in subsection (b)(3)(A), to be submitted to the Administrator; and

(4) addresses the matters specified in subsection (c).

(e) **Database.**—The Administrator shall establish, maintain, and make available to the public by electronic and other means a national coastal recreation water pollution occurrence database that provides—

(1) the data reported to the Administrator under subsections (b)(3)(A)(i) and (d)(3); and

(2) other information concerning pathogens and pathogen indicators in coastal recreation waters that—

(A) is made available to the Administrator by a State or local government, from a coastal water quality monitoring program of the State or local government; and

(B) the Administrator determines should be included.

(f) **Technical Assistance for Monitoring Floatable Material.**— The Administrator shall provide technical assistance to States and local governments for the development of assessment and monitoring procedures for floatable material to protect public health and safety in coastal recreation waters.

(g) **List of Waters.**—

(1) **In General.**—Beginning not later than 18 months after the date of publication of performance criteria under subsection (a), based on information made available to the Administrator, the Administrator shall identify, and maintain a list of, discrete coastal recreation waters adjacent to beaches or similar points of access that are used by the public that—

(A) specifies any waters described in this paragraph that are subject to a monitoring and notification program consistent with the performance criteria established under subsection (a); and

(B) specifies any waters described in this paragraph for which there is no monitoring and notification program (including waters for which fiscal constraints will prevent the State or the Administrator from performing monitoring and notification consistent with the performance criteria established under subsection (a)).

(2) **Availability.**—The Administrator shall make the list described in paragraph

(1) available to the public through—

(A) publication in the Federal Register; and

(B) electronic media.

(3) **Updates.**—The Administrator shall update the list described in paragraph (1) periodically as new information becomes available.

(h) **EPA Implementation.—**In the case of a State that has no program for monitoring and notification that is consistent with the performance criteria published under subsection (a) after the last day of the 3year period beginning on the date on which the Administrator lists waters in the State under subsection (g)(1)(B), the Administrator shall conduct a monitoring and notification program for the listed waters based on a priority ranking established by the Administrator using funds appropriated for grants under subsection (i)—

(1) to conduct monitoring and notification; and

(2) for related salaries, expenses, and travel.

(i) **Authorization of Appropriations.—**There is authorized to be appropriated for making grants under subsection (b), including implementation of monitoring and notification programs by the Administrator under subsection (h), $30,000,000 for each of fiscal years 2001 through 2005.

SECTION 5. DEFINITIONS.

Section 502 of the Federal Water Pollution Control Act (33 U.S.C. 1362) is amended by adding at the end the following:

(21) **Coastal Recreation Waters.**—

(A) **In General.**—The term 'coastal recreation waters' means—

(i) the Great Lakes; and

(ii) marine coastal waters (including coastal estuaries) that are designated under section 303(c) by a State for use for swimming, bathing, surfing, or similar water contact activities.

(B) **Exclusions.**—The term 'coastal recreation waters' does not include—

(i) inland waters; or

(ii) waters upstream of the mouth of a river or stream having an unimpaired natural connection with the open sea.

(22) **Floatable Material.**—

(A) **In General.**—The term 'floatable material' means any foreign matter that may float or remain suspended in the water column.

(B) **Inclusions.**—The term 'floatable material' includes—

(i) plastic;

(ii) aluminum cans;

(iii) wood products;

(iv) bottles; and

(v) paper products.

(23) **Pathogen Indicator.**—The term ‘pathogen indicator’ means a substance that indicates the potential for human infectious disease.

SECTION 6. INDIAN TRIBES.

Section 518(e) of the Federal Water Pollution Control Act (33 U.S.C. 1377(e)) is amended by striking ‘‘and 404’’ and inserting “404, and 406’’.

SECTION 7. REPORT.

(a) **In General.**—Not later than 4 years after the date of the enactment of this Act, and every 4 years thereafter, the Administrator of the Environmental Protection Agency shall submit to Congress a report that includes—

(1) recommendations concerning the need for additional water quality criteria for pathogens and pathogen indicators and other actions that should be taken to improve the quality of coastal recreation waters;

(2) an evaluation of Federal, State, and local efforts to implement this Act, including the amendments made by this Act; and

(3) recommendations on improvements to methodologies and techniques for monitoring of coastal recreation waters.

(b) **Coordination.**—The Administrator of the Environmental Protection Agency may coordinate the report under this section with other reporting requirements under the Federal Water Pollution Control Act (33 U.S.C. 1251 et seq.).

Appendix B: Reaffirmation of EPA's Recommended Water Quality Criteria for Bacteria

The following sections describe the scientific rationale underlying EPA's 1986 guidance, EPA's re-evaluation of its recommended criteria, and subsequent research conducted following EPA's issuance of the 1986 guidance.

B.1 Does EPA continue to support its *Ambient Water Quality Criteria for Bacteria* – 1986?

EPA reviewed its original studies supporting its recommended 1986 water quality criteria for bacteria and the literature on epidemiological research studies conducted since EPA performed its marine and freshwater research studies of swimming-associated health effects. Based on these reviews, **[EPA continues to believe that]** when appropriately applied and implemented, EPA's recommended water quality criteria for bacteria are protective of human health for acute gastrointestinal illness.

The epidemiological and statistical methods used to derive EPA's water quality criteria for bacteria represent a sound scientific rationale. Aside from measuring pathogens directly, the use of bacterial indicators provides the best known approach to protecting swimmers against potential waterborne diseases that may be fecal in origin. Despite this fact, there are many known limitations of using indicators as the basis for protective criteria. The criteria published by EPA are targeted toward protecting recreators from acute gastrointestinal illness and may not provide protection against other waterborne diseases, such as eye, ear, skin, and upper respiratory infections, nor illnesses that may be transmitted from swimmer to swimmer. Also, certain subgroups of the population may contract illnesses more readily than the general population, such as children, the elderly, and immuno-compromised individuals. Because pathogens are not being measured directly, the concentration of pathogens causing acute gastrointestinal illness may not be constant over time and at different locations relative to the measured concentrations of bacterial indicators. For instance, depending upon the type of source and the type and number of pathogens contributed by the source of fecal pollution, the actual number of illnesses realized for a given level of bacteria may be more or less than the rates observed in EPA's epidemiological studies that formed the basis of the criteria. On this topic, the *Ambient Water Quality Criteria for Bacteria*–1986 stated:

> ...the major limitations of the criteria are that the observed relationship may not be valid if the size of the population contributing the fecal wastes becomes too small or if epidemic conditions are present in a community. In both cases the pathogen to indicator ratio, which is approximately constant in a large population becomes unpredictable and therefore, the criteria may not be reliable under these circumstances.

Lastly, new pathogens and strains of antibiotic resistant bacteria capable of causing gastrointestinal illness have been identified since EPA's studies were conducted. The introduction of these new pathogens into the environment may cause a greater number of illnesses to occur at a given level of indicator organisms.

These uncertainties and limitations demonstrate the need for appropriate implementation of water quality criteria for bacteria. To assure protection of recreational water users, EPA recommends:

- frequent monitoring of known recreation areas to establish a more complete database upon which to determine if the waterbody is attaining the water quality criteria;
- assuring that where mixing zones for bacteria are authorized, they do not impinge upon known primary contact recreation areas; and
- conducting a sanitary survey when higher than normal levels of bacteria are measured. (See section 4 for additional information on conducting sanitary surveys.)

In addition to its re-evaluation of the original studies, EPA reviewed the literature for epidemiological research studies conducted after EPA performed its marine and freshwater studies of swimming-associated health effects. The review examined recent studies to determine if EPA's indicator relationship findings were supported or if different indicator bacteria were consistently shown to have quantitatively better predictive abilities. EPA's Office of Research and Development reviewed 11 separate peer-reviewed studies. This detailed review is contained in Appendix B. Following this review, EPA's Office of Research and Development concluded:

> The epidemiological studies conducted since 1984, which examined the relationships between water quality and swimming-associated health effects, have not established any new or unique principles that might significantly affect the current guidance EPA recommends for maintaining the microbiological safety of marine and freshwater bathing beaches. Many of the studies have, in fact, confirmed and validated the findings of the U.S. EPA studies. There would appear to be no good reason for modifying the Agency's current guidance for recreational waters at this time (Dufour, 1999).

As a result of this examination, EPA's 1986 water quality criteria for bacteria continue to represent the best available science and serve as a defensible foundation for protecting public health in recreational waters. EPA has no new scientific information or data justifying a revision of the Agency's recommended 1986 water quality criteria for bacteria at this time. When appropriately applied and implemented, EPA's recommended *Ambient Water Quality Criteria for Bacteria*–1986 are protective of human health for acute gastrointestinal illness.

B.2 Have subsequent studies affected EPA's recommended water quality criteria for bacteria?

In examining the relationships between water quality and swimming-associated gastrointestinal illness, the epidemiological studies conducted since 1984 offer no new or unique principles that significantly affect the current water quality criteria EPA recommends for protecting and maintaining recreational uses of marine and fresh waters. Many of the studies have, in fact, confirmed and validated the findings of EPA's studies. Thus, EPA has no new scientific information or data justifying a revision of the Agency's recommended 1986 water quality criteria for bacteria at this time.

None of the epidemiological studies examined by EPA in its recent review presented compelling evidence that necessitate revising the 1986 water quality criteria for bacteria recommended by EPA. Most of the studies used a survey plan similar to that used by EPA in the Agency's studies during the 1970's and 1980's. The study sites chosen by most of the investigators were similar to those studied by EPA. In the studies, one site was typically a beach with some fecal contamination, and the other site was usually a relatively unpolluted beach. Most of the bacteria loadings at the polluted beach sites came from known point sources. The results from these studies were similar to those found in the EPA studies, i.e., swimming in fecally contaminated water was associated with a higher rate of gastrointestinal illnesses in swimmers when compared to non-swimmers. This outcome was not observed in two of the reviewed studies. The reason for a negative finding is unclear, but could be related to factors such as the short length of time between the swimming event and the follow-up contact, the small numbers of children in the study groups, or the selection of a study site in which the pollution source was poorly defined.

Only a limited number of studies attempted to show a dose-response relationship between swimming water quality and gastrointestinal illness. Six of the studies (McBride et al., 1998; Kay et al., 1994; Cheung et al., 1990; Ferley et al., 1989; Seyfried et al., 1985) showed that as the level of pollution increased, there was also an increase in swimming-associated illness. Only two studies that looked for a relationship between swimming-associated illness and the level of water quality failed to find such a relationship (Kueh et al., 1995; Corbett et al., 1993). It is possible that these findings were related to the indicator organisms measured (i.e., fecal coliforms and fecal streptococci) or to the methodology used to detect the indicators. In general, the result of these studies was similar to the results found in the EPA studies: swimming-associated illness rates increased with increasing water pollution levels.

It has been shown that some indicator organisms are superior predictors of gastrointestinal illness in swimmers. In the EPA studies, *E. coli* and enterococci exhibited the strongest relationships to swimming-associated gastrointestinal illness. Some of the studies reviewed describe other microbes having strong relationships with swimming-associated gastrointestinal illness, such as staphylococci (Seyfried et al., 1985), *Clostridium perfringens* (Kueh et al., 1995), and *Aeromonas* spp. (Kueh et al., 1995). Most of the studies, however, had findings similar to those of the EPA studies in which enterococci were shown to be the most efficient indicators for measuring marine water quality. One of the two fresh water studies indicated that *E. coli* and enterococci both exhibited very strong correlations with swimming-associated gastrointestinal illness. In general, the best indicator organisms for measuring water quality in the reviewed studies were *E. coli* and enterococci, results similar to those documented in EPA's studies.

A recent review by Pruss[1] of all studies since 1953 that examined the relationship between swimming-associated gastroenteritis and water quality, indicated that nine separate marine studies and at least two fresh water studies were conducted since the EPA studies were completed in 1984. In this review, each of the later studies is summarized with regard to the size of the study, study design, water quality indicator bacteria measured, and the results of the study with respect to gastrointestinal illness. Some of the studies looked only at whether an association existed between swimming and illness at a polluted beach or a non-polluted beach, while other studies attempted to determine the relationship between increasing levels of poor water quality and the levels of gastrointestinal illness associated with those increases. This review does not address studies that examined non-enteric illnesses or infections unrelated to gastrointestinal disease. The intent of the review is to carefully examine all of the studies conducted subsequent to the EPA studies and to determine if they have a significant impact on the current water quality criteria for bacteria recommended by the Agency.

Marine Water Studies

In 1987, Fattal et al.[2] reported on a study of health and swimming conducted at beaches near Tel-Aviv, Israel. The study design was the same that used by EPA. (In those studies described here using the same design as the epidemiological studies conducted by EPA in support of its 1986 water quality criteria for bacteria recommendations, it will state that the EPA design was used rather than describing it in detail each time.) Beach water quality was measured using fecal coliforms, enterococci, and *E. coli*. Three beaches with different water qualities were studied. Symptoms among bathers were analyzed according to high and low categories of bacterial indicator densities in the seawater. The high and low categories for fecal coliforms were above and below 50 colony forming units (cfu) per 100 ml. The limits for enterococci and *E. coli* were 24 cfu per 100 ml. Excess illness was observed only in swimmers 0-4 years old at low categories of the indicators. Significant differences in risk levels between swimmers and non-swimmers occurred only at high indicator densities. Enterococci were the most predictive indicator for enteric disease symptoms.

In 1990, Cheung and his co-workers[3] reported on a health effects study related to beach water pollution in Hong Kong. The basic EPA design was used in conducting this investigation. Nine microbial indicators were examined as potentially useful measures of water quality. They included fecal coliforms, *E. coli, Klebsiella* spp., fecal streptococci, enterococci, staphylococci, *Pseudomonas aeruginosa, Candida albicans*, and total fungi. The study was carried out at nine beaches that were polluted either by human sewage discharged from a submarine outfall or carried by storm water drains into the beaches. Two of the beaches were contaminated mainly by livestock wastes. Approximately nineteen thousand usable responses were obtained, of which about 77% were from swimmers. The enterococci densities at the beaches ranged from 31 to 248 cfu per 100 ml. The range for *E. coli* was from 69 to 1,714 cfu per 100 ml. The overall gastrointestinal risk levels were significantly higher in swimmers than in non-swimmers. Children under 10 years old were more likely to exhibit gastrointestinal illness (GI) and highly credible gastrointestinal illness (HCGI) symptoms than individuals older than 10 years. The best relationship between a microbial indicator density and swimming-associated health effects was between *E. coli* and HCGI.

Health risks associated with bathing in sea water in the United Kingdom were described by Balarajan et al.[4] in 1991. This study also used the EPA design for their trials. The study was conducted at one beach where 1,883 individuals participated (1,044 bathers and 839 non-bathers). The methods used to measure water quality were not given. Ratios of illness in swimmers to non-swimmers were developed. The rate of gastrointestinal illness was found to be significantly greater in bathers than in non-bathers. The risk of illness increased with the degree of exposure, ranging from 1.25 in waders, 1.31 in swimmers, to 1.81 in surfers or divers. The authors concluded that the increase was indicative of a dose-response relationship.

Von Schirnding and others[5] conducted a study to determine the relationship between swimming-associated illness and the quality of bathing beach waters. A series of discrete, prospective trials was carried out at a relatively clean and a moderately polluted beach following the methodology used in the EPA studies. The beaches were situated on the Atlantic coast of South Africa. The moderately polluted beach was affected by septic tank overflows, storm water run-off, and feces-contaminated river water. A number of potential indicator organisms were measured including enterococci, fecal coliforms, coliphages, staphylococci, and F-male-specific bacteriophages. A total of 1,024 people were contacted, of whom 733 comprised the final study population. The moderately polluted beach was characterized by fecal coliforms and enterococci. The median fecal coliform density was 77 cfu per 100 ml and the median enterococci density was 52 cfu per 100 ml. The median fecal coliform and enterococci densities at the relatively clean beach were 8 and 2 cfu per 100 ml, respectively. The rates for gastrointestinal symptoms were appreciably higher for swimmers than non-swimmers at the more polluted beach as compared with the less polluted beach, but the differences were not statistically significant, either for children less than ten years of age or for adults. The lack of statistical significance may have been due in part to the uncertain sources of fecal contamination.

In 1993, Corbett et al.[6] conducted a study to determine the health risks of swimming at ocean beaches in Sydney, Australia. The study used a design slightly modified from the EPA approach. First, no one under the age of 15 was recruited for the study and, second, multiple samples were taken at the time of swimming activity. The inclusion of families and social groups was minimized. Water quality was measured using fecal coliforms and fecal streptococci. A total of 2,869 individuals participated in the study. Of this group, 32.2% reported that they did not swim. In general, gastrointestinal symptoms in swimmers did not increase with increasing counts of fecal bacteria. However, fecal streptococci were worse predictors of swimming-associated illness than fecal coliforms. Although no relationship was observed between the measured indicators and gastrointestinal illness, swimmers who swam for more than 30 minutes were 4.6 times more likely to develop gastrointestinal symptoms than were those that swam for less than 30 minutes. The lack of a relationship between increasing fecal coliform densities and gastrointestinal symptoms was similar to results noted in the EPA marine and freshwater studies where increasing risk levels were not associated with increasing fecal coliform densities.

In 1994, Kay et al.[7] conducted a series of four trials at bathing beaches in the United Kingdom to examine the relationship between swimming-associated illness and water quality. The design of this study differed from previous studies in that the study population was selected prior to each trial. On the trial date, half of the participants were randomly assigned to be swimmers, with the remaining participants were non-swimmers. Each swimmer swam in a designated area that was monitored by taking a sample every 30 minutes. Samples were analyzed for total and fecal coliforms, fecal streptococci, *Pseudomonas aeruginosa,* and total staphylococci. The total number of participants in the study was 1,112, of which 46% were selected as swimmers. All of the study volunteers were older than 18 years of age. Analysis of the data indicated that the rates of gastroenteritis were significantly higher in the swimming group than in the non-swimming group. Only fecal streptococci showed a significant dose-response relationship with gastroenteritis. The analysis suggested that the risk of gastroenteritis did not increase until bathers were exposed to about 40 streptococci per 100 ml.

In 1995, Kueh et al.[8] reported a second study conducted at Hong Kong beaches. Only two beaches were examined in the second study, rather than the nine beaches examined in the 1990 Hong Kong study. The study design for collecting health data was similar to that followed in the EPA studies. The ages of study participants ranged from 10 to 49 years of age. Unlike the EPA studies, follow-up telephone calls were made two days after the swimming event rather than seven to 10 days. Another aspect of the Hong Kong study differing from the EPA studies was the collection of clinical specimens from ill participants with their consent. Stool specimens were analyzed for Rotavirus, *Salmonella* spp., *Shigella* spp., *Vibrio* spp., and *Aeromonas* spp. Throat swabs were examined for Influenza A and B; Parainfluenza virus types 1, 2 and 3; Respiratory Syncytial Virus, and Adenovirus. Water samples were examined for *E. coli*, fecal coliforms, staphylococci, *Aeromonas* spp., *Clostridium perfringens, Vibrio cholera, Vibrio parahemolyticus, Vibrio vulnificus, Salmonella* spp., and *Shigella* spp. A total of 18,122 individuals participated in the study. Although the levels of indicator densities were not reported for the beaches, the gastrointestinal risk levels were significantly higher at the more polluted beach. This study did not find a relationship between *E. coli* and swimming-associated illness as had been found in the original Hong Kong study. This may have been, as pointed out by the authors, due to the fact that only two beaches were examined rather than nine. The cause of the infections could not be ascertained from the clinical specimens obtained from ill individuals.

In 1998, McBride et al.[9] reported prospective epidemiological studies on the possible health effects from sea bathing at seven New Zealand beaches. A total of 1,577 and 2,307 non-swimmers participated in the studies. Although the EPA study design was used, it was slightly modified in that follow-up interviews were conducted three to five days after the swimming event rather than the seven to 10 days used in the U.S. studies. Fecal coliforms, *E. coli*, and enterococci were used to measure water quality. The results of the study showed that enterococci were most strongly and consistently associated with illness risk for the exposed groups. Risk differences between swimmers and non-swimmers were significantly increased if swimmers stayed in the water for more than 30 minutes as compared to those in the water less than 30 minutes. The risk differences were slightly greater for paddlers than for swimmers.

The most recent study of possible adverse health effects associated with swimming in marine waters was conducted at beaches on Santa Monica Bay, California, by Haile and others.[10] The objective of this study was to determine if excess swimming-associated illness could be observed in swimmers exposed to waters receiving discharges from a storm drain. The study design was patterned after the U.S. EPA studies. Water samples were taken at ankle depth and collected from sites at the storm drain, 100 yards up-coast, and 100 yards down-coast. Samples were also collected 400 yards up-coast or down-coast of the storm drain, depending on which location would be used as a control area. The samples were analyzed for total coliforms, fecal coliforms, enterococci, and *E. coli*. One sample was collected each Friday, Saturday, and Sunday during the study period at the mouth of the storm drain and analyzed for enteric viruses. Subjects of all ages participated in the study. A total of 11,686 subjects volunteered to take part in the study. The results of the study with regard to associations between bacterial indicators and health outcomes were presented in terms of thresholds of bacterial densities, which were somewhat arbitrarily chosen. No positive associations, as measured by risk ratios, were observed for *E. coli* at bacterial density thresholds of 35 and 70 cfu per 100 ml. A less arbitrary analysis using a continuous model showed more positive associations, especially for enterococci. The model for enterococci indicated positive associations with fever, skin rash, nausea, diarrhea, stomach pain, coughing, runny nose, and highly credible gastrointestinal illness. The associations of symptoms with indicators were very weak in the case of *E. coli* and fecal coliforms. However, the authors found that the total coliform to fecal coliform ratio was very informative. Using a ratio of 5.0 as a threshold, diarrhea and highly credible gastrointestinal illness were associated with a lower total coliform to fecal coliform ratio regardless of the absolute level of fecal coliforms. When their analysis was restricted to subjects where the total coliforms exceeded 5,000 cfu per 100 ml, significantly higher risks were detected for most outcomes. One of the general conclusions of the study was that excess gastrointestinal illness is associated with swimming in feces-polluted bathing water.

Fresh Water Studies

In 1985, Seyfried et al.[11] reported on a prospective epidemiological study of swimming-associated illness in Canada. These investigations used the EPA methodology in carrying out the study. Water quality was measured with the following bacterial indicators of swimming water quality: fecal coliforms, fecal streptococci, heterotrophic bacteria, *Pseudomonas aeruginosa*, and total staphylococci. A total of 4,537 individuals participated in the study, of which 2,743 were swimmers and 1,794 were non-swimmers. Swimmers were found to have significantly higher gastrointestinal risk levels than non-swimmers, and swimmers under the age of 16 had substantially higher rates than swimmers 16 and older. Logistic regression analysis was performed to determine the best relationship between water quality indicators and swimming-associated illness. A small degree of correlation was observed between fecal streptococci and gastrointestinal illness. The best correlation was between gastrointestinal illness and staphylococcus densities.

In 1989, Ferley et al.[12] described an epidemiological study conducted in France that examined health effects associated with swimming in a freshwater river. A total of 5,737 individuals participated in the study. The quality of the water was measured by assaying for fecal coliforms, fecal streptococci, and *Pseudomonas aeruginosa*. The study design for collecting health data was unique. The maximum latency period for the illness category groups examined in this study was three days. Illnesses occurring during the course of the study were assigned to the nearest day within the latency period on which a sample was taken. A weighted linear regression was performed to relate gastrointestinal morbidity incidence rates to different levels of exposure to indicator bacteria. Significant excess gastrointestinal illness was observed in swimmers. Furthermore, regression of gastrointestinal illness incidence to the concentration of indicator organisms showed a good relationship between swimming-associated illness for both fecal coliforms and fecal streptococci. The strongest correlations occurred between incidence rates of acute gastrointestinal disease and fecal streptococci densities. The authors indicated that their definition of fecal streptococci essentially included what the EPA studies call enterococci.

Summary of Research Conducted Since 1984

Researcher	Year	Location	Type of Water	Microorganisms Evaluated	Relevant Findings
Fattal et al.[2]	1987	Israel	Marine	Fecal coliforms Enterococci *E. coli*	• Enterococci were the most predictive indicator for enteric disease symptoms
Cheung et al.[3]	1990	Hong Kong	Marine	Fecal coliforms *E. coli* *Klebsiella* spp. Enterococci Fecal streptococci Staphylococci *Pseudomonas aeruginosa* *Candida albicans* Total fungi	• Best relationship between a microbial indicator density and swimming-associated health effects was between *E. coli* and highly credible gastrointestinal illness.
Balarajan et al.[4]	1991	United Kingdom	Marine	Unknown	• Risk of illness increased with degree of exposure. If the non-exposed population risk ranked at 1, risk increased to 1.25 for waders, 1.31 for swimmers, and 1.81 in surfers or divers.
Von Schirnding et al.[5]	1992	South Africa (Atlantic coast)	Marine	Enterococci Fecal coliforms Coliphages Staphylococci F-male-specific bacteriophages	• Uncertainty in sources of fecal contamination may explain lack of statistically significant rates of illness between swimmers and non-swimmers.
Corbett et al.[6]	1993	Sydney, Australia	Marine	Fecal coliforms Fecal streptococci	• Gastrointestinal symptoms in swimmers did not increase with increasing counts of fecal bacteria. • Counts of fecal streptococci were worse predictors of swimming-associated illness than fecal coliforms.

Summary of Research Conducted Since 1984					
Researcher	**Year**	**Location**	**Type of Water**	**Microorganisms Evaluated**	**Relevant Findings**
Kay et al.[7]	1994	United Kingdom	Marine	Total coliforms Fecal coliforms Fecal streptococci *Pseudomonas aeruginosa* Total staphylococci	• Only fecal streptococci were associated with increased rates of gastroenteritis. • Risk of gastroenteritis did not increase until bathers were exposed to about 40 fecal streptococci per 100 ml.
Kueh et al.[8]	1995	Hong Kong	Marine	*E. coli* Fecal coliforms Staphylococci *Aeromonas* spp. *Clostridium perfringens* *Vibrio cholera* *Vibrio parahemolyticus* *Salmonella* spp. *Shigella* spp.	• Also analyzed stool specimens for rotavirus, *Salmonella* spp., *Shigella* spp., *Vibrio* spp., and *Aeromonas* spp.; throat swabs for Influenza A and B; Parainfluenza Virus types 1, 2, and 3; Respiratory Syncytial Virus; and Adenovirus. • Did not find a relationship between *E. coli* and swimming-associated illness [possibly due to low number of beaches sampled (only two)].
McBride et al.[9]	1998	New Zealand	Marine	Fecal coliforms *E. coli* Enterococci	• Enterococci were most strongly and consistently associated with illness risk for the exposed groups. • Risk differences significantly greater between swimmers and non-swimmers if swimmers remained in water for more than 30 minutes.
Haile et al.[10]	1996	California, USA	Marine	Total coliforms Fecal coliforms Enterococci *E. coli*	• Results for enterococci indicate positive associations with fever, skin rash, nausea, diarrhea, stomach pain, coughing, runny nose, and highly credible gastrointestinal illness. • Association of symptoms with both *E. coli* and fecal coliforms were very weak. • Total coliform to fecal coliform ratio very informative — below the cutpoint of 5.0, diarrhea and highly credible gastrointestinal illness were associated with a lower ratio regardless of the absolute level of fecal coliforms.

Summary of Research Conducted Since 1984

Researcher	Year	Location	Type of Water	Microorganisms Evaluated	Relevant Findings
Seyfried et al.[11]	1985	Canada	Fresh	Fecal coliforms Fecal streptococci Heterotrophic bacteria *Pseudomonas aeruginosa* Total staphylococci	• Small degree of correlation observed between fecal streptococci and gastrointestinal illness. • Best correlation was between gastrointestinal illness and staphylococcus densities.
Ferley et al.[12]	1989	France	Fresh	Fecal coliforms Fecal streptococci *Pseudomonas aeruginosa*	• In this study, the definition of fecal streptococci is essentially the same as the U.S. definition of enterococci. • Good relationship between swimming associated illness and fecal coliform and fecal streptococci concentrations. • Strongest relationship was between gastrointestinal disease and fecal streptococci densities.

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Appendix C: Development of *Enterococci/E. Coli* Water Quality Criteria for Adoption into Water Quality Standards

This appendix describes how states can calculate enterococci and *E. Coli* water quality criteria based on different risk levels; calculate upper percentile values, and; adjust upper percentile values based on standard deviations calculated from local data. These methods are described in *Ambient Water Quality Criteria for Bacteria*–1986.

C.1 Geometric Mean

As described in this guidance, EPA recommends states and authorized tribes use a geometric mean as one component of their bacteria criteria. Whereas an arithmetic mean is equal to the sum of samples divided by the number of samples, a geometric mean is the *n*th root of the product of *n* samples; this helps to minimize the effect of measurements that might otherwise be considered outliers. In order to develop a geometric mean criterion, permitting authorities must decide upon a risk level, based on a gastrointestinal illness rate. Then, one can develop geometric mean criteria as the following:

Freshwater

$$\textit{Enterococci}\text{ Geometric Mean Criteria} = 4.656 * 10^{(1.064\ *\ \text{acceptable illness rate})}$$

$$\textit{E. Coli}\text{ Geometric Mean Criteria} = 17.742 * 10^{(1.064\ *\ \text{acceptable illness rate})}$$

Marine Water

$$\textit{Enterococci}\text{ Geometric Mean Criteria} = 0.963 * 10^{(0.822\ *\ \text{acceptable illness rate})}$$

The above equations are based on the numerical results from EPA's epidemiological studies *Health Effects Criteria for Marine Recreational Waters* (EPA-600/1-80-031) and *Health Effects Criteria for Fresh Recreational Waters* (EPA-600/1-84-004).

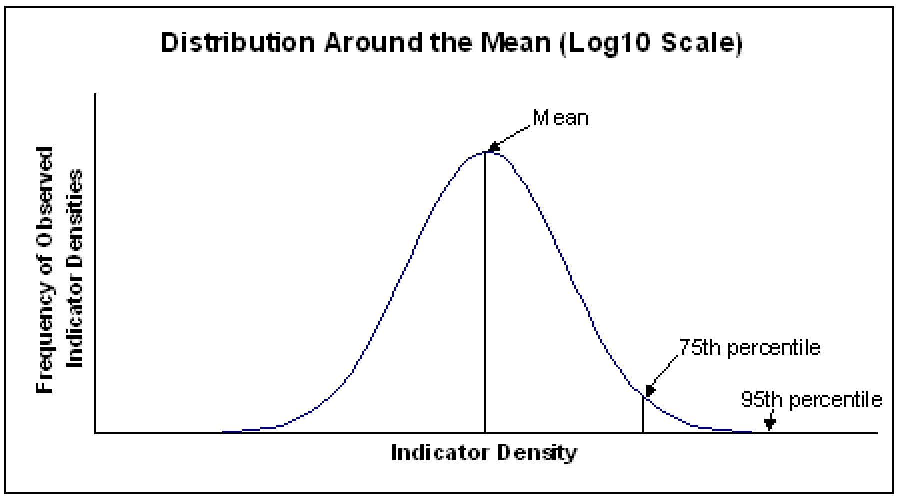
The geometric mean of *n* samples collected for monitoring is compared to a geometric mean criterion to determine whether the beach is in compliance. The geometric mean of *n* samples is computed by

$$\dot{X}_{GM} = \prod_{i=1}^{n} X_i^{\frac{1}{n}}$$

where X_i is the ith value of samples.

EPA recommends sampling frequency be related to the intensity of the use of the water body. In areas where weekend use is substantial, weekly samples collected during the peak use periods are reasonable. In less heavily used areas biweekly or monthly samples may be adequate to determine bacterial water quality. In general, samples should be collected during dry weather periods to establish so-called "steady state" conditions. Special studies may be necessary to evaluate the effects of wet weather conditions on waters of interest especially if sanitary surveys indicate the area may be subject to storm water effects.

C.2 Upper Percentile Value



Once water quality managers determine a waterbody is meeting its geometric mean requirements, they may consider the use of a site-specific upper percentile value. To set an upper percentile value, water quality managers should specify the "confidence level" factor[8] based on the use of recreational waters. The "confidence level" factors for the recommended criteria are specified as the following:

Upper percentile	Confidence Level Factor
75%	0.68
82%	0.94
90%	1.28
95%	1.65

Upper percentile values are computed as

Upper Percentile Value = **Geometric Mean** $*10^{(\text{Confidence Level Factor} * \sigma)}$

where σ is the standard deviation of the logarithm of indicator densities. EPA's studies show that the values of σ are 0.4 for freshwater *E. Coli* and Enterococci and 0.7 for marine water Enterococci. Each jurisdiction may establish its own σ or use the estimate of σ, $\hat{\sigma}$, based on similar indicator density data from the following equation:

$$\hat{\sigma} = \sqrt{\frac{\sum_{i=1}^{n}\left(\log X_i - \frac{\sum_{i=1}^{n}\log X_i}{n}\right)^2}{n-1}}$$

[8]The "confidence level" factors can be found in the "z-score" table in most elementary statistical textbooks.

Tables C-1 and C-2 present geometric mean and upper percentile values for various risk levels using the equations and the values of σ from the above. The computed values are rounded to the nearest integers to represent count densities.

Table C-1 Water Quality Criteria for Bacteria for Fresh Recreational Waters

Enterococci Criteria

Risk level (% of swimmers)	**Geometric Mean Density**	**Upper Percentile Allowable Density**			
		75th Percentile	**82nd Percentile**	**90th Percentile**	**95th Percentile**
0.8	**33**	62	79	107	151
0.9	**42**	79	100	137	193
1.0	**54**	101	128	175	247

E. coli Criteria

Risk Level (% of swimmers)	**Geometric Mean Density**	**Upper Percentile Allowable Density**			
		75th Percentile	**82nd Percentile**	**90th Percentile**	**95th Percentile**
0.8	**126**	236	299	409	576
0.9	**161**	301	382	523	736
1.0	**206**	385	489	668	940

Table C-2 Water Quality Criteria for Bacteria for Marine Recreational Waters

Enterococci Criteria

Risk Level (% of swimmers)	Geometric Mean Density	Upper Percentile Allowable Density			
		75th Percentile	82nd Percentile	90th Percentile	95th Percentile
0.8	**4**	13	20	35	63
0.9	**5**	16	24	42	76
1.0	**6**	19	29	50	91
1.1	**8**	23	35	61	110
1.2	**9**	28	42	73	133
1.3	**11**	34	51	89	161
1.4	**14**	41	62	107	195
1.5	**17**	49	75	130	235
1.6	**20**	60	91	157	284
1.7	**24**	72	109	189	344
1.8	**29**	87	132	229	415
1.9	**35**	104	158	276	501

Appendix D: Data Used to Create Chapter 1 Figures

Source for all data: "Health Effects Criteria for Fresh Recreational Waters", EPA 1984

Figure 1.1 *E. coli* and Illness Rates

E. coli Density	Symptom Rate
23	2.3
47	4.6
137	4.8
236	14.7
146	11
138	5.1
19	0.5
52	5.2
71	3

Figure 1.2 Confidence Limits

Y	log(*Y*)	Predicted *X*	upper interval *X*	lower interval *X*
12	1.079181	-1.5957	3.718494354	-6.90989
15	1.176091	-0.68474	4.08871877	-5.4582
20	1.30103	0.489682	4.591664639	-3.6123
30	1.477121	2.14494	5.381913256	-1.09203
45	1.653213	3.800198	6.355532015	1.244863
60	1.778151	4.974622	7.25143933	2.697804
80	1.90309	6.149046	8.395429295	3.902662
120	2.079181	7.804304	10.43178017	5.176827
165	2.217484	9.104349	12.27375787	5.93494
210	2.322219	10.08886	13.75072976	6.426993
260	2.414973	10.96075	15.09565718	6.825842
300	2.477121	11.54494	16.01049737	7.079382
340	2.531479	12.0559	16.81757873	7.294225
380	2.579784	12.50997	17.5392383	7.480693
420	2.623249	12.91854	18.19163543	7.645451
480	2.681241	13.46367	19.06586369	7.861472
520	2.716003	13.79043	19.59170718	7.989156
560	2.748188	14.09297	20.07962439	8.106311

Figure 1.3 Fecal Coliform and Illness Rates

Fecal Coliform Density	Symptom Rate
37	4.8
104	14.7
60	11
436	5.1
51	0.5
230	5.2
234	3