United States Environmental Protection Agency
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# GREAT LAKES BEACH SANITARY SURVEY USER MANUAL

# Executive Summary

The U.S. Environmental Protection Agency (EPA) developed this Beach Sanitary Survey Tool as part of the 2004 Great Lakes Regional Collaboration (GLRC) to provide beach managers with a technically sound and consistent approach to identify pollution sources and share information. The beach sanitary survey provides a method for developing a documented historical record of beach and watershed water quality. It serves as a baseline to which future assessments of the overall health of the beach and watershed can be compared, and it enables beach managers to perform long-range water quality and resource planning. The tool will help beach managers collect and share pollutant data for watershed assessments, use the data in predictive models, and better enable them to remediate bacterial pollution sources to beaches.

EPA developed two types of beach sanitary surveys—the *Routine On-site Sanitary Survey* and the *Annual Sanitary Survey*—to assist with short- and long-term beach assessments, respectively. The *Routine On-site Sanitary Survey* is performed at the same time that water quality samples are taken. It includes a form, which can be used to document the methods used to collect data during the *Routine On-site Sanitary Survey*. The *Annual Sanitary Survey* records information about factors in the surrounding watershed that might affect water quality at the beach. This survey includes, for example, information on septic tanks in the contributing watershed and land use information. Both surveys include forms to help document the information collected durin the survey. These forms are in paper and electronic format.

EPA initially developed a draft Beach Sanitary Survey Tool in 2006. In the summer of 2007, the Beach Sanitary Survey Tool was tested at 61 beaches in the Great Lakes. The state and local governments testing the tool provided comments to EPA, who then used these comments to develop this final Beach Sanitary Survey Tool.

For more information on the EPA Beach Program and on beach sanitary surveys, please contact:
U.S. Environmental Protection Agency, Office of Water, BEACH Program (4305T), 1200 Pennsylvania Avenue, NW, Washington DC 20460. Information about the Beach Sanitary Survey Tool is also available on the BEACH Program webpage: www.epa.gov/waterscience/beaches/

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# Contents

# 1. Overview

The U.S. Environmental Protection Agency (EPA) developed this Beach Sanitary Survey Tool as part of the 2004 Great Lakes Regional Collaboration (GLRC) to provide beach managers with a technically sound and consistent approach to identify pollutant sources and share information.

The GLRC is a wide-ranging, cooperative effort to design and implement a strategy for the restoration, protection, and sustainable use of the Great Lakes. It was created by presidential executive order in May 2004. The Executive Order recognized the Great Lakes as a *national treasure* and created a federal Great Lakes Interagency Task Force (GLITF) to improve federal coordination in addressing Great Lakes issues. EPA is the lead agency responsible for coordinating and implementing the GLRC.

In December 2005 EPA selected eight near-term prioritized actions in the Great Lakes Strategy for implementation. One of these actions is the development of a standardized approach to help beach managers identify sources of contamination at beaches. The tool will help beach managers collect and share pollutant data for watershed assessments, use the data in predictive models, and take action to remediate bacterial pollutant sources to reduce public exposure to fecal bacterial contamination while swimming at the beach.

# 2. Introduction

## *2.1 Why did EPA create the Great Lakes Beach Sanitary Survey?*

EPA developed the Beach Sanitary Survey Tool to help beach managers in the Great Lakes synthesize all contributing beach and watershed information—including water quality data, pollutant source data, and land use data—so that they can improve Great Lakes water quality for swimming. This beach sanitary survey tool is tailored to the beach environment in the Great Lakes. In addition, beach managers can use sanitary survey data (e.g., bacteria levels, source flow, turbidity, rainfall) to develop models to predict daily bathing beach water quality, if appropriate.

State beach program managers can use the data collected and synthesized by means of a sanitary survey to prioritize which beaches to monitor as part of a BEACH Act monitoring and notification program. The EPA BEACH Act Grant program provides grants to states, territories, and tribes for beach monitoring and notification programs. As part of the program, states are required to prioritize beaches for monitoring.

## *2.2 What is the Great Lakes Beach Sanitary Survey?*

The survey consists of three forms in paper and electronic format. One survey form is the routine on-site survey, which is designed to be filled out each time water quality samples are taken. The information for this form is collected by observation and measurement at or near the beach. The second form is the methods form, which documents the methods used for measurement in the routine form. The third form is the annual survey form, which records information about factors in the surrounding watershed that might affect water quality at the beach. This form might include, for example, information on septic tanks in the contributing watershed or land use information, depending on the beach being surveyed.

## *2.3 What are the benefits of the Great Lakes Beach Sanitary Survey?*

The beach sanitary survey provides a documented historical record of beach and watershed water quality. It serves as a baseline to which future beach and watershed assessments of the overall health of the beach and watershed can be compared, and it enables beach managers to perform long-range water quality and resource planning. The sanitary survey also provides support for enforcement actions by establishing a record of conditions and operations at a point in time. The information in the survey also benefits stormwater program managers, wastewater facility managers, local elected officials, local planning authorities, academic researchers, and other Great Lakes beach and water quality professionals.

## *2.4 Who are the intended users of the survey?*

Local beach managers and public health officials can use the survey to identify bacterial sources of pollutants affecting beaches, assess beach health, share information, and conduct watershed planning.

## *2.5 How can the Great Lakes Beach Sanitary Survey be used in a BEACH Act Grant Program?*

The Beach Sanitary Survey will help beach managers meet the requirements of the BEACH Act Grant Program, as described in the *National Beach Guidance and Required Performance Criteria for Grants* (USEPA 2002b).

The Beach Guidance document lists nine grant performance criteria a state must meet when developing and implementing a beach monitoring and notification program. Two grant performance criteria suggest using a sanitary survey to develop a risk-based approach and to develop a tiered plan for developing and implementing a beach monitoring and notification program. Additional references to sanitary surveys are provided in Appendices F and G of the Beach Guidance document (USEPA 2002b).

In Chapters 3, 4, and 5 and Appendix K, the Beach Guidance document also describes the use of predictive tools and models to minimize swimmer risk at the beach (USEPA 2002b). Models are used at coastal and Great Lakes beaches across the nation. Using a beach sanitary survey will help a beach manager identify the beaches where a model would benefit the beach monitoring and notification program.

## *2.6 How is this user manual organized?*

This user manual is intended to be used as a reference for the sanitary survey forms that EPA developed. Section 3 describes the sanitary survey forms and provides background information on the sanitary survey process. Section 4 describes steps to consider in preparing to conduct a sanitary survey. Sections 5 and 6 provide detailed information on how to complete each type of survey. The data elements for the *Routine On-site Sanitary Survey* are given in Section 5, and the data elements for the *Annual Sanitary Survey* are given in Section 6. The subsection numbers correspond with the numbered sections of the survey forms.

# 3. Types of Beach Sanitary Surveys

## *3.1 Background*

Because beaches are dynamic systems, they need to be gauged frequently for short- and long-term health risks. EPA has developed two types of beach sanitary surveys—the *Routine On-site Sanitary Survey* and the *Annual Sanitary Survey*—to assist with short- and long-term assessments. The *Routine On-site Sanitary Survey* is performed with water quality samples, and it supports the annual survey. In addition, EPA also developed the *Routine On-site Sanitary Survey Methods* form, which can be used to document the methods used to collect data during the *Routine On-site Sanitary Survey*.

## *3.2 Survey forms*

The beach sanitary survey offers two different approaches to collect and assess information. The three forms are briefly described here and fully described in Sections 5 and 6.

1. The *Routine On-site Sanitary Survey* is designed to be used each time a water sample is collected during regular bacterial monitoring to supplement information collected during water quality sampling. The survey will help to provide useful information on water quality to support the annual surveys. The *Routine On-site Sanitary Survey* will help identify underlying conditions at the beach that can be observed frequently (e.g., wind speed and direction, wave height, rainfall) and that can contribute to microbiological contamination of the recreational waters and beach areas. This survey is more local and site-specific than the *Annual Sanitary Survey*. The *Routine On-site Sanitary Survey* form is in Appendix A.

2. The *Routine On-site Sanitary Survey Methods Form* is designed as a way to document the methods used when collecting data for the *Routine On-site Sanitary Survey*. The form is in Appendix B.

3. The *Annual Sanitary Survey* requires the same type of information collected for the *Routine On-site Sanitary Survey* plus area maps, annual and seasonal trends, and additional information on potential sources of contamination. This survey expands geographically to include the contributing watershed and surrounding shoreline. The *Annual Sanitary Survey* form is in Appendix C.

## *3.3 When should beach sanitary surveys be conducted?*

Beach sanitary surveys should be conducted to develop or continue a historic record of beach conditions and sources of pollutants. They should be used when new beaches open, at the beginning of the swimming season, and when beaches have been identified as problem areas. In addition, you could perform sanitary surveys periodically during a swimming season, when an emergency situation occurs, when a bacterial exceedance is detected, or more frequently (depending on the length of the bathing season) to assess sudden changes in beach water quality (CTDEP 1992; Figueras et al. 2000; Great Lakes-Upper Mississippi River Board of State Sanitary Engineers 1990).

## Routine On-site Sanitary Survey

This survey is a simple, two-page form and it should be completed every time water quality sampling is performed throughout the beach season. Over time, collecting additional data with every sample will aid those looking for correlation between conditions at the beach and water quality (i.e., indicator bacteria levels), leading to the development of predictive models. The data will help show whether bacteria levels correlate to other parameters or observable conditions at a beach. Before you conduct your first *Routine On-site Sanitary Survey*, perform an initial assessment of the beach. Review all available information about the beach, including historical data and knowledge, uses, and possible sources of bacterial contamination. EPA recommends that you perform at least one *Routine On-site Sanitary Survey* before the start of the swimming season.

## Routine On-site Sanitary Survey Methods

This form, a companion form to the *Routine On-site Sanitary Survey*, should be completed when you do the first *Routine On-site Sanitary Survey*, likely at the beginning of the beach season. You do not need to complete this form again during the beach season unless any of the methods you use change.

## Annual Sanitary Survey

Ideally, an annual survey should be conducted on each beach once a year to determine the condition of the beach, locate potential pollutant sources, and determine whether there are other issues that can affect water quality. This survey can be performed at the end of a beach season, before the next season begins. That way, you can determine whether you should make any changes to your monitoring program before the next season starts.

In addition, a sanitary survey should be conducted as part of any proposal to expand or develop a recreational beach area or when a newly proposed activity would significantly alter the water quality in an existing recreational beach area. Beach managers should use the findings of the survey as a prime consideration in any decision to proceed with development. In some states, such as Maryland, a permit for operating a bathing beach may not be issued if a detailed sanitary survey reveals sources of pollutants that affect or might affect the bathing beach (Maryland Department of Health and Mental Hygiene 1978).

# 4. Steps for Conducting a Beach Sanitary Survey

## 4.1 Seek the assistance of professional staff

Before you begin preparing to conduct a beach sanitary, if possible, consult a public health official or a registered sanitarian. EPA recommends that a public health official or registered sanitarian from a state, tribal, or local agency maintain primary responsibility for overseeing the performance of annual sanitary surveys at the beach. Lifeguards or citizen volunteers may be used to help complete or gather information for *Routine On-site Sanitary Surveys* at the same sampling stations at which they perform bacterial monitoring for a state, tribal, or local agency. Volunteers should be properly trained in completing the survey forms and in using the methods chosen to collect information for the survey (see Section 4.5).

## 4.2 Make an initial assessment of a beach

The next step in preparing to conduct a sanitary survey is to make an initial assessment of all beaches to identify at which beaches a sanitary survey should be conducted. During this assessment, compile known data on beaches with past problems and beaches that have and have not been sampled for microbial analysis.

## 4.3 Make an initial assessment of the contributing watershed

The watershed, basin, or land area contributing runoff to a beach can vary widely depending on the beach. For some beaches, the contributing area could be simply the area from the dunes down to the shoreline. There might not be a stream or river nearby that is contributing drainage from a large land area. The water in the lake might be coming from other watersheds through long-shore currents; in such a case, you might want to investigate the direction from which water entering the system is coming. During the initial assessment, you might not be sure about whether an area is a contributing area. The sanitary survey process can be used to investigate further and rule something out or confirm that it is contributing drainage to the beach.

As part of the initial assessment, you should consider information from other Clean Water Act programs that might provide relevant water quality data and information on potential sources of pollutants affecting the beach.

> *National Pollutant Discharge Elimination System (NPDES)*. The NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. For more information on the NPDES permit program, see http://cfpub.epa.gov/npdes.
>
> *Nonpoint Source Management Program (Clean Water Act 319)*. The Clean Water Act section 319 Nonpoint Source Management Program helps focus state, tribal, and local government nonpoint source efforts. Under section 319, states, territories, and Indian tribes receive grant money that supports a wide variety of activities, including monitoring to assess the success of specific nonpoint source implementation projects. For more information on the section 319 Nonpoint Source Management Program, see www.epa.gov/nps.
>
> *Total Maximum Daily Load (TMDL) program*. States develop TMDLs for waterbodies that are listed as water quality-limited or impaired because of pollution, including fecal contamination. A TMDL

identifies the pollutant sources and the necessary reductions in those sources to achieve meeting water quality standards. For more information on the TMDL program, see www.epa.gov/owow/tmdl.

*305(b) water quality reports.* Under section 305(b) of the Clean Water Act, states are required to submit a biannual report to EPA that provides water quality information (including information on 303[d]-listed waters) to the public. The information the states provide serves as the basis for EPA's *National Water Quality Inventory Report to Congress*. This document characterizes the water quality, identifies widespread water quality problems of national significance, and describes various programs implemented to restore and protect waters throughout the United States. For more information on 305(b) reports, see www.epa.gov/305b.

## 4.4 Determine the purpose and identify the appropriate form

Once the beaches have been assessed and identified for a sanitary survey, determine the purpose of the survey and develop a plan. The plan should have goals and timelines to identify sources, gather data, conduct monitoring, analyze results, develop a sanitary survey report, and discuss next steps. EPA developed two types of survey forms (*Routine On-site Sanitary Survey* and *Annual Sanitary Survey*), along with the *Routine On-site Sanitary Survey Methods* form, on the basis of how frequently the surveys would be performed and what resources would be available to the beach manager. For a detailed description of the forms and their uses, see Sections 3.2 and 3.3 of this document.

The sanitary survey forms will help you to determine the following:

1. An approach to address all the data elements necessary to complete the forms and best describe the conditions at a beach
2. What data elements are currently collected through an existing monitoring plan and what additional data elements need to be collected
3. The equipment and supplies needed to collect the data
4. The agencies or groups responsible for collecting and analyzing the data

Sections 5 and 6 provide descriptions of the survey data fields. Not all of the questions on the survey forms are applicable to all beaches. In addition, you might want to collect specific data for your beach that are not included on the forms. You can amend the forms to best fit the needs of your beaches.

## 4.5 Use trained staff

The staff who perform the sanitary surveys should be adequately trained in sampling procedures, equipment use, completing forms, and health and safety precautions before they begin to perform sanitary surveys. EPA recommends that relevant quality assurance (QA) documentation (e.g., quality assurance project plan, sampling and analysis plan, standard operating procedures [SOPs]) be distributed to all participants during training. The training should stress the importance and relevance of the sanitary surveys in helping to identify potential sources of contamination, how to conduct quality control (QC) activities, and how to follow the protocols specified in the SOPs. The quality of information produced by the sanitary surveys depends on the quality of the work that the field staff and others involved in the beach program perform. Follow-up or continuing training should be held as needed for as long as the sanitary surveys are performed. For more information on QA/QC, see Appendix D.

## *4.6 Collect data*

Now that you have identified the beaches to survey and the data to be collected, it's time to collect data. Gather maps and use tools like global positioning system (GPS) units to identify the locations of beach sampling stations, pollutant sources, and watershed uses.

Sources of maps include the U.S. Geological Survey (USGS), county/state offices, online companies (e.g., GoogleEarth), and others. Order USGS topographic maps for your watershed (see http://topomaps.usgs.gov/ordering_maps.html). Think about other sources of data for your beach and watershed, such as local or state universities or other government offices. Sources of data might vary depending on your beach location and the level of interest in your region. For more ideas on where to find data, see Section 6.2.

Collect water quality data and other parameter data at a beach to complete the *Routine On-site Survey* and meet the data needs you identified for the *Annual Sanitary Survey* in section 4.3.

Follow the QA/QC procedures listed in Appendix D.

## *4.7 Document all observations and data sources*

No field data collection is complete without basic information on who collected the data and when. Sometimes basic field observations that might seem insignificant turn out to be very important, but they won't be useful unless they are documented. Also, other personnel will likely use the data you collect in the future, and your documentation will be essential to their ability to understand the data.

## *4.8 Consider health and safety*

Health and safety should be a key consideration for all volunteers and others engaged in surveying and monitoring. The fact that surveying and sampling might focus on areas in close proximity to combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs) and might be conducted during periods of beach closure suggests that the risk of potential exposure to pathogenic agents will be higher than that of recreational beach users. Heightened awareness of personal protection is the responsibility of every member of the survey team. The effective use of basic personal protective equipment and supplies can significantly limit exposure to potentially infectious waters. For instance,

- Limit exposure of *any* open wounds to survey site waters.
- Carry a hand sanitizer, and use it immediately after working at each survey location. (Use care when collecting samples not to make any contact with the inside of the sample containers.)
- Wear latex gloves, rubber boots, and safety glasses when contact is required or during sampling to minimize the potential for direct exposure to surface waters that are potentially contaminated.
- Carry a spray bottle with dilute bleach solution as part of your survey supplies for immediate disinfection if accidental exposure occurs.
- Practice good personal hygiene.
  - Avoid direct hand-to-mouth, -nose, or -face contact in the field.
  - Avoid eating, drinking, or chewing gum during site surveys. Delay drinking or consuming snacks and meals until you have removed all personal protective equipment and washed your hands and face thoroughly.
  - Promptly shower and wash your clothing with hot water after a day of surveying.

Although your survey activity might not entail longer or closer contact with surface water than the exposure of bathers, fishermen, or others, surveys might be required in less desirable areas or during beach closures mandated by measured exceedances of recreational standards.

## *4.9 Record data for the Annual Sanitary Survey*

Once you have collected your data, use the data to complete an *Annual Sanitary Survey*. All field data should be entered onto the paper form and stored electronically. It is important to provide all data to and consult with a sanitarian or public health official when analyzing the data and assessing the effects of a pollutant source on a beach.

## *4.10 Record management*

As mentioned earlier, everything should be well documented, including the person who enters the data, the person who completes the survey form, sources of information, and so forth. All paper copies of survey forms should be collected and stored together and scanned into an electronic format, if possible, so that electronic files can be stored. EPA suggests recording the survey data in a locally accessible database.

## *4.11 Next steps*

**Analysis of survey results**. Although you will perform some analyses while conducting the sanitary survey (the annual survey in particular), once you are finished with the surveys, you should go through the survey results thoroughly and develop a Sanitary Survey Report (see the following paragraph). For the *Routine On-site Sanitary Survey*, you should evaluate the results at the end of the beach season (which might be done as part of the *Annual Sanitary Survey*), as well as periodically throughout the season. Evaluating the survey results during the beach season can help you identify trends that you should be aware of, such as “rainfall over 0.5 in. correlates with high bacteria counts,” or “algae growth has become worse and needs to be dealt with.” You should also evaluate whether you are collecting appropriate data, whether your methods of data collection need to be adjusted, or both.

**Sanitary Survey Report**. A written Sanitary Survey Report is needed to integrate the data into a comprehensive information analysis. This report must include a compilation of all data collected, an analysis of those data using recognized statistical techniques to determine adverse pollution conditions, conclusions as to the appropriate monitoring strategy and frequency, and recommendations for necessary follow-up actions such as remediation efforts or further investigations.

**Resource allocation and beach assessment**. Analyzing the sanitary survey will help you determine data trends and correlations with bacteria sample results. It will provide you with more information to identify pollutant sources and their contribution to water quality impairment. That information, in turn, will help you decide on future allocation of resources and possible remediation needs. The information will also help you to more effectively prioritize beaches for monitoring frequency and resource allocation.

The sanitary survey can help you determine the best frequency of monitoring (e.g., daily, biweekly, weekly, monthly); the number of samples that should be collected (e.g., one sample collected every 500 meters); and the types of remediation activities that should be performed at your beach (e.g., pet owner education, improved plumbing at public restrooms).

**Remediation steps**. The results of the sanitary survey will help a beach manager identify persistent problems, sources of pollutants, and the magnitude of pollution from those sources. The beach manager will have a documented record of the pollutant sources to use to propose management actions, enforcement, and options to control sources. Once the source and extent of pollutants are determined, appropriate remediation activities can be planned with the assistance and collaboration of federal, state, and local programs.

**Modeling**. Data from beach sanitary surveys might help a beach manager identify factors that correlate with bacteria counts in the water. It might be possible to develop a predictive model using these data. A predictive model can benefit a beach monitoring and notification program by allowing beach managers to make advisory decisions based on predicted high levels of pathogens before people become exposed. An example of a predictive model that is relatively easy to develop is the *rainfall advisory model*, which statistically correlates the bacteria results with rainfall data collected during the *Routine On-site Sanitary Survey*.

**Sharing information**. As part of the sanitary survey process, you may choose to store the survey data electronically. This approach will make it easier for you to share your data with other counties and states.

# 5. Data Elements for the Routine On-site Sanitary Survey

This section describes the data fields for the *Routine On-site Sanitary Survey*. For each data field, it gives an example of the data followed by a detailed description and an explanation of methods that you can use to collect the data. Section 6 provides the data fields for the *Annual Sanitary Survey*.

The *Routine On-site Sanitary Survey* is designed to be filled out each time a water sample is taken for bacterial analysis. The information requested in this form is primarily information that can be gathered locally, at the beach.

## *5.1 General conditions*

### Air temperature

*Example*

75 °F, 24 °C

*Description*

Air temperature, in combination with other conditions and situations, such as timing (e.g., after significant rainfall) or a particular wind direction, can increase of the likelihood of higher levels of microorganisms at certain times.

*Methods*

Liquid-in-glass thermometers are the most common types of thermometers because they are easy to read and inexpensive to manufacture. Highly accurate electrical thermometers measure temperature by measuring the electrical resistance of some material. Because the resistance of these materials changes with temperature, the resistance can be measured and calibrated to the temperature.

Temperature measurements are typically taken at 1.5 meters above grassy surfaces. Ideally, the thermometer should be housed in an instrument shelter that is away from materials that might absorb heat and prevent an accurate air temperature reading. All air temperature readings are conducted in the shade to prevent sunlight from warming the liquid in the thermometer. Instrument shelters should allow air to flow through freely to ensure that the air in the shelter is not warmed by the shelter itself.

Report air temperature in the Fahrenheit or Celsius temperature scale, specifying which one was used. If both scales are available, the Celsius scale is preferred because it was developed for and is most commonly used for scientific purposes.

### Rainfall

*Example*

Yes, rainfall occurred during the past 72 hours. Rainfall amount was 1.2 inches.

*Description*

Bacterial contamination at bathing beaches can result from rain events. CSO discharges can occur during heavy rainfall events and can reach bathing beaches, causing contamination problems. In addition, nonpoint source pollution of bathing beaches can be caused by rainfall or snowmelt moving over and through the ground and carrying natural and human-made pollutants into the receiving water.

Rainfall measurements can be used in models to predict bacterial contamination at bathing beaches during rainfall events (USEPA 1999). It is also important to document whether the rain event occurred within 72 hours of a previous rain event to help differentiate between dry-weather and wet-weather contamination sources.

Rain intensity should also be noted. Rain events that are of short duration but high intensity can cause higher runoff than longer rain events of low intensity, possibly correlating more with increased bacteria levels in the water.

*Methods*

Record the amount of rainfall in inches or centimeters, as well as the time (24, 48, 72, or more hours) since the rainfall event occurred. If rainfall is measured using a rain gauge near the sampling stations (weather station or airport), record the distance from the rain gauge in miles. Also note the intensity of the rainfall.

## Wind speed and direction

*Example*

East at 5 knots or light breeze

*Description*

A description of the wind speed and direction using the Beaufort Wind Scale, which can be found at www.spc.noaa.gov/faq/tornado/beaufort.html, might provide valuable information concerning the actual or potential effect of pollutant transport to the area.

*Methods*

Wind is difficult for forecasters to measure because wind speed and direction can vary quickly and abruptly over short distances, especially in cities and other areas with many obstructions.

An anemometer is the main instrument used to measure the speed of the wind. It consists of three or four hemispheric cups, mounted on each end of a pair of horizontal arms, which lie at equal angles to each other. A vertical shaft that the cups turn passes through the center of the arms, and a train of wheel-work counts the number of turns the shaft makes. From the number of turns made in any given period, the velocity of the wind during that period is calculated.

Aerovanes are commonly used at many weather stations and airports to measure wind direction and speed. The tail orients the instrument into the wind for direction, while the propellers measure the wind speed.

If you don't have the necessary equipment to measure wind speed and direction, you can provide data from a nearby weather station, ideally one within a 5-mile radius of the beach. If you use this method, note in the survey the distance to the station.

Wind direction is always reported as the direction from which the wind is coming. In other words, a north wind pushes air from the north to the south. When reporting wind speeds, always provide the units (e.g., miles per hour [mph], kilometers per hour [kmh], knots). (1 knot = 1.15 mph.)

## Sky conditions

*Example*

Partly cloudy

*Description*

The predominant/average sky condition is described by using octants (eighths) of the sky covered by opaque (not transparent) clouds. The National Oceanic and Atmospheric Administration (NOAA) uses the following scale:

| Sky condition | Cloud coverage |
|---|---|
| Sunny | 0/8 |
| Mostly sunny | 1/8–2/8 |
| Partly cloudy | 3/8–4/8 |
| Mostly cloudy | 5/8–7/8 |
| Cloudy | 8/8 |

*Method*

Estimate the weather or provide information from a nearby weather station.

## Wave height

*Example*

Normal intensity, 1–2 feet in height (estimated)

*Description*

Waves are the main source of energy that causes beaches to change in size, shape, and sediment type. They also move marine debris between the beach and the offshore zone. Waves are generated by the wind blowing over water. Waves formed where the wind is blowing, which are often irregular, are called wind waves. As these waves move away from the area where the wind is blowing, they sort themselves out into groups with similar speeds and form regular patterns known as swells.

The three main characteristics of waves are the height, the wavelength, and the direction from which they approach. Wave height is the vertical distance from the crest of the wave to the trough. Wavelength is the time, measured in seconds, between two successive wave crests. Wave direction is the direction from which the waves approach.

Bacteria permeating wet sands can be carried away by waves, increasing bacteria levels in the adjacent waters. Studies at beaches along the southern shore of Lake Michigan have also shown that *Escherichia coli* concentrations in the sands of the swash zone are high, or higher, than those of the water (Whitman et al. 1999). When storm winds initiate waves and direct them onto the beaches, the foreshore sand is eroded and “stored” bacteria are released into the water, raising the *E. coli* concentrations to levels above the allowable threshold for full body contact (Whitman et al. 1999; Haack et al. 2002).

*Method*

Wave height is measured by carrying a graduated stick or a ranging pole (a pole with measured sections in red and white) out into the water to just seaward of where the waves are breaking and then recording where the wave crest and the following wave trough cut the stick. The difference between the two is the wave height. Alternatively, you can estimate the wave height. Such estimates should be made in the units with which you are most comfortable. Often it is best to have two observers independently estimate wave height and then compare their results. Measure or estimate the height of at least five separate waves, and then take the average. Also note the wave intensity on the survey form.

## Longshore current speed and direction

*Example*

Current is moving toward the east at approximately 5 centimeters per second.

*Description*

A longshore or littoral current is in the surf zone and runs parallel to the shore as a result of waves breaking at an angle on the shore. The current speed and direction are critical parameters that help to identify the actual or potential effect of pollutant transport to the area, as well as to predict potential unhealthy conditions from known outfalls in the vicinity of the beach.

*Methods*

A number of models are available to accurately measure longshore current speed. They require several measured parameters and meters to capture the varying current speeds.

It is possible to estimate the longshore current speed and direction using a stick, line, ball, and watch. A practical and inexpensive technique for measuring the longshore current speed is shown here, adapted from the Education Program at the New Jersey Marine Sciences Consortium (www.njmsc.org/Education/Lesson_Plans/LongshoreCurrent.pdf). You'll need a meter stick (or other measuring device), an orange or two, a watch with a second hand, and at least two people.

<u>Procedure</u>

1. Measure off and draw a 10-meter line in the sand parallel to the waterbody.
2. Position one person at each end of the line you have drawn. One person should assume the role of timekeeper and have a watch with a second hand.
3. Throw an orange (or a piece of driftwood) into the water, just behind the line of breakers, approximately 2 meters upstream of the beginning of your line. Note: The longshore current is closer to the shore than you might expect! All persons should watch the orange as it moves.
4. When the orange passes the beginning of the line, the timekeeper starts timing.
5. When the orange passes the person stationed at the end of the line, that person tells the timekeeper to stop timing. Record the time.
6. If time permits, repeat this process so you can calculate the average of the two (or three) trials. You can repeat it in a different area along the beach as well.

7. Using the formula of *speed = (distance / time)*, calculate the speed of the longshore current for all trials, and then calculate the average of the longshore current.
8. This procedure is not foolproof. If the orange does not move after a few minutes, try again. If you can't get this to work at all, it might be because of weather conditions, or there might not be a longshore current at all.

To measure direction, you can observe the direction the orange flows in the above procedure. Alternatively, you can use a dye tablet. For this, place the dye tablet into the water (this can be done at the same time that you place the orange in the water for the above procedure). The observers on the beach watch and record the direction in which the dye moves. Current direction, recorded in degrees, is the direction toward which the current is going (as in 0 to 180 degrees, 0 being north, 45 east, 90 south, and 135 west). If a current is going from north to south, the current direction is recorded as south or south-going; similarly, a current going from east to west is recorded as west or west-going. (This is the opposite of wind direction, which is recorded as the direction from which the wind is blowing.)

Measurements of speed and direction can be repeated at several different places along the beach to see if the current speed and direction are the same or if they vary.

In addition, satellite imagery might be available for you to use to detect the movement of a plume along the beach.

## *5.2 Water quality*

### Bacteria samples collected

*Example*

Sample Point: 1-A
Sample ID: 100002
Parameter: *E. coli*
Comments: Grab sample collected at knee depth

*Description*

Fecal bacteria have been used as an indicator of the possible presence of pathogens in surface waters and the risk of disease, on the basis of epidemiological evidence of gastrointestinal disorders from ingesting contaminated surface water or raw shellfish. Contact with contaminated water can lead to ear or skin infections, and inhaling contaminated water can cause respiratory diseases. The pathogens responsible for these diseases can be bacteria, viruses, protozoans, fungi, or parasites that live in the gastrointestinal tract and are shed in the feces of warm-blooded animals.

Enterococci and *E. coli* are used as the primary indicators of fecal contamination and are recommended as the basis for bacterial water quality standards in EPA's 1986 *Ambient Water Quality Criteria for Bacteria* document (both for fresh waters, enterococci for marine waters). The standards are defined as a concentration of the indicator above which the health risk from waterborne disease is unacceptably high.

*Methods*

Qualified local laboratory services are a tremendous information resource. In addition to providing analytical support for monitoring recreational waters for pathogens, laboratories typically provide their own sterilized sample containers and custody documents to record dates, times, and sampling locations. Local laboratories often provide training for sampling personnel or offer laminated sampling guides to assist sampling staff in appropriately collecting samples and completing sample documentation. Sampling procedures should be developed into SOPs on the basis of the variety of sampling requirements for the target sites. (For example, variable accessibility and sampling depths in the monitoring design might require that different techniques be employed at different locations.) In general, samples should be collected at the desired depth(s) directly into sterilized containers, sealed, labeled, and chilled for transport to the local laboratory.

If you are taking samples while wading, take care not to disturb bottom sediments or substrates as you sample. Pathogens adhere to solids, and excessive resuspension might produce results that exceed local advisory limits.

The first sample collected for the day should be a field blank. A field blank is simply a volume of reagent water or sterilized buffer solution transported to the field and transferred into a sample container to assess potential contamination from the sampling technique.

Duplicate samples, if included in the monitoring design, should be collected simultaneously if possible (if two containers can be held at once in one hand). If two containers can't be managed without spillage, the duplicates should be collected sequentially.

Chapter 4 and Appendix J of the *National Beach Guidance and Required Performance Criteria for Grants* (USEPA 2002b) provide detailed discussions on sample collection, sample handling, and suggested procedures. Before developing SOPs, consult the local laboratory for recommendations because protocols that are relevant and applicable to the sampling design might already be available.

Local laboratory support is critical because laboratory analysis for pathogenic indicators should be initiated within 24 hours of collection (the measurement holding time). Samples collected for compliance purposes for the measurement of pathogen indicators must be initiated within 8 hours of collection (6 hours for transport to the laboratory and 2 hours to initiate processing in the laboratory). Local laboratory resources that are qualified to perform testing can be readily identified through local departments of health. Note, however, that many laboratories certified to perform analysis of pathogen indicators might not be certified for the preferred indicators for recreational waters—*E. coli* and enterococci. Part of the laboratory selection process should include reviewing and assessing laboratory certifications. In some programs laboratories might certify by pollutant or parameter or might certify to the method level.

*Analytical methods*

Membrane filter tests for enterococci**:**

- EPA Method 1600 (mEI media)
- EPA Method 1106.1 (mE media)

Membrane filter tests for *E. coli*:

- Modified EPA Method 1103.1 (Modified mTEC media)
- EPA Method 1103.1 (mTEC agar)

Most probable number tests for *E. coli*:

LTB EC-MUG (Standard Methods 9221B.1/9221F)

ONPG-MUG (Standard Methods 9223B, AOAC 991.15, Colilert, Colilert-18, and Autoanalysis Colilert)

CPRG-MUG (Standard Methods 9223B, Colisure™)

Membrane filter tests for *E. coli*:

mEndo, LES-Endo, or mFC followed by transfer to NA-MUG media (Standard Methods 9222B/9222G or 9222D/9222G)

MI agar

m-ColiBlue24 broth

## Water temperature

*Example*

68 ºF

*Description*

This parameter is measured for use in taking temperature-dependent measurements such as pH and conductivity. Water temperature can also be important in assessing the quality of potential habitat for aquatic species and for some less-desirable pathogenic organisms.

*Methods*

With relative ease, you can measure water temperature by using multiprobes or other handheld electronic measurement devices or by using simple graduated thermometers. The accuracy of common, wide-scale thermometers and electronic instruments can be verified with simple ice-point (0 ºC or 32 ºF) and boiling point (100 ºC or 212 ºF) measurements. If the ice point and boiling point do not register correct temperatures, the results for the two measurements can be plotted on simple graph paper to translate field measurements to corrected values. Electronic meters can be professionally calibrated if the manufacturer's specifications do not include calibration procedures. Local and regional water temperatures for recreational beaches are also generally broadcast on NOAA Weatherband radios and local radio stations. Temperature ranges can be expected to be in the 60s, 70s, and 80s (in Fahrenheit) during the recreational swimming seasons.

Multiprobes are electronic instruments used to measure an array of parameters (e.g., dissolved oxygen, pH, temperature, conductivity, turbidity) *in situ* (in place) by special sensors. Multiprobes are usually portable, handheld devices that are used to collect instantaneous water quality measurements during focused environmental investigations; however, they can also be deployed for extended periods for specialized studies to capture the diurnal (24-hour) quality cycle. Multiprobes are favored for routine environmental investigations because they can collect data for parameters like dissolved oxygen (DO) and pH, which have extremely limited holding times, and they don't call for the transport and use of field chemistry test kits or necessitate the disposal of waste reagents or spent samples after measurement. (Field test kits often use acids or other toxics that require specialized disposal or pretreatment before disposal.)

For larger counties or regional coordinators, using multiprobes can be a cost-effective way to garner a large amount of information relatively quickly. Depending on the background and qualifications of the monitoring teams, the cost of training might be prohibitive because multiple persons would likely require training. Because multiprobes are reasonably portable and are subject to calibration, the uncertainty and subjectivity associated with measurement are highly controlled. Some jurisdictions or regional survey programs might already include the use of multiprobes.

### Odor

*Example*
Sulfur

*Description*
An odor given off by a waterbody can indicate pollution, such as sewage, present at the beach.

*Method*
As you walk around the beach, note whether any detectable odor is present and mark it down on the survey form.

### Turbidity

*Example*
Clear, or 0 NTU [nephelometric turbidity units]

*Description*
Turbidity is a measure of the cloudiness of water and is also measured *in situ*. It is an aggregate property of the solution. Turbidity is not specific to the types of particles in the water. They can be suspended or colloidal matter, and they can be inorganic, organic, or biological. At high concentrations, turbidity is perceived as cloudiness or haze or an absence of clarity in the water.

*Methods*
The most common instrument for measuring scattered light in a water sample is a nephelometer. A nephelometer measures light scattered at a right angle (90°) to the light beam. Light scattered at other angles can also be measured, but the 90° angle defines a nephelometric measurement. The light source for nephelometric measurements can be one of two types to meet EPA or International Organization for Standardization (ISO) specifications. EPA specifies a tungsten lamp with a color temperature of 2,200–3,000 K (Kelvin). The unit of measurement for the EPA method is the nephelometric turbidity unit (NTU). The ISO specifies a light-emitting diode (LED) with a wavelength of 860 nanometers and a spectral bandwidth less than or equal to 60 nanometers. The unit of measurement for the ISO method is the formazin nephelometric unit (FNU). Also see the description of multiprobes in this section under Water Temperature

## *5.3 Bather load*

*Example*
200 people at the beach, 50 people in the water

*Description*
The sanitary survey should include a discussion of the effects of bather load on recreational areas, particularly for recreational areas with poor water circulation. If there is poor water circulation, heavy bather loads can

cause significant elevation in bacterial counts for total and fecal coliform bacteria and enterococcus bacteria. High-use areas with poor water circulation might also indicate a need for increased monitoring of microbiological indicator organisms and might require that attention be paid to the potential for blue-green algae blooms.

*Methods*

When performing the *Routine On-site Sanitary Survey*, count the number of people at the beach. If you perform the count in the morning when bather density is low or zero, note that on the form and try to obtain bather density data from the lifeguards or park gate. Lifeguards often maintain records of bather density throughout the day. You can also use gate or visitor numbers for the beach if available.

The following are some examples of methods for estimating bather load:

- Count by hand the number of people at the beach. Count the total number of people and estimate the number of people in the water as a percentage of the total number of people at the beach. If the beach is large, choose a representative area to use to count the number of people and extrapolate the number to the entire beach using the size of the area as it compares to the total size of the beach.
- Take photos of the beach and count the number of people in them. Make sure to note how much of the beach area each photo covers. If possible, try to cover the entire beach using photos, but make sure the photos do not overlap and that people are not counted twice.
- Count people or take photos from a helicopter or plane flying over the beach.
- Count the number of cars at parking lots used for beach parking and use that number to estimate bather load.
- Count the number of visitors by using a laser counting device. Laser counting devices have been used at beaches in Encinitas, California, to count the number of bathers visiting a beach. The devices can be installed alongside stairwells leading to the beach. To tally visitors, the counters use a laser beam that is directed across the stairwells or narrow paths leading to a beach. Each person walking through the beam registers 0.5 on the counter to count a person arriving and departing as one visitor. The laser counter does have its limitations. All beach entrances need to have a counter, and entrances need to be clearly defined. Laser counters would not work at a beach where the main beach entrance is several blocks long or where visitors can access the beach from several other areas or side streets. Also, people who walk past several times are counted as more than one person.

The following data should be recorded when counting beach attendance:

- Number of people at the beach
- Number of people in the water (e.g., swimming, diving, clamming)
- Number of people not recreating in or on the water

## 5.4 Potential pollutant sources

The person performing the *Routine On-site Sanitary Survey* should identify visible sources of pollutants up to 500 feet from the beach boundary and, if possible, quantify the sources.

## Sources of Pollutants

*Example*

River is brown and has a bad odor. River is to the east of the designated beach area, about 500 feet away from the beach.

*Description*

Visible sources, including rivers, ponds, and outfalls, might carry contaminants that affect bathing beach water quality. Ground water, usually not visible, might also be a pollutant source. Investigating ground water as a pollutant source is not addressed in this sanitary survey. The level of investigation of potential pollutant sources will vary depending on the resources available for the investigation and on priorities.

Documenting the river or stream discharge (or the volume of water passing a certain point per unit time) of the water body and the concentration of contaminant or indicator bacteria allows managers to calculate and approximate "load" for that period. Measuring the discharge and the concentration of these sources can provide information about the magnitude of the potential pollutant loads carried by these sources to the bathing beach. It's important to have information on both the concentration in a stream and the stream discharge because with that information a total load per day can be calculated.

*Methods*

Identify visible sources that are affecting the beach up to 500 feet from the sampling station. If visible sources are suspected of affecting water quality, you might collect bacterial samples from these sources and take discharge measurements, estimate discharge, or find discharge measurements from the USGS or another agency.

Document the name of each visible source and the corresponding velocity or flow rate on the *Routine On-site Sanitary Survey* form. In the Comments/Observations section, add additional notes such as whether the visible sources occur only in conjunction with specific weather conditions.

*Discharge or Flow Measurement*

Stream or river "discharge" is sometimes called "flow." A discharge measurement is a combination of a velocity measurement and a cross-sectional area measurement. The units in these two measurements are as follows: velocity = length per unit time, and cross-sectional area = width x depth of the stream (units are length squared). When these two values are multiplied together, the resulting units are length cubed, or volume per unit time. Examples of this follow: cubic feet per second, million gallons per day. For a complete reference on measuring stream discharge, refer to USGS Water Supply Paper 2175 (USGS 1982).

*Velocity*

Measure velocity in a straight section of the stream or reach that has a stable bottom. Velocity can be measured using a velocity meter (sometimes called a flow meter). It is important to stand downstream and to the side of the velocity meter when taking measurements and to operate the meter properly.

> *Current velocity meter*s are available as mechanical or electronic units. A current velocity meter consists of a sensor or current meter, the support system for the sensor, and a counter. The signal from the sensors or current meter is processed or read by the counter. Many factors must be considered when selecting the proper current measuring equipment. In general, you should know if you will be measuring

current from an overhead structure or while wading. It also helps to know the approximate speed of the water to be measured because there are specialty meters available for very slow currents, and those are most likely what is present in recreational waters. Training and experience are necessary to operate current velocity meters consistently and to select appropriate stream reaches for taking measurements.

*Velocity estimates* can be obtained using an orange or a floating ball and a stopwatch. The measurement is the time it takes the floating object to travel downstream a pre-measured (and pre-marked) distance (e.g., 10 meters). See the procedure given earlier for longshore current speed measurement.

*USGS stream flow data* for the stream of interest might be available from the USGS's National Water Information System (NWIS). The NWIS is a comprehensive and distributed application that supports the acquisition, processing, and long-term storage of water data. Data for a large network of rivers and streams are available for stream levels, stream flow (discharge), reservoir and lake levels, surface-water quality, and rainfall. The data are collected by automatic recorders and manual field measurements at installations across the nation. For more information, see http://waterdata.usgs.gov/nwis/sw.

*National Hydrography Dataset (NHD)* is another resource that might be useful. The NHD is a comprehensive set of digital spatial data that encodes information about naturally occurring and constructed bodies of water, paths through which water flows, and related entities. The data support many applications, such as making maps, modeling the flow of water, and maintaining data. The NHD is the culmination of cooperative efforts of EPA and the USGS. For more information, see http://nhd.usgs.gov/index.html.

*Volume* is another way to document the amount of discharge from a pollutant source. This is often how information from a wastewater treatment plant is reported and recorded on a Discharge Monitoring Report.

*Estimated amount* is used if you aren't able to measure the flow or volume of a discharge to the beach. In this case, you can enter a general amount of high (H), medium (M), or low (L) to indicate the significance of the discharge. This information could be useful for making relative comparisons over a beach season, as long as the people making the measurements have the same idea of what constitutes high, medium, and low.

## Floatables present

*Example*

Yes, floatables are present in the water. Types found include trash such as household waste and medical items.

*Description*

Floatable debris causes problems at beaches because it can easily come into contact with aquatic animals, people, boats, fishing nets, and other objects. Communities also lose money when beaches must be closed or cleaned up, and the fishing industry and recreational and commercial boaters spend thousands of dollars every year to repair vessels damaged by floatable debris (USEPA 2002a). Floatable debris also can be a source of bacterial contamination to bathing beaches.

Types of floatables present in water include street litter (e.g., cigarette butts, filters, and filter elements); medical items (e.g, syringes); resin pellets; food packaging; beverage containers; sewage-related items (condoms, tampons, applicators); pieces of wood and siding from construction projects; fishing equipment (e.g., nets, lures, lines, bait boxes, ropes, and rods); household trash; plastic bags and sheeting; and beverage yokes (six-pack rings for beverage containers) (USEPA 2002a).

*Methods*

Record the types and amount of floatable debris. For further guidance on measuring floatable debris, see EPA's *Assessing and Monitoring Floating Debris* (USEPA 2002a), available at www.epa.gov/owow/oceans/debris/floatingdebris/pdf.html.

## Amount and type of beach debris/litter on beach

*Example*

Low (1%–20%) amount of beach has litter present. Types of litter found are street litter, household waste, and tar.

*Description*

Beach debris or litter can cause problems similar to those caused by floatable debris (described above) because they can easily be washed into the bathing beach water and affect wildlife. In addition, the presence of certain materials, such as medical waste and sewage-related items, on the beach can pose an immediate health hazard to beachgoers and can be a source of bacterial contamination to the beach.

*Methods*

Record the types of beach debris or litter observed, along with the percentage of the beach length that has each type of debris or litter. Describe additional types of debris or litter not already provided on the form next to Other.

## Amount of algae in nearshore water/beach

*Example*

Low (1%–20%) amount of beach has algae present. Type of algae found is free floating. Color is bright green.

*Description*

Algae can be a nuisance at Great Lakes bathing beaches when they reach the beach. Decaying algae can produce a foul odor that can deter people from visiting affected bathing beaches. Algae also have been suspected of harboring *E. coli*, which can lead to beach closures (Pfeiffer 2005; see www.wnrmag.com/stories/2005/jun05/algae.htm).

*Methods*

Record the amount of algae found in the nearshore water and covering the beach. There are separate fields for algae in the nearshore water and for algae on the beach itself. The types of algae present, if known, should be recorded, as well as the color of the algae. Additional information can be given, if needed, in the Comments and Observations section of the form.

## Presence of wildlife and domestic animals

*Example*

20 gulls seen on the beach and in the water.

*Description*

The presence of wildlife and domestic animals at bathing beaches affects water quality. Waste from these animals, whether entering the water directly from waterfowl droppings or indirectly from runoff carrying waste from dogs and other animals, can cause bacterial concentrations to rise to the point where recreational standards are exceeded, resulting in beach closure. Data like the types and numbers of animals present at the bathing beach could be used to help identify major sources of bacterial contamination and potential best management practices (e.g., pet owner education, better trash management to reduce available food sources at the beach) that could be used to reduce the amount of animal waste reaching the bathing beach.

*Methods*

Determine the presence of animals at the bathing beach through visual observation. Use binoculars and a handheld counter to keep track of the number of animals present.

Record both the types and number of animals present at the beach. Note the presence of any types of animals not already listed on the form next to Other. Also note in the Comments and Observations section the number of each type of animal present in the water, on the beach, and in the air.

## List the number of each species of bird found dead on the beach

*Example*

Common loons (2), long-tailed ducks (1)

*Description*

Bird die-offs indicate problems in water quality

*Methods*

As you walk the beach to conduct the sanitary survey, look for any dead birds on the shore or in the water. If you can’t identify the species of bird, write a description of the bird and take a photo if possible.

## List the number of dead fish on the beach

*Example*

Found a total of 4 dead fish on the beach—2 at the east end at the same location, 1 in the middle, and 1 on the west end.

*Description*

Fish die-offs indicate problems in water quality.

*Methods*

As you walk the beach to conduct the sanitary survey, look for any dead fish on the shore or in the water. If you can't identify the species of fish, write a description of the fish and take a photo if possible.

# 6. Data Elements for the Annual Sanitary Survey

This section includes descriptions of the types of data you should consider collecting if you are conducting an *Annual Sanitary Survey*. Make sure that you document all sources of information, including dates that data were collected or recorded. In addition, if you used the Internet to obtain information (such as maps), note the most recent date for the Web page.

## *6.1 Basic information*

In the first section of the *Annual Sanitary Survey* form, list the basic information about your beach, such as the name, ID, and location. The Beach IDs you use should include the one you submit to EPA for the PRAWN database. If you have a separate ID for other purposes, you may list that as well.

## *6.2 Description of land use in the watershed*

### Current land use in watershed and overall development

As described in EPA's 2002 *National Beach Guidance and Required Performance Criteria for Grants*, you can use beach characterization data, including surrounding land uses, to evaluate potential risk and rank beaches. Pollutant loadings into nearby bathing beaches and other surface waters generally increase as a watershed becomes more developed and more impervious surfaces are created. Using environmentally sound land use planning techniques and implementing controls can help reduce the impacts of development on bathing beaches.

Land use maps or aerial photos of the watershed can usually be obtained through a city, county, or state planning department. In addition, some land use and land cover (LULC) data are available from the USGS for the conterminous United States and Hawaii, although coverage is not complete for all areas. The Web site for LULC information is http://edc.usgs.gov/products/landcover/lulc.html. Also, Web sites like www.googleearth.com can be helpful in providing maps. When using these types of sources, make sure to note the most recent date on which updates were made to the Web page and when updates are expected.

You can use the information provided by these sources to estimate the percentage of various land uses, including residential, industrial, commercial, and agricultural, in the watershed. You can also use it to visually confirm locations of potential pollutant sources like wastewater treatment plants and concentrated animal feeding operations (CAFOs). In addition, you can use this information to determine the overall percentages of developed and undeveloped area in the watershed.

In addition, you should consider conducting site visits throughout the watershed to verify or update land use data and maps and to collect visual data in unknown areas or areas suspected of being sources of contamination.

### Uses

You can use beach use information to identify potential sources of pollutants. For example, if small oil or gasoline spills are often noted, you can investigate nearby motorized boats as a potential source of bacterial contamination. You can determine beach uses through direct observations of activities that occur at the beach and services offered at the beach (e.g., boat rentals). The uses included on the *Annual Sanitary Survey* form are boating, fishing, surfing, windsurfing, diving, and other. Select the uses that occur at your beach, and describe them further, if necessary, in the Comments section on the form. Describe any uses not listed on the form in the space next to the Other category. In addition, if the *Routine On-site Beach Sanitary Survey* was conducted, you can summarize the results from Part III, Bather Load, collected over the course of the season; Part III asks for information on beach use.

## Mapping

You can use maps to help identify potential impacts on the beach within the watershed or along adjacent shoreline. They can help you determine the proximity of pollutant sources to the beach. Even simple maps like those obtained from places such as GoogleEarth can be useful. Attach copies of any maps you have to the *Annual Sanitary Survey*, or list the locations of the files if hard copies are not available.

You can obtain topographic maps from USGS directly or through a retailer. Information on ordering these maps is provided on USGS's Web site at http://topomaps.usgs.gov/ordering_maps.html. Topographic maps provide an indication of geographic boundaries and contours that influence stormwater flow and, ultimately, pollutant loads to recreational waters. You can use topographic maps to delineate surface watershed boundaries, if this has not been done already.

Detailed maps of survey areas are valuable to understanding the annual surveys and to ensuring the consistency and continuity of the annual survey program. Maps help you to document specific conditions about waterfront and adjacent properties being developed, which can include pollutant sources or pollutant management controls. Graphic representations of key features help future surveyors verify and document the effects of nearshore development activities and pollutant control or sanitation enhancements from one year to the next.

Local governments maintain maps of their jurisdictions in their planning and zoning offices. You should note on such maps the key features identified in the survey, including primary (central) GPS locations for survey reaches or sub-reaches (permanent structural markers such as buildings [addresses], light poles, or utility poles might serve as references to the location of GPS measurements because some GPS measurement devices have greater resolution than others); locations of water sampling and physical measurement stations; the location and direction of any digital photos (to serve as an index); the locations of significant potential sources (e.g., CSO/SSO or other discharge conveyances or apparent stormwater runoff, marinas, docks with recreational watercraft); surrounding development and land uses, including any active construction; and permanent or temporary sanitary facilities for swimmers and beach patrons. A map of sufficiently small scale should provide an opportunity to make notations regarding most features or perspectives for most of the detailed observations on the *Annual Sanitary Survey* form.

The survey includes a list of possible items to include on the map, such as pollutant sources, marinas, sanitary facilities, and bounding structures. Check to see if the things on the list that are applicable to your beach are on the map, and in the Other category add any additional things that are not on the list.

## Erosion/accretion measurements

High water levels, storms, wind, ground water seepage, surface water runoff, ice, and frost are important factors that cause beach erosion. In addition, jetties and seawalls intended to protect against storm waves can actually accelerate beach erosion and reduce the capacity of beaches to absorb storm energy (NOAA 2003). Erosion can result in public losses to recreational facilities, roads, public works, and homes located along the shore (Surfrider 2007).

To determine whether a beach is eroding or accreting over time, and whether you need to implement an erosion control plan, you can take measurements from a fixed object behind the beach, such as a building or parking lot, to the high watermark, and compare changes over time. The high watermark is the highest point that waves reach on the day the measurement is taken. It can usually be identified as the line on the beach between where it is wet and where it is dry or by a line of debris (e.g., seaweed, shells). If there is more than one line of debris on the beach, use the line closest to the waterbody because other debris lines farther from the beach might be the result of previous storms (UNESCO 2005).

Two people are needed to perform this measurement. For beaches at least one mile long, choose at least three points along the beach for the erosion/accretion measurements. You can add additional points as needed. For instance, you can take measurements directly in front of and adjacent to man-made bounding structures to study their effects (UNESCO 2005).

At the first point (point A), select the fixed object and record a description of it on the sanitary survey form. In addition, take pictures of both the high watermark location and a corresponding fixed object, and record a description of these photos on the sanitary survey form. One person should stand at the high watermark and lay the tape measure on the ground. The other should stretch the tape measure to the fixed object and pull the tape measure taut. One of the persons should record on the sanitary survey form the distance in feet or meters. Then proceed to the next point, repeating the measurement and recording corresponding information on the sanitary survey form. Finally, the two people should measure the distances between sampling points (UNESCO 2005) and record them on the sanitary survey form.

The University of Minnesota Extension Service's Web site provides examples of some best management practices that can be used to reduce erosion at beaches: www.extension.umn.edu/distribution/naturalresources/components/DD6946g.html.

## Bounding structures

Alterations of the coastal environment can occur from the installation of man-made bounding structures like jetties, groins, and seawalls. Alterations affect coastal dynamics and have far-reaching effects on coastal ecosystems, hydrodynamic and tidal regimes, and sediment transport rates. Usually, bounding structures are placed in environments to counteract erosion in sediment-deficient areas or to deter accretion in dynamic areas such as inlets. Adjacent downdrift areas typically experience increased erosion after these structures have been installed (NPS 2006).

Groins are perpendicular structures used to maintain updrift beaches or to restrict longshore sediment transport. Jetties, another type of perpendicular hard structure, are normally placed adjacent to tidal inlets to control inlet migration and to minimize sediment deposition within the inlet. Seawalls, bulkheads, and revetments are shore-parallel structures designed to protect the beach in front of a property or properties. Structures like breakwaters, headlands, sills, and reefs are designed to alter the effects of waves and stop or alter natural coastal changes (NPS 2006). For more information on these structures, see www2.nature.nps.gov/geology/coastal/human_impact.cfm.

Take photos of bounding structures. Record corresponding descriptions of the pictures on the sanitary survey form in the Photos section.

## Beach materials/sediments

Beaches can be characterized by the types of materials or sediments present. Sediment type can correlate to bacteria densities at some beaches. In addition, changes in the types of materials or sediments present over time (e.g., from fine-grain to coarse sand) can indicate erosion problems. If beach nourishment projects are undertaken, the grain size of the replacement sand should match as closely as possible the existing sand grain sizes to avoid problems like beach narrowing.

In addition, some researches have found that bacteria can thrive in beach sand, possibly contributing to the bacteria in the beach water. For example, Lake Huron beach sand provides the nutrients, temperatures, and other conditions needed to support growth of *E. coli* (Alm et al. 2006). Data show that wet freshwater beach sand is a reservoir of fecal indicator bacteria and that activity in this zone can bring the bacteria to the sand surface or into the water (Alm et al. 2003)

Simple, subjective observations (e.g., “sandy, very”) can be used to describe the materials or sediments present at a beach. This is adequate for most beaches.

If you have the time and resources, however, collecting sediment samples and sending them to a lab for analysis will provide better data. If you choose to do this, the following is a simple procedure for collecting samples (recommended by Richard Whitman of the USGS, 2006).

1. Choose up to three plots that are 1 square meter in dimension. Plots should be approximately 1 meter beachward (i.e., away from the water) from the waterline. If the sediments at your beach are fairly uniform, one plot is likely enough.
2. Describe the locations of the plots and note them on a diagram or photo so that they can be revisited in the future.
3. Within each plot, collect five equally sized sediment samples—one from each corner of the square plot and one from the center of the square. Composite the samples into one pre-labeled bottle or bag.
4. Send the samples to a lab to analyze the sediment size. The lab should determine the mean grain size diameter, as well as the uniformity coefficient.

## Photos

Photos are a good way to document beach and watershed conditions. Take some general photos showing the overall beach condition and the locations of fixed objects. These photos can be used as a reference points to determine whether changes have been made from year to year. In addition, take photos of beach use, bounding structures, sediments, habitat, sampling locations, pollutant sources, evidence of pollutants (such as pluming from creeks and streams, runoff, and mysterious pipes, evident in aerial photos), sanitary facilities, and other facilities. If you are using a digital camera, write down the photo number, a description, the date and time, and the file name (once the file is uploaded to a computer) for each photo taken. Attach relevant photos to the survey form.

## Habitat

Changes in the types of habitats present at a beach over time can indicate erosion problems. For example, if dunes are starting to disappear, beach restoration efforts might be needed to slow the erosion process. Special measures might be needed to maintain critical habitat for a threatened species at a beach, such as the piping plover (*Charadrius melodus*).

Record on the sanitary survey form the types of habitat present at a beach (e.g., dunes, wetlands, river/stream, forest, park, urban area, or protected habitat or reserve).

## *6.3 Weather conditions*

One or more weather parameters might correlate with bacteria densities in the water. For this part of the survey, you should closely examine the data you have collected over the previous season(s), if applicable, and look for trends and possible correlations with the bacteria sample results. For example, once you display the data graphically, you might notice that bacteria counts are usually high when the water temperature is at its highest. Or perhaps bacteria sample results at certain sample points at one beach are higher than at other sample points, possibly because a current typically moves from west to east along the shore.

In addition, if sky conditions (such as sunny or cloudy) were observed using the Routine Sanitary Survey, the survey results should be examined to determine the typical sky condition for the beach. Sky conditions from the routine survey can also be examined along with the bacteria sampling results to determine whether there is any correlation between the sky conditions and the sampling results.

The results of the *Routine On-site Sanitary Survey* can be used to calculate the average, typical, or maximum measurements of air temperature, water temperature, and wind speed and direction during beach season. If those data are not available, the National Weather Service Web site or other Web sites might be a source of data. The following is a list of Internet sources that you can use to access historical weather data.

*NOAA*
http://tidesandcurrents.noaa.gov/station_retrieve.shtml?type=Great%20Lakes%20Water%20Level%20Data&sort=A.STATION_ID&state=&id1
This Web site allows you to purchase data from 1996 to the present collected by major airport weather stations. The data include daily temperature extremes, precipitation, and winds. Some current data are available free of charge, but additional data come in the form of monthly or annual records and cost $4 per record.

*NOAA–NCDC*
www7.ncdc.noaa.gov/IPS/getcoopstates.html
This Web site contains records for weather stations in the United States ranging from the year 1800 to two or three months ago. The database is searchable by state and city. It gives results as .pdf files showing scanned monthly logs with a daily account of temperature extremes (participating locations) and precipitation, snow, and snow depth. Data are available for the thousands of sites that are a part of the cooperative observing network in the United States. This information is free, but if you need certified copies, they cost about $1 to $4 per monthly data sheet ordered.

*NOAA–Great Lakes Environmental Research Laboratory*
www.glerl.noaa.gov/data/precip/precip.html
This site compiles historical rainfall precipitation data from all the weather stations in the states surrounding the Great Lakes in the form of one zipped file for each state. The stations are subfiles that can be opened in Microsoft Excel.

*NOAA-National Weather Service*

www.nws.noaa.gov/

The National Weather Service site provides locations of weather stations and weather radio information. Archived data for the previous year are available.

## *6.4 Physical beach conditions*

### Beach length or dimensions

Comparing beach dimensions over several years can provide information on how local development might be affecting the beach. For instance, uncontrolled development near the beach can prevent natural dune restoration, which in turn can decrease the width of the beach. Beach length measurements can be used to help identify sampling locations and other features. Beach dimensions can also be useful in calculating how much sand will be needed for a beach nourishment project. In addition, beaches that are receiving funds from an EPA's BEACH Act Grant must provide beach length data to EPA.

Two people are needed to measure the length of the section of beach to which the sanitary survey applies. Note the fixed objects or beach formations that will be used as boundaries for the length of beach (e.g., lifeguard chair to lifeguard chair, edge of building to inlet) on the sanitary survey form. Before using objects like lifeguard chairs, make sure they are actually fixed objects and are not moved from year to year. In addition, take pictures of the boundaries and record descriptions of these photos on the sanitary survey form. To measure the beach, one person should stand at one end of the beach and lay a tape measure on the ground. The second person should stretch the tape measure to the other end of the beach or as far as it will allow. If the beach is longer than the length of the tape measure, take incremental beach length measurements in a field notebook. Add the incremental measurements, and record them on the sanitary survey form.

Enter on the sanitary survey form the three previously made beach width measurements (distance from fixed object to high watermark) for the erosion/accretion measurements for width Z1, width Z2, and width Z3. Average the three measurements, and enter the value on the form for width (average) (UNESCO 2005).

Alternatively, you can take GPS readings to determine beach length or dimensions, or you can estimate the distances by pacing the beach. Make sure you document on the survey form the method you use to calculate beach length or dimensions.

### Local water level variation

Variations in Great Lakes water levels affect beach widths; if low water levels are experienced, beach widths expand. During 1998 and 1999, low precipitation and warm water temperatures (leading to increased evaporation) contributed to lower-than-normal lake levels. Several marinas needed to extend their docks during this period to reduce boater maintenance problems experienced in shallow waters. Algae blooms were also more common during this time because of the high water temperatures (MDEQ 2006).

Comparisons of daily Great Lake water levels with prior levels measured at reference gauges on each lake are on the NOAA Great Lakes Environmental Research Laboratory's Web site at www.glerl.noaa.gov/data/now/wlevels/levels.html. Real-time water level data for additional gauges are on the Great Lakes Information Network at www.great-lakes.net/envt/water/levels/hydro.html.

## Longshore or nearshore currents

Review data from the prior beach season(s) and determine the significance of longshore or nearshore currents. Examine the current data alongside the bacteria sample results at each sample point to determine whether there might be a correlation between the currents and bacteria concentrations at certain sample points. For more information on measuring currents or data sources, see the description of currents in Section 5.1 of this document.

## Slope at the swim area

Beaches exposed to high-energy waves tend to have a steeper slope than those exposed to low-energy waves. Steep, man-made, structure-induced slopes can be vulnerable to erosion when the structure is removed during beach nourishment operations if this fact is not considered in design (NOAA 2003).

Measure the slope at one or more of the locations selected for erosion/accretion measurements. The equipment needed for slope measurements includes two poles of equal length, tied together with several meters of string, and a tape measure. Alternatively, you can use surveying equipment, such as a laser level, if available, to measure slope.

Choose a fixed object behind the beach, such as a building or tree. Use the same fixed starting point when taking future slope measurements so that any changes in slope over time can be measured. Take photos of the fixed starting point, and record corresponding information on the sanitary survey form (UNESCO 2005).

Place a pole at the fixed starting point, and place a second pole down-gradient of the first pole. Pull the string taut. Move the string up or down on the poles until it is level (use a line level to determine this). Measure the distance between the two poles (Z), and the distance between the string and the top of each pole (X and Y), and record the data in a field notebook. For wide beach areas, move the first pole up to the second pole and repeat the process at each break of slope. The end of the profile should be the water's edge (Paraska 1999). For each set of measurements, calculate the difference between X and Y. That is the elevation or height. Divide this number by the distance between the two polls, and that is the slope. This process is illustrated in Figure 1. You can calculate percent slope for sections of the beach for a beach profile, or you can calculate an overall percent slope using the start and end point measurements.

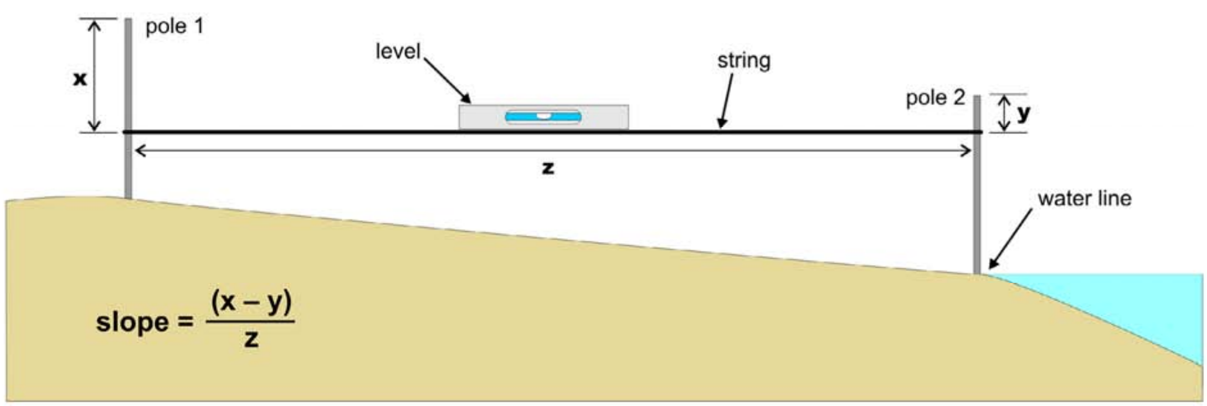


**Figure 1. Calculating a beach's slope.**

### Date and description of the last beach rehabilitation

Beach rehabilitation can help restore major habitats and reduce pollutant sources. Major rehabilitation could include projects such as planting beach grass and erecting fences to protect dune ecosystems, removing litter, dredging, adding sand, and conducting beach nourishment. You should list in part 11, Potential Pollutant Sources, other types of rehabilitation, such as constructing bathroom facilities.

## *6.5 Bather load*

It is important for the beach manager to know the number or approximate number of people using the beach. You can collect the bather load numbers using several different approaches to determine annual, seasonal, and daily cycles. Bather load should best be measured during times of the day when people are most likely to be at the beach. Lifeguards in many counties routinely collect daily counts during swimming season, and therefore they might have data that are of use in the survey. County health departments or beach program managers might also have historical beach attendance data that could be of use in the annual or routine surveys. For details on how to measure bather load, see Section 5.3.

Bather load numbers should be reviewed alongside bacteria sample results to determine whether there is any type of correlation between beach use and bacteria concentrations. Evaluate each sample point separately because one sample point might be more affected by bather load than the others. Describe any trends detected or any particular days when there might have been a correlation between these data sets.

## *6.6 Beach cleaning*

### Cleanup activities

Beaches are typically cleaned using mechanical cleaners, volunteers (e.g., Adopt-a-Beach programs, county- or city-sponsored beach cleanup days), or both. Mechanical beach cleaners groom the sand by mechanically raking and sifting it, and they can remove both large and small pieces of debris. This process might or might not be followed by leveling of the sand. Beach grooming without leveling has been shown to significantly reduce the amount of bacterial contamination during dry-weather events (Northeast–Midwest Institute 2003). Mechanical beach cleaning can be performed daily during the early morning or late evening.

Volunteers can perform manual beach cleaning in year-round Adopt-a-Beach programs, which require participants to clean a designated area of beach at least five times a year and include litter monitoring, cleanup, and simple monitoring activities (Alliance for the Great Lakes 2004). Municipalities or counties might also sponsor beach cleanup events one or more times a year.

In this part of the survey, note the frequency of any beach cleaning activities and give a short description of any activities performed at the beach. Also list any particular type of equipment that was used for beach cleaning, if known.

### Amount and types of beach debris/litter on the beach

Review the results of the routine survey, or other documentation of this type of activity, and estimate how frequently debris or litter is found on the beach and whether it is causing a problem. Note which types of debris or litter are found, including tar, oil or grease, trash, plastic, or medical waste.

## *6.7 Information on sampling location*

### Sampling location

Describe the sampling locations, including details about each sample point. List the time of day that samples are usually taken. EPA recommends that water quality samples be taken in the middle of a typical bathing area. Samples can be taken at a point corresponding to each lifeguard chair, or every 500 meters. If a beach is more than 5 miles long, samples should be taken at the most populated/used areas of the beach and spread out along the length of the beach (USEPA 2002b).

You can use measurements and landmarks to identify specific locations and to ensure future consistency in sample collection. A more precise way to identify your sampling location is to take a GPS reading and record the coordinates.

Collect samples in the morning if possible to ensure that the holding times are met and that the laboratory has the maximum time to process the samples. Note on the sampling form the name of the laboratory and distance from the sampling sites to the lab to determine the best time for collecting samples.

### Sampling plan, equipment maintenance and calibration procedures

Before the beach season, beach managers and their staff should review the sampling plan and equipment maintenance and calibration procedures (if applicable). Keep these documents on-hand so that before each sampling event, field staff can review them as needed. Review these documents during the annual sanitary survey, and if there are any changes in factors such as beach use, number of swimmers, new sources, or equipment used, make any adjustments in the sample plan or equipment maintenance and calibration procedures.

### Hydrometric network

A hydrometric network is the network of monitoring stations that collect data such as flow and rainfall. Check to see if flowmeters or rain gauges are in place in the watershed, and note their locations and owners. NOAA might be able to provide rainfall data (for Web site information, see Section 6.3). However, you might want to operate your own rain gauge or weather station so that it is in the immediate vicinity of your beach. You could also coordinate with a local university that might be interested in these data or might have a rain gauge or weather station of its own.

Flow data might also be available from the USGS NWIS (http://waterdata.usgs.gov/nwis/sw) (USGS 2007a). The NWIS is a comprehensive and distributed application that supports the acquisition, processing, and long-term storage of water data. Data are available for stream levels, stream flow (discharge), reservoir and lake levels, surface-water quality, and rainfall. The data are collected by automatic recorders and manual field measurements at installations across the nation.

Another resource that might be useful is the NHD, at http://nhd.usgs.gov/index.html (USGS 2007b). The NHD is a comprehensive set of digital spatial data that encodes information about naturally occurring and constructed bodies of water, paths through which water flows, and related entities. The data support many applications, such as making maps, modeling the flow of water, and maintaining data. The NHD is the culmination of the cooperative efforts of EPA and USGS.

### *6.8 Water quality sampling*

#### Laboratory information

Use this section to provide the name of the laboratory that analyzes the beach water samples. List the approximate distance from the beach to the laboratory.

#### Sampling and analysis plan

Note on the survey whether a sampling plan or a sampling and analysis plan exists. Review the plan to determine whether it adequately describes sampling and analysis procedures for this beach. Before the start of the beach season, management and all staff that will participate in beach monitoring or data analysis should review the sampling plans. Managers should make sure that the staff members understand the sampling plan and all the procedures they might help with. If any new equipment will be used, update the sampling plan with information on the new equipment, and train staff appropriately.

#### Biological survey results

Biological surveys are often performed by county or state natural resource departments as part of a comprehensive approach to water resource protection and management. They are sometimes performed for purposes related to the 305(b) assessments and the Clean Lakes, Nonpoint Source, TMDL, and NPDES programs, as well as other water quality programs. Our increased understanding of how lake systems function and respond to human activity has led to the recognition that environmental protection requires a holistic approach to lake management and protection. It has been necessary to expand our thinking with respect to lake monitoring approaches, incorporating biological assessments into traditional chemical and physical evaluations (USEPA 1998). For guidance on how to conduct a biological survey and to help you determine whether such a survey is appropriate for your beach, see EPA's *Lake and Reservoir Bioassessment and Biocriteria: Technical Guidance Document* (available at www.epa.gov/owow/monitoring/tech/lakes.html).

Since the 1800s, more than 160 nonindigenous aquatic species have invaded the Great Lakes ecosystem, causing severe economic and ecological impacts. These species include zebra mussel, round goby, sea lamprey, Eurasian ruffe, purple loosestrife, Eurasian watermilfoil, and spiny and fishhook waterfleas. The Great Lakes Commission has made preventing the introduction and spread of aquatic nuisance species a priority (GLC 2004).

Pictures and descriptions of exotic invasive species commonly found in the Great Lakes region are provided on the Minnesota Sea Grant Web site at www.seagrant.umn.edu/exotics/fieldguide.html and www.seagrant.umn.edu/exotics/index.html.

#### Duration and identification of species of algae blooms

Algae can be a nuisance at Great Lakes bathing beaches. *Cladophora* species have been found in the nearshore water and on beaches themselves. *Cladophora* species have been reported to have a foul odor that can deter people from visiting affected bathing beaches. Algae also have been suspected of harboring *E. coli*, which can lead to beach closures (Pfeiffer 2005; see www.wnrmag.com/stories/2005/jun05/algae.htm).

- Field personnel can reference the following NOAA Web site, an electronic field guide to algae found in the Great Lakes: www.glerl.noaa.gov/seagrant/GLWL/Algae/Algae1.html.

- In addition, you can use taxonomic guides like *Freshwater Algae of North America: Ecology and Classification (Aquatic Ecology)* (Wehr and Sheath 2003) to identify algae observed in the nearshore water and on the beach.

## Current and/or historical amounts of algae

- Record on the *Annual Sanitary Survey* form the amount of algae found in the nearshore water. Select the type of algae present, if known, and/or note the color(s) of algae seen.
- Record the amount of algae found covering the beach. This should be measured as the percentage of the length of the beach that has algae present. In the Comments and Observations section of the form, record the type of algae present, if known.
- Review the results of the *Routine On-site Sanitary Survey* for previous years and summarize them on the *Annual Sanitary Survey* to determine whether there are any long-term issues and whether there is a correlation between the presence of algae and bacterial sample results.

In addition, list any other aquatic organisms that were found at your beach, including infectious snails.

## Historical presence of wildlife and domestic animals

You can determine the presence of animals at the bathing beach by visual observation. This should be performed routinely (during the *Routine On-site Sanitary Survey*). Use binoculars and a handheld counter to keep track of the number of animals present. Record on the *Annual Sanitary Survey* form both the types and number of animals present at the beach. Note next to Other the presence at the beach of any types of animals not already listed on the form. Also note in the Comments and Observations section the number of each type of animal present in the water, on the beach, and in the air. Summarize the results from the *Routine On-site Sanitary Survey* conducted during prior seasons on the annual sanitary survey. Look to see how often animals were found at the beach and whether their presence can be correlated with bacteria sampling results. Also include a discussion of whether any fecal droppings were actually seen or are a common occurrence. If routine surveys were not performed and there are no historical data, note the current presence of any wildlife and domestic animals.

## Bacterial samples collected

Beach managers should compile bacteria indicator concentrations (*E. coli* or enterococcus or both (USEPA 1986)) and calculate trends, geometric mean, annual/seasonal averages, minimum concentration, and maximum concentrations to assist in measuring the beach water quality. Bacteria concentrations should be compared to previous years' data to determine whether any significant changes have occurred or whether any trends can be detected. Bacteria data should be examined alongside all other data collected, including weather, rainfall, algae, debris, wildlife, flow, and water quality. Consider doing a statistical analysis on data correlation. Examples of bacteria monitoring methods and calculations are included in Appendix F.

## Water quality

Water quality data (including water temperature, pH, rainfall, turbidity, and conductivity) should be compared to previous years' data. You should also examine data alongside bacteria results to determine whether there are any correlations between bacteria concentrations and water quality results. The following paragraphs give more details on specific water quality parameters.

**Water temperature**

- You can measure water temperature with relative ease using one of the following:
  - A multiprobe
  - Other handheld electronic measurement device
  - Graduated thermometer

  The accuracy of common, wide-scale thermometers and electronic instruments can be verified with simple ice point (0 degrees Celsius [°C] or 32 degrees Fahrenheit [°F]) and boiling point (100 °C or 212 °F) measurements. If the ice point and boiling point do not register correct temperatures, you can plot results for the two measurements on simple graph paper to translate field measurements to corrected values. Electronic meters can be professionally calibrated if the manufacturer's specifications do not include calibration procedures (USGS 2006). See the description for multiprobe in the previous section under the methods used for water temperature.

- Local and regional water temperatures for recreational beaches are also generally broadcast on NOAA Weatherband radios and local radio stations. Temperature ranges can be expected to be in the 60s, 70s, and 80s (in degrees Fahrenheit) during the recreational swimming seasons.

**pH**

- You can conduct measurement of pH using one of the following:
  - Simple pH strips
  - Field test kits
  - Handheld electronic meters (see the description for multiprobe in the previous section under the methods listed for water temperature)

- Common pH strips of a range expected for recreational waters are generally accurate enough for routine surveys. Their cost is usually less than $0.15 per strip.

**Rainfall**

- You can measure rainfall using a rain gauge near the sampling station(s). You can purchase relatively inexpensive rain gauges ($50.00 to $150.00) that can also provide historical rainfall records through vendors like Ben Meadows Company (www.benmeadows.com) and Weather Connection (www.weatherconnection.com).

- Alternatively, you can obtain rainfall measurements from a local airport. The distance from the airport to the sampling station should be noted, as well as whether they are in the same watershed. Record on the *Annual Sanitary Survey* form the amount of rainfall in inches or centimeters, as well as the time from the previous rainfall event. The Web sites listed under Weather Conditions could also be a source of rainfall data.

**Turbidity**

- You can use simple, subjective observations (e.g., "slightly turbid, clear") to describe the turbidity of nearshore waters.

- Alternatively, you can use test kits (using a visual or titrimetric test method), such as the LaMotte test kit for turbidity, for interpreting turbidity results. The results from using this method are reported in Jackson turbidity units (JTU). Visual methods use reagents to react with a substance in the sample, causing a change in color. The concentration of the substance can be determined using the included color comparators or color sheets. Titrimetric methods use a titrant solution that is added to the sample in precise quantities until a color change indicates a completed reaction. The amount of titrant added is used to determine concentration.

- There are two common methods for instruments to measure turbidity.
  - Instruments can measure the attenuation of a light beam passing through a sample. In the attenuation method, the intensity of a light beam passing through turbid sample is compared with the intensity passing through a turbidity-free sample at 180° from the light source. This method is good for highly turbid samples.
  - Instruments can measure the scattered light from a light beam passing through a sample. The most common instrument for measuring scattered light in a water sample is a nephelometer, which measures light scattered at a right angle (90°) to the light beam. Light scattered at other angles can also be measured, but the 90° angle defines a nephelometric measurement. The light source for nephelometric measurements can be one of two types to meet EPA or ISO specifications. EPA specifies a tungsten lamp with a color temperature of 2,200–3,000 K. The unit of measurement for the EPA method is the nephelometric turbidity unit (NTU). The ISO specifies a light-emitting diode (LED) with a wavelength of 860 nanometers and a spectral bandwidth less than or equal to 60 nanometers. The unit of measurement for the ISO method is the formazin nephelometric unit, or FNU (APHA 1998).

- Portable turbidimeters are available for use in the field. Bathing beach water is first collected in the vial provided in the turbidimeter kit and then placed in the turbidimeter to obtain measurements. The results, provided in NTUs, are based on comparisons to known turbidity standards (also provided in the kit) through instrument calibration. Also refer to the information on multiprobes given in the previous section under the methods for water temperature.

**Conductivity**

A conductivity meter is commonly included in several types of multiprobes. Conductivity is measured electronically primarily, using a device called the Wheatstone bridge, which measures the conductance across two electrodes. Also refer to the information on multiprobes given in the previous section under the methods for water temperature.

Conductivity is highly correlated with, the concentration of dissolved solids within the water column. It is one way to measure the overall health of a lake because aquatic organisms require a relatively constant concentration of the major dissolved ions in the water. Levels too high or too low may limit survival, growth, or reproduction.

By measuring conductivity (how easily electric current passes through the seawater), scientists can obtain a measurement of that water sample's salinity because electric current passes much more easily through water with a higher salt content. If you know the conductivity of the water, you can calculate how much salt is present in the water (Murty et al.).

The conductivity of lake water is influenced by a number of factors, explained in more detail in *A Citizen's Guide to Understanding and Monitoring Lakes and Streams* (Michaud 1991).

## *6.9 Modeling*

Predictive models are used to estimate bacterial indicator levels. They are based on single or multiple correlations between hydrologic meteorology or other data with bacterial indicator counts. In most cases, several years of data have been used to develop a good model. These correlations are useful information in a sanitary survey because they might provide information on sources of contamination on or near the beach that could be remediated. The usefulness of models to predict indicator bacteria counts is mostly in the models' timeliness: Bacteria samples currently take at least 18 hours to analyze, and models can predict bacteria counts—or the likelihood of an exceedance of the water quality standard—more quickly so that timely decisions can be made. Predictive models do not replace the need for sampling, however. Successfully managed beach programs that use models continually verify their models. And models might change as remediation efforts take place or as conditions change.

If your beach already has had a model developed for it, you should collect information on the type of model, how it was developed, how it is applied to the beach, the frequency of use, and results from its application. If the model used is a rainfall advisory, investigate and document how this advisory was developed and how the rainfall threshold level was determined. In addition, if you are not using models but have plans to use them in the future, describe your plans in the Comments/Observations section.

Examples of predictive models being used or developed are statistical tools like *Swimming Advisory Forecast Estimate (SAFE)* (www.glsc.usgs.gov/projectSAFE.php) and *SwimCast* (www.earth911.org/waterquality) for Lake Michigan and *Nowcast* models (www.ohionowcast.info/index.asp) for Lake Erie.

Compared to current models, *SAFE* models provide a far better real-time estimate of *E. coli* counts, and they can be applied to five beaches simultaneously.

*Nowcast* models can provide quick, reliable indicators of recreational water quality. Real-time forecasting using mathematical models can help resolve the delayed notification problems inherent with the present approach. Mathematical models use easily measured environmental and water-quality variables (*explanatory variables)*, such as wave height and rainfall, to estimate the *E. coli* concentrations or the probability of exceeding 235 col/100 mL of *E. coli*. This method provides a *nowcast* of recreational water quality, which is similar to a weather forecast except that it estimates current conditions instead of future ones.

## *6.10 Advisories/Closings*

Beach advisory and closing data from the previous season provide useful information about water quality and potential sources of contamination. Beach managers should maintain records of this information in a central file to facilitate compiling advisory and closing data from previous beach seasons and comparing those data with data from the current beach season.

By finding out the number of days the beach was under advisory or closed during a season, a beach manager can determine whether overall water quality at a bathing beach is improving or declining. In addition, a beach manager can determine whether the dates the beach was under advisory or closed during a season correlate with other beach conditions, such as rain events, elevated water temperatures, pollutant discharges, high winds, or high wildlife counts. The beach manager should be able to obtain notes on the beach conditions during sample collection on corresponding *Routine On-site Sanitary Survey* forms. The table on the *Annual Sanitary Survey* form can be expanded as needed to include all advisories and closings.

## *6.11 Potential pollutant sources*

The most important objectives of the beach sanitary survey are to identify sources that affect the beach, determine their exact location, and measure/calculate the source contribution. The beach manager should compile potential pollutant information from previously conducted *Routine On-site Sanitary Surveys*. The beach manager should also use mapping tools; review the topographic map and the detailed map developed for the *Annual Sanitary Survey* to determine what nearby sources (e.g., landfills, marinas, bathhouses) might be affecting bathing beach water quality; and add this information, along with corresponding latitude and longitude data, to this part of the *Annual Sanitary Survey* form. The beach manager, with the assistance of a sanitarian or public health official, should then estimate the percent annual contribution and peak contribution amounts for each potential pollutant source. This information will be very useful for prioritizing the potential sources for further investigation.

Potential pollutant sources are listed in Section 11 of the *Annual Sanitary Survey* form. There are some resources that might be useful in helping you locate pollutant sources. For example, you can access the Permit Compliance System (PCS) to find dischargers in the watershed. You can check for other state and county documents that might contain information on things like dischargers, industries, and utilities in the area. You can walk or drive around the entire watershed, looking for signs of pollutants and potential sources of discharge. You can use the aerial photos on map sites like GoogleEarth.

Identify whether the source is a high, medium, or low contributor to beach pollution. If possible, determine when the source contributes to beach bacteria pollution; the frequency of occurrence; the amount of contamination; and how it is influenced during dry, wet, and storm conditions. Depending on the source, this information might be available from city, county, or state reports, or you might be able to estimate contributions until further investigations can be done to quantify the pollutants.

## *6.12 Description of sanitary facilities and other facilities*

You should examine the sanitary facilities to determine whether they could be a source of pollutants to the beach. Note the number of toilets, showers, sinks, and the like to determine whether the facilities are adequate to accommodate the average and peak bather loads. Note their condition, their general location, and their distance from the beach and the water line.

If other facilities, such as restaurants, play areas, or parking lots, that could be a source of pollutants are present at the beach, examine them as well. You can consult with a sanitarian, city official, or public health official to access the plans and layouts of any sewer lines in the beach area to determine their original intended capacity.

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# Appendix A. Routine On-site Sanitary Survey Form

GREAT LAKES BEACHES ROUTINE ON-SITE SANITARY SURVEY

| | |
|---|---|
| Name of Beach: | Date and Time of Survey: |
| Beach ID: | Surveyor Name(s): |
| Sampling Station(s)/ID: | Surveyor Affiliation: |
| STORET Organizational ID: | |

## PART I – GENERAL BEACH CONDITIONS

Air Temperature: __________°C or °F | Wind: Speed (mph) ________________
Direction (e.g., E or 90°) _____________ (From which direction the wind is coming)

Rainfall: ☐ <24 hours ☐ <48 hours ☐ <72 ☐ >72 hours since last rain event and _______ inches **or** _______cm rainfall measured

Rain Intensity: ☐ Misting ☐ Light Rain ☐ Steady Rain ☐ Heavy Rain ☐ Other

Weather Conditions:

| | | | | | |
|---|---|---|---|---|---|
| Sky Condition | ☐ Sunny | ☐ Mostly Sunny | ☐ Partly Sunny | ☐ Mostly Cloudy | ☐ Cloudy |
| Amount of cloud coverage | No Clouds | 1/8 to 2/8 | 3/8 to 1/2 | 5/8 to 7/8 | Total Coverage |

Wave Intensity: ☐ Calm ☐ Normal ☐ Rough Wave Height: __________ft ☐ Estimated or ☐ Actual

Longshore current speed and direction (cm/sec, S or 180°):

Comments/Observations

## PART II – WATER QUALITY

Bacteria Samples Collected (list samples collected from beach water and potential pollutant sources, if applicable—see Part IV)

| Sample Point | Sample # | Parameter (*E. coli*, enterococci, etc.) | Comments: |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

Water Temperature: ___________°C or °F Change in Color? ☐ yes ☐ no If yes, describe ____________________

Odor: ☐ None ☐ Septic ☐ Algae ☐ Sulfur ☐ Other ____________________

Turbidity: ☐ Clear ☐ Slightly Turbid ☐ Turbid ☐ Opaque or NTU:

Comments/Observations

## PART III – BATHER LOAD

Total number of people in the water: ________________ Total number of people out of the water: ________________

Total number of people at the beach: ________________

List of Activities Seen (optional):

| | | | | |
|---|---|---|---|---|
| Type of Activity | | | | |
| Number of People | | | | |

Comments/Observations

## PART IV – POTENTIAL POLLUTANT SOURCES

Sources of Discharge:

| Type | River(s) | Pond(s) | Wetland(s) | Outfall(s) | Other (specify): |
|---|---|---|---|---|---|
| Name(s) of Source(s) | | | | | |
| Amount (H, M, L) | | | | | |
| Flow Rate (M/sec) | | | | | |
| Volume | | | | | |
| Characteristics | | | | | |

Did you collect any bacteria samples from the sources listed in the table above? ☐ yes ☐ no

If "Yes", did you list the samples in the table in Part II, Water Quality? ☐ yes ☐ no

Floatables present: ☐ yes ☐ no Please circle the following floatables if found:

| Type | Street litter | Food-related litter | Medical items | Sewage-related | Building materials | Fishing related | Household waste | Other: |
|---|---|---|---|---|---|---|---|---|
| Example | Cigarette filters | Food packing, beverage containers | Syringes | Condoms, tampons | Pieces of wood, siding | Fishing line, nets, lures | Household trash, plastic bags | |

Amount of Beach Debris/Litter on Beach: ☐ None ☐ Low (1-20%) ☐ Moderate (21-50%) ☐ High (>50%)

Type of Debris/Litter Found (please circle)

| Type | Street litter | Food-related litter | Medical items | Sewage-related | Building materials | Fishing related | Household waste | Tar | Oil/ Grease | Other: |
|---|---|---|---|---|---|---|---|---|---|---|
| Example | Cigarette filters | Food packing, beverage containers | Syringes | Condoms, tampons | Pieces of wood, siding | Fishing line, nets, lures | Household trash, plastic bags | Tar balls | Oil slick | |

Amount of Algae in Nearshore Water: ☐ None ☐ Low (1-20%) ☐ Moderate (21-50%) ☐ High (>50%)

Amount of Algae on Beach: ☐ None ☐ Low (1-20%) ☐ Moderate (21-50%) ☐ High (>50%)

Circle the types of algae found

| Type | Periphyton | Globular | Free floating | Other |
|---|---|---|---|---|
| Description | Attached to rocks, stringy | Blobs of floating materials | No obvious mass of materials | Please describe |

Circle the color of algae found

| Light green | Bright green | Dark green | Yellow | Brown | Other |
|---|---|---|---|---|---|

Presence of Wildlife and Domestic Animals

| Type | Geese | Gulls | Dogs | Other (specify) |
|---|---|---|---|---|
| Number | | | | |

List the number of each species of bird found dead on the beach

| Type | Common loons | Herring gulls | Ring-billed gulls | Double crested cormorants | Long-tailed ducks | White-winged scoter | Horned grebes | Red-necked grebes | Other |
|---|---|---|---|---|---|---|---|---|---|
| Number found dead | | | | | | | | | |

Number of dead fish found on the beach: ______________

Comments/Observations (continue on back if necessary):

# Appendix B. Routine On-site Sanitary Survey Methods Form

## PART I – GENERAL BEACH CONDITIONS

Air Temperature: ☐ Liquid-in-glass thermometer ☐ Electronic thermometer ☐ Weather report from local airport
☐ Weather report from local weather station ☐ Other (describe): ____________________

Wind Speed and Direction:
☐ Wind vane for direction ☐ Wind sock for direction and speed ☐ Anemometer for wind speed
☐ Aerovane for wind direction and speed ☐ Weather report from local airport ☐ Weather report from local weather station
☐ Other (describe): ____________________
☐ Distance from station: (ft / mi)

Weather Conditions: ☐ Visual observations ☐ Other (describe): ____________________

Rainfall: ☐ Rain gauge ☐ Weather report ☐ Other (describe): ____________________

☐ Distance from station or gauge: __________ (ft / mi)

Longshore Current Speed: ☐ Stick with fishing reel with water balloon on end ☐ Ball and tether
☐ Other (describe): ____________________

Wave Height: ☐ Visual examination of wave height ☐ Graduated stick and ranging pole
☐ Other (describe): ____________________

## PART II – WATER QUALITY

Water temperature: ☐ Multiprobe ☐ Electronic meter ☐ Graduated thermometer ☐ Report from local radio station
☐ Report from NOAA weatherband radio ☐ Other (describe): ____________________

Turbidity: ☐ Simple visual observation ☐ Visual test kit ☐ Titrimetric test kit ☐ Nephelometer/Turbidimeter
☐ Other (describe): ____________________

## PART III – BATHER LOAD

Numbers of People Participating in Various Activities: ☐ Counting by surveyor ☐ Counting by lifeguards ☐ Photos
☐ Turnstyles ☐ Other (describe): ____________________

## PART IV – POTENTIAL POLLUTANT SOURCES

Sources of Discharge:
(a) Source identification: ☐ Visual observation ☐ WWTP Notification/Report ☐ Other (describe): ______________

(b) Flow/velocity or Volume measured: ☐ Mechanical flow meter ☐ Electric flow meter ☐ USGS Gauging Station ☐ WWTP Notification/Report ☐ Orange (float) and stopwatch ☐ Other (describe): ______________

Floatables Present: ☐ Visual observation ☐ Cleanup event results ☐ Other (describe): ______________

Amount and Type of Beach Debris/Litter on Beach: ☐ Visual observation ☐ Cleanup event results
☐ Other (describe): ______________

Algae in Nearshore Water and Beach:
(a) Amount and Color: ☐ Visual observation ☐ Other (describe): ______________

(b) Identification: ☐ Field guide or internet site for taxonomic identification (describe): ______________
☐ Other (describe): ______________

Presence of Wildlife and Domestic Animals: ☐ Counting using hand-held counter, and if necessary, binoculars
☐ Other (describe): ______________

Dead birds:
(a) Amount: ☐ Visual observation ☐ Other (describe): ______________

(b) Identification: ☐ Field guide or internet site for taxonomic identification (describe): ______________
☐ Other (describe): ______________

Dead fish:
(a) Amount: ☐ Visual observation ☐ Other (describe): ______________

(b) Identification: ☐ Field guide or internet site for taxonomic identification (describe): ______________
☐ Other (describe): ______________

# Appendix C. Annual Sanitary Survey Form

GREAT LAKES BEACH ANNUAL SANITARY SURVEY

## 1. BASIC INFORMATION

| | |
|---|---|
| Name of Beach: | Date(s) of Survey: |
| Beach ID: | Name of Waterbody: |
| Town/City/County/State: | Number of Routine Surveys Used: |
| Sampling Station(s)/ID: | Name(s) of Surveyor(s): |
| STORET Organizational ID: | Surveyor Affiliation: |

## 2. DESCRIPTION OF LAND USE IN WATERSHED

Current Land Use in Watershed

| Type | Residential | Industrial | Commercial | Agricultural | Other (specify): |
|---|---|---|---|---|---|
| Percentage | | | | | |

| Development | Describe |
|---|---|
| % undeveloped | |
| % developed | |

How was land use measured:

Waterbody Uses: ☐ Boating ☐ Fishing ☐ Surfing ☐ Windsurfing ☐ Diving ☐ Other (specify)

Are maps of the beach area attached? ☐ yes ☐ no Are maps of the watershed attached? ☐ yes ☐ no

List maps and their sources:

Does the detailed map include locations of:

| | | | |
|---|---|---|---|
| Sample Points | ☐ yes | ☐ no | (explain): |
| Hydrometric Network | ☐ yes | ☐ no | (explain): |
| Pollutant Sources | ☐ yes | ☐ no | (explain): |
| Boat Traffic | ☐ yes | ☐ no | (explain): |
| Marinas | ☐ yes | ☐ no | (explain): |
| Boat dockage | ☐ yes | ☐ no | (explain): |
| Fishing | ☐ yes | ☐ no | (explain): |
| Bathing/Swimming | ☐ yes | ☐ no | (explain): |
| Bounding Structures: | | | |
| Jetty | ☐ yes | ☐ no | (explain): |
| Groin | ☐ yes | ☐ no | (explain): |
| Seawall | ☐ yes | ☐ no | (explain): |
| Other | ☐ yes | ☐ no | (explain): |
| Sanitary Facilities | ☐ yes | ☐ no | (explain): |
| Restaurants/Bars | ☐ yes | ☐ no | (explain): |
| Playground | ☐ yes | ☐ no | (explain): |
| Parking Lot(s) | ☐ yes | ☐ no | (explain): |
| Other | ☐ yes | ☐ no | (explain): |

Erosion/Accretion Measurements

| High Watermark Location Identification | Fixed Object Description (e.g., tree, building) | Distance from Fixed Object to High Watermark | Feet or Meters? | Distance between High Watermark Locations | Feet or Meters? |
|---|---|---|---|---|---|
| A | | | | A↔B: | |
| B | | | | B↔C: | |
| C | | | | C↔D: | |
| D (optional) | | | | D↔E: | |
| E (optional) | | | | | |

Bounding Structures

| Bounding Structure | Number | Description or Comment |
|---|---|---|
| Jetty | | |
| Groin | | |
| Seawall | | |
| Natural formation | | |
| Other (specify): | | |
| Other (specify): | | |

Beach Materials/Sediments:

☐ Sandy ☐ Mucky ☐ Rocky ☐ Other:

Or, Beach Materials/Sediments Lab Analysis (attach diagram or photos of plot locations)

| | | | |
|---|---|---|---|
| Name of Lab Used: | | | |
| Date of Sample Collection: | | | |
| Plot ID | Mean Grain Size Diameter | Uniformity Coefficient | Description of Plot Location: |
| | | | |
| | | | |
| | | | |
| Average | | | |

Describe the results and conclusion of the sediment analysis and potential effects of the sediment distribution at this beach:

Photos Taken in the Beach Area or Surrounding Watershed

| Image Number | Date/Time | File Name | Description of Photograph (Include Pictures of High Watermark Locations and Corresponding Fixed Objects) |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Habitat around beach:

☐ Dunes ☐ Wetlands ☐ River/stream ☐ Forest ☐ Park ☐ Protected Habitat or Reserve

☐ Other:

## 3. Weather CONDITIONS

Examine the weather data collected over the prior beach season(s) along with bacteria sampling results.
Do the bacteria concentrations at this beach appear to correlate with any of the following?

| | | | |
|---|---|---|---|
| Rainfall | ☐ yes | ☐ no | (explain): |
| Air Temperature | ☐ yes | ☐ no | (explain): |
| Water Temperature | ☐ yes | ☐ no | (explain): |
| Cloud Cover | ☐ yes | ☐ no | (explain): |
| Wind Speed | ☐ yes | ☐ no | (explain): |
| Wind Direction | ☐ yes | ☐ no | (explain): |
| Longshore Current | ☐ yes | ☐ no | (explain): |
| Wave Height or Intensity | ☐ yes | ☐ no | (explain): |
| Other Weather | ☐ yes | ☐ no | (explain): |

Have any statistical analyses been done to calculate the degree of correlation? ☐ yes ☐ no

Describe any analyses done, and any trends or correlations found (add lines if needed to describe in detail):

| | |
|---|---|
| Average air temperature during beach season: ° C or ° F | Average water temperature during beach season: ° C or °F |
| Average wind speed and direction during beach season (e.g., E or 90° at 15 mph): | |
| Typical weather conditions: ☐ Sunny ☐ Mostly Sunny ☐ Partly Cloudy ☐ Mostly Cloudy ☐ Overcast ☐ Rainy | |
| Rainfall total for the beach season (in): | Average rainfall for all beach seasons (in): |
| Does rainfall intensity correlate with bacteria sample results? ☐ yes ☐ no Describe: | |

| | |
|---|---|
| Number of significant rain events: | What constitutes “significant?” (e.g., 1 inch or more rain) |

Additional Comments/Observations:

## 4. PHYSICAL BEACH CONDITIONS

Beach length or dimensions (indicate Z1, Z2, and Z3 on a map)

| | | |
|---|---|---|
| Length (m): | Width (average, in m): | |
| Width Z1 (m): | Width Z2 (m): | Width Z3 (m): |
| Local water level variation: feet inches | Hydrographic influences (e.g., seiches): | |

Characterize any longshore or nearshore currents and their potential effects based on bacteria sampling results

Approximate beach slope at swim area: ________ %

Description and date of last beach rehabilitation (example: new sand, nourishment, dredging, etc., physical structures will be described in Sections 12 and 13):

Comments/Observations:

## 5. BATHER LOAD (# OF BEACH USERS)

Is bather load measured? ☐ yes ☐ no

If yes, describe how beachgoer numbers are calculated (i.e., turnstile, counting at noon, photos):

Beach Use

| Beachgoer Category | Number of People Per Day Using the Beach: Peak Use for the Season (Daily Use) | Seasonal Average (Daily Use) | Holiday Average (Daily Use) | Weekend Average (Daily Use) | Weekday Average (Daily Use) | Off-Season Average if applicable (Daily Use) |
|---|---|---|---|---|---|---|
| Total people in the water | | | | | | |
| Total people out of the water | | | | | | |
| Total people at the beach | | | | | | |
| Breakdown of Activities (if activities were broken down on the Routine-Onsite Sanitary Survey, summarize them here) | | | | | | |
| Activity 1: | | | | | | |
| Activity 2: | | | | | | |
| Activity 3: | | | | | | |
| Activity 4: | | | | | | |
| Activity 5: | | | | | | |
| Activity 6: | | | | | | |
| Frequency of measurements (e.g., daily, weekly, monthly) | | | | | | |

Examine bather load data along with sampling results for the past beach season(s). Look at each sampling point. Does bather load appear to correlate with bacteria concentrations at any of these sampling points? Does the amount of people in the water or out of the water correlate with bacteria concentrations? Has a statistical analysis been done? Describe:

Comments/Observations:

## 6. BEACH CLEANING

Beach cleaning frequency during season:

Description of cleanup activities

| | Leveling of Sand | Trimming or Removing Vegetation | Removing Debris | Removing Trash | Construction and Maintenance of a Temporary Pathway Directly to Open Water | Other (specify): |
|---|---|---|---|---|---|---|
| Check activities that were done | | | | | | |
| Equipment used (if applicable) | | | | | | |

How often are floatables found at the beach? ☐ Never ☐ Sometimes ☐ Frequently ☐ Very frequently

Known sources of floatables:

Types of floatables found ☐ Street litter ☐ Food-related litter ☐ Medical items ☐ Sewage-related ☐ Building materials ☐ Fishing-related ☐ Household waste ☐ Other:

How often is beach debris/litter found on the beach? ☐ Never ☐ Sometimes ☐ Frequently ☐ Very frequently

Known sources of debris:

Type of Debris/Litter Found

☐ Street litter ☐ Food-related litter ☐ Medical items ☐ Sewage-related ☐ Building materials
☐ Fishing-related ☐ Household waste ☐ Tar ☐ Oil/Grease ☐ Other:

Comments/Observations:

## 7. INFORMATION ON SAMPLING LOCATION

Description of Sample Points (include beach water and potential pollutant sources)

| Sample Point Name/ID | Location | Description | Sample Frequency | Time of Day of Sample Collection |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Description of hydrometric network [note that this is a network of monitoring stations that collect data such as rainfall and stream flow]

Comments/Observations:

## 8. WATER QUALITY SAMPLING

Name of laboratory: ____________ Distance to laboratory: ________ miles

Is there a sampling and analysis plan? ☐ yes ☐ no Is it adequate? ☐ yes ☐ no (explain):

Are the sampling staff properly trained on sampling techniques, equipment maintenance, and calibration procedures? ☐ yes ☐ no

Biological Survey Results:

Were invasive/nonnative species present? ☐ yes ☐ no (describe): ____________

Have algae blooms been observed during the beach season? (If so, specify duration and algae species) ____________

Percent of beach season where algae was present in significant amounts in the nearshore water: ☐ None ☐ Low (1–20%) ☐ Moderate (21–50%) ☐ High (> 50%)

Percent of beach season where algae was present in significant amounts on the beach: ☐ None ☐ Low (1–20%) ☐ Moderate (21–50%) ☐ High (> 50%)

List types of algae found: ____________

Colors of algae most commonly found: ____________

List any infectious snails that were found: ____________

List any dangerous aquatic organisms that were found: ____________

Presence of Wildlife and Domestic Animals

| Type | Degree of Presence (Low, Mod, High) | Does the Presence Appear to Correlate with Bacteria Results? (Yes, No, Don't Know) | Describe Further (include whether fecal droppings are seen and are a problem) |
|---|---|---|---|
| Geese | | | |
| Gulls | | | |
| Dogs | | | |
| Other (specify): | | | |
| Other (specify): | | | |
| Other (specify): | | | |

Was a significant number of dead birds found on the beach during beach season? ☐ yes ☐ no
Describe types and numbers found and possible causes: ______

Was a significant number of dead fish found on the beach during the beach season? ☐ yes ☐ no
Describe numbers found and possible causes: ______

Bacteria Samples Collected

Do you test for *Escherichia coli*? ☐ yes ☐ no Analytical Method Used: ______
Do you test for *Enterococcus*? ☐ yes ☐ no Analytical Method Used: ______
Do you test for fecal coliform? ☐ yes ☐ no Analytical Method Used: ______
List any additional bacteria tested and associated analytical methods: ______
Do you composite any bacteria samples? ☐ yes ☐ no If yes, explain: ______

How do this past season's bacteria results compare to that of previous years'? ______

Do the bacteria results correlate to other parameters, such as water quality, weather, flow, bather load, algae, or wildlife? ☐ yes ☐ no Describe in detail analyses that were performed on the data (add additional lines as needed).

Water Quality (check all that are measured regularly)

| Temperature | pH | Rainfall | Turbidity | Conductivity | Other |
|---|---|---|---|---|---|
| | | | | | |

How does the water quality data compare to data from previous years? ______

Do any data correlate with bacteria sample results? ☐ yes ☐ no If yes, explain: ______

Were there any unusual results, such as extremely high or low values detected, or unusual trends? ☐ yes ☐ no If yes, explain what was found and any potential causes: ______________________________

Are water quality annual trend data attached? ☐ yes ☐ no

Comments/Observations:

## 9. MODELING

Are models being used? ☐ yes ☐ no

If yes, list types of models being used and a brief description of the models:

Comments/Observations:

## 10. ADVISORIES/CLOSINGS

List any advisories and closings that occurred, whether bacteria levels were high, and any possible reasons for advisory or closing or high bacteria level, such as stormwater runoff, sewage spill, or wildlife on the beach.

| Advisory or Closing (specify one) | Start and End Dates | Length of Advisory or Closing (Days) | Did Bacteria Concentrations Exceed GM or SSM Criteria? | Reason for Advisory or Closing or Possible Contributing Factors |
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Total number of closings issued: __________ Total number of days under an advisory: ______________

Total number of advisories issued: __________ Total number of days beach was closed: ______________

Comments/Observations:

## 11. POTENTIAL POLLUTANT SOURCES

| Type of Source | Level of Concern (H, M, L, or NA) | Latitude* | Longitude* | Describe how this source might contribute to beach pollutants and frequency of contribution |
|---|---|---|---|---|
| Wastewater discharges | | | | |
| Sewage overflows | | | | |
| Septic systems | | | | |
| Subsurface sewage disposal | | | | |
| Stormwater outfalls | | | | |
| Natural outfalls | | | | |
| CAFOs or AFOs | | | | |
| Wildlife | | | | |
| Agriculture runoff | | | | |
| Urban runoff, industrial waste | | | | |
| Marinas, harbors | | | | |
| Mooring boats | | | | |
| Domestic animals | | | | |
| Unsewered areas | | | | |
| Erosion-prone areas | | | | |
| Landfills, open dumps | | | | |
| Groundwater seepage | | | | |
| Bathhouse leakage | | | | |
| Drains and pipes nearby | | | | |
| Stream or wetland drainage | | | | |
| Vacant areas | | | | |
| Other (specify): | | | | |
| Other (specify): | | | | |
| Other (specify): | | | | |

*If latitude and longitude are unknown, show the location on the detailed map and describe in the Comments/Observations section below.

Have potential pollutant sources identified above been included on the detailed map? ☐ yes ☐ no (explain):

______________________________

______________________________

Did you collect bacteria samples from any potential pollutant sources, such as streams or outfalls? ☐ yes ☐ no (explain):

______________________________

______________________________

If yes, describe any analyses performed and a summary of the results: ______________________________

______________________________

______________________________

Are there any discharge reports available for dischargers in the watershed? ☐ yes ☐ no If yes, attach report or pertinent sections and summarize here: ______________________________

______________________________

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Have any sources been remediated, or have steps been taken to remediate sources? ☐ yes ☐ no (explain):

Comments/Observations:

## 12. DESCRIPTION OF SANITARY FACILITIES

Bathhouses: Total number of bathhouses at the beach:

| Number or ID | Location | Condition (Good, Fair, or Poor) | Distance from Waterline (feet) | Frequency of Cleaning (Daily, Weekly, Monthly) |
|---|---|---|---|---|
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Describe further. Include number of toilets, showers, sinks, etc., and whether these facilities are adequate to support beach use.

Litterbins: Total number of litterbins at the beach:

| Number or ID | Location | Condition (Good, Fair, or Poor) | Distance from Waterline (feet) | Frequency of Emptying (Daily, Weekly, Monthly) |
|---|---|---|---|---|
| | | | | |
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Describe further. Include whether number and location of litterbins is adequate to support beach use.

## 13. DESCRIPTION OF OTHER FACILITIES

List facilities in the beach area, such as restaurants, bars, playgrounds, parking lots, and dog parks.

| Facility Name/Type | Location | Condition (Good, Fair, or Poor) | Distance from Beach (feet) | How might this facility contribute to water quality problems? |
|---|---|---|---|---|
| | | | | |
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Comments/Observations:

# Appendix D. Quality Assurance and Quality Control

States, tribes, and local agencies should use the information in this document and follow their agency-specific QA/QC procedures for data collection, entry, and analysis when performing sanitary surveys.

Most agencies should already have QA/QC procedures for performing beach monitoring because such procedures are required to obtain BEACH Grants in accordance with the EPA regulations at 40 CFR 31.45 governing grants to states, tribes, and local governments. Specifically, the regulations require the following:

> If the grantee's project involves environmentally related measurements or data generation, the grantee shall develop and implement quality assurance practices consisting of policies, procedures, specifications, standards, and documentation sufficient to produce data of quality adequate to meet project objectives and to minimize loss of data due to out-of-control conditions or malfunctions.

An agency's QA/QC procedures should be updated, as needed, to include QA/QC procedures for performing the sanitary surveys described in this document. An agency's QA/QC procedures are generally documented in quality management plans (QMPs), quality assurance project plans (QAPPs), and standard operating procedures (SOPs). If an agency needs to develop additional quality documentation for performing sanitary surveys, it should refer to the documents below (available on EPA's quality Web site at www.epa.gov/quality/qa_docs.html) for requirements and guidance:

- *EPA Requirements for Quality Management Plans* (QA/R-2)
- *EPA Requirements for QA Project Plans* (QA/R-5)
- *Guidance for Quality Assurance Project Plan*s (QA/G-5)
- *Guidance for Preparing Standard Operating Procedures* (QA/G-6)

Typically, the written quality documentation takes the form of a QAPP. A QAPP typically details the technical activities and QA/QC procedures that should be implemented to ensure that data meet the specified standards. The QAPP should identify who will be involved in the project and their responsibilities; the nature of the study or monitoring program; the questions to be addressed or decisions to be made on the basis of the data collected; where, how, and when samples will be taken and analyzed; the requirements for data quality; the specific activities and procedures to be performed to obtain the requisite level of quality, including QC checks and oversight; and how the data will be managed, analyzed, checked to ensure that it meets the project goals, and reported. The QAPP should be implemented to ensure that data collected and analytical data generated are complete, accurate, and suitable for the intended purpose.

States, tribes, and local agencies should also document their methods and assessment procedures in their quality system documentation. For routine implementation of these methods, SOPs, which can be referenced in and provided with the quality system documentation, provide a tool to assist the person(s) performing the activities. An SOP typically presents in detail the method for a given technical (not administrative) operation, analysis, or action in sequential steps. It includes specific facilities, equipment, materials, and methods; QA and QC procedures; and other factors necessary to perform the operation, analysis, or action. If the SOP is followed, the operation should be performed the same way every time; that is, the operation is standardized. The activities being performed might include field sampling and database management. The format and content requirements for an SOP are flexible because the content and level of detail vary according to the nature of the procedure. SOPs should be revised when new equipment is used, when comments by personnel indicate that the directions are not clear, or when a problem occurs. States, tribes, and local agencies should ensure that obsolete documents are removed and that the revised SOPs are used in subsequent tasks.

EPA recommends that a registered sanitarian supervise the first few Routine On-site Sanitary Surveys performed by volunteers or lifeguards. In addition, as Routine On-site Sanitary Survey forms are completed, the registered sanitarian or designee should review the forms for any problems (e.g., incomplete answers, questionable responses). The registered sanitarian should provide some guidance to the volunteers or lifeguards to ensure that problems are remedied. The following are some additional quality guidelines that should be followed:

- Make sure a second person checks the sanitary survey form to be sure it has been filled out correctly.
- Follow the calibration procedures for each instrument carefully. Flow meters have been factory-calibrated, but they must be checked regularly to ensure that they are working properly before use. The calibration of pH, conductivity/salinity, dissolved oxygen, temperature, and turbidity probes should be checked (at a minimum) once daily, before initial deployment, or as deemed necessary by the equipment manufacturer, using the standard solutions.
- Contact the laboratory at least 8 to 10 hours (24 hours is ideal) before the start of the sampling event to determine whether additional volumes of samples must be collected for QC analyses in the laboratory. If field blanks, trip blanks, and field duplicates are required (requirements should be specified in the QAPP), they must be collected as specified by the lab. If a sampling trip is cancelled, notify the lab immediately.
- Prevent contamination of samples at all times. Take care with respect to equipment handling, container handling and storage, decontamination, and record keeping. Rinse and clean sample collection equipment as necessary before and after each sampling episode, with the exception of pre-preserved containers. Wear clean, powder-free gloves or make sure your hands are clean.

In addition to the general quality considerations, EPA recommend that you develop SOPs for each activity or piece of equipment. Because completing the survey and performing sampling generally require the application of best professional judgment in addition to following predetermined steps, EPA recommends that only persons who have received training in the operation of each type of equipment and have experience in monitoring water quality be responsible for completing the sanitary survey.

# Appendix E. Equipment and Supplies

A list of potential vendors to help you locate beach water quality supplies is in the *Minnesota Pollution Control Agency Volunteer Surface Water Monitoring Guide,* at www.pca.state.mn.us/water/monitoring-guide.html.

The overall potential cost of a sanitary survey ranges from tens to thousands of dollars. For the purposes of this evaluation, the expense assessment is associated with monitoring equipment and health and safety equipment for the survey teams. Health and safety are not considered optional; however, there are some cost-control opportunities in the selection and use of safety equipment. For the purpose of this analysis, the minimum safety requirements are safety glasses, gloves, and rubber boots.

Again, safety equipment is not an option. Therefore, the overall expense variable lies primarily with the sampling and water quality testing equipment and supplies. Some or most of this expense might already be covered by a beach monitoring program. Critical to these are (1) what capital equipment might be available in the survey sponsorship organizations, (2) what data are most important to the sponsors, (3) the overall qualifications of the sampling team staff, (4) how many survey stations or locations are identified within a sponsor's jurisdiction, and (5) the time frame for completing the surveys. A significant number of stations or transects to be surveyed might dictate the need for a more expensive monitoring option, but the number of stations will ultimately drive down the cost per survey. As a basic estimate of some of the costs of field measurement equipment, a single-parameter nephelometer/turbidimeter runs between $700 and $1,000, and multiprobe instruments that can measure temperature, pH, conductivity, and dissolved oxygen are in the $1,700–$2,000 range (without turbidity probe). Portable digital thermometers range from less than $100 to $300 for a high-quality, National Institute of Standards and Testing (NIST) traceable calibration.

# Appendix F: Sampling and Analytical Methods for Bacteria

## F.1 Methods of sample collection

Qualified local laboratory services are a tremendous source for information. In addition to providing analytical support for monitoring recreational waters for pathogens, laboratories usually provide their own sterilized sample containers and custody documents to record dates, times, and sample locations. Local laboratories often provide training for sampling personnel, or laminated sampling guides to assist in appropriately collecting samples and completing sample documentation. Sampling procedures should be developed into standard operating procedures (SOPs) based on the variety of sampling requirements for the target sites. (For example, variable accessibility and sampling depths in the monitoring design could require that different techniques be employed at different locations.) In general, samples should be collected at the desired depth(s) directly into sterilized containers. The containers should then be sealed, labeled, and chilled for transport to the local laboratory.

The first sample collected for the day should be a field blank. A field blank is simply a volume of reagent water or sterilized buffer solution that was transported to the field and transferred into a sample container to assess potential contamination from the sampling technique.

Duplicate samples, if included in the monitoring design, should be collected simultaneously, if possible (i.e., if two containers can be held at once in one hand). If two containers can't be managed without spillage, collect the duplicates sequentially.

Chapter 4 and Appendix J of the *National Beach Guidance and Required Performance Criteria for Grants* (USEPA 2002b) provide detailed discussions on sample collection, sample handling, and suggested procedures. Before developing SOPs, you should consult the local laboratory for recommendations because protocols that are relevant and applicable to the sampling design might already be available.

Local laboratory support is critical because laboratory analysis for pathogenic indicators should be performed within 24 hours of sample collection (the measurement holding time). Analysis of samples collected for compliance purposes for the measurement of pathogen indicators must be initiated within 8 hours of collection (6 hours transport to the laboratory and 2 hours to initiate processing in the laboratory). Local laboratory resources that are qualified to perform testing can be readily identified through local departments of health. Note, however, that many laboratories certified to analyze pathogen indicators might not be certified for the preferred indicators for recreational waters, *E. coli* and enterococci. Part of your laboratory selection process should include reviewing and assessing laboratory certifications, which, in some programs, might certify by pollutant or parameter or might certify to the method level.

## F.2 Methods of analysis

On the basis of the potential for other data uses and the critical need to protect human health, EPA recommends using the established, reproducible methods described at 40 CFR Part 136 for measuring pathogenic indicators, *E. coli*, enterococci, and any additional indicators of interest. The methods identified at Part 136 include methods published in the 1995 *Official Methods of Analysis of AOAC International*, the 20th edition of

*Standard Methods*, the 2000 edition of the *Annual Book of ASTM Standards* (Vols. 11.01 and 11.02), and additional methods of analysis developed by commercial vendors, including Hach and IDEXX Laboratories. In addition, Part 136 describes a program for laboratories to obtain approval of alternative test procedures (ATP). A number of methods have been proposed to update Table 1A of Part 136 to exploit advances in measurement systems and technology toward a faster, more reliable assessment of bacterial indicators. Consultation with local laboratory resources will reveal the analytical options available locally for use in monitoring recreational waters.

Analytical methods for microbiological analysis of pathogens and pathogen indicators typically consist of introducing or exposing samples to a growth medium (or more than one medium) followed by incubation and examination of the number and type of biological colonies grown. Sample introduction can include inoculation of a sample into a liquid medium or filtration of a sample through a filter, which is placed in its entirety onto a medium for incubation. Different media are selectively fortified with nutrients most beneficial to different target organisms; thus, between the selection of media and incubation temperatures, different conditions assist in isolating different target organisms or classes of organisms.

In general, the analysis methods for reporting *E. coli* and enterococci in aqueous samples are described as membrane filtration (MF) and most probable number (MPN). MF is a direct-plating method in which sample dilutions/volumes are filtered through membrane filters and transferred to petri plates containing selective media. A second substrate medium is used in the two-step MF procedures to differentiate the target organisms. In MPN tests, a series of test tubes containing growth media are inoculated with sample or sample dilutions, and the number of test tubes or wells producing a positive reaction provides an estimate of the original, undiluted density (concentration) of target organisms in the sample. This estimate of target organisms, based on probability formulas, is called the *most probable number.* MPN tests can be conducted in multiple-tube fermentation (MTF), multiple-tube enzyme substrate, or multiple-well enzyme substrate formats.

Chapter 4 of the *National Beach Guidance and Required Performance Criteria for Grants* (USEPA 2002b) provides a number of EPA and other methods within these two categories. Among them are the four preferred MF methods of analysis described in detail as follows:

*Membrane filter tests for enterococci*

**EPA Method 1600** (mEI media). Method 1600 is a single-step MF procedure that provides a direct count of enterococci in water based on the development of colonies on the surface of a filter when placed on selective mEI agar (USEPA 1997). This medium, a modification of the mE agar in EPA Method 1106.1, contains a reduced amount of 2-3-5-triphenyltetrazolium chloride, and an added chromogen, indoxyl-ß-D-glucoside. This change in ingredients allows for results in 24 hours rather than 48 hours, and it eliminates the second filter transfer step from mE to Esculin iron agar (EIA). In this method, a water sample is filtered, and the filter is placed on mEI agar and incubated at 41 ± 0.5 °C for 24 hours. Following incubation, all colonies with a blue halo, regardless of colony color, are counted as enterococci. Results are reported as enterococci per 100 mL.

**EPA Method 1106.1** (mE media). EPA Method 1106.1 is a two-step MF procedure that provides a direct count of enterococci in water based on the development of colonies on the surface of a membrane filter when placed on a selective medium (USEPA 1985). A water sample is filtered through a 0.45-µm membrane filter, and the filter is placed on a plate containing selective mE agar. After the plate is incubated at 41 ± 0.5 °C for 48 hours, the filter is transferred to an EIA plate and incubated at 41 ± 0.5 °C for 20 to 30 minutes. After incubation, all pink to red colonies on the mE agar that form a black or reddish-brown precipitate on the underside of the filter when placed on EIA are counted as enterococci. The organism density is reported as enterococci per 100 mL.

*Membrane filter tests for* E. coli

**Modified EPA Method 1103.1** (Modified mTEC Media). Modified EPA Method 1103.1 is a single-step MF procedure that provides a direct count of *E. coli* in water based on the development of colonies on the surface of a filter when placed on a selective modified mTEC medium (USEPA 1985). This is a modification of the standard mTEC media that eliminates bromcresol purple and bromphenol red from the medium, adds the chromogen 5-bromo-6-chloro-3-indolyl- ß -D-glucuronide, and eliminates the transfer of the filter to a second substrate medium. In this method, a water sample is filtered through a 0.45-µm membrane filter. The filter is placed on modified mTEC agar, incubated at 35 ± 0.5 °C for 2 hours to resuscitate injured or stressed bacteria, and then incubated for 23 ± 1 hours in a 44.5 ± 0.2 °C water bath. Following incubation, all red or magenta colonies are counted as *E. coli*.

**EPA Method 1103.1** (mTEC Agar). EPA Method 1103.1 is a two-step procedure that provides a direct count of *E. coli* in water based on the development of colonies on the surface of a membrane filter when placed on a selective nutrient and substrate medium (USEPA 1985). EPA originally developed this method to monitor the quality of recreation waters. This method also was used in health studies to develop the bacteriological ambient water quality criteria for *E. coli*. In this method, a water sample is filtered through a 0.45-µm membrane filter, the filter is placed on mTEC agar (a selective primary isolation medium), and the plate is incubated first at 35 ± 0.5 °C for 2 hours to resuscitate injured or stressed bacteria and then at 44.5 ± 0.2 °C for 23 ± 1 hours in a water bath. Following incubation, the filter is transferred to a filter pad saturated with urea substrate medium. After 15 minutes, all yellow or yellow-brown colonies (occasionally yellow-green) are counted as positive for *E. coli*.

The Beach Guidance continues to describe and recommend an EPA video, *Improved Enumeration Methods for the Recreational Water Quality Indicators: Enterococci and* Escherichia coli, which demonstrates the four methods EPA recommends. These are the mEI and the mE agar methods for enterococci and the modified mTEC and mTEC agar methods for *E. coli*. The purpose of the video is to introduce and demonstrate the improved methods. Accompanying the video is a laboratory manual having the same name that explains all four methods step by step (USEPA 2000b). The laboratory manual also contains color photos of the target colonies on all media to aid in identification. The video and methods manual are available to all interested laboratories. For copies of the manual (EPA 821R-97-004) or videotape (EPA 822V-99-001), send a request to EPA's National Service Center for Environmental Publications (www.epa.gov/ncepihom or phone 513-489-8190). The manual is also available at www.epa.gov/waterscience/beaches or www.epa.gov/microbes.

*Other methods recommended in the 40 CFR Part 136 rule*

In the Part 136 (*Guidelines Establishing Test Procedures for the Analysis of Pollutants; Analytical Methods for Biological Pollutants in Ambient Water; Final Rule*), EPA outlined several additional methods to be used to enumerate *E. coli* and enterococci. Additional information on these methods is at www.epa.gov/waterscience/methods.

*Most probable number tests for* E. coli:

- LTB EC-MUG (Standard Methods 9221B.1/9221F)
- ONPG-MUG (Standard Methods 9223B, AOAC 991.15, Colilert, Colilert-18, and Autoanalysis Colilert)
- CPRG-MUG (Standard Methods 9223B, Colisure™)

*Membrane filter tests for* E. coli:

- mEndo, LES-Endo, or mFC followed by transfer to NA-MUG media (Standard Methods 9222B/9222G or 9222D/9222G)
- MI agar
- m-ColiBlue24 broth

*Most probable number tests for enterooccci:*

- Azide Dextrose/PSE/BHI (Standard Methods 9230B)
- MUG media (ASTM D6503-99, Enterolert)

These alternative method descriptions are followed by a cautionary statement that beach managers "should be aware of the methods that may be used for analyzing the water samples from beaches to meet particular monitoring program objectives."

The single-step methods are preferred overall in light of the speed of the analysis and the opportunity to make decisions and take rapid action if there are elevated results or water quality exceedances (i.e., resampling, swimmer advisories, or beach closures).

*Data interpretation*

Data interpretation and determination of attainment for pathogen indicator criteria are discussed in Section 5.3.2 of the implementation guide (USEPA 2002), and they depend on the number and type of sampling events that were conducted and on the criterion established locally for issuing advisories or closing beaches. EPA recommended in its 1986 water quality criteria, as well as in its 2002 draft implementation guidance (USEPA 2002), that rather than a prescriptive concentration standard of colony-forming units of *E. coli* and enterococci per unit volume (100 mL), local standards be established on the basis of a maximum acceptable predictive risk stated in illnesses per 1,000 bathers. Calculation of criteria for selected illness rates are included in the tables in Appendix C of the implementation guide, along with the formulas from which they are derived.

EPA recommends establishing local sample maximum and geometric mean criteria on the basis of monitoring frequency and frequency of use for recreational waters. So, too, should local action plans be developed to define what sample measurement values dictate what corrective measures. These actions should consider not only the measurement data collected during routine monitoring but also the seasonality and the frequency of use during the sampling periods. For instance, more remote or infrequently used beaches are likely to be subject to lesser monitoring priorities; thus, they are not as likely to issue advisories or closures because of moderately elevated results. Similarly, consideration of seasonality should be included in both monitoring and assessment plans to ensure that criteria for advisories or closures are less stringent during non-swimming seasons and that they do not suggest the need for unnecessary additional treatment in local POTWs. Excessive disinfection can cause formation of disinfection by-products (like trihalomethanes), which are themselves an environmental concern and potential health hazard.

Geometric means are widely used because they incorporate a rolling average, thereby limiting the impact of sample variability common in pathogenic indicators. Pathogens have been observed to exhibit significant variability by time of day and in light of prevailing weather conditions. Geometric mean criteria also generally include a stipulated minimum number of samples included in the assessment, commonly five samples over 30 days; however, this criterion might be unrealistic for smaller monitoring jurisdictions or for more remote, less-used waters. Table 5-1 in the draft implementation guide explores monitoring approaches and assessments for less frequently used primary contact waters. You should always consider the frequency of monitoring when adapting criteria and when determining whether the water attains water quality standards.