User Manual: Sanitary Surveys for Marine Waters with Recreational Uses

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Executive Summary

The U.S. Environmental Protection Agency (EPA) developed sanitary surveys and a corresponding app, *Sanitary Survey App for Marine and Fresh Waters,* to help managers of recreational waters in states, territories, tribes, and local jurisdictions identify and synthesize recreational water and watershed information–including water quality data, pollutant source data, and land use data—so they can improve water quality for swimming. The intent is to provide states, territories, tribes, local governments, non-governmental organizations (NGOs), citizen science, environmental groups, and the public a technically sound and consistent approach to identify pollution sources, collect information on potential harmful algal bloom (HAB) events and to share information.

The marine sanitary surveys consist of two surveys, a routine and an annual survey, to assist with short-term and long-term beach water quality assessments. The *Marine Routine Sanitary Survey* is typically done when water quality samples are taken and collects current day data and captures the methods used to collect data during the survey. The *Marine Annual Sanitary Survey* is better for long-term assessments and collects information about factors in the surrounding watershed that might affect water quality. The annual survey includes, for example, information on septic tanks in the contributing watershed and land use information. This user manual provides guidance for completing the marine routine and annual sanitary surveys in EPA's app and in paper format.

The sanitary survey provides valuable information that can be used to identify and address water quality issues. State public health and environmental programs can use the sanitary survey data to understand what's happening in their watersheds and to characterize potential human health risks from exposure to poor water quality. Managers can then use the risk information to rank their recreational waters and help determine appropriate priorities for monitoring of water quality, notifying the public, and other activities. Managers can also use the sanitary survey to help identify sources of contamination that should be considered for remediation to reduce human health risks at swimming areas. The sanitary survey provides a documented historical record of water quality for the recreational waterbody and the watershed. It serves as a baseline to which future assessment of the overall health of the recreational water and watershed can be compared, and it enables states, territories, tribes and local governments to perform long-range water quality and resource planning. The tool will help managers of recreational waters collect and share pollutant data for watershed assessments, use the data in models to predict water quality, and better enable them to remediate bacterial pollution sources and to identify potential HAB events in recreational waters. Surveys can also be used for other purposes such as documenting conditions when new recreational areas open, at the beginning of the swimming season, or when waterbodies have been identified as problem areas. Sanitary surveys are a valuable tool for identifying and testing research hypotheses. While the surveys were initially developed for use in EPA's Beach Program, they can be used to assess water quality for any waterbody (lakes, rivers, streams, and marine beaches) including gathering data on harmful algal blooms.

Sanitary survey information can be useful to a variety of audiences. Program managers of beaches and other recreational waters and public health officials use the information and it can be a valuable benefit for stormwater program managers, wastewater facility managers, other local officials, nongovernmental organizations, academic researchers, and others.

For more information on sanitary surveys for recreational waters and the EPA's Beach Program, please visit our sanitary survey web page at https://www.epa.gov/beach-tech/sanitary-surveys-recreational-waters. You can send questions via the Contact Us link there.

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1. Introduction

The U.S. Environmental Protection Agency (EPA) developed sanitary surveys for recreational waters and a corresponding app, *Sanitary Survey App for Marine and Fresh Waters,* to help states, territories, tribes, local jurisdictions and others monitoring and assessing water quality to identify and synthesize recreational waterbody and watershed information including water quality data, pollutant source data, and land use data. The intent is to provide a technically sound and consistent approach to identify pollution sources, collect information on potential HAB events, and to improve water quality for swimming.

Sanitary survey information can be useful to a variety of audiences. Local beach and program managers and public health officials use the information and it can be a valuable benefit for stormwater program managers, wastewater facility managers, other local officials, local nongovernmental organizations, academic researchers, and others.

The *EPA Sanitary Survey App for Marine and Fresh Waters* was developed to make it easier to collect and share sanitary survey data and use the data to develop predictive models for making timely decisions. Users can complete surveys without the need for WiFi or Internet access and all their data are uploaded and stored in a central location on the EPA GeoPlatform at no cost. Data can only be accessed and viewed by the individual who submitted it but can downloaded in multiple formats and shared. The GeoPlatform includes tools such as data analysis for analyzing trends in water quality over time.

The marine surveys are tailored to the marine beach environment. The surveys include detailed questions on winds, tides, and other characteristics that affect marine beaches. EPA reviewed existing marine surveys and consulted with experts to determine what topics would be appropriate for marine beaches. A different set of surveys, the *Freshwater Sanitary Surveys for Recreational Waters,* is more appropriate to use with freshwater recreational waters. While paper versions of the marine sanitary surveys are also available, we encourage broad adoption and use of the app. Instructions for accessing the app can be found at https://www.epa.gov/beach-tech/sanitary-surveys-recreational-waters.

1.1 Types of Surveys

EPA developed two sanitary surveys—the *Marine Routine Sanitary Survey* and the *Marine Annual Sanitary Survey*—to assist with short- and long-term beach assessments of marine recreational waters. The *Marine Routine Sanitary Survey* is performed at the same time that water quality samples are taken. It collects current day data and captures the methods used to collect the data. The *Marine Annual Sanitary Survey* is better for long-term assessments and 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 paper and electronic (i.e., app) versions to help document the information collected during the survey.

The marine sanitary surveys provide valuable information that can be used to support a variety of purposes, including the following:

Characterize risk and prioritize beaches and other recreational waters. State public health and environmental programs can use the data collected with the sanitary surveys or the *Sanitary Survey App for Marine and Fresh Waters* to understand what's happening in their watersheds and to characterize potential human health risk from exposure to poor water quality. Managers of recreational waters can then use the risk information to rank their beaches and other recreational waters and help determine appropriate priorities for monitoring of water quality, notifying the public, and other activities.

Identify appropriate remediation. Managers of recreational waters can use the sanitary survey to help identify sources of contamination that should be considered for remediation efforts to reduce human health risks at swimming areas.

- ***Facilitate waterbody and watershed planning.*** The sanitary survey makes it easier to document the historical record for the recreational waterbody and its surrounding watershed. The data can serve as a baseline for future assessments of recreational waters and associated watersheds and enables recreational managers and city/county planners to do long-range water quality and resource planning. The tool will help managers collect and share pollutant data for watershed assessments.
- ***Develop predictive models.*** Managers of recreational waters can use sanitary survey data (e.g., bacteria levels, source flow, turbidity, rainfall) to develop models to predict daily water quality, if desired and appropriate.
- ***Support other uses***. Surveys can be used for other purposes such as documenting conditions when new recreational areas open at the beginning of the swimming season, or when waters have been identified as problem areas. Also, surveys are a valuable tool for identifying and testing research hypotheses.

1.2 Organization

This user manual is intended to be used as a reference for completing the marine routine and annual sanitary surveys in EPA's app and in paper format.

- Section 2 describes the marine sanitary surveys and provides background information on the sanitary survey process.
- Section 3 describes steps to consider in preparing to conduct a sanitary survey.
- Sections 4 and 5 provide detailed information on how to complete each type of survey.
  - The data elements for the *Marine Routine Sanitary Survey* are in Section 4.
  - The data elements for the *Marine Annual Sanitary Survey* are in Section 5.
  - The subsection numbers correspond with the numbered sections of the survey.

Screen shots of the app's *Marine Routine Sanitary Survey* are provided in this manual. Due to the length and the level of detail in the *Marine Annual Sanitary Survey*, the screen shots for that survey are not included here. For information on how to access and use the *EPA Sanitary Survey App for Marine and Fresh Waters* go to https://www.epa.gov/beach-tech/sanitary-surveys-recreational-waters.

1.3 Disclaimers

The user manual is a companion document for the *Marine Routine Sanitary Survey* and *Marine Annual Sanitary Survey*. It is intended to provide supplemental discussions, examples and additional references that may be helpful to program managers of recreational waters and others as they conduct sanitary surveys. The user manual does not impose any legally binding requirements on EPA, states, territories, tribes, or the regulated community. It is informational only and thus does not establish additional requirements for EPA's BEACH program or other programs. The document may be revised from time to time.

Reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government and shall not be used for advertising or product endorsement purposes.

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2. Types of Sanitary Surveys for Recreational Waters

2.1 Background

Because marine beaches are dynamic systems, they need to be gauged frequently for short- and long-term health risks. EPA has developed two types of sanitary surveys —the *Marine Routine Sanitary Survey* and the *Marine Annual Sanitary Survey*—to assist with short- and long-term assessments. The *Marine Routine Sanitary Survey* is typically conducted during routine monitoring when collecting water quality samples, and it supports the annual survey. Both surveys are included in the *Sanitary Survey App for Marine and Fresh Waters*.

2.2 Surveys

The sanitary survey offers two approaches to collect and assess information. The surveys are briefly described here and fully described in Sections 4 and 5.

Routine Sanitary Survey

The *Marine Routine 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 *Marine Routine Sanitary Survey* is used to help identify underlying conditions in the recreational water 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. The app also collects information on potential harmful algal blooms. This survey includes questions on survey methods used to gather data.

Over time, collecting additional data with every sample will aid those looking for correlation between conditions in the recreational water and water quality (i.e., fecal indicator bacteria [FIB] levels), leading to the development of predictive models. The data could help show whether bacteria levels correlate to other parameters or observable conditions at a beach. Before you conduct your first *Marine Routine Sanitary Survey*, do an initial assessment of the beach or waterbody. Review all available information, including historical data and knowledge, uses, and possible sources of bacterial contamination. EPA recommends that you do at least one routine sanitary survey before the start of the swimming season.

Annual Sanitary Survey

The *Marine Annual Sanitary Survey* requires the same type of information collected for the *Marine Routine 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.

Ideally, an annual survey should be done on each swim area once a year to determine the condition of the water, 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 the swim 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 swim area or when a newly proposed activity would significantly alter the water quality in an existing recreational swim area. Managers should use the findings of the survey as an important consideration in key operational decisions to proceed with development. In some states, such as Maryland, a permit for operating a bathing beach may not be issued unless the sanitary survey demonstrates that the beach does not represent a public health risk (Code of Maryland Regulations [COMAR] 26.08.09.03).

EPA has provided a comprehensive, detailed sanitary survey that gives states, territories, tribes, and localities a consistent way to share and compare the results of their investigations. In some cases, you might want to use only portions of the survey or tailor it to better fit your program's needs. For a more detailed discussion of the sanitary survey's purpose, consult Section 3.4.

3. Steps for Conducting a Sanitary Survey

3.1 Seek the Assistance of Professional Staff

Before you begin preparing to conduct a sanitary survey, 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 can help complete or gather information for the *Marine Routine Sanitary Survey* 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 (Section 3.5).

3.2 Make an Initial Assessment of a Swim Areas

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

3.3 Make an Initial Assessment of the Contributing Watershed

The watershed, basin, or land area contributing runoff to a swim area can vary widely depending on the nearby area. For some beaches, for example the contributing area could be simply the area from the dunes down to the shoreline. There might be a stream, river, or storm drain nearby that is contributing drainage from a large land area. Some beaches might receive poorer quality water from a different location through longshore or nearshore currents; in such cases, 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 swim area.

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 swim area.

> *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, visit https://www.epa.gov/npdes.
>
> *Nonpoint Source Management Program (Clean Water Act section 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 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, visit https://www.epa.gov/nps/319-grant-program-states-and-territories.
>
> *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 meet water quality standards. For more information on the TMDL program, visit https://www.epa.gov/tmdl.
>
> *Clean Water Act section 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, visit https://www.epa.gov/waterdata/national-water-quality-inventory-report-congress.

3.4 Determine the Purpose and Identify the Appropriate Survey

After the swim areas have been assessed and identified for a sanitary survey, determine the purpose of the survey (e.g., to characterize risk and prioritize waters, support planning for the recreational waterbody and the watershed, develop predictive models), 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 surveys (*Marine Routine Sanitary Survey* and *Marine Annual Sanitary Survey*) on the basis of how frequently the surveys would be performed and what resources would be available to the manager of recreational waters. For a detailed description of the surveys and their uses, consult Section 2.2.

The sanitary survey will help you to determine the following:

1. An approach to address all the data elements necessary to complete the surveys and best describe the conditions at a beach.
2. Which data elements are currently collected through an existing monitoring plan and which 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 4 and 5 provide descriptions of the survey data fields. Depending on the purpose of collecting information you will want to consider tailoring these surveys to best fit your program's needs. Not all the questions on the surveys are applicable to all recreational waters. You might want to collect specific data for your swim area that are not included on the surveys.

3.5 Use Trained Staff

The staff members who perform the sanitary surveys should be adequately trained in sampling procedures, equipment use, completing the surveys, and health and safety precautions before they begin to perform them. EPA recommends that relevant quality assurance (QA) documentation (e.g., QA 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.

3.6 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. The *Sanitary Survey App for Marine and Fresh Waters* will automatically geolocate your beach or pollution sampling location in the field.

Sources of maps and other geographic data include the U.S. Geological Survey (USGS), county/state offices, online companies (e.g., Google Earth), and others. You can download USGS topographic maps for your water shed by visiting https://www.usgs.gov/core-science-systems/national-geospatial-program/topographic-maps. 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, consult Section 5.3.

Collect water quality data and other parameter data at a beach to complete the *Marine Routine Sanitary Survey* and meet the data needs you identified for the *Marine Annual Sanitary Survey*.

3.7 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 you document them. 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.

3.8 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 near 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 contaminated waters. For example:

- 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, nitrile, or other protective 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.

3.9 Record Data for the Annual Sanitary Survey

After you have collected your data, you can use the *Marine Routine Sanitary Survey* data to complete the *Marine Annual Sanitary Survey*. All field data should be entered onto the paper form or the app 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.

3.10 Record Management

Everything should be well documented, including identification of the person who enters the data and the person who completes the survey, sources of information, and so forth. The *Sanitary Survey App for Marine and Fresh Waters* makes data collection and download in several file formats easy, and data storage free. However, if using the paper surveys, copies of completed paper surveys should be collected, scanned into an electronic format, and stored together, if possible. EPA suggests storing the survey data in a locally accessible database.

3.11 Next Steps

Analysis of survey results. Although you will perform some analyses while conducting the sanitary survey (the annual survey in particular), after you are finished with the surveys, you should thoroughly go through the survey results and develop a Sanitary Survey Report (described next). For the *Marine Routine Sanitary Survey*, you should evaluate the results at the end of the swim season (which might be done as part of the *Marine Annual Sanitary Survey*), and periodically throughout the season. Evaluating the survey results during the swim season can help you identify trends that you should be aware of, such as "rainfall over 0.5 inches 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 should 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 data 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, and help you to more effectively prioritize swim areas 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 recreational area (e.g., educate pet owners, improve plumbing at public restrooms).

Remediation steps. The results of the sanitary survey will help a manager of recreational waters identify persistent problems, sources of pollutants, and the magnitude of pollution from those sources. The manager will have a documented record of the pollutant sources to use to propose management actions, enforcement, and options to control sources. After 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 sanitary surveys might help a manager of recreational waters 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 managers of recreational waters to make advisory decisions on the basis of 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* that statistically correlates the bacteria results with rainfall data collected during the routine sanitary survey.

EPA has conducted research and developed guidance on predictive tools. *Predictive Tools for Beach Notification Volume I: Review and Technical Protocol* summarizes modeling approaches and associated considerations. The guidance document, *Six Key Steps to Developing and Using Predictive Tools at Your Beach*, provides a simple, straightforward approach to developing a predictive model for a beach. These documents can be found at https://www.epa.gov/beach-tech/models-predicting-beach-water-quality.

Sharing information. As part of the sanitary survey process, you might choose to electronically store the survey data locally and/or on the EPA GeoPlatform when you use the *EPA Sanitary Survey App for Marine and Fresh Waters*. This approach will make it easier for you to share your data with other counties, agencies, and states.

4. Data Elements for the Marine Routine Sanitary Survey

This section describes the data fields for the *Marine Routine Sanitary Survey*. While it contains screen shots to show how to collect data using the app, it also contains information that could be useful in collecting information using the paper surveys. 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 5 describes the data fields for the *Marine Annual Sanitary Survey*.

The *Marine Routine Sanitary Survey* should be filled out each time a water sample is taken for bacterial analysis. The information in this survey is primarily information that can be gathered locally at the recreational water.

4.1 Intro: Beach Location Information

This section collects information on swim area identification and location. If you are using the *EPA Sanitary Survey App for Marine and Fresh Waters* app, there are only a few required fields (designated with a red asterisk [*]) that must be completed to submit data collected (e.g., beach name, surveyor name and affiliation, time and date of survey). The remaining fields are voluntary; fill in the ones most useful to your program.

Start the survey by selecting the waterbody type being surveyed and then provide basic information about the beach or waterbody, such as the name, ID, surveyor name, surveyor affiliation and location. The Beach IDs you use should include the ones you submit to EPA for the PRAWN database, https://watersgeo.epa.gov/beacon2/Beacon.html. If you have a separate ID for other purposes, you may list that as well. Include the Sampling Station ID and Water Quality Exchange (WQX) Organization ID (https://www.waterqualitydata.us/portal/) when possible (Figure 1). In the *EPA Sanitary Survey App for Marine and Fresh Waters*, links are available to specific databases to search for these IDs. The app does not autopopulate this information, so you will need to manually enter this information.

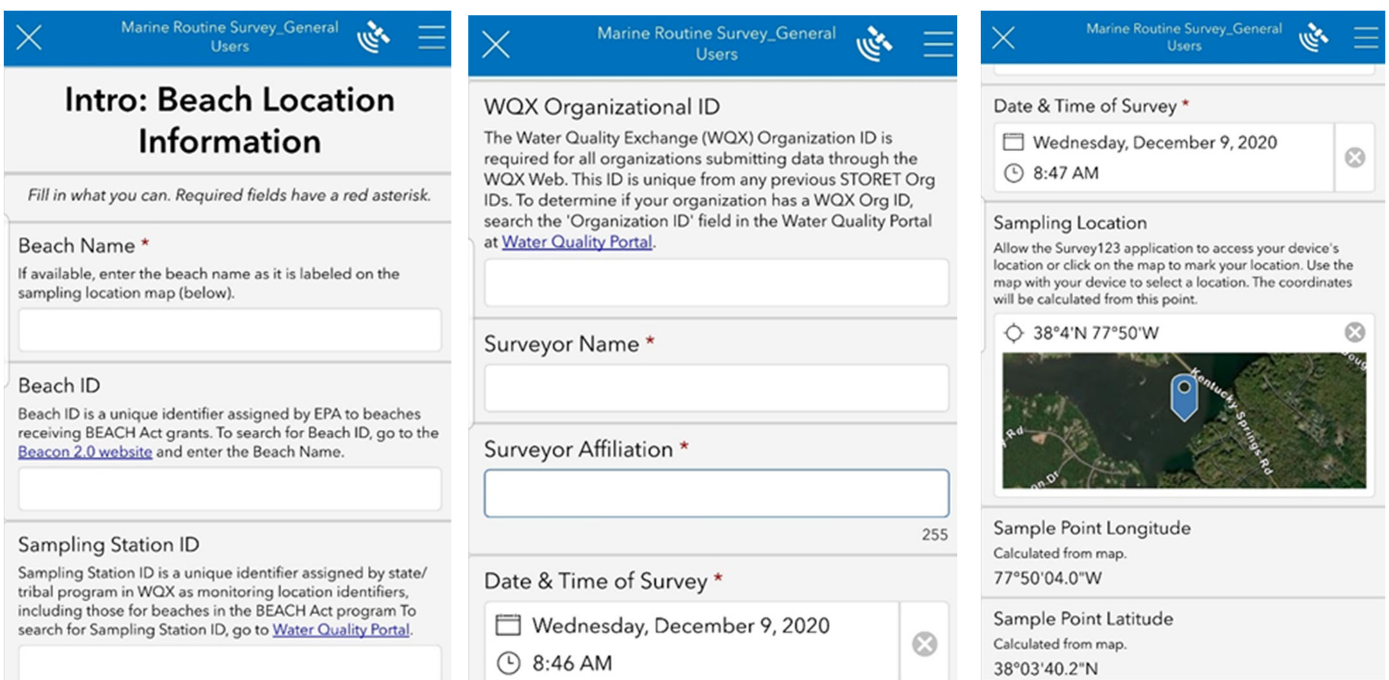


Figure 1. Marine Sanitary Survey Beach Location Information Screen

Identifying your site or sample location is easy in the *EPA Sanitary Survey App for Marine and Fresh Waters* app because the app automatically pinpoints your location in the field even without a WiFi connection (Figure 2). Your current location is shown by an arrow on the map and by the latitude and longitude coordinates calculated.

To change your location, click on the map shown in the Sampling Location section of the survey. To change the location, enter the new location in the search field or scroll through the map to the designated point. To confirm the location, select the checkmark (✓) at the bottom right corner of the page.

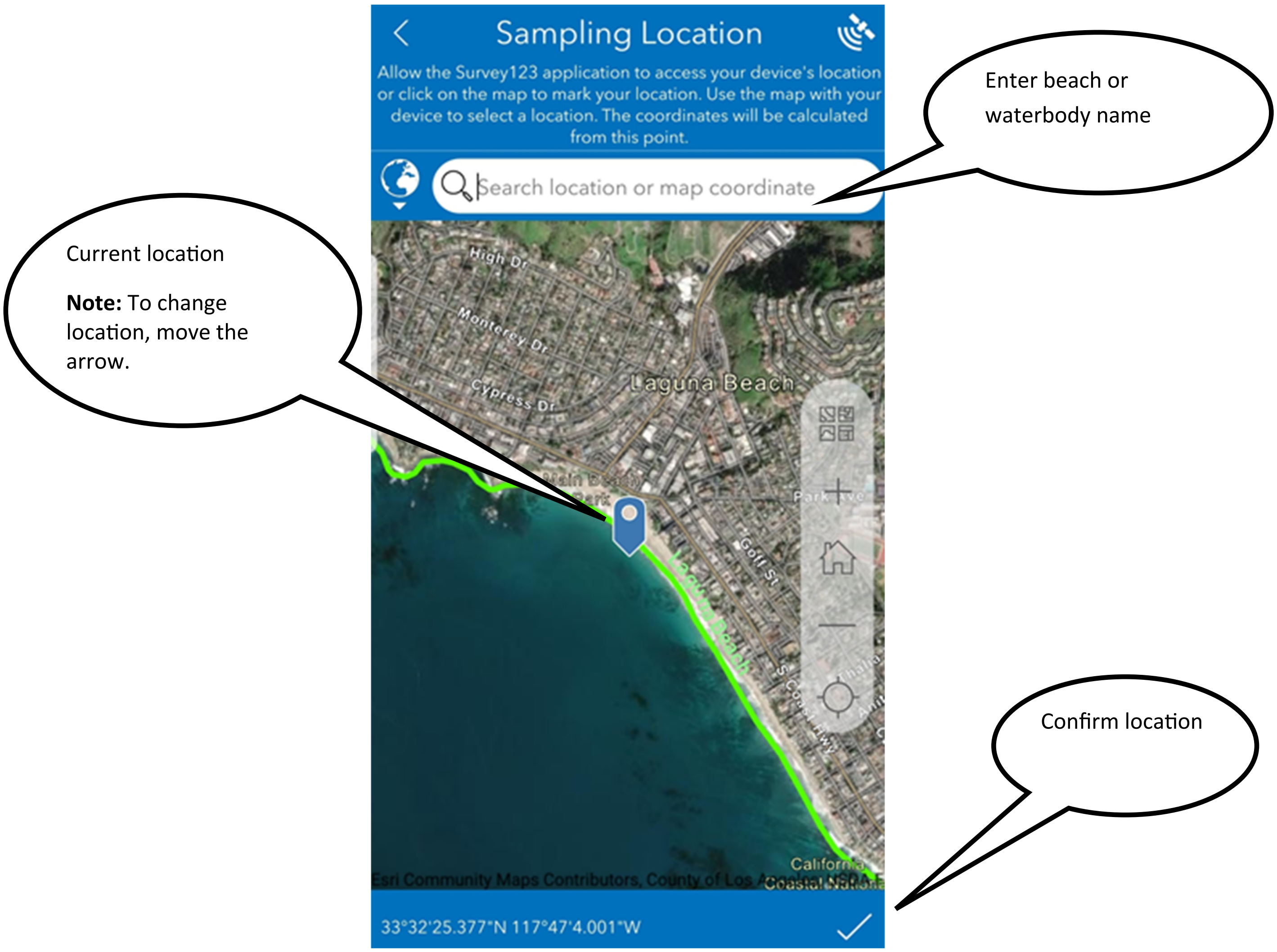


Figure 2. Search for Sampling Location

4.2 Quality Assurance Project Plan (QAPP) Requirement

Most agencies should already have Quality Assurance/Quality Control (QA/QC) procedures for performing monitoring. These procedures should be updated, as needed, to include QA/QC procedures for performing sanitary surveys. States, territories, 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. App users are required to certify that sanitary survey data are collected using an approved QAPP and provide a link or submit a copy of the approved QAPP in order to submit their sanitary survey data to the GeoPlatform (Figure 3).

Figure 3. Quality Assurance Requirement to Submit Data

4.3 Part 1: Weather & General Beach Conditions

Air temperature

Example
75 degrees Fahrenheit (°F), 24 degrees Celsius (°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 (Figure 4a).

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 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 do not have the necessary equipment to measure wind speed and direction, you can provide data from a weather app or nearby weather station, ideally one within a 5-mile radius of the beach. If you use a nearby weather station, note in the survey the distance to the station (Figure 4a).

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 [km/hr], knots) (1 knot = 1.15 mph.) (Figures 4a and 4b). Also record whether wind is onshore or offshore. Onshore winds are those that blow from a body of water and move in the direction of the land (also known as sea breezes). Offshore winds are those that originate on land and blow toward a body of water (also known as land breezes) (Figure 4a).

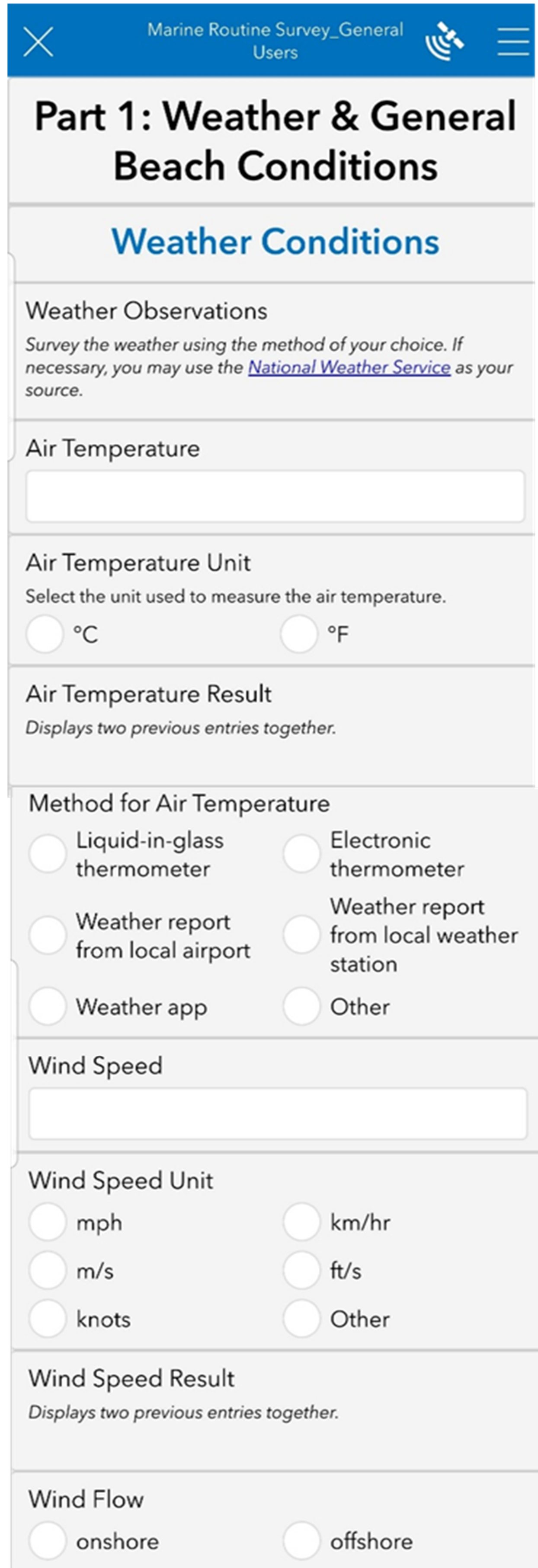


Figure 4a. Weather & General Waterbody Conditions

Simple estimates of wind speed can also be useful. The sanitary survey technician can estimate whether there was no or relatively little wind, medium wind speeds (5–15 knots), and high wind speeds (more than 15 knots). At beaches, wind can be the driving agent for resuspension of particles along the beach, often causing resuspension of fecal contamination and bacteria attached to sediment.

Rainfall

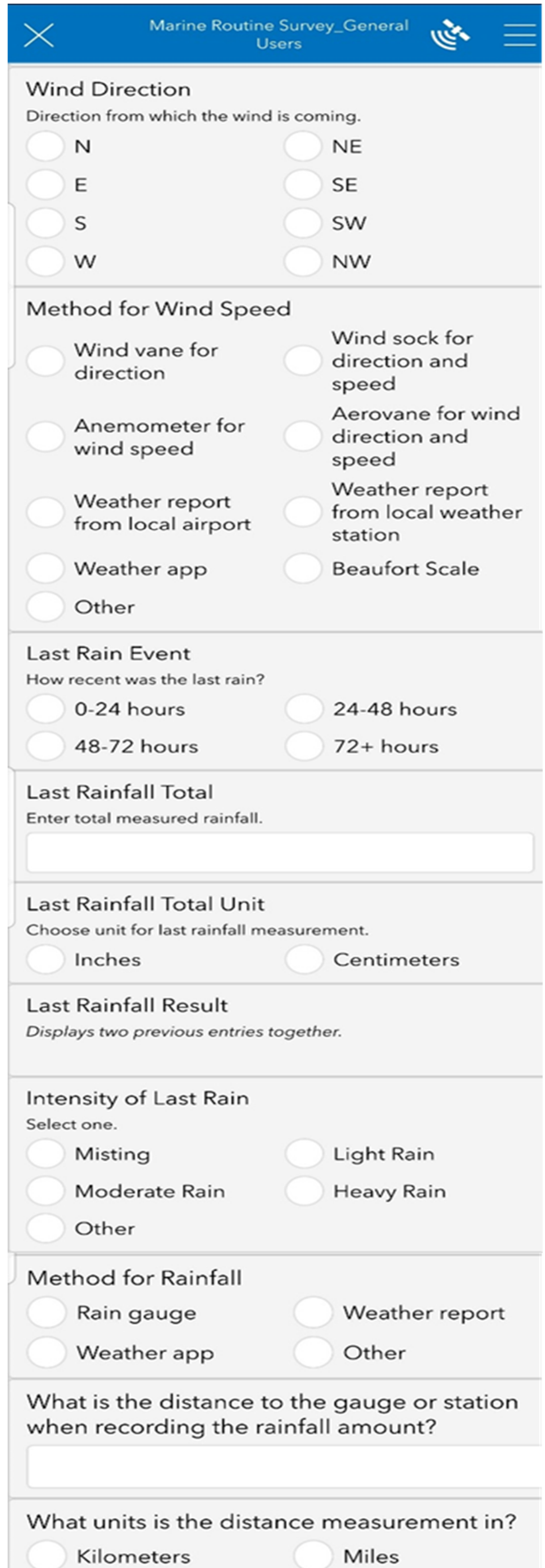
Example
72+ hours. Rainfall amount was 1.2 inches.

Description
Bacterial contamination at swimming areas can result from rain events. CSO discharges can occur during heavy rainfall events and can reach swimming areas, causing contamination problems. In addition, nonpoint source pollution 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 in recreational waters during rainfall events (USEPA 1999a). It is also important to document the time since the last measurable precipitation because an antecedent rain event can have a strong effect on the contamination levels observed. For example, using 24-hour storm totals can be helpful if the FIB contamination to an area is surmised to be strongly caused by stormwater (non-point source) runoff.

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. Rain intensity can be noted by using hourly intervals, or hour totals for rainfall events, and this information can be found through the use of radar-based data such as that available on https://www.wunderground.com/ and other database websites. Weather apps are also another source of rainfall data.

Methods
Record the amount of rainfall in inches or centimeters, and 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 (e.g., misting, light rain, steady rain), and how it occurred over the duration of the storm (Figure 4b). If two storms occurred back to back, indicate the relative amounts of rainfall if known, along with the


Marine Routine Survey_General Users

Wind Direction
Direction from which the wind is coming.
N / NE / E / SE / S / SW / W / NW

Method for Wind Speed
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 / Weather app / Beaufort Scale / Other

Last Rain Event
How recent was the last rain?
0-24 hours / 24-48 hours / 48-72 hours / 72+ hours

Last Rainfall Total
Enter total measured rainfall.

Last Rainfall Total Unit
Choose unit for last rainfall measurement.
Inches / Centimeters

Last Rainfall Result
Displays two previous entries together.

Intensity of Last Rain
Select one.
Misting / Light Rain / Moderate Rain / Heavy Rain / Other

Method for Rainfall
Rain gauge / Weather report / Weather app / Other

What is the distance to the gauge or station when recording the rainfall amount?

What units is the distance measurement in?
Kilometers / Miles

Figure 4b. Weather & General Waterbody Conditions—Continued duration of the storm for each (include this information in Weather Observations). You can use websites such as https://www.ncdc.noaa.gov/ to gather very specific rainfall estimates for any location in the United States. You can also obtain rainfall data from your local weather station or from wunderground at https://www.wunderground.com/wundermap/.

Sky conditions

Example
Partly cloudy (3/8 to 4/8 coverage)

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
Clear/Sunny	0/8
Mostly clear/Mostly sunny	1/8–2/8
Partly cloudy/Partly sunny	3/8–4/8
Mostly cloudy/Considerable cloudiness	5/8–7/8
Cloudy	8/8

Method
Estimate the weather or provide information from a nearby weather station at https://www.wunderground.com/ or a weather app (Figure 4c).

Wave height and intensity

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.

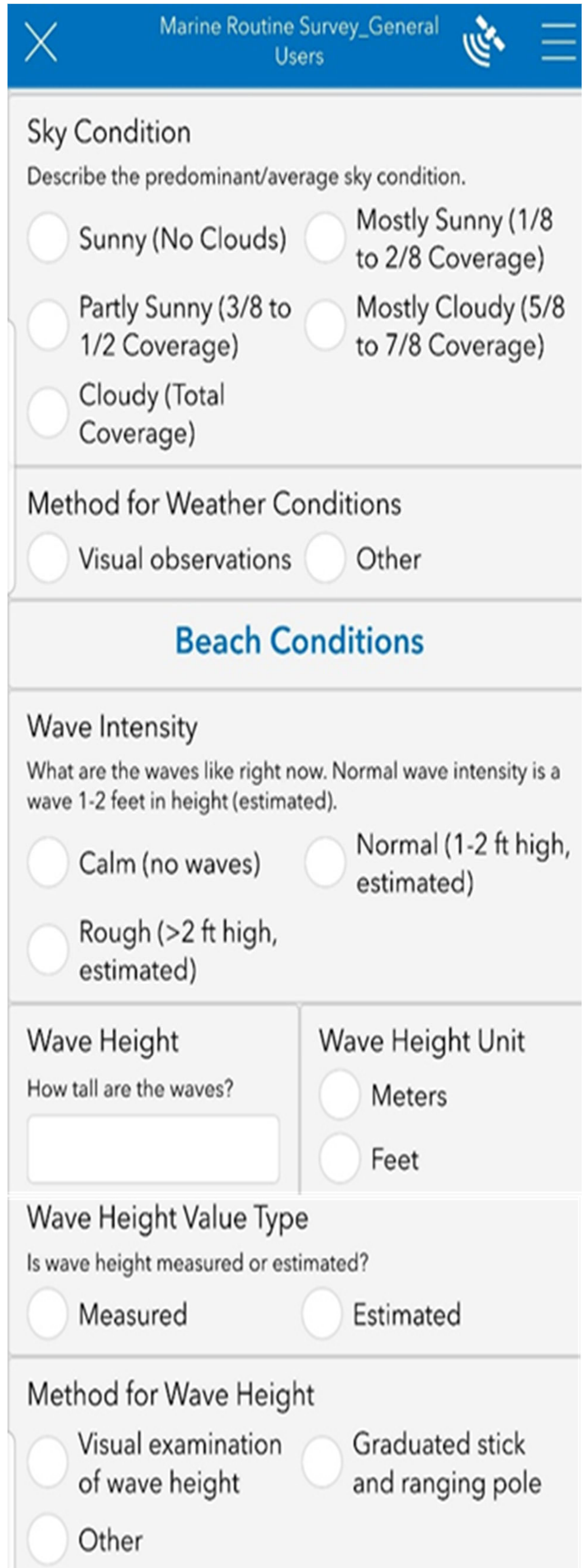


Figure 4c. Weather & General Waterbody Conditions—Continued

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 wave's crest 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.

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 on the survey the wave intensity (e.g., calm, normal, rough) (Figure 4c).

Tides

Example
High tide, ebb tide

Description
Tides are the periodic rise and fall of a body of water resulting from gravitational interactions among the sun, moon, and earth. Noting the tidal phase gives a point of reference for other pieces of information that you are collecting.

There are two main approaches for fecal indicator bacteria (FIB) monitoring at tidally influenced beaches and estuaries. The first approach is to consistently sample on an ebb tide, i.e., the period between high water and the succeeding low water, to remove the variability associated with tide from the sampling framework (Figure 5). The guidance for this sampling approach is to sample on the ebb tide (falling from high tide to low tide) within 3 hours of approaching the actual low tide time (Figure 5 depicts a diurnal tide fluctuation, with the shaded areas highlighting the optimal sampling window). This sampling window is the case where FIB concentrations in the water are typically the most representative of the immediate land-water interface because dilution from the effects of high tide has been minimalized. A second approach is to conduct random sampling, i.e., without regard to tide, with sampling conducted at roughly the same time each day. This ensures that sampling is conducted over the wide array of tidal influence and that one portion of the tidal cycle does not influence sampling more than another. This second

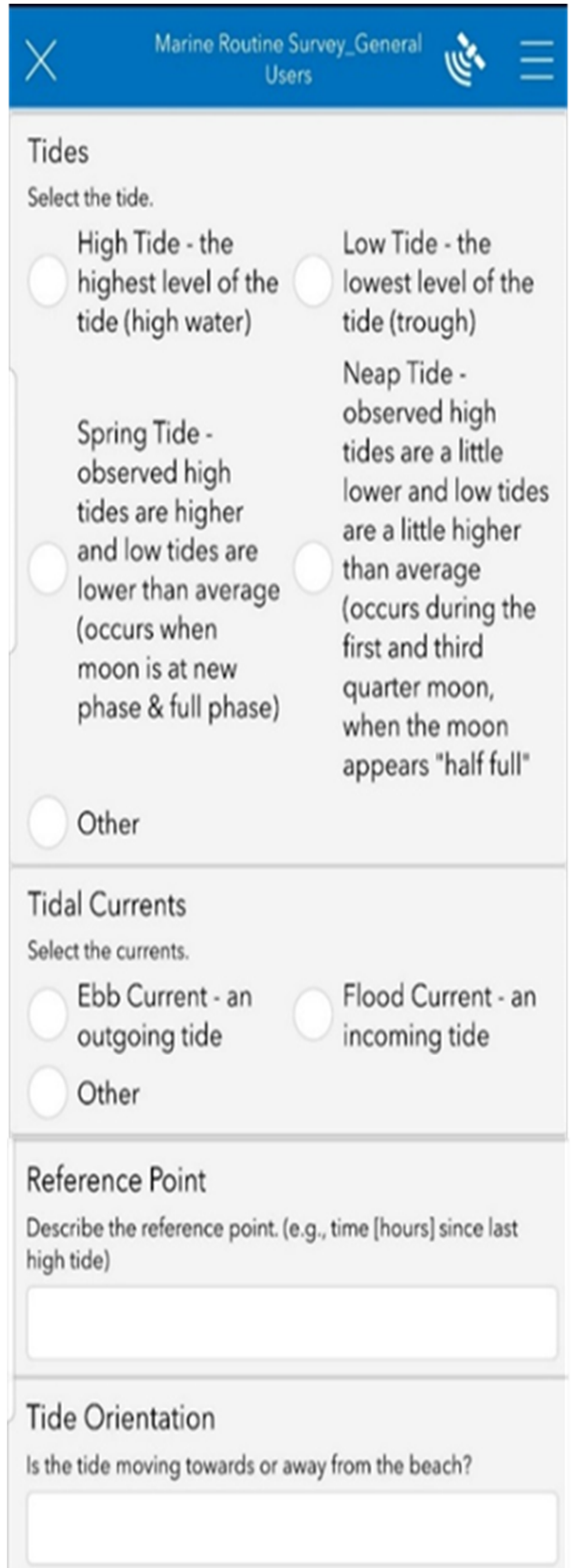


Figure 4d. Weather & General Waterbody Conditions—Continued

approach might also be easier from a logistical standpoint.

Methods
NOAA (and its predecessor organization) has been tracking tides in U.S. marine waters since the 1800s. In the past, tides were measured using mechanical devices to record water levels. NOAA now uses measurement devices that collect data every 6 minutes and transmit by satellite to NOAA headquarters.

Information on tides can be obtained from NOAA's Center for Operational Oceanographic Products and Services, https://tidesandcurrents.noaa.gov/, or from your local weather service.

Observe tides during sampling or obtain tidal information from NOAA or local weather service and report tidal information in Part 1 of the *Marine Routine Sanitary Survey* (Figure 4d).

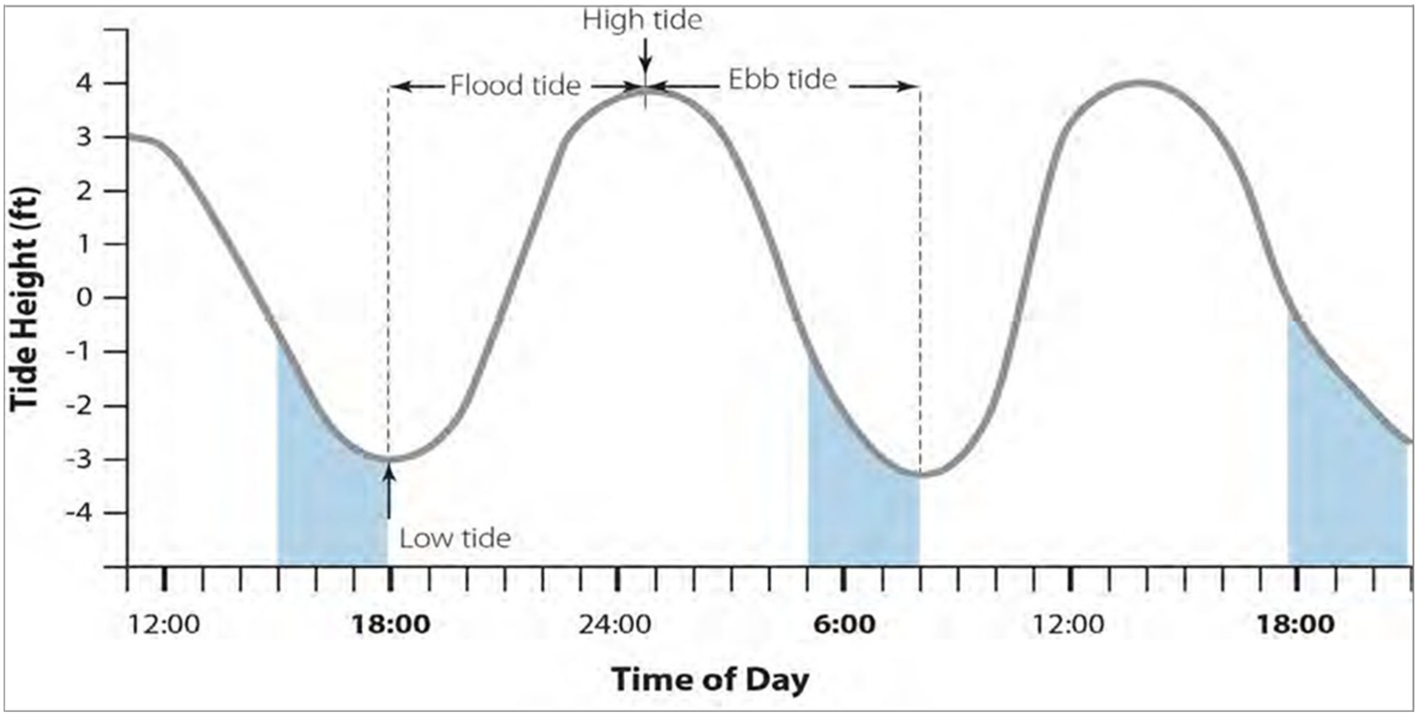


Figure 5. Recommended sampling window for a beach with a diurnal tide

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, and 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 might be 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 described here, adapted from the Education Program at the New Jersey Sea Grant Consortium (http://njseagrant.org/wp-content/

uploads/2014/03/longshore_current.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.

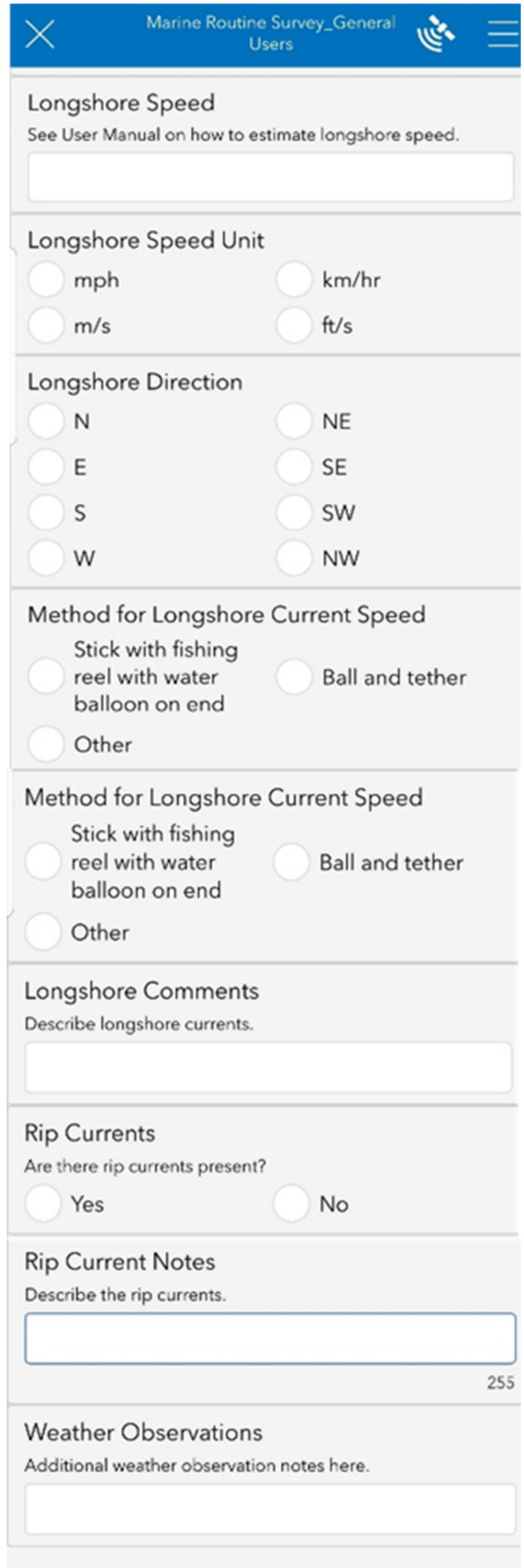
Procedure

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 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 moving (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 determine if the current speed and direction are the same or if they vary. Report measurements in Part 1 of the *Marine Routine Sanitary Survey* (Figure 4e).

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



Marine Routine Survey_General Users

Longshore Speed
See User Manual on how to estimate longshore speed.

Longshore Speed Unit
mph | km/hr | m/s | ft/s

Longshore Direction
N | NE | E | SE | S | SW | W | NW

Method for Longshore Current Speed
Stick with fishing reel with water balloon on end | Ball and tether | Other

Method for Longshore Current Speed
Stick with fishing reel with water balloon on end | Ball and tether | Other

Longshore Comments
Describe longshore currents.

Rip Currents
Are there rip currents present?
Yes | No

Rip Current Notes
Describe the rip currents.
255

Weather Observations
Additional weather observation notes here.

Figure 4e. Weather & General Waterbody Conditions—Continued

4.4 Part 2: Water Quality

Bacteria samples collected

Example
Sample Point: 1-A
Sample ID: 100002
Parameter: Enterococcus
Comments: Grab sample collected at knee depth

Description
FIB have been used as an indicator of the possible presence of pathogens in surface waters and therefore as marks of the risk of disease, because of epidemiological evidence of gastrointestinal disorders from ingesting contaminated surface water. Contact with contaminated water can lead to ear or skin infections, and ingesting 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 are one of the most commonly used indicators of fecal contamination and, therefore, are termed fecal indicator bacteria or FIB.

Methods
EPA recommends the following approved culture methods and validated qPCR methods for recreational waters.

- EPA Method 1600 or any equivalent method that measures culturable enterococci
- EPA Enterococcus spp. qPCR Method 1609.1

Chapter 4 of the *National Beach Guidance and Required Performance Criteria for Grants - 2014 Edition* (USEPA 2014) provides more information on the recommended EPA's methods for testing recreational waters. Approved microbiological analytical methods, Other microbiological CWA methods and information on the alternate test procedure (ATP) program can be found at: https://www.epa.gov/cwa-methods.

Guidance on sampling is in section 4.3 of the *National Beach Guidance*. EPA's general recommendation for all beaches is that samples be taken at knee depth. However, local conditions will dictate the sampling depth selected for a beach.

Appropriate sampling procedures should be determined for a monitoring program on the basis of the sampling design, the availability of facilities and equipment, and how the samples will be processed. In addition, it is important to use consistent procedures and take careful notes in the field when collecting samples. Additional information about EPA-recommended SOPs for sample

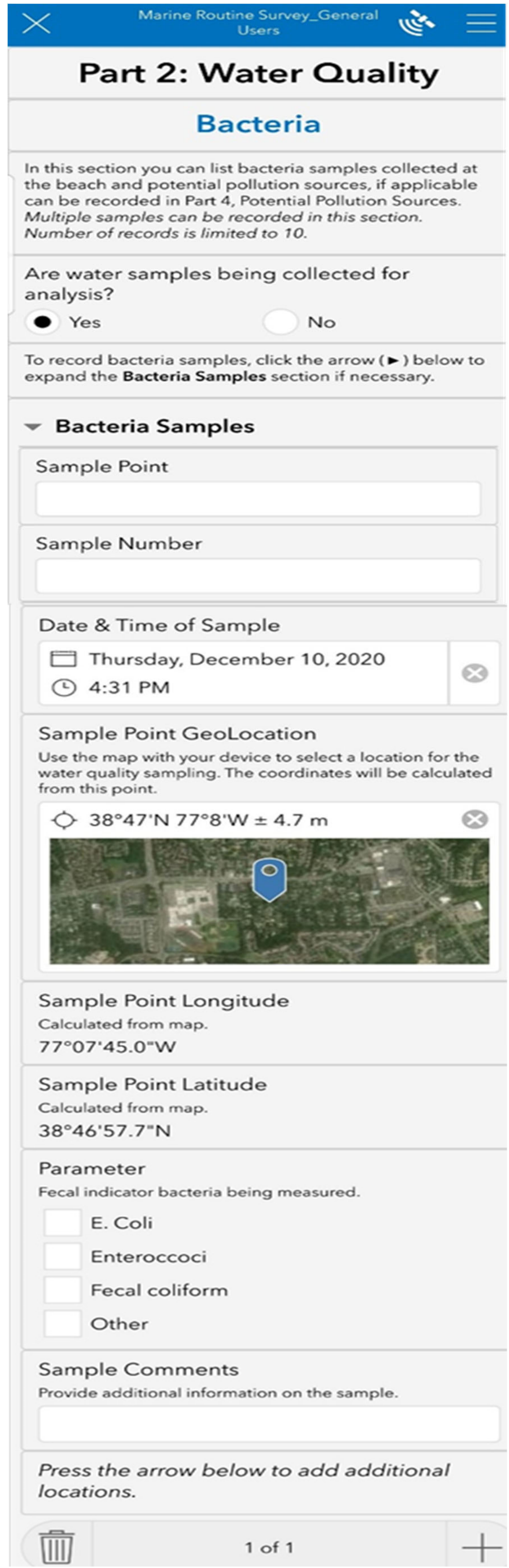


Figure 6. Water Quality - Bacteria Section

collection, handling, and subsequent analysis can be found in Standard Methods for the Examination of Water and Wastewater (APHA 2018).

States that want to use culture methods other than the currently approved methods at 40 CFR part 136 must go through EPA's Alternate Test Procedure (ATP) program. Figure 6 shows the Bacteria section of the app's *Marine Routine Sanitary Survey*.

Water temperature

Example
68 ºF, 20 ºC

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, widescale 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 broadcasted on NOAA Weatherband radios and local radio stations. Water temperature ranges can be expected to be in the 60s, 70s, and 80s (in Fahrenheit) during the recreational swimming seasons (Figure 7a).

Multiprobes are electronic instruments used to measure an array of parameters (e.g., dissolved oxygen [DO], 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; 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

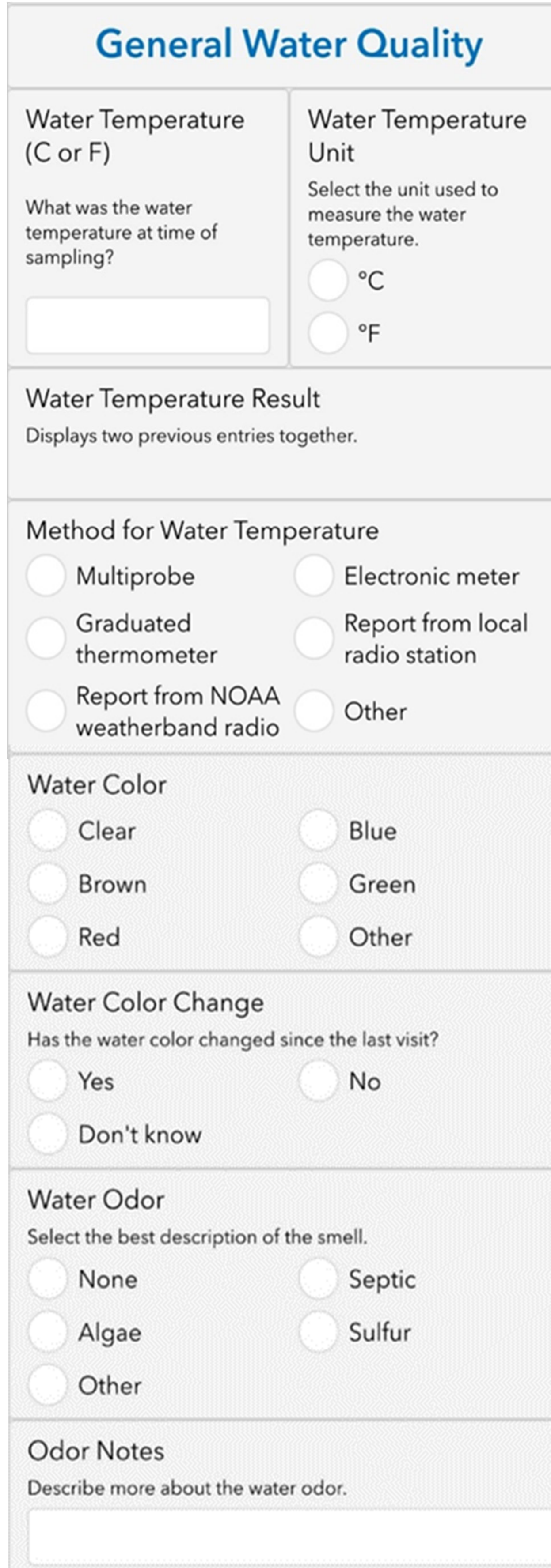


Figure 7a. Water Quality – General Water Quality Section

collect data for parameters like 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 gather a large amount of information relatively quickly. 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.

Color

Example
Red

Description
Red water color can indicate an algal bloom is present.

Method
As you walk around the beach, note the water color and/or change in color on subsequent sampling visits on the survey (Figure 7a).

Odor

Example
Sulfur, septic, other (diatomaceous earth, sewage)

Description
An odor given off by a waterbody can indicate pollution, such as sewage, is present.

Method
As you walk around the beach, note whether there is any detectable odor on the survey (Figure 7a).

pH

Example
pH = 6.5

Description
pH is a measure of how acidic or basic water is. The range goes from 0 to 14, with 7 being neutral. pH values less than 7

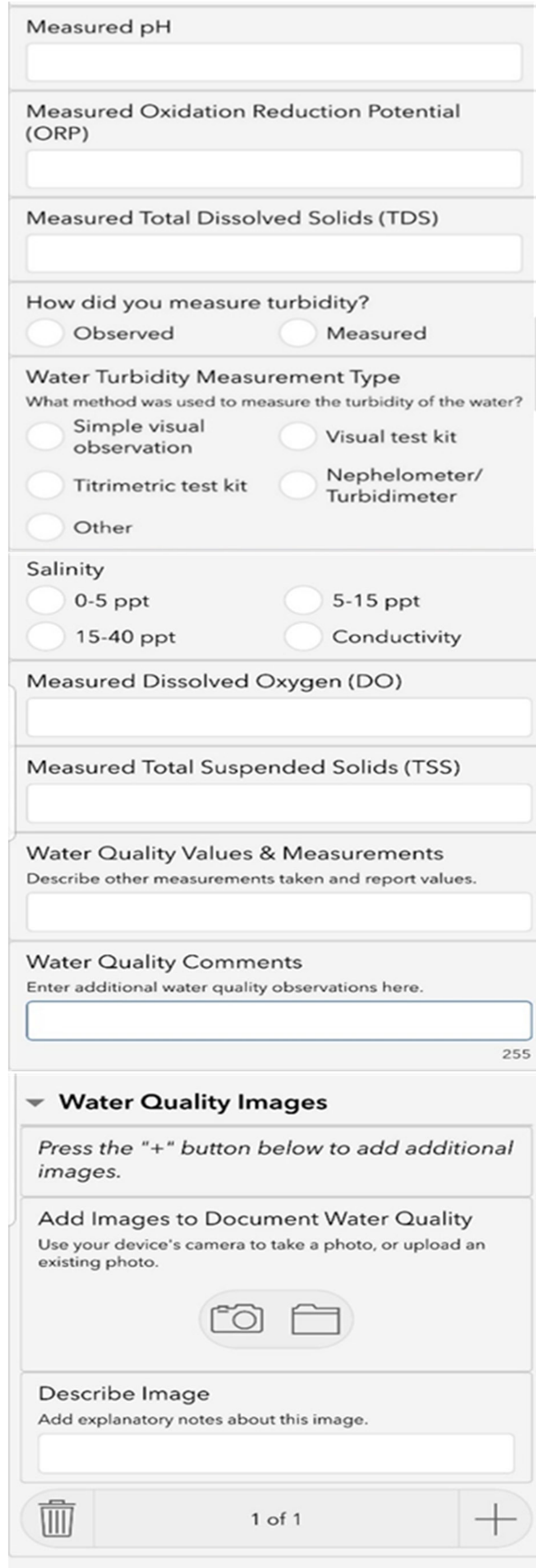


Figure 7b. Water Quality –General Water Quality Section — Continued

indicate acidity, while values greater than 7 indicates a base (Figure 7b). Since pH can be affected by chemicals in the water it is an important indicator of water that is changing chemically. pH is reported in “logarithmic units”. Each number represents a 10-fold change in the acidity/basicness of the water (USGS 2020).

Methods
You can measure pH using one of the following:

- Simple pH strips
- Field test kits
- Handheld electronic meters (the description for multiprobe is 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. For more information on pH visit https://www.usgs.gov/special-topic/water-science-school/science/ph-and-water.

Oxidation Reduction Potential

Example
ORP = +340mV or Eh = +340mV

Description
Oxidation is the process of liberating electrons or gaining oxygen. Examples of oxidation include conversion of elemental iron to rust, elemental sulfur to sulfate, and elemental hydrogen to water. Reduction is the process of gaining electrons resulting in the charge on some atomic unit in the species to be reduced. Oxidation-reduction potential (ORP) or redox potential is a measure of the intensity or activity of an aqueous environment or soil to mediate reactions of important elements in biological systems (e.g., O, N, Mn, Fe, S, and C) and other metallic elements (USEPA 2017a).

Methods
ORP measurements should be conducted in a fashion that prevents the addition or loss of any potential oxidants or reductants. Results could be compromised by exposing the sample to air or allowing hydrogen sulfide (H_2S) to off-gas from anoxic samples. Like dissolved oxygen measurements, ORP measurements should be conducted in situ or by using a flow-through cell evacuated of air (consult the SESD *Operating Procedure for Field Measurement of Dissolved Oxygen* (USEPA 2017b)). Good results are commonly obtained with the use of an overtopping cell where the environmental media is pumped into the bottom of a narrow cup (generally field fabricated from a sample container) containing the instrument sensors. The sensors are continually flushed with fresh media as the cup is allowed to overflow. Caution should be exercised at very low flow rates where the media in the cup could potentially re-oxygenate.

When using multi-parameter probes for ORP measurements, the general guidelines for probe deployment described in the *SESD Operating Procedure for Field Measurement of Dissolved Oxygen* (USEPA 2017b) and the *SESD Operating Procedure for In-situ Water Quality Monitoring* (USEPA 2018) apply.

ORP probes must be operated and maintained in accordance with the manufacturer’s instructions. Reference electrodes in multi-parameter probes may require regular filling or replacement. Single parameter ORP electrodes may require regular filling and operation in an upright position to assure that proper salt bridge flow is maintained. Platinum electrode surfaces are easily contaminated and polishing or cleaning of the electrodes should be performed as recommended by the manufacturer.

Measurements should be recorded to the nearest mV. Report the method used to measure the ORP in the Water Quality Comments field (Figure 7b).

ORP is a temperature sensitive measurement, but ORP instruments are not temperature compensated. Consequently, the media temperature should always be recorded at the same time as the ORP is recorded (https://www.epa.gov/sites/production/files/2017-07/documents/field_measurement_of_orp113_af.r2.pdf) (USEPA 2017a). Likewise, as ORP is often pH dependent, pH should also be recorded at the time of ORP measurement. More information on measuring ORP can be found at https://www.epa.gov/quality/field-measurement-oxidation-reduction-potential.

Total Dissolved Solids

Example
1,000 mg/L

Description
Total dissolved solids (TDS) is the sum of all the substances, organic and inorganic, dissolved in water. Most of the dissolved solids in water is made up of inorganic salts such as calcium, magnesium, sodium as well as a small amount of organic matter. Total solids are measured in milligrams per liter (mg/L) (Figure 7b).

Methods
To measure TDS, a sample of water is taken and analyzed in a lab. In shallow waters, carefully wade into the center current to collect the sample. Use a boat to sample deep sites. Try to maneuver the boat into the center of the main current to collect the water sample.

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 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). A description of multiprobes, which are available with turbidity sensors, is in this section under Water Temperature.

Turbidity is not the same as total suspended solids (TSS), and in some cases it may be useful to have both measurements at a beach. However, turbidity is much easier and less time consuming to measure. Some agencies use TSS and turbidity measurements as proxies for one another. However, to do this you need to perform a side-by-side comparison of the two to demonstrate equivalency because they are not strongly correlated in all waterbodies.

Report whether turbidity was Observed (clear, slightly turbid or opaque) or Measured and the method used to report turbidity (Figure 7b).

Salinity and conductivity

Example
Salinity: 5 parts per thousand (ppt); Conductivity: 5 siemens per meter (S/m)

Description
Salinity is a measurement of the salt content in water. Typically, salinity is measured in ppt or ‰. Conductivity is the measure of the ability to conduct electricity. Conductivity is generally measured in (S/m), but it can also be reported in microsiemens (µS) or millisiemens (mS) per centimeter (µS or mS/cm). The two measures can be calculated from each other, if you know the water temperature (Figure 7b).

Method
You can use physical and chemical methods to measure salinity. Typically, physical methods are quicker and more convenient than chemical methods. Three common physical methods are hydrometer, conductivity meter, or refractometer. The chemical methods determine chlorinity (the chloride concentration), which is closely related to salinity. Conductivity is typically measured with a conductivity meter.

A hydrometer measures the specific gravity (the ratio of the mass of a liquid to the mass of an equal volume of pure water) of liquids. Hydrometers are calibrated for different reference and sample temperatures to account for changes to the density of a liquid changes with changes in temperature. To measure salinity with a hydrometer, a sample of water is taken and a hydrometer is used to measure the specific gravity and temperature of the water, and this information is converted into a salinity measure using a hydrometer conversion table.

You can use a conductivity meter to measure the electrical conductivity in a sample of water. Conductivity is an approximation of salinity—a salty solution that is full of charged particles conducts electricity. Conductivity can be converted into a measure of salinity that is dependent on the temperature of the water.

A refractometer measures how light bends as it passes through a material. In water, the amount of bending is related to how much salt is dissolved in the water. When using a refractometer, a sample is placed on an optical prism in the sample window. As light shines through the sample, it is bent according to the salinity of the water, and it casts a shadow on the scale that can be read directly through the eyepiece. Using a refractometer is a cheap, consistent, and reliable way to measure salinity in water samples, and because they require little calibration.

Some multiprobes also have the ability to measure salinity or conductivity in addition to other parameters. Instructions for using a multiprobe will be specific to the instrument, and you should follow the manufacturer's instructions. When using a multiprobe, regular calibration is required.

Estimate the salinity range or measure conductivity and report methods used in the Water Quality Comments field (Figure 7b).

Dissolved oxygen

Example
5 milligrams per liter (mg/L)

Description
Dissolved oxygen (DO) is the measure of the amount of gaseous oxygen (O_2) in aqueous solution, and it can significantly affect the health of aquatic organisms. Concentrations of DO in a waterbody vary over time and can be affected by a number of physical, chemical, and biological factors. During the day, oxygen is produced by photosynthesis of aquatic plants, and concentrations fall at night when photosynthesis ceases. On a given day, the amount of sunlight can affect the amount of DO produced in the waterbody. DO concentrations can vary by depth. For instance, in estuaries in the late spring and summer, vertical stratification occurs as a result of warmer, fresher waters flowing over colder, saltier waters. This stratification can limit the transfer of oxygen between the upper and lower layers. Stratification can be affected by changing seasons or storms, allowing oxygen-rich, surface water to mix with the oxygen-poor, deep water. Because of this variation, it is important to sample year-round to get an accurate picture of DO concentrations in the waterbody you are sampling. It is useful to sample at approximately the same time of day so that measurements can be more easily compared. Consider taking samples at different depths.

Method
DO can be measured with a meter or test kit. To use a test kit, a water sample is collected and titrated using the Winkler method. If titration is not done in the field, the sample should be fixed in the field and measured in a lab within 8 hours. Measuring DO with a meter (or probe) is a much more straightforward process; each meter should be calibrated according to the manufacturer's instructions. As discussed in the temperature section, many multiprobe devices can measure DO concentrations along with other parameters. A multiprobe should be calibrated regularly to ensure accurate DO measurements.

Report the dissolved oxygen concentration measured and the method used in General Water Quality section of the survey (Figure 7b).

Total suspended solids

Example
100 mg/L

Description
Total suspended solids (TSS) is the amount of materials suspended in the water column.

Method
To measure TSS, a sample of water is taken and analyzed in a lab. In the lab the sample is filtered, and the remaining residue on the filter is weighed to determine the total solids. Samples should be preserved at 4 °C and measured within 7 days. More detail about methods for preserving and measuring TSS are in EPA Method 160.2 (https://19january2017snapshot.epa.gov/sites/production/files/2015-06/documents/160_2.pdf [USEPA 1999b]) or Standard Methods for the Examination of Water and Wastewater, 2540 SOLIDS published by the American Public Health Association, American Water Works Association, and Water Environment Federation (APHA 2018). TSS is not the same as turbidity, and if one measure is to be replaced by the other, a side-by-side assessment of the two should be conducted to assess equivalency.

Other water quality measurements

Report other water quality parameters measured and values in the Water Quality Measurements and Values field. Methods used to measure each parameter can be recorded in Water Quality Comments (Figure 7b).

Water quality images

Add images to document the conditions at the beach during sampling (Figure 7b).

4.5 Part 3: People/Bather Load

Example
200 people total, 50 people in the water

Description
The sanitary survey should include a discussion of the effects of people/bather load on recreational areas, particularly for recreational areas with poor water circulation. If there is poor water circulation, a high number of people in the water can cause significant elevation in bacterial counts for E.coli and enterococcus bacteria. High-use areas with poor water circulation might also indicate a need for increased monitoring of FIB and might require that you pay attention to the potential for blue-green algae blooms.

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

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

- Count by hand the number of people . Count the total number of people and estimate the number of people in the water as a percentage of the total number of people. If the beach or swim area is large, choose a representative area to use to count the number of people and
  extrapolate the number to the entire area using the size of the representative area as it compares to the total size.
- Take photos and count the number of people in them. Make sure to note how much of the area each photo covers. If possible, try to cover the entire area using photos, but make sure the photos do not overlap and that people are not counted twice. Photos will also provide information on the proximity of people to the beach.
- Count people or take photos from a helicopter or plane flying overhead.
- Count the number of cars at nearby parking lots and use that number to estimate people/bather load.
- Count the number of visitors by using a laser counting

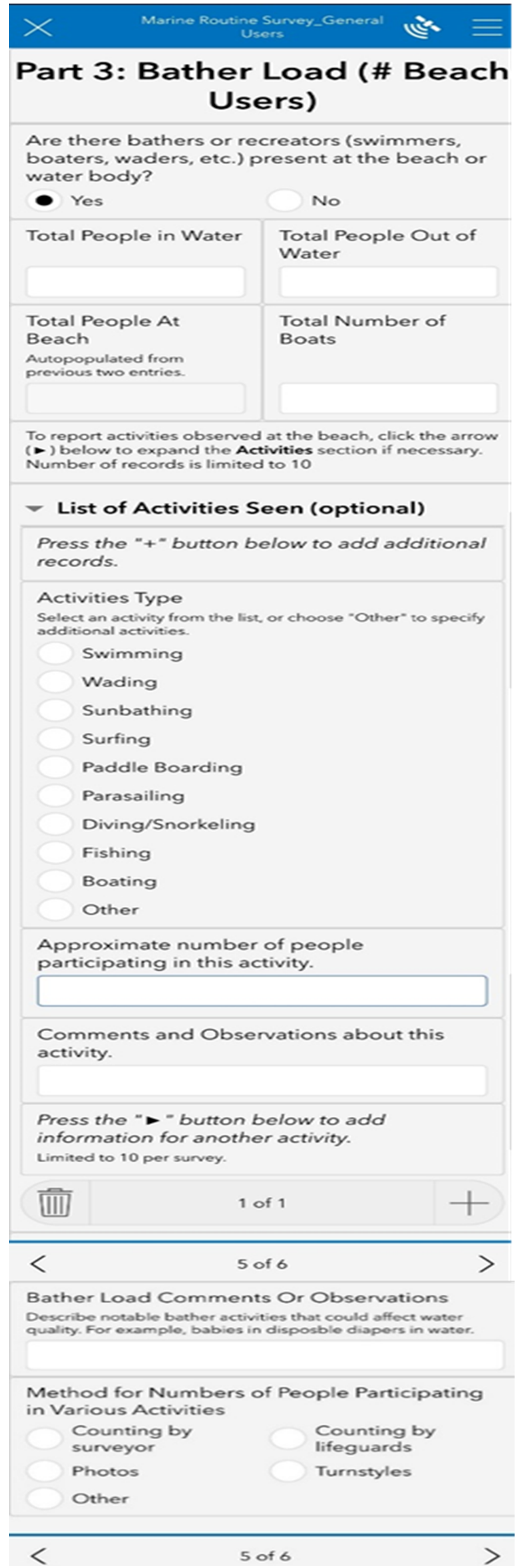


Figure 8. People/Bather Load Section

device. Laser counting devices have been used at beaches in Encinitas, California, to count the number of people 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 has 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. Cell phone data can also be used for counting beach visitations (Merrill et al., 2020).

The following data should be recorded when counting attendance (Figure 8):

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

You might also want to record the types of activities in which people are engaged (e.g., swimming, boating, sunbathing) and the number of people engaged in each activity (Figure 8).

4.6 Part 4: Potential Pollution Sources

The person performing the *Marine Routine Sanitary Survey* should identify visible sources of pollution up to 500 feet from the water boundary and, if possible, quantify the sources. Photos may be taken with or uploaded into the *EPA Sanitary Survey App for Marine and Fresh Waters* to document discharge sources, algae, HABs and animal images (Figure 9a).

Sources of pollutants

Example
A storm drain's discharge is brown and has a bad odor. The discharge is to the east of the designated beach area, about 500 feet away from the swim area.

Description
Visible sources, including rivers, estuaries, outfalls, discharges (such as storm drains), and ponds, might carry contaminants that affect recreational water quality. Ground water, usually not visible, might also be a pollutant source.

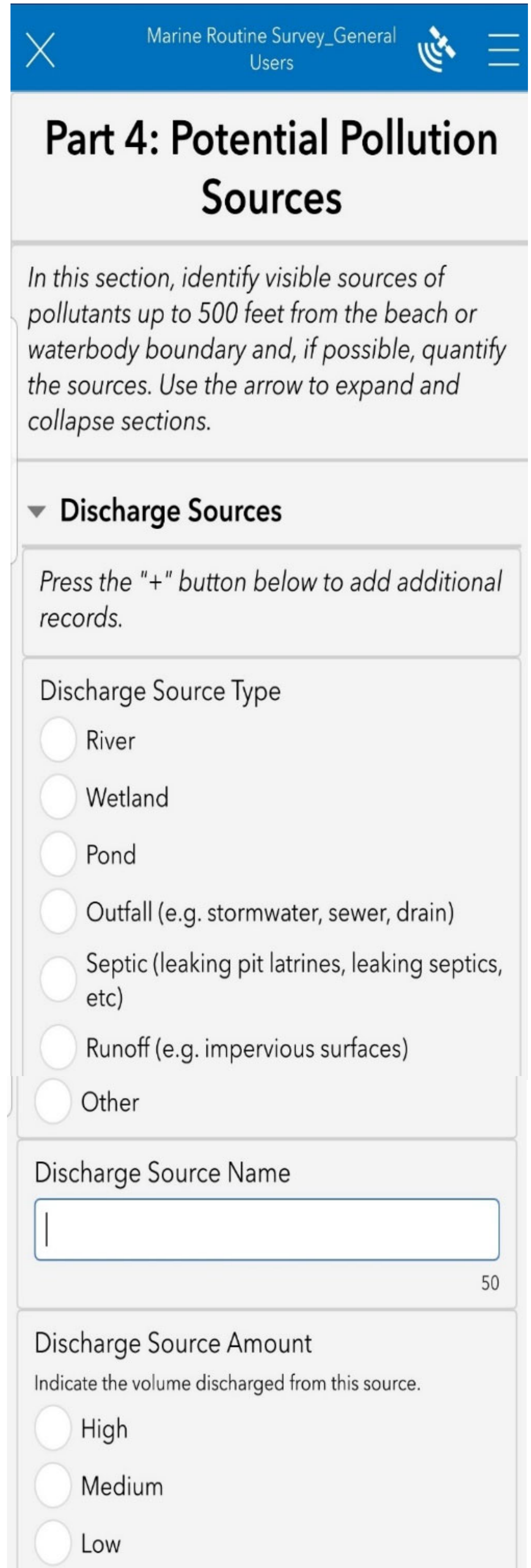


Figure 9a. Potential Pollution Sources

Investigating ground water as a pollution source is not addressed in this sanitary survey. The level of investigation of potential pollution 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 waterbody and the concentration of contaminant or FIB allows managers to calculate an 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 swim area. It is 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 water up to 500 feet from the sampling station (Figure 9a). If visible sources are suspected of affecting water quality, you might collect bacteria 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 *Marine Routine Sanitary Survey*. In the Comments/Observations section, add additional notes such as whether the visible sources occur only in conjunction with specific weather conditions. If you take bacteria samples from any pollutant sources, indicate that on the routine survey. Also note if those samples are included in the water quality table on the survey (Figure 6).

Discharge or Flow Measurement. Discharge from a stream, river or manmade structure (e.g., outfall) is sometimes called flow. A discharge measurement is a combination of a velocity measurement and a cross-sectional area measurement. It is important to measure the flow of the potential pollutant sources (Figure 9b).

Velocity. Measure velocity in a straight section of the discharge source. 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 meters* 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 should be considered when selecting the proper current measuring equipment. In general, you should know if you will be

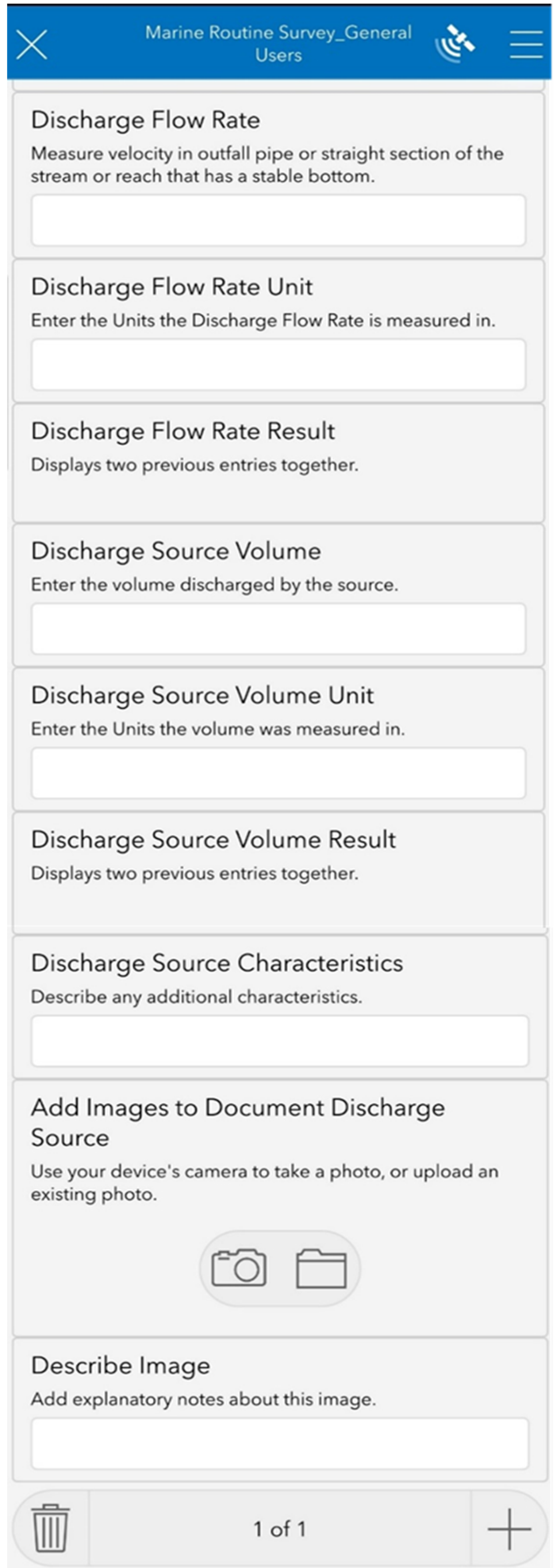


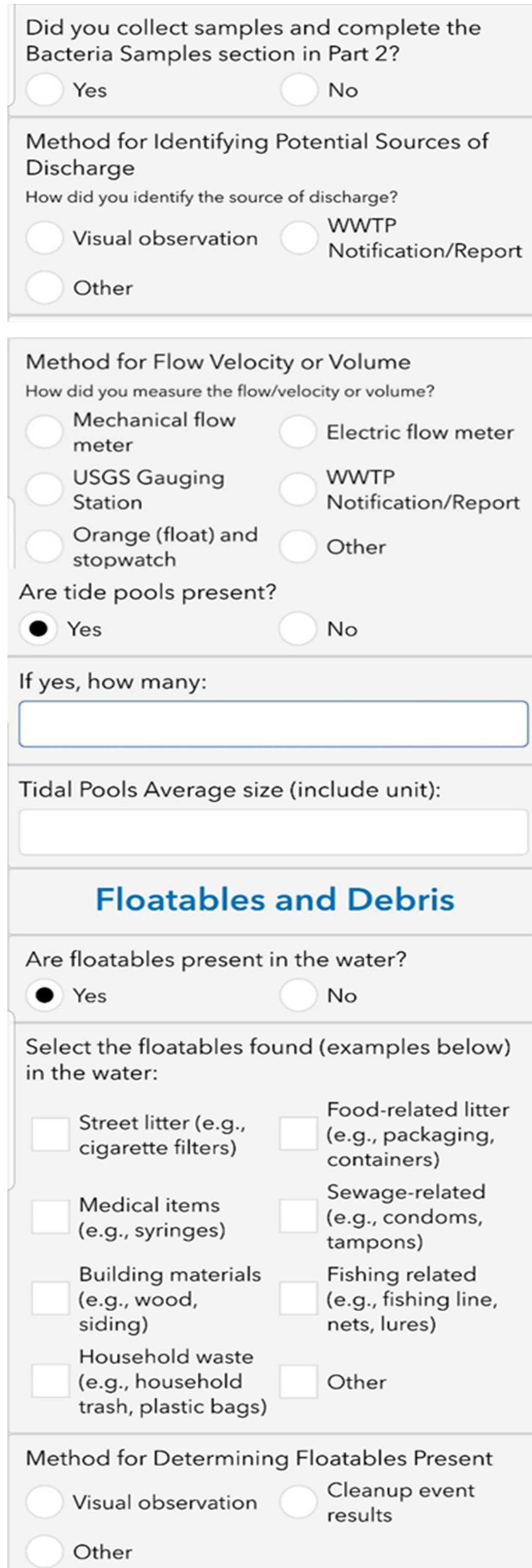
Figure 9b. Potential Pollution Sources—Continued

measuring current from an overhead structure or while wading. It also helps to know the approximate speed of the water to be measured because specialty meters are 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). Consult 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, visit 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, model ing the flow of water, and maintaining data. The NHD is the culmination of cooperative efforts of EPA and the USGS. For more information, visit 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 swim season, as long as the people making the measurements have the same idea of what constitutes high, medium, and low.

Tide pools present

Example
Yes. One tide pool is present measuring 1 meter by 3 meters; 18 inches deep at deepest point (Figure 9c).


Did you collect samples and complete the Bacteria Samples section in Part 2?
Yes
No

Method for Identifying Potential Sources of Discharge
How did you identify the source of discharge?
Visual observation
WWTP Notification/Report
Other

Method for Flow Velocity or Volume
How did you measure the flow/velocity or volume?
Mechanical flow meter
Electric flow meter
USGS Gauging Station
WWTP Notification/Report
Orange (float) and stopwatch
Other

Are tide pools present?
Yes
No

If yes, how many:

Tidal Pools Average size (include unit):

Floatables and Debris

Are floatables present in the water?
Yes
No

Select the floatables found (examples below) in the water:
Street litter (e.g., cigarette filters)
Food-related litter (e.g., packaging, containers)
Medical items (e.g., syringes)
Sewage-related (e.g., condoms, tampons)
Building materials (e.g., wood, siding)
Fishing related (e.g., fishing line, nets, lures)
Household waste (e.g., household trash, plastic bags)
Other

Method for Determining Floatables Present
Visual observation
Cleanup event results
Other

Figure 9c. Potential Pollution Sources—Continued

Description
Tide pools are areas where water is left behind when the ocean recedes at low tide. They can be big or small, shallow or deep, and sandy or rocky depending on the type of beach. Tide pools can be formed in either rocky depressions or along sandy beaches.

Method
Visiting the beach at low tide, you might see tide pools left when the tide went out. You should note whether tide pools are common at your beach and whether people recreate in them. In some cases, seaweed and wrack in the tide pools can serve as a substrate for FIB growth, and if possible, you should quantify it.

Report if tidal pools are present, how many are at the waterbody being sampled and approximate size of pools (Figure 9c). Additional information on tidal pools can be recorded in the Comments or Observations field.

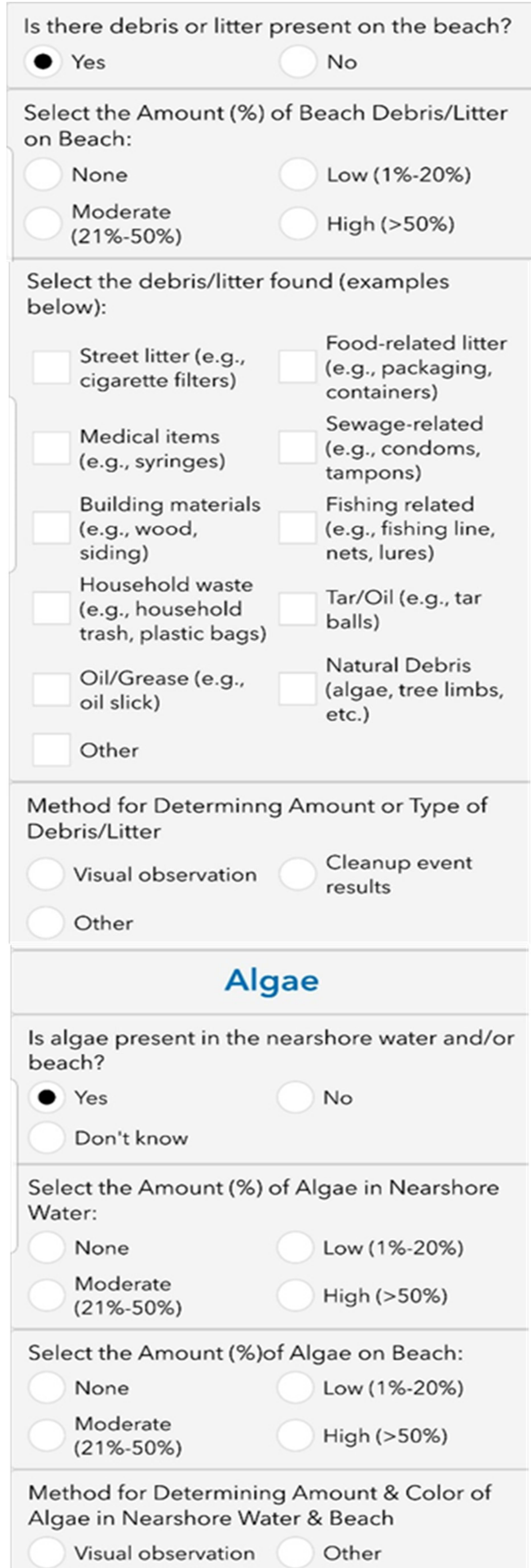
Floatables present

Example
Yes, floatables are present in the water. Types found include trash such as household waste and medical items (Figure 9c).

Description
Floatable debris causes problems because it can easily come into contact with aquatic animals, people, boats, fishing nets, and other objects. Communities also lose money when recreational beaches need to 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 2002). Floatable debris also can be a source of bacterial contamination to swim areas.

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 2002).

Methods
Record the types and amount of floatable debris (Figure 9c). For further guidance on measuring floatable debris, consult EPA's *Assessing and Monitoring Floating Debris* (USEPA 2002) at https://www.epa.gov/sites/production/files/2018-12/documents/assess-monitor-floatable-debris.pdf.


Is there debris or litter present on the beach?
Yes
No

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

Select the debris/litter found (examples below):
Street litter (e.g., cigarette filters)
Food-related litter (e.g., packaging, containers)
Medical items (e.g., syringes)
Sewage-related (e.g., condoms, tampons)
Building materials (e.g., wood, siding)
Fishing related (e.g., fishing line, nets, lures)
Household waste (e.g., household trash, plastic bags)
Tar/Oil (e.g., tar balls)
Oil/Grease (e.g., oil slick)
Natural Debris (algae, tree limbs, etc.)
Other

Method for Determinng Amount or Type of Debris/Litter
Visual observation
Cleanup event results
Other

Algae

Is algae present in the nearshore water and/or beach?
Yes
No
Don't know

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

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

Method for Determining Amount & Color of Algae in Nearshore Water & Beach
Visual observation
Other

Figure 9d. Identify debris and presence of algae

Amount and type of beach debris/litter

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 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. Specify additional types of debris or litter not already provided on the survey in the “Other” field (Figure 9d).

Amount of algae in nearshore water/beach

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

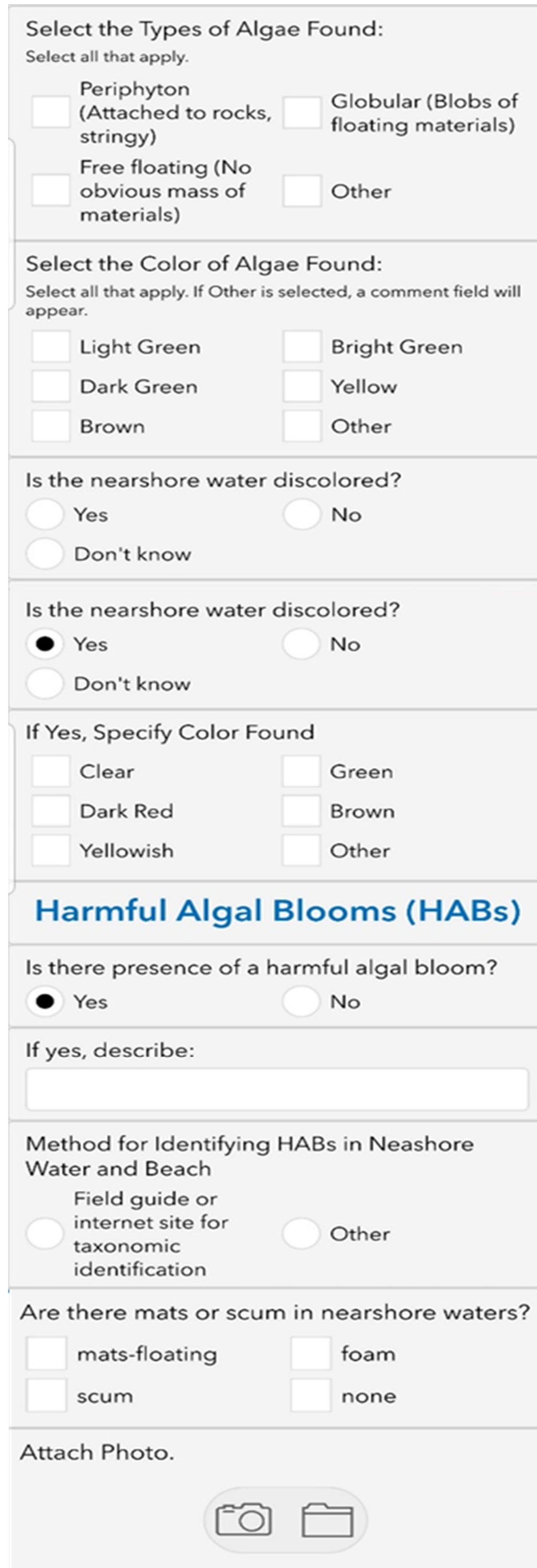
Description
Algae can be a nuisance. Decaying algae can produce a foul odor that can deter people from visiting. Algae also have been suspected of harboring fecal indicator bacteria, which can lead to beach closures (Whitman et al., 2003).

Methods
Record the amount of algae found in the nearshore water and covering the beach (Figures 9d and 9e). The survey has 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 along with the color of the algae. If algae are known to be harmful, indicate that on the survey and describe the algae. Additional information can be given, if needed, in Comments or Observations.

Presence of a harmful algal bloom

Example
Yes. A harmful algal bloom (HAB) is present.

Description
An algal bloom is a large accumulation of algae—either


Select the Types of Algae Found:
Select all that apply.
Periphyton (Attached to rocks, stringy)
Globular (Blobs of floating materials)
Free floating (No obvious mass of materials)
Other

Select the Color of Algae Found:
Select all that apply. If Other is selected, a comment field will appear.
Light Green
Bright Green
Dark Green
Yellow
Brown
Other

Is the nearshore water discolored?
Yes
No
Don't know

Is the nearshore water discolored?
Yes
No
Don't know

If Yes, Specify Color Found
Clear
Green
Dark Red
Brown
Yellowish
Other

Harmful Algal Blooms (HABs)

Is there presence of a harmful algal bloom?
Yes
No

If yes, describe:

Method for Identifying HABs in Neashore Water and Beach
Field guide or internet site for taxonomic identification
Other

Are there mats or scum in nearshore waters?
mats-floating
foam
scum
none

Attach Photo.

Figure 9e. Potential Pollution Sources—Continued microscopic species or the larger, multicellular species. A HAB is visible to the human eye and can affect aquatic species, pets, wildlife, and humans. HABs can have a variety of effects on the environment and humans. In some cases, algae might not be toxic but can discolor water, form piles on beaches, or cause drinking water and fish to taste bad. HABs can cause depletion of oxygen in the water column or clog the gills of aquatic organisms, leading to death of aquatic species. HABs can also be a nuisance for people trying to recreate in or on the water. Some HAB species are toxic and can kill aquatic organisms or cause illness to humans, pets, or wildlife when they come into contact with or ingest water containing the HAB. HABs can appear as scum, mat, or filamentous mass in the waterbody (Figures 9e and 9f).

Method

Although it is not possible to determine whether an algal bloom is toxic through observation, or whether enough biomass has accumulated to cause oxygen depletion, visual monitoring for algal blooms is the first step in identifying an HAB. NOAA provides resources on marine HABs at https://oceanservice.noaa.gov/hazards/hab/. If HABs are identified, EPA has resources including a Cyanotoxins Preparedness and Response Toolkit and communications materials.

In addition, research programs such as NOAA's Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) Program collect data used to predict HAB development for coastal states.

Presence of wildlife and domestic animals

Example

Gulls (20) on the beach (on sand below high tide line) and 20 gulls in the water.

Description

The presence of wildlife and domestic animals at swimming areas 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 bacteria concentrations to rise to the point where recreational standards are exceeded, resulting in closure. Data like the types and numbers of animals present at the swimming area 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 on the beach or shoreline) that could be used to reduce the amount of animal waste reaching the water.

Methods

Record both the types and number of animals present. Determine the presence of animals through visual


Are there dead fish or other dead wildlife deaths present with bloom?
Yes No

Have any illnesses (e.g., itchy throat, cough, gastrointestinal) been reported by local or state health department?
Yes No
Don't know

Is algal toxin monitoring conducted?
Yes No
Don't know

Have algal species been identified?
Yes No
Don't know

Presence of Wildlife & Domestic Animals

Are wildlife and domestic animals present?
Yes No

Specify which animals are present
Select all that apply. Additional fields will appear to enter more information.
Geese Gulls
Shorebirds Ducks
Pigeons Turtles
Dogs Horses
Rodents Other

Method for Determing Presence of Wildlife and Domestic Animals
Counting using hand-held counter, and if necessary, binoculars
Other

Presence of Dead Birds

Are dead birds present?
Yes No

Select the species that were found dead on the beach
Select all that apply. Additional fields will appear to enter more information.
Common Loons Herring Gulls
Ring-billed Gulls Double crested cormorants
Long-tailed ducks White-winged scoter
Horned Grebes Red-necked grebes
Other

Method for Determining Number of Dead Birds
Visual observation Other

Method for Identifying Dead Birds
Field guide or internet site for taxonomic identification
Other

Figure 9f. Potential Pollution Sources—Continued 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 on the beach. Next, count the number of animals that are actually in the water. If you can note the proximity of the animals to the water (e.g., below high tide line, above high tide line), this can be useful information. Note the presence of any types of animals not already listed on the survey in the Other field. Note in the Comments or Observations

field the number of each type of animal present in the water, on the beach or shoreline, and in the air (Figure 9f).

Presence of dead birds

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

Description
Bird die-offs indicate problems in water quality.

Methods
As you conduct the sanitary survey, look for any dead birds or scat on the shore or in the water. If you find dead birds but can't identify the species, write a description of the bird and take a photo if possible (Figure 9f).

Presence of dead fish

Example
4 dead fish floating at the shoreline

Description
Fish die-offs indicate problems in water quality.

Methods
As you conduct the sanitary survey, look for any dead fish on the shore or in the water. If you can't identify the species, write a description of the fish and take a photo if possible. Note the location of any dead fish, especially as it relates to the swimming area in the Comments or Observation field (Figure 9g).

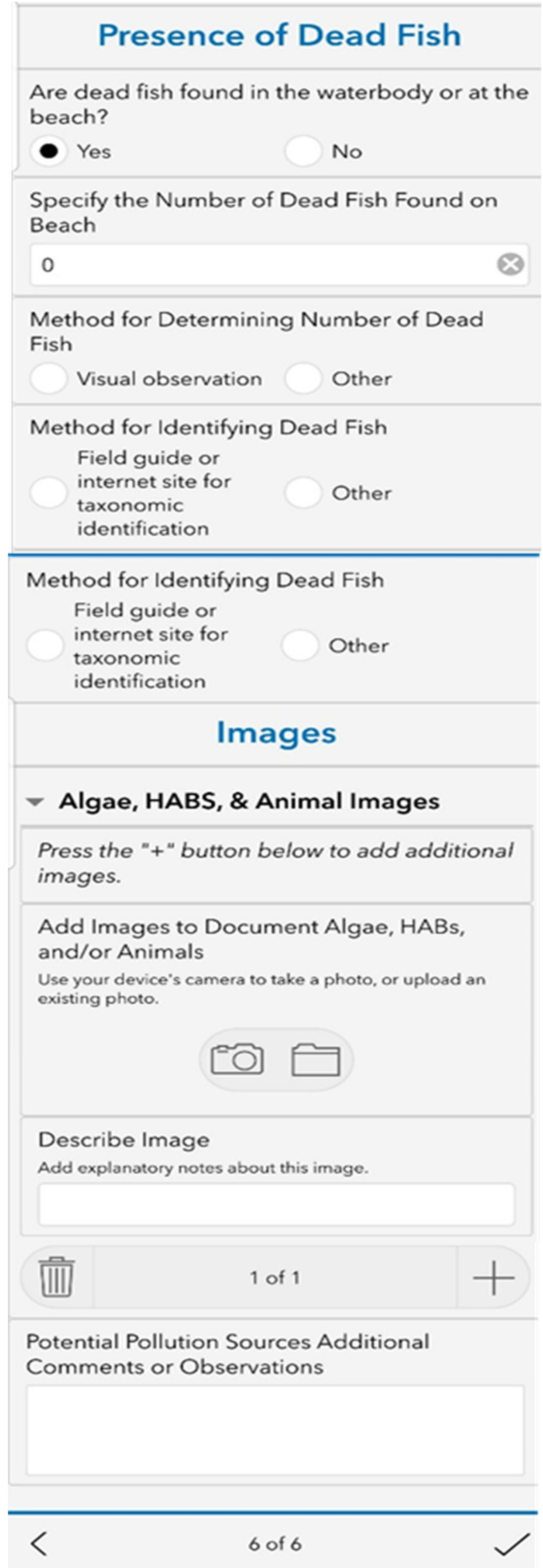


Figure 9g. Potential Pollution Sources—Continued

5. Data Elements for the Annual Sanitary Survey

This section includes descriptions of the types of data you should consider collecting if you are conducting a *Marine Annual Sanitary Survey*. Information that could be useful in completing the annual survey either using the paper surveys or the app are provided. Due to the length and the level of detail in this survey, screen shots of the annual survey are not included in this section. 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.

5.1 Part 1: Basic information

In the first section of the *Marine Annual Sanitary Survey*, 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 Program tracking, beach Advisories, Water quality standards, and Nutrients (PRAWN) database. If you have a separate ID for other purposes, you may list that as well. Also include dates of the beach season. In the *EPA Sanitary Survey App for Marine and Fresh Waters*, links are available to specific databases to search for these IDs. You must enter the IDs in the appropriate fields because the app does not autopopulate this information. Required fields (designated with a red asterisk [*]) must be completed in order to submit data collected using the app.

5.2 Part 2: Quality Assurance Project Plan (QAPP) Requirement

Most agencies should already have Quality Assurance/Quality Control (QA/QC) procedures for performing monitoring. These procedures should be updated, as needed, to include QA/QC procedures for performing sanitary surveys. States, territories, 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. App users are required to certify that sanitary survey data are collected using an approved QAPP and provide a link or submit a copy of the approved QAPP in order to submit their sanitary survey data to the EPA GeoPlatform.

5.3 Part 3: Description of Land Use in the Watershed

Current land use in watershed and overall development

As described in EPA's *National Beach Guidance and Required Performance Criteria for Grants – 2014 Edition* (USEPA 2014), you can use beach characterization data, including surrounding land uses, to evaluate potential risk and rank beaches. Pollutant loadings into nearby swimming 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 beaches.

Land use maps, aerial photos of the watershed, or other geographic data can usually be obtained through a city, county, or state planning department. In addition, NOAA maintains a coastal land cover database (https://coast.noaa.gov/digitalcoast/data/ccapregional.html). Some land use and land cover (LULC) data are also available from the USGS for the conterminous United States and Hawaii, although coverage is not complete for all areas. The website for LULC information is https://www.usgs.gov/land-resources/eros/lulc. Websites like Google Earth at https://www.google.com/earth/ can also 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 webpage 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, including the percent of impervious cover.

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.

Beach 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 uses through direct observations of activities that occur and services offered (e.g., boat rentals). The uses included on the *Marine Annual Sanitary Survey* are swimming, boating, fishing, surfing, windsurfing, diving, kayaking, jet skiing, beachcombing, vehicular traffic, kiteboarding, and other. Select the uses that occur at your waterbody, and describe them further, if necessary, in the Comments section. Describe any uses not listed on the survey in Other. In addition, if the *Marine Routine Beach Sanitary Survey* was conducted, you can summarize the results from Part 3, People/Bather Load, collected over the course of the season.

Mapping

You can use maps and other geographic information to help identify potential impacts in the swim area within the watershed or along adjacent shoreline. Geographic information can help you determine the proximity of pollutant sources to the swim area. Even simple maps like those obtained from places such as Google Earth can be useful. Attach copies of any maps you have to the *Marine Annual Sanitary Survey* or list the locations of the files if hard copies are not available. Document land use in the watershed by uploading photos.

You can obtain topographic maps from USGS directly or through a retailer. Information on downloading these maps is on USGS's website at https://www.usgs.gov/core-science-systems/national-geospatial-program/topographic-maps. 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.
- Location and direction of any digital photos (to serve as an index).
- 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.
- 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 *Marine Annual Sanitary Survey*.

The survey includes a list of possible items to include on the map, such as pollutant sources, marinas, sanitary facilities, and bounding structures. Check if the things on the list that are applicable to your swim area are on the map, and in the Other field add any additional items 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. The extent and severity of the problem is worsening with global sea level rise. Shoreline hardening structures such as jetties and seawalls intended to protect against storm waves can actually accelerate beach erosion and reduce the capacity of beaches to absorb storm energy. Erosion can result in public losses to recreational facilities, roads, public works, and homes along the shore.

Recent research has examined the effect of beach erosion and accretion on the redistribution of enterococci, and some ongoing research has indicated that the movement of sand by erosion and accretion has the potential to redistribute enterococci.

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. 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. 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 distance in feet or meters on sanitary survey. Then proceed to the next point, repeating the measurement and recording corresponding information on the sanitary survey. Finally, the two people should measure the distances between sampling points (UNESCO 2005) and record them on the sanitary survey. A GPS device might also be used to take these measurements.

The University of Minnesota Extension Service's website provides examples of some best management practices that can be used to reduce erosion at beaches: https://extension.umn.edu/water/shoreland-properties.

Bounding structures

Alterations of the coastal environment can be made by installing man-made shoreline hardening (bounding) structures like jetties, groins, piers, and seawalls/bulkheads. Alterations affect coastal dynamics and have far-reaching effects on coastal ecosystems, hydrodynamic and tidal regimes, and sediment transport rates. Usually, shoreline hardening 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 2016).

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 in 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 2016). Piers are designed more for recreational use but can alter the beach area as well.

Shoreline hardening and circulation control structures can affect water circulation, and this can affect FIB concentrations. Features such as breakwaters or groins can promote non- uniform distribution of FIB (Bertke 2007). For example, Bordalo (2003) reports significant differences in bacterial water quality and in temperature and salinity for two beaches separated by a 250-meter-long jetty. A schematic drawing showing the beach and relevant features is presented in Figure 10. Observed trends at both beaches (response to rainfall events, diurnal variation in FIB density, variations with tidal cycle) were similar, but one beach had consistently higher FIB density. The beach with the consistently higher density was confined on both sides by jetties, whereas the other beach was described as more open to the ocean. Higher densities in the confined waters can be explained by reduced dilution from the inhibition of mixing by the jetties.

On a Lake Michigan beach, breakwaters are also believed to influence mixing, retaining FIB (and other pollution) originating from terrestrial sources (beach sands, runoff) and carried in longshore currents at Chicago beaches (Whitman and Nevers 2008). Among the 23 Lake Michigan beaches studied by these researchers, *E. coli* densities exhibited similar time variation at all beaches but three during a 5-year study; it was surmised that the physical features of the three beaches, particularly the presence of breakwaters, caused the different temporal fluctuations observed at those beaches.

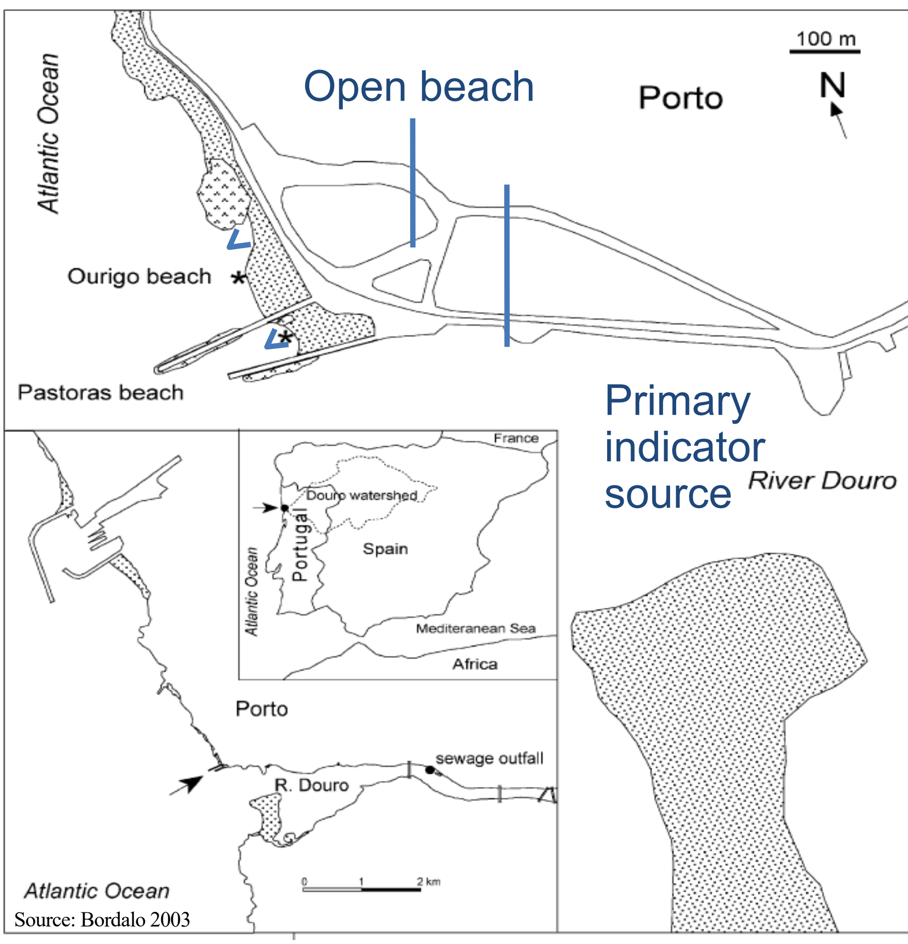


Figure 10. Illustration of beach features promoting non-uniform indicator density in parts of a beach.

The mobilization of FIB from sands and sediments is related to waves which, in turn, are related to the beach physical configuration. Yamahara et al. (2007) used an N-way ANOVA to determine which factors influenced presence/absence and density of enterococci and *E. coli* in beach sands at multiple beaches along the California coast. Among other factors, presence and density were most influenced by wave action and presence of a source. Sheltered beaches (low wave action) with a FIB source had the highest sand enterococci densities among beaches studied.

Groin extensions and jetties can cause or exacerbate adverse water quality by enclosing beaches. In some cases, a beach area already suffers from poor circulation, and a groin extension exacerbates the problem (e.g., Cabrillo Beach in southern California). In some cases the jetty or groin extension can actually cause the enclosure (e.g., Baby Beach in Dana Point, California). Enclosed beaches have been noted as a significant problem for water quality (Largier and Taggart 2006), and are the locations of the greatest beach water quality issues in the State of California. Some states such as Rhode Island have existing controls on the building of further future shoreline hardening structures. State policy makers have noted the adverse impacts of these structures on water quality and wave action that is primarily responsible for natural sand movement along the coast.

Shoreline hardening structures retain shore-based pollution through trapping and attempts to promote circulation may assist the manager. Contaminated groundwater contributed to areas with reduced circulation due to shoreline hardening structures degrades coastal water quality and may require promotion of advective mixing and diffusion in the beach boundary layer.

Due to the strong impacts of shoreline hardening structures on beach water quality, take photos of shoreline hardening structures. Record corresponding descriptions of the pictures on the sanitary survey form in the Photos section. In areas where groins and jetties have created enclosed beaches note the collection or trapping of materials along the beach where the public is recreating. Examples may be collection or trapping of seaweed wrack, surface scums or mats of algal, areas where trash and debris has collected, to name a few. During periods where materials are trapped at the beach, note wind speed and direction and alongshore flow of water. Take photos of bounding structures.

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. 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.

Simple, subjective observations (e.g., “ very sandy”) 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, collecting sediment samples and sending them to a lab for analysis will provide better data. If you 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 revisit ed 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, and the uniformity coefficient.

Grain size is classified on the Udden-Wentworth scale with the following sizes for each type of sand: very coarse sand = 1–2 millimeter (mm), coarse sand = 0.5–1 mm, medium sand = 0.25–0.5 mm, fine sand = 0.125–0.25 mm, and very fine sand = 0.0625–0.125 mm. One commonly used term is sugar sand. Sugar sand is approximately 0.15–0.2 mm, similar to fine sand.

Shellfish growing areas

States that have shellfish growing areas will typically have a shellfish sanitation monitoring program. The Interstate Shellfish Sanitation Conference typically oversees these programs. You should determine whether a shellfish growing area is near your swim area because data collected for that area might also be applicable to your swim area. If shellfish growing areas and swimming beaches overlap, the shellfish and beach programs should consider combining efforts to address pollution sources affecting both resources.

On the *Marine Annual Sanitary Survey* you should include information about the general size of the area, proximity to the swim area, type of harvest, summary of closures and advisories, and any other information that might correlate to health risk to swimmers. Cite and attach relevant summary reports if they exist. Certain types of shellfish can be problematic to human health because of the risk of cuts and scrapes on shell exteriors and the potential for *Vibrio spp*. infections, especially during warm months, so documenting oyster growing areas in proximity to high-use recreational areas is necessary.

Photos

Photos are a good way to document conditions for the recreational waterbody and the watershed. Take some general photos showing the overall water and shoreline condition and the locations of fixed objects. These photos can be used as reference points to determine whether changes have occurred 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. Upload or attach relevant photos to the survey.

Habitat

Changes in the types of habitats present 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, such as the piping plover (*Charadrius melodus*).

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

5.4 Part 4: Weather Conditions and Physical Characteristics

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 *Marine Routine Sanitary Survey*, you should examine the survey results to determine the typical sky condition for the beach. You can also examine sky conditions from the routine survey along with the bacteria sampling results to determine whether there is any correlation between the sky conditions and the sampling results. Indicate when there is a correlation between weather and bacteria concentrations.

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

- *NOAA*
  https://tidesandcurrents.noaa.gov/historic_tide_tables.html
  This website provides tides and tidal current data from 2008 to the present.

- *NOAA–NCDC*
  https://www.weather.gov/timeline. This website contains records for weather stations in the United States ranging from 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 online.

- *NOAA-National Weather Service*
  https://www.weather.gov/. The National Weather Service site provides locations of weather stations and weather radio information. Archived data for the previous year are available.

Winds

Recent research has examined the effect of wind speed and direction on bacteria concentrations, and some studies have shown that there is a correlation between onshore wind speed and concentrations of bacteria in a water quality sample. Onshore winds can prevent pollutants from moving away from the beach area or bring submarine effluents toward the shore. More information about collecting information on wind speeds and direction is in Section 4.

Waves

As part of the annual survey, you should describe the typical wave conditions during the beach season.

Correlation with bacteria levels. The mobilization of FIB from sands and sediments is related to waves which, in turn, are related to the physical configuration of the waterbody. Yamahara et al. (2007) used an *N*-way ANOVA to determine which factors influenced presence/absence and density of enterococci and *E. coli* in beach sands at multiple beaches along the California coast. Among other factors, presence and density were most influenced by wave action and presence of a source. Sheltered beaches (low wave action) with a FIB source had the highest sand enterococci densities among beaches studied. Pollutants from stormwater and other effluent outfalls can be carried as waves travel toward the shore, and wave action can resuspend bacteria that have been deposited in the sand layer.

Tides

Water movement from tidal fluctuations can cause erosion, transportation and deposition of sediment, and redistribution of associated microorganisms (WHO 2003). Water quality at swim areas can be related to tidal extent and manifestation, and tidal river/stream discharges. For instance, during high tide, the swimming zone is moved onshore, where more human activities take place, and this can affect bacteria concentrations in area waters. In a 2005 study, Boehm and Weisberg found that during spring-ebb tides bacteria levels can be higher; during tidal events, enterococci densities were found at beaches with no obvious point source. This study points to several potential sources for enterococci, including beach sands and sediments, decaying plant material, and polluted ground water—all of which were affected by the strength of the spring tides. You should also note how tidal flow is manifested and whether the tides create a cross-current. Information on whether tidal rivers or streams discharge near the beach and the relationship of tidal flow to known point or nonpoint pollution sources can also provide information that can be useful in beach management decisions.

Tide pools

Tide pools are areas where water is left behind when the ocean recedes at low tide. They can be big or small, shallow or deep, and sandy or rocky depending on the type of beach.

Because of the lack of movement of water in and out of tide pools, they could harbor bacteria for longer periods. At some beaches, tide pools are popular playing areas for small children, so you should note whether tide pools are common at your beach and whether people recreate in them.

Longshore and nearshore currents

Review data from the prior beach season(s) and determine the significance of longshore currents, cross currents, and 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, a description of currents is in Section 4.

5.5 Part 5: Beach Dimensions

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 the 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 on the sanitary survey 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). 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. 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.

Enter on the sanitary survey 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 survey 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 the method you use to calculate beach length or dimensions.

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. In Part 12, Potential Pollutant Sources, list other types of rehabilitation and physical structures, such as constructing bathroom facilities.

5.6 Part 6: People/Bather Load

It is important for the manager of recreational waters to know the number or approximate number of people using the swim water. You can collect the people/bather load numbers using several different approaches to determine annual, seasonal, and daily cycles. Numbers of people should best be measured during times of the day when people are most likely to be at the recreational water. Lifeguards in many counties routinely collect daily counts during swimming season, and, therefore, 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 used in the annual or routine surveys. For details on how to measure the number of people, consult Section 4.5.

Numbers of people 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 the number of people than the others. Describe any trends detected or any particular days when there might have been a correlation between these data sets.

5.7 Part 7: Beach/Shoreline 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 be used to 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. Mechanical beach cleaning can be performed daily during the early morning or late evening.

Municipalities, counties or other organizations might sponsor beach cleanup events one or more times a year. In this part of the survey, note the frequency of any cleaning activities and give a short description of any activities performed. Also list any particular type of equipment that was used, if known.

Amount and types of floatables

Estimate what types of floatables are found in the water. Include the types of floatables found, including tar, oil or grease, trash, plastic, or medical waste. This type of information might be available from routine surveys or other documentation of this type of activity.

Amount and types of beach debris/litter

Review the results of the routine survey, or other documentation of this type of activity, and estimate how frequently debris or litter is found 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. Any known source of debris should also be noted.

5.8 Part 8: Information on Sampling Location

Sampling point descriptions

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 swimming area. Samples can be taken at a point corresponding to each lifeguard chair, or every 500 meters. If a swimming area is more than 5 miles long, take samples at the most populated/used areas of the beach and spread out along the length of the swim area (USEPA 2014).

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.

Hydrometric network

A hydrometric network is the network of monitoring stations that collect data such as flow and rainfall. Check 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 website information, consult Section 4.3). However, you might want to operate your own rain gauge or weather station so that it is in the immediate vicinity of your swim area. 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). 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.

The NHD might also be useful (http://nhd.usgs.gov/index.html). 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.

5.9 Part 9: Water Quality Sampling

Laboratory information

Use this section to provide the name of the laboratory that analyzes the water samples. List the approximate distance from waterbody to the laboratory and how long it takes to get the samples to the lab.

Sampling and analysis plan, equipment maintenance and calibration procedures

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 waterbody. If any new equipment will be used, update the sampling plan with information on the new equipment, and train staff appropriately.

Before the swim season, managers of recreational waters 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 *Marine Annual Sanitary Survey*, and if there are any changes in factors such as amount or duration of use, number of swimmers, new sources, or equipment used, make any adjustments in the sample plan or equipment maintenance and calibration procedures.

Duration and identification of algal species

Algae in marine waters range from single-celled forms (microalgae) to seaweed (macroalgae). Cyanobacteria are of particular concern because of their ability to produce toxins. They have some characteristics of algae and some of bacteria (WHO 2003).

Macroalgae

Although not generally harmful to human health, macroalgae can be a nuisance at some marine beaches, affecting the visual appearance of the beach by reducing transparency, discoloring water, forming scum on the surface of the water or beach, and causing odors (WHO 2003). 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 swimming beaches. Explain whether macroalgae are growing or commonly found at this beach and how extensive their coverage is.

Field personnel can reference websites with electronic field guides on marine algae. The Smithsonian website includes a marine flora bibliography that provides references to regional guides. For more information, visit http://botany.si.edu/projects/algae/biblio.htm.

Current and historical amounts of macroalgae:
- Indicate if algae is present during the swim season.
- Record on the Annual Sanitary Survey the amount (%) of algae found in the nearshore water and macroalgae present on the beach. This should be measured as the percentage of the length of the beach that has algae present. In the Comments or Observations section, record the type of algae present, if known.
- Select the type of algae present, if known, or note the color(s) of algae seen.
- Review the results of the *Marine Routine 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.
- Take or upload photos to document the presence of algae in the nearshore or at the beach.

Microalgae

Although the risk is generally low at most marine beaches, certain types of algae can be a risk to human health. Certain type of marine cyanobacteria can cause cyanobacterial dermatitis (i.e., swimmer's itch) or other types of skin irritation (WHO 2003). Exposure to *Pfiesteria* has been shown to increase the risk of developing a clinical syndrome that causes difficulty in learning and higher cognitive function (WHO 2003). Blooms of *Nodularia spumigena* (a cyanobacteria) have not been shown to affect humans. However, they have poisoned ducks, cattle, and sheep, so it is possible that humans, especially small children, could be affected (WHO 2003). Dinoflagellates of the genera *Alexandrium*, *Gymnodinium*, and *Pyrodinium* cause paralytic shellfish poisoning (PSP). PSP causes neurological symptoms that can result in paralysis or death through respiratory arrest (Lewitus et al. 2012). Diatoms of *Pseudo-nitzschia* produce domoic acid which causes amnesic shellfish poisoning (ASP) in humans. ASP can be life-threatening and can result in gastrointestinal and neurological disorders within 24-48 hours of eating toxic shellfish (Lewitus et al. 2012). A recent incident of PSP occurred in Alaska in 2020, resulting in the death of an individual (Food Safety News 2020). *Alexandrium* and *Pseudo-nitzschia* cause most of the blooms in

California (NOAA no date). On the annual survey state whether any visible microalgal blooms were observed during the beach season and include the type of bloom, dates, species, and effects, if known.

Harmful algal blooms (HABs)

Algae can cause HABs in marine waters and can affect nearby beaches. Summarize on the *Marine Annual Sanitary Survey* whether any HABs occurred over the past year and how they affected the beach water quality and recreational activities.

On the annual survey state whether any HABs were observed during the swim season and include the type of bloom, dates, species, and effects, if known. State whether the bloom was determined to be toxic or harmful and add images to document HABs. Consult Section 4.6 for more details.

Dangerous aquatic organisms

You might want to list any other aquatic organisms that were found near the swimming area, such as jellyfish, sea nettles, and so forth. These are not known to affect bacteria concentrations or water quality in general, but this can be useful information from a public safety standpoint. Describe the location of where these organisms were found (e.g., swimming area, beach near swimming area, downshore of swimming area).

Historical presence of wildlife and domestic animals

You can determine the presence of animals at the recreational area by visual observation. This should be performed routinely (during the *Marine Routine Sanitary Survey*). Use binoculars and a handheld counter to keep track of the number of animals present. Record on the *Marine Annual Sanitary Survey* both the types and number of animals present at the beach. Note in the Other field the presence at the beach of any types of animals not already listed on the survey. Also note in the Comments or Observations field the number of each type of animal present in the water, on the beach or shoreline, and in the air. Review the results from the *Marine Routine Sanitary Survey* conducted during prior seasons and summarize them on the *Marine Annual Sanitary Survey*. Determine 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. If wildlife management areas are near the beach, indicate this and describe on the survey.

Note whether any dead birds or animals have been found on the beach, particularly near the swimming area. Describe the suspected cause of death and attach any photos.

Bacteria samples collected at the beach

Managers of recreational waters should compile FIB concentrations—*E. coli* or enterococcus or both (USEPA 2012)— 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. Describe where samples are collected, relative to any potential pollution sources. If samples are collected from pollution sources (such as an outfall or river), describe this on the survey.

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, widescale thermometers and electronic instruments can be verified with simple ice point (0 °C or 32 °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). A description for multiprobe is in Section 4 under the methods used for water temperature.

- Local and regional water temperatures for recreational beaches are 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 measure pH using one of the following:
  - Simple pH strips.
  - Field test kits.
  - Handheld electronic meters (a description for multiprobe is 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.

Rainfall

- You can measure rainfall using a rain gauge near the sampling station(s). You can purchase relatively inexpensive rain gauges that can also provide historical rainfall records.
- You can obtain rainfall measurements from another agency (e.g., NOAA, https://www.ncdc.noaa.gov/temp-and-precip/us-maps/) or from a local weather station (e.g., a local airport) or weather app. The distance from the airport to the sampling station should be noted, and whether they are in the same watershed. Record on the *Annual Sanitary Survey* the amount of rainfall in inches or centimeters and the time from the previous rainfall event. The websites listed under Weather Conditions could also be a source of rainfall data. More information about sources of precipitation data is available in Section 4.

Turbidity

- You can use simple, subjective observations (e.g., "slightly turbid, clear") to describe the turbidity of nearshore waters.
- 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 three common methods using 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 NTU. The ISO specifies an 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 2018).
- Portable turbidimeters are available for use in the field. 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 that 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 in 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 can 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 in the water.

Salinity

- Salinity is measured in one of several ways—with a hydrometer, a refractometer, or by using a conductivity meter and translating the measure of conductivity into to salinity. Some multi-probes can be used to measure salinity.
- If salinity measures are routinely taken, note if there is any correlation to bacteria concentrations at the sampling site. Some types of bacteria may be affected by water column salinity. For instance, the rate of growth of *E. coli* can be slowed in saline environments. Enterococcus is less likely to die off in saline waters.

Dissolved Oxygen

- Dissolved oxygen (DO) concentrations can be affected by wave and tidal actions. Movement of water can lead to a higher concentration of DO in the waterbody.
- You can measure DO with a test kit or oxygen meter. More information about measuring DO is in Section 4.

Total Suspended Solids

- Total suspended solids (TSS) is a measure of solids suspended in water. These materials can be soils from erosion, silt, decaying plant and animal matter, and other materials discharged into a waterbody (e.g., via runoff). Solids are measured by filtering a sample of water and weighing the residue.

5.10 Part 10: Modeling and Other Studies

In this section on the *Marine Annual Sanitary Survey* you provide details on predictive models used at your swim area. You can also provide information on other studies that have been done that provide information related to water quality, including quantitative microbial risk assessment (QMRA), microbial source tracking (MST), tests for optical brighteners, smoke testing for sanitary sewer cross connections, and results of visual screening for pollutants. If other studies were done, summarize those as well.

Predictive models

Predictive models are used to estimate FIB concentrations (USEPA 2010; Gonzalez et al. 2012). They are based on single or multiple correlations between hydrologic meteorology or other data with FIB 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 FIB counts is mostly in the models' timeliness. Culture methods for analyzing 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. 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 swim area 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. If you are not using models but have plans to use them in the future, describe your plans in the Comments/Observations field.

Quantitative microbial risk assessment (QMRA)

QMRA can be used to predict the illness risk to beachgoers from pathogens attributed to nonpoint sources at recreational waters. If a QMRA has been done on your beach you should summarize the conclusions from the study in the Marine Annual Sanitary Survey and consider the results as you review other pollution source data.

Microbial source tracking (MST)

MST methods are sometimes used to help identify nonpoint sources responsible for the fecal pollution of water systems. MST tools are now being applied in developing TMDLs as part of Clean Water Act requirements and in the evaluation of the effectiveness of best management practices.

MST might be a useful tool for managers of recreational waters too. MST can be used to detect and quantify specific types of fecal contamination to a beach, estuary, or other waterbody. The studies need to be done over a range of conditions, and it is important to make measurements of markers that are relevant for use in your geographic area.

Selection of MST tools and approaches are dependent on the goals of the study and the availability of technical and financial support. If MST has been done at your beach you should summarize the conclusions from the study in the *Annual Sanitary Survey* and consider the results as you review other pollution source data.

Optical brighteners

Optical brighteners are often used in commercial or retail products such as detergents and personal care products. Excess product is typically flushed down the drain, so the presence of optical brighteners in water can indicate human sources of contamination (i.e., from an illicit discharge/straight pipe or graywater, or malfunctioning septic system) (Maine Healthy Beaches Program 2010). A beach or program manager can determine whether a test for optical brighteners would be useful at a beach. If a test for optical brighteners has been done you should summarize the results in the Annual Survey and consider them as you review other pollution source data. Optical brightener data should be treated with care because specific compounds can cause false positive readings. Therefore, newer approaches such as that presented by Cao et al. (2013) should be used to ensure that false positives have been appropriately assessed.

Smoke testing for sanitary sewer cross connections

Smoke testing can be used to find leaks in sewer systems responsible for inflow and infiltration that could lead to high flows during storm events. It can be used to find cross connections between sanitary and storm sewers. During the test, smoke-filled air is forced through a sewer system, and leaks are detected by points where the smoke escapes. Leaks can be from things such as broken pipes, cracks in pavement, and improper connections. You can check with your public utilities whether smoke testing has been done for the sewer system near your beach.

Visual screening

A visual inspection of the recreational area can provide useful information for managing the area. You can walk or drive around the area to inspect for pollution sources and issues. Take notes and photos of what you find and make sure they are documented, as appropriate. This type of inspection could also provide details about what types of issues might need future investigation.

5.11 Part 11: Advisories/Closings

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

By finding out the number of days the swim area was under advisory or closed during a season, a manager of recreational waters can determine whether overall water quality at a swimming beach is improving or declining. Bacteria levels can be compared to the 2012 Recreational Water Quality Criteria statistical threshold values or beach action values recommendations to determine if there were exceedances. In addition, a manager of recreational waters can determine whether the dates the swim area was under advisory or closed during a season correlate with conditions, such as rain events, elevated water temperatures, pollutant discharges, high winds, or high wildlife counts. The manager of recreational waters should be able to obtain notes on the beach conditions during sample collection from previous routine sanitary surveys conducted. Multiple advisories and closings can be reported in the table in the *Marine Annual Sanitary Survey*.

5.12 Part 12: Potential Pollution Sources

The most important objectives of the beach sanitary survey are to identify sources that affect the swim area, determine their exact location, and measure or calculate the source contribution. The manager of recreational waters should compile potential pollution information from previously completed *Marine Routine Sanitary Surveys*. The manager of recreational waters 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 recreational water quality; and add this information, along with corresponding latitude and longitude data, to this part of the *Marine Annual Sanitary Survey*. The manager of recreational waters, with the assistance of a sanitarian or public health official, should then estimate the percent annual contribution and peak contribution amounts for each potential pollution source. This information will be very useful for prioritizing the potential sources for further investigation.

Potential pollution sources are listed in Section 11 of the Annual Sanitary Survey form. Some resources might be useful in helping you locate pollution sources. For example, you can access the Permit Compliance System and Integrated Compliance Information System databases (PCS-ICIS) 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 pollution and potential sources of discharge. You can use the aerial photos on map sites like Google Earth.

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. Consult Section 3.3 for links to Clean Water Act programs with potential sources of pollutants affecting the water.

5.13 Part 13: Description of Sanitary Facilities and Other Facilities

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

5.14 Part 14: Description of Other Facilities

If other facilities, such as restaurants, play areas, or parking lots that could be a source of pollutants are present, document and photograph 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 area to determine their original intended capacity.

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