Appendix A: Beach Guidance Review Team

The authors gratefully acknowledge the many comments received from the state and local environmental and health agency members and the environmental group members of the external Beach Guidance Review Team. These members include:

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Sarah Chasis, Natural Resources Defense Council
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Linda Eichmiller, Association of State and Interstate Water Pollution Control Administrators
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Mark Gold, Heal the Bay
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Catherine Hazelwood, The Ocean Conservancy
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Susan Sylvester, WI Department of Natural Resources
Sol Sussman, Texas General Land Office
Mitzy Taggart, Heal the Bay
Blake Traudt, Texas General Land Office
Leslie Williams, Florida Department of Environmental Protection

Appendix B: EPA Grant Coordinators

Table B-1 provides the names of the EPA headquarters and regional Grant Coordinators and corresponding contact information.

Table B-1. Regional Grant Coordinators

Region	Name	Address	Telephone/Fax	E-mail
Headquarters Washington, DC	Charles Kovatch	USEPA 1200 Pennsylvania Ave., NW Mail code: 4305 Washington, DC 20460	202-566-0399 202-566-0409	kovatch.charles@epa.gov
Region 1 Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island	Matt Liebman	USEPA Region 1 One Congress Street Suite 1100-CWQ Boston, MA 02114-2023	617-918-1626 617-918-1505	liebman.matt@epa.gov
Region 2 New Jersey, New York, Puerto Rico, U.S. Virgin Islands	Helen Grebe	USEPA Region 2 2890 Woodbridge Ave. (MS220) Edison, NJ 08837-3679	732-321-6797 732-321-6616	grebe.helen@epa.gov
Region 3 Delaware, Maryland, Pennsylvania, Virginia	Nancy Grundahl	USEPA Region 3 1650 Arch Street (3ES10) Philadelphia, PA 19103-2029	215-814-2729 215-814-2782	grundahl.nancy@epa.gov
Region 4 Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina	Joel Hansel	USEPA Region 4 61 Forsyth Street, 15th Floor Atlanta, GA 30303-3415	404-562-9274 404-562-9224	hansel.joel@epa.gov
Region 5 Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin	Holly Wirick	USEPA Region 5 77 West Jackson Blvd. (WQ-16J) Chicago, IL 60604-3507	312-353-6704 312-886-0168	wirick.holiday@epa.gov
Region 6 Louisiana, Texas	Mike Schaub	USEPA Region 6 1445 Ross Ave. (6WQ-EW) Dallas, TX 75202-2733	214-665-7314 214-665-6689	schaub.mike@epa.gov

Table B-1. (continued)

Region	Name	Address	Telephone/Fax	E-mail
Region 9 American Samoa, California, Commonwealth of the Northern Mariana Islands, Guam, Hawaii	Terry Fleming	USEPA Region 9 75 Hawthorne Street (WTR-2) San Francisco, CA 94105	415-972-3462 415-947-3537	fleming.terrence@epa.gov
Region 10 Alaska, Oregon, Washington	Rob Pedersen	USEPA Region 10 120 Sixth Ave. (OW-134) Seattle, WA 98101	206-553-1646 206-553-1065	pedersen.rob@epa.gov

Appendix C: BEACH Act and BEACH Act Fact Sheet

PUBLIC LAW 106–284—OCT. 10, 2000

BEACHES ENVIRONMENTAL ASSESSMENT AND COASTAL HEALTH ACT OF 2000

Public Law 106–284
106th Congress

An Act

Oct. 10, 2000
[H.R. 999]

To amend the Federal Water Pollution Control Act to improve the quality of coastal recreation waters, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Beaches Environmental Assessment and Coastal Health Act of 2000.
Inter-governmental relations.
Public health and safety.
33 USC 1251 note.

SECTION 1. SHORT TITLE.

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

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

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

"(i) COASTAL RECREATION WATER QUALITY CRITERIA.—

Deadlines.

"(1) ADOPTION BY STATES.—

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

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

"(2) FAILURE OF STATES TO ADOPT.—

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

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

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

SEC. 3. REVISIONS TO WATER QUALITY CRITERIA.

(a) STUDIES CONCERNING PATHOGEN INDICATORS IN COASTAL RECREATION WATERS.—Section 104 of the Federal Water Pollution Control Act (33 U.S.C. 1254) is amended by adding at the end the following:

"(v) STUDIES CONCERNING PATHOGEN INDICATORS IN COASTAL RECREATION WATERS.—Not later than 18 months after the date of the enactment of this subsection, after consultation and in cooperation with appropriate Federal, State, tribal, and local officials (including local health officials), the Administrator shall initiate, and, not later than 3 years after the date of the enactment of this subsection, shall complete, in cooperation with the heads of other Federal agencies, studies to provide additional information for use in developing— Deadlines.

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

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

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

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

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

"(9) REVISED CRITERIA FOR COASTAL RECREATION WATERS.— Deadlines.

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

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

SEC. 4. COASTAL RECREATION WATER QUALITY MONITORING AND NOTIFICATION.

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

33 USC 1346.

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

Deadline. Publication.

“(a) MONITORING AND NOTIFICATION.—

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

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

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

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

“(b) PROGRAM DEVELOPMENT AND IMPLEMENTATION GRANTS.—

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

“(2) LIMITATIONS.—

“(A) IN GENERAL.—The Administrator may award a grant to a State or a local government to implement a monitoring and notification program if—

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

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

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

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

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

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

"(3) OTHER REQUIREMENTS.—

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

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

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

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

"(4) FEDERAL SHARE.—

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

"(B) NON-FEDERAL SHARE.—The non-Federal share of the costs of developing and implementing a monitoring and notification program may be—

"(i) in an amount not to exceed 50 percent, as determined by the Administrator in consultation with State, tribal, and local government representatives; and

"(ii) provided in cash or in kind.

"(c) CONTENT OF STATE AND LOCAL GOVERNMENT PROGRAMS.—As a condition of receipt of a grant under subsection (b), a State or local government program for monitoring and notification under this section shall identify—

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Deadline.

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

"(1) protects the public health and safety;

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

Reports.

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

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

Public information.

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

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

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

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

"(B) the Administrator determines should be included.

"(f) TECHNICAL ASSISTANCE FOR MONITORING FLOATABLE MATERIAL.—The Administrator shall provide technical assistance to States and local governments for the development of assessment and monitoring procedures for floatable material to protect public health and safety in coastal recreation waters.

"(g) LIST OF WATERS.—

Deadline.

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

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

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

Public information.

Federal Register, publication.

"(2) AVAILABILITY.—The Administrator shall make the list described in paragraph (1) available to the public through—

"(A) publication in the Federal Register; and

"(B) electronic media.

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

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

"(1) to conduct monitoring and notification; and

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

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

SEC. 5. DEFINITIONS.

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

"(21) COASTAL RECREATION WATERS.—

"(A) IN GENERAL.—The term 'coastal recreation waters' means—

"(i) the Great Lakes; and

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

"(B) EXCLUSIONS.—The term 'coastal recreation waters' does not include—

"(i) inland waters; or

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

"(22) FLOATABLE MATERIAL.—

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

"(B) INCLUSIONS.—The term 'floatable material' includes—

"(i) plastic;

"(ii) aluminum cans;

"(iii) wood products;

"(iv) bottles; and

"(v) paper products.

"(23) PATHOGEN INDICATOR.—The term 'pathogen indicator' means a substance that indicates the potential for human infectious disease.".

SEC. 6. INDIAN TRIBES.

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

33 USC 1375a.

SEC. 7. REPORT.

Deadline.

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

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

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

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

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

SEC. 8. AUTHORIZATION OF APPROPRIATIONS.

There are authorized to be appropriated to carry out the provisions of this Act, including the amendments made by this Act, for which amounts are not otherwise specifically authorized to be appropriated, such sums as are necessary for each of fiscal years 2001 through 2005.

Approved October 10, 2000.

LEGISLATIVE HISTORY—H.R. 999 (S. 522):

HOUSE REPORTS: No. 106–98 (Comm. on Transportation and Infrastructure).
SENATE REPORTS: No. 106–366 accompanying S. 522 (Comm. on Environment and Public Works).
CONGRESSIONAL RECORD:
Vol. 145 (1999): Apr. 22, considered and passed House.
Vol. 146 (2000): Sept. 21, considered and passed Senate, amended.
Sept. 26, House concurred in Senate amendment.
WEEKLY COMPILATION OF PRESIDENTIAL DOCUMENTS, Vol. 36 (2000):
Oct. 10, Presidential statement.

United States Environmental Protection Agency | Office of Water (4305) | EPA 823-F-01-06 January 2001

Beaches Environmental Assessment and Coastal Health Act of 2000 Public Law 106-284

Overview

On October 10, 2000, the Beaches Environmental Assessment and Coastal Health Act was signed into law. This new law authorizes a national grant program to assist state, tribal, and local governments in developing and implementing monitoring and public notification programs for their coastal recreation waters. It also requires states to adopt improved water quality standards for pathogens and pathogen indicators and requires EPA to conduct studies and develop improved microbiological water quality criteria guidance. In addition, the law requires EPA to develop performance criteria for monitoring, notification, and public information databases and requires other federal agencies to establish certain programs.

BEACH Watch

Purpose and Title

This legislation amends the Federal Water Pollution Control Act (also known as the Clean Water Act, or CWA) to improve the quality of coastal recreation waters and attain other objectives. The following summary is provided for the convenience of the reader. It does not substitute for the statute. Grant applicants should consult the statute and applicable grant regulations prior to filing such applications.

Section 1. Short Title

"Beaches Environmental Assessment and Coastal Health Act of 2000"

Water Quality Standards and Criteria

Section 2. Adoption of Coastal Recreation Water Quality Criteria and Standards by States

The provisions of this section amend section 303 of the CWA with respect to the following:

- ***Initial Criteria and Standards***: *[By April 10, 2004]*, states having coastal recreation waters are required to adopt water quality criteria and standards for pathogens and pathogen indicators for which the EPA Administrator has published criteria under the act. *[This refers to EPA's 1986 Water Quality Criteria for Bacteria.]*
- ***New or Revised Criteria and Standards***: Requires states to adopt new or revised standards for coastal recreation waters not later than 36 months after the EPA Administrator publishes new or revised criteria guidance for pathogens and pathogen indicators.
- ***Failure to Adopt***: If a state fails to adopt criteria and standards for pathogens and pathogen indicators that are "as protective of human health as EPA criteria *[by April 10, 2004]*," the EPA Administrator shall promptly propose regulations setting forth revised criteria and standards.

Section 3. Revisions to Water Quality Criteria

This section adds the following to section 104 of the CWA as "Studies Concerning Pathogen Indicators In Coastal Recreation Waters":

- ***New Studies***: *[By October 10, 2003]*, the EPA Administrator shall complete studies for use in developing: (1) an assessment of potential health risks from exposure to pathogens in coastal recreation waters; (2) appropriate and effective indicators and appropriate, accurate, and expeditious methods for detecting or predicting the presence of pathogens in coastal recreational waters; and (3) guidance for state application of EPA's criteria guidance for pathogens to account for the diversity of geographic and aquatic conditions.
- ***Revised Criteria***: Requires the EPA Administrator to publish new or revised water quality criteria guidance for pathogens in such waters not later than *October 10, 2005*. Criteria is to be reviewed at least once every five years thereafter.

A copy of the Beaches Environmental Assessment and Coastal Health Act can be found on the BEACH Watch website at <www.epa/ost/beaches>.

Monitoring and Notification

Section 4. Coastal Recreation Water Quality Monitoring and Notification

The provisions of this section amend Title IV of the CWA to add section 406, “Coastal Recreation Water Quality Monitoring and Notification.” This section includes the following provisions:

- ***Monitoring and Notification Performance Criteria***: Directs the EPA Administrator, by *April 10, 2002,* to publish “performance criteria” for a monitoring and notification grants program. The criteria will address the following topics: (1) the monitoring and assessment of coastal recreation waters adjacent to beaches for attainment of water quality standards for pathogens, including methods for such monitoring and assessment; and (2) prompt notification of local governments, the public, and the EPA Administrator of exceedances, or the likelihood of exceedances, of standards for such waters so that public health and safety can be maintained.
- ***Program Development and Implementation Grants***: Authorizes the EPA Administrator to make grants to states, tribes, and local governments to develop and implement monitoring and notification programs. To qualify for an implementation grant, a grantee would need to: (1) be consistent with EPA’s performance criteria; (2) prioritize use of grant funds based on use of the water and risk to human health, and identify factors considered in setting priorities; (3) develop a list of waters not subject to the monitoring and notification program due to fiscal constraints; and (4) provide an opportunity for public comment. States may delegate responsibilities and provide funding to local governments to implement a program. Local agencies may also apply for a grant under certain circumstances.
- ***Content of State, Tribal, and Local Programs***: As a condition of the grant, a state, tribe, or local government shall: (1) list coastal recreational waters adjacent to beaches used by the public; (2) identify the delegation process; (3) identify monitoring and assessment methods including frequency and location of monitoring; and (4) identify communication procedures and measures.
- ***Federal Agency Programs***: Requires Federal agencies to develop programs for certain coastal recreation waters within three years. These programs should be designed to: (1) protect public health and safety; (2) meet EPA’s performance criteria; and (3) address certain other matters required for state and local programs.
- ***EPA Database and Technical Assistance***: Directs the EPA Administrator to: (1) establish a national coastal recreation water pollution occurrence database; and (2) provide technical assistance for development of assessment and monitoring procedures for floatable materials in those waters.
- ***List of Waters***: EPA is required to maintain a publicly available “list of waters” that are subject to a monitoring and notification program, as well as those not subject to a program because of fiscal constraints.
- ***EPA Implementation***: In states that do not have a program consistent with EPA’s performance criteria, EPA is required to conduct such a program for listed priority waters using grant funds that otherwise would have been awarded to those states. This “backstop” would commence three years after EPA lists waters in such states.
- ***Authorization of Appropriations***: Authorizes annual appropriations of $30 million for fiscal years 2001 through 2005. *[Actual funding levels depend on specific appropriations enacted annually by Congress.]*

Other Provisions

Section 5. Definitions

- ***Defines “Coastal Recreation Waters”***: This term includes: “(i) the Great Lakes and (ii) marine coastal waters (including coastal estuaries) that are designated under section 303(c) by a State for use for swimming, bathing, surfing, or similar water contact activities.” The term does not include “(i) inland waters or (ii) waters upstream of the mouth of a river or stream having an unimpaired natural connection with the open sea.”

Section 6. Indian Tribes

- ***Tribes Are Treated Like States***: Adds language which allows EPA to treat Indian tribes in a manner similar to states for purposes of section 406 of the act, which include coastal recreation water quality monitoring and notification programs and grants. EPA already had authority to treat tribes in a manner similar to states for purposes of section 303 of the act.

Section 7. Report

- ***Reporting Schedule***: Requires that EPA report to Congress every four years.

Section 8. Authorization of Appropriations

- ***Appropriation Authority***: Authorizes appropriations to carry out the act.

Appendix D: Indicator Organisms

This appendix provides further background information about indicator organisms and EPA's review of epidemiological studies. For a more complete discussion, refer to EPA's *Implementation Guidance for Ambient Water Quality Criteria for Bacteria* (USEPA, 2000).

D.1 Organisms That Can Indicate Fecal Contamination

Because many pathogens are not easily detected, indicator organisms are a fundamental monitoring tool used to measure both changes in environmental (water) quality or conditions and the potential presence of hard-to-detect target pathogenic organisms. An indicator organism provides evidence of the presence or absence of a pathogenic organism surviving under similar physical, chemical, and nutrient conditions. For fecal contamination, indicator organisms should (Sloat and Ziel, 1992; Thomann and Mueller, 1987):

- Be easily detected using simple laboratory tests.
- Generally not be present in unpolluted waters.
- Appear in concentrations that can be correlated with the extent of contamination.
- Have a die-off rate that is not faster than the die-off rate of the pathogens of concern.

Indicator bacteria are usually harmless, more plentiful, and easier to detect than pathogens (Wilhelm and Maluk, 1999). Methods are not currently available to culture or enumerate all the disease-causing organisms that might be present in natural waters. For example, viruses and protozoans are generally not used as indicators because of difficulties associated with isolating them and detecting their presence in environmental samples. The bacteria species chosen as indicators are indigenous to the intestines of warm-blooded animals and indicate the potential presence of dangerous pathogens that can cause human illnesses.

Use and reliability are two factors that states and tribes should consider when selecting a pathogen indicator. The lack of correlation between certain indicators and pathogen-caused diseases in humans, as well as the uncertain relationship between indicators and different sources of pathogens, is a limitation of bacterial indicators. A positive result for the indicator organism means that the indicator is present in the waterbody, not necessarily that waterborne pathogens are also present. The presence of an indicator might not indicate whether those pathogens (if present) are viable or capable of causing disease and whether the source of the contamination is humans or other animals.

Indicators vary in their ability to reliably predict potential risks to human health. Some indicators have been shown to have a greater statistical relationship to disease than others. Also, current

indicators are based on fecal contamination and might not accurately assess the potential for disease from other pathogens that can cause skin, upper respiratory tract, eye, ear, nose, and throat disease (USEPA, 1999). More research on the use of other bacteria and viruses as indicators is being conducted at the federal, state, and local levels. Despite variability in the ability of indicators to reliably predict potential risks to human health, EPA studies indicate that enterococci and *E. coli* are the most effective available primary indicators for predicting the presence of gastrointestinal illness-causing pathogens,
and for marine waters, enterococci is most appropriate.

One area of current scientific debate is whether indicator bacteria react differently under various climatic and environmental conditions. Preliminary evidence suggests that *E. coli* and enterococci can be detected at tropical locales such as Puerto Rico, Hawaii, and Guam in waters where there is no apparent source of contamination from warm-blooded animals (USEPA, 1999). EPA and others are evaluating whether the current indicator bacteria grow and persist in natural tropical environments. If *E. coli* and enterococci are determined to propagate naturally in tropical conditions, EPA will conduct additional research to identify alternative indicators for tropical areas.

D.2 EPA's Review of Recent Epidemiological Studies

Since the publication of EPA's 1986 criteria, a number of studies related to bacterial indicators have been completed. Therefore, EPA reviewed relevant recent studies to determine whether the studies continue to support EPA's recommendation to use *E. coli* and enterococci as bacterial water quality indicators. EPA's review focused on the epidemiological studies that related swimming-associated health effects to marine and freshwater bacterial water quality using studies performed after 1984. (For a complete discussion of these studies, see EPA's *Implementation Guidance on Water Quality Criteria for Bacteria*, USEPA, 2000).

EPA's Office of Research and Development (ORD) concluded:

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

The new studies added an additional body of evidence that supports EPA's 1986 criteria. As a result of this examination, EPA determined that its 1986 water quality criteria for bacteria continue to represent the best available science and serve as a defensible foundation for protecting public health from gastroenteritis in recreational waters. EPA found no reason to undertake a revision of the criteria at that time (USEPA, 2000).

The following table includes the relevant findings of the research EPA reviewed that has been conducted on indicator organisms since 1986.

Table D-1. Summary of Research Conducted Since 1986

Researcher/Year/ Location	Type of Water	Microorganisms Evaluated	Relevant Findings
Fattal et al. (1987) Israel	Marine	Fecal coliforms Enterococci *Escherichia coli*	Of the indicators tested, enterococci were the most predictive indicator for enteric disease symptoms.
Cheung et al. (1990) Hong Kong	Marine	Fecal coliforms *E. coli* *Klebsiella* spp. Enterococci Fecal streptococci Staphylococci *Pseudomonas aeruginosa* *Candida albicans* Total fungi	Of the indicators tested, *E. coli* showed the highest significant correlation with combined swimming-associated gastroenteritis and skin symptom rates.
Balarajan et al. (1991) United Kingdom	Marine	Unknown	Risk of illness increased with degree of exposure.
Von Schirnding et al. (1992) South Africa (Atlantic Coast)	Marine	Enterococci Fecal coliforms Coliphages Staphylococci F-male-specific bacteriophages	Uncertainty about the sources of fecal contamination may explain the lack of statistically significant relationship rates of illness between swimmers and non-swimmers.
Corbett et al. (1993) Sydney, Australia	Marine	Fecal coliforms Fecal steptococci	Gastrointestinal symptoms in swimmers did not increase with increasing counts of fecal bacteria. Counts of fecal coliforms were better predictors of swimming-associated illness than streptococci.

Table D-1. (continued)

Researcher/Year/ Location	Type of Water	Microorganisms Evaluated	Relevant Findings
Kay et al. (1994) United Kingdom	Marine	Total coliforms Fecal coliforms Fecal streptococci *Pseudomonas aeruginosa* Total staphylococci	Compared to the other indicators tested, fecal streptococci were the best indicator of gastrointestinal symptoms.
Kueh et al. (1995) Hong Kong	Marine	*E. coli* Fecal coliforms Staphylococci *Aeromonas* spp. *Clostridium perfringens* *Vibrio cholera* *Vibrio parahemotylicus* *Salmonella* spp. *Shigella* spp.	No statistical relationship between *E. coli* and swimming-associated illness was found (possibly because only two beaches were sampled).
Fleisher et al. (1996) United Kingdom	Marine	Total coliform Fecal coliform Fecal streptococci Total staphylococci *Pseudomonas aeruginosa*	Nonenteric illness can be transmitted through recreational contact with marine waters contaminated with sewage.
Haile et al. (1996) California, USA	Marine	Total coliforms Fecal coliforms Enterococci *E. coli*	The association of symptoms with both *E. coli* and fecal coliforms was very weak
McBride et al. (1998) New Zealand	Marine	Fecal coliforms *E. coli* Enterococci	Enterococci were most strongly and consistently associated with illness risk for the exposed groups. If swimmers remained in the water for more than 30 minutes, the risk differences were significantly greater between swimmers and nonswimmers.
Seyfried et al. (1985) Canada	Fresh	Fecal coliforms Fecal streptococci Heterotrophic bacteria *Pseudomonas aeroginosa* Total staphylococci	A small correlation was observed between fecal streptococci and gastrointestinal illness.
Ferley et al. (1989) France	Fresh	Fecal coliforms Fecal streptococci	The best relationship is between fecal streptococci and gastrointestinal illness.

Table D-1. (continued)

Researcher/Year/ Location	Type of Water	Microorganisms Evaluated	Relevant Findings
Francy et al. (1993) Ohio, USA	Fresh	*E. coli* Fecal coliforms	In this study, the relationship between *E. coli* and fecal coliform bacteria was found to be statistically significant. This relationship can differ from one data source to another.

D.3 References

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Appendix E: Draft Data Elements

The following is a draft list of data elements for states, territories, and tribes to use when developing their databases and electronic data reporting systems. The data elements cover general program information, beach monitoring data fields, swimming advisory fields, and location data which may be submitted to EPA to meet the grant requirements.

Table E-1. Beaches Program Tracking Draft Data Element List

Table	Description	Type of User Entry
Beach Tracking One-time Submissions		
Beach		
Name	Typical beach name (e.g., Jones beach)	Free-text entry
Description	Beach descriptive information (e.g., relative location, season length)	Free-text entry
Comment Text	Additional descriptive information about a beach	Free-text entry
Organization		
Organization Type	Grouping of organizations (e.g., state agency, local agency, public interest group)	Chosen from List of Possible Data Elements
Organization Role	Grouping of possible organization roles for a beach (e.g., sampling agency, lead beach agency, laboratory)	Chosen from List of Possible Data Elements
Name	Typical organization name or an organization affiliated with a beach (e.g., x state Dept. of Environmental Protection)	Free-text entry
Description	Descriptive information about an organization affiliated with a beach	Free-text entry
Short Name/Abbreviation	Typical abbreviation of an organization's name (e.g., state DEP)	Free-text entry
State Lead Contact		
First Name	The first name of a person affiliated with a beach	Free-text entry
Last Name	The last name of a person affiliated with a beach	Free-text entry
Middle Initial	The middle initial of a person affiliated with a beach	Free-text entry
Suffix	The suffix of a person affiliated with a beach (e.g., MD)	Free-text entry
Title	The title of a person affiliated with a beach (that person's official title in his/her job or organization, not that person's role with respect to the beach)	Free-text entry
Suite/POBox/Street First Line	First line of a street address, suite name, or Post Office (PO) box for an organization or person	Free-text entry
Suite/POBox/Street Second Line	Second line of a street address, suite name, or PO box for an organization or person	Free-text entry

Table E-1. (continued)

Table	Description	Type of User Entry
Suite/POBox/Street Third Line	Third line of a street address, suite name, or PO box for an organization or person	Free-text entry
City Name	Name of the city in an address for an organization or person	Free-text entry
State	Two-character representation of the state for an organization or person	Chosen from List of Possible Data Elements
ZIP Code	The ZIP Code for an organization or person	Free-text entry
Nonelectronic Address Type	Grouping of addresses used to indicate what type of nonelectronic address an organization or person uses (e.g., mailing address)	Chosen from List of Possible Data Elements
Address Start Date	Used for historical purposes to indicate when an address is entered or will begin being used	Free-text entry
Address Stop Date	Used for historical purposes to indicate when an address is no longer used	Free-text entry
Beach Lead Contact		
First Name	The first name of a person affiliated with a beach	Free-text entry
Last Name	The last name of a person affiliated with a beach	Free-text entry
Middle Initial	The middle initial of a person affiliated with a beach	Free-text entry
Suffix	The suffix of a person affiliated with a beach (e.g., MD)	Free-text entry
Title	The title of a person affiliated with a beach (that person's official title in his/her job or organization, not that person's role with respect to the beach)	Free-text entry
Suite/POBox/Street First Line	First line of a street address, suite name, or PO box for an organization or person	Free-text entry
Suite/POBox/Street Second Line	Second line of a street address, suite name, or PO box for an organization or person	Free-text entry
Suite/POBox/Street Third Line	Third line of a street address, suite name, or PO box for an organization or person	Free-text entry
City Name	Name of the city in an address for an organization or person	Free-text entry
State	Two-character representation of the state for an organization or person	Chosen from List of Possible Data Elements
ZIP Code	The ZIP code for an organization or person	Free-text entry
Nonelectronic Address Type	Grouping of addresses used to indicate what type of nonelectronic address an organization or person uses (e.g., mailing address)	Chosen from List of Possible Data Elements
Address Start Date	Used for historical purposes to indicate when an address is entered or will begin being used	Free-text entry

Table E-1. (continued)

Table	Description	Type of User Entry
Address Stop Date	Used for historical purposes to indicate when an address is no longer used	Free-text entry
Notification Lead Contact		
First Name	The first name of a person affiliated with a beach	Free-text entry
Last Name	The last name of a person affiliated with a beach	Free-text entry
Middle Initial	The middle initial of a person affiliated with a beach	Free-text entry
Suffix	The suffix of a person affiliated with a beach (e.g., MD)	Free-text entry
Title	The title of a person affiliated with a beach (that person's official title in his/her job or organization, not that person's role with respect to the beach)	Free-text entry
Suite/POBox/Street First Line	First line of a street address, suite name, or PO Box for an organization or person	Free-text entry
Suite/POBox/Street Second Line	Second line of a street address, suite name, or PO Box for an organization or person	Free-text entry
Suite/POBox/Street Third Line	Third line of a street address, suite name, or PO Box for an organization or person	Free-text entry
City Name	Name of the city in an address for an organization or person	Free-text entry
State	Two-character representation of the state for an organization or person	Chosen from List of Possible Data Elements
ZIP Code	Number of the ZIP code for an organization or person	Free-text entry
Nonelectronic Address Type	Grouping of addresses used to indicate what type of nonelectronic address an organization or person uses (e.g., mailing address)	Chosen from List of Possible Data Elements
Address Start Date	Used for historical purposes to indicate when an address is entered or will begin being used	Free-text entry
Address Stop Date	Used for historical purposes to indicate when an address is no longer used	Free-text entry
Electronic Address (to be included for all contacts)		
Description	Description of the electronic address for an organization or person	Free-text entry
Electronic Address Type	Grouping of electronic addresses used to indicate what type of electronic address an organization or person uses (e.g., URL, e-mail)	Chosen from List of Possible Data Elements
Address Start Date	Used for historical purposes to indicate when an address is entered or will begin being used	Free-text entry
Address Stop Date	Used for historical purposes to indicate when an address is no longer used	Free-text entry

Table E-1. (continued)

Table	Description	Type of User Entry
Telephone (to be included for all contacts)		
Number	Numeric representation of the phone number for an organization or person	Free-text entry
Number Start Date	Used for historical purposes to indicate when a number is entered or will begin being used	Free-text entry
Number Stop Date	Used for historical purposes to indicate when a number is no longer used	Free-text entry
Phone Type	Grouping of phone numbers used to indicate what type of phone number an organization or person uses (e.g., fax, voice)	Chosen from List of Possible Data Elements
Advisory/Closing/ Posting Procedure		
Organization Role	Grouping of possible organization roles for a beach-specific procedure (e.g., issuance authority, notification authority)	Chosen from List of Possible Data Elements
Procedure Type	Grouping of procedures used to indicate what type of procedure is being performed by the beach for advisories, closings, and postings (e.g., issuance method, determination method)	Chosen from List of Possible Data Elements
Procedure Name	Typical name used for the beach-specific advisory, closing, or posting procedure	Free-text entry
Procedure Description	Description of the beach-specific advisory, closing, or posting procedure	Free-text entry
Beach Tracking Continuous Submissions		
Beach Activity		
Activity Type	Grouping of beach activities that indicates what type of activity is being performed (e.g., closure, advisory, posting)	Chosen from List of Possible Data Elements
Name	Name of the specific beach activity being performed	Free-text entry
Actual Start Date	Start date of the specific beach activity being performed (e.g., beach closure begin date)	Free-text entry
Actual End Date	Stop date of the specific beach activity being performed (e.g., beach closure end date)	Free-text entry
Description	Description of the specific beach activity being performed	Free-text entry
Comment Text	Comments about the specific beach activity being performed	Free-text entry
Activity Status	Status of the specific activity being performed (e.g., active, rescinded)	Chosen from List of Possible Data Elements
Reason	The specific reason why the beach activity is being performed (e.g., criteria exceeded)	Chosen from List of Possible Data Elements

Table E-1. (continued)

Table	Description	Type of User Entry
Reason Description/Source	Additional descriptive information regarding the reason that a beach activity is being performed, including specific source information	Free-text entry
Monitoring One-time Submissions		
Sampling Station		
Station Identifier	User-defined identifier for beach sampling location	Free-text entry
Station Name	Common name for beach sampling location	Free-text entry
Station Description	Text describing the sampling station and/or beach monitoring area	Free-text entry
Water Level Measure	Water depth at sampling site	Free-text entry
Water Level Unit Code	Unit code associated with water level measure	Chosen from List of Possible Data Elements
Sampling Location Point		
Absolute Location Point Type	Type of location point (e.g., point of record, sampling)	Chosen from List of Possible Data Elements
Geopositioning Datum Code	The code that represents the reference datum used in determining latitude and longitude coordinates	Chosen from List of Possible Data Elements
Geopositioning Method Code	The method used to determine the latitude and longitude coordinates for a point on earth	Chosen from List of Possible Data Elements
Latitude Direction	North or South	Chosen from List of Possible Data Elements
Latitude Measure - Degrees	Degree component of latitude measure	Free-text entry
Latitude Measure - Minutes	Minute component of latitude measure	Free-text entry
Latitude Measure - Seconds	Second component of latitude measure	Free-text entry
Longitude Direction	East or West	Chosen from List of Possible Data Elements
Longitude Measure - Degrees	Degree component of longitude measure	Free-text entry
Longitude Measure - Minutes	Minute component of longitude measure	Free-text entry
Longitude Measure - Seconds	Second component of longitude measure	Free-text entry
Associated Estuary	Name of estuary associated with the location point	Free-text entry

Table E-1. (continued)

Table	Description	Type of User Entry
Great Lake Waterbody Name	Name of Great Lake waterbody associated with the location point	Chosen from List of Possible Data Elements
Ocean Waterbody Name	Name of ocean waterbody associated with the location point	Chosen from List of Possible Data Elements
Shore Relation	Indicates if the station is nearshore or offshore	Chosen from List of Possible Data Elements
Pollution Source Location Point		
Geopositioning Datum Code	The code that represents the reference datum used in determining latitude and longitude coordinates	Chosen from List of Possible Data Elements
Geopositioning Method Code	The method used to determine the latitude and longitude coordinates for a point on earth	Chosen from List of Possible Data Elements
Latitude Direction	North or South	Chosen from List of Possible Data Elements
Latitude Measure - Degrees	Degree component of latitude measure	Free-text entry
Latitude Measure - Minutes	Minute component of latitude measure	Free-text entry
Latitude Measure - Seconds	Second component of latitude measure	Free-text entry
Longitude Direction	East or West	Chosen from List of Possible Data Elements
Longitude Measure - Degrees	Degree component of longitude measure	Free-text entry
Longitude Measure - Minutes	Minute component of longitude measure	Free-text entry
Longitude Measure - Seconds	Second component of longitude measure	Free-text entry
Associated Estuary	Name of estuary associated with the location point	Free-text entry
Waterbody Name	Name of Great Lake waterbody associated with the location point	Chosen from List of Possible Data Elements
Waterbody Name	Name of ocean waterbody associated with the location point	Chosen from List of Possible Data Elements
Shore Relation	Indicates if the station is nearshore or offshore	Chosen from List of Possible Data Elements
Beach Station Assignment		
Beach/Project Name	Name of beach associated with sampling station	Chosen from List of Possible Data Elements

Table E-1. (continued)

Table	Description	Type of User Entry
Station Identification Code	Station identification code for sampling station	Chosen from List of Possible Data Elements
Beach Program Assignment		
Beach/Project Name	Name of beach associated with federal program	Chosen from List of Possible Data Elements
Program Identification Code	Program code associated with federal program	Chosen from List of Possible Data Elements
Monitoring Lead Contact		
First Name	The first name of a person affiliated with a beach	Free-text entry
Last Name	The last name of a person affiliated with a beach	Free-text entry
Middle Initial	The middle initial of a person affiliated with a beach	Free-text entry
Suffix	The suffix of a person affiliated with a beach (e.g., MD)	Free-text entry
Title	The title of a person affiliated with a beach (that person's official title in his/her job or organization, not that person's role with regards to the beach)	Free-text entry
Suite/POBox/Street First Line	First line of a street address, suite name, or PO Box for an organization or person	Free-text entry
Suite/POBox/Street Second Line	Second line of a street address, suite name, or PO Box for an organization or person	Free-text entry
Suite/POBox/Street Third Line	Third line of a street address, suite name, or PO Box for an organization or person	Free-text entry
City Name	Name of the city in an address for an organization or person	Free-text entry
State	Two-character representation of the state for an organization or person	Chosen from List of Possible Data Elements
ZIP Code	The ZIP Code for an organization or person	Free-text entry
Nonelectronic Address Type	Grouping of addresses used to indicate what type of nonelectronic address an organization or person uses (e.g., mailing address)	Chosen from List of Possible Data Elements
Address Start Date	Used for historical purposes to indicate when an address is entered or will begin being used	Free-text entry
Address Stop Date	Used for historical purposes to indicate when an address is no longer used	Free-text entry
Electronic Address		
Description	Description of the electronic address for an organization or person	Free-text entry

Table E-1. (continued)

Table	Description	Type of User Entry
Electronic Address Type	Grouping of electronic addresses used to indicate what type of electronic address an organization or person uses (e.g., URL, e-mail)	Chosen from List of Possible Data Elements
Address Start Date	Used for historical purposes to indicate when an address is entered or will begin being used	Free-text entry
Address Stop Date	Used for historical purposes to indicate when an address is no longer used	Free-text entry
Telephone		
Number	Numeric representation of the phone number for an organization or person	Free-text entry
Number Start Date	Used for historical purposes to indicate when a number is entered or will begin being used	Free-text entry
Number Stop Date	Used for historical purposes to indicate when a number is no longer used	Free-text entry
Phone Type	Grouping of phone numbers used to indicate what type of phone number an organization or person uses (e.g., fax, voice)	Chosen from List of Possible Data Elements
Monitoring Continuous Submissions		
Field Activity		
Field Activity Category	Type of sample collected during field activity (e.g., composite, routine sample, observation)	Chosen from List of Possible Data Elements
Identification Code	User-defined identifier for field activity	Free-text entry
Start Date/Time	Start date and time of sampling activity	Free-text entry
Field Activity Beach Assignment		
Field Activity Identification Code	Field activity identification code	Free-text entry
Beach/Project Name	Name of beach associated with field activity	Chosen from List of Possible Data Elements
Sample		
Associated Field Activity	Field activity associated with this sample.	Chosen from List of Possible Data Elements
Total Volume	Total volume of collected sample	Free-text entry
Total Volume Unit Code	Unit code associated with total volume	Chosen from List of Possible Data Elements
Container Color	Color of sample collection container	Free-text entry
Container Type	Type of sample collection container	Free-text entry
Container Size	Size of sample collection container	Free-text entry

Table E-1. (continued)

Table	Description	Type of User Entry
Container Size Unit Code	Unit code associated with container size	Chosen from List of Possible Data Elements
Result		
Result Sequence Number	Result identification number	Free-text entry
Completion Indicator Code	Indicates whether the result is completely described	Chosen from List of Possible Data Elements
Result Value	Value of the result for the specified sample and characteristic	Free-text entry
Result Characteristic	Characteristic with which the result is associated. This includes both biological characteristics (e.g., *E. coli*, fecal coliform bacteria), as well as observation characteristics (e.g., weather conditions, air temperature, water temperature)	Chosen from List of Possible Data Elements
Result Unit of Measure	Unit code associated with result value	Chosen from List of Possible Data Elements
Result Status	Indicates if the result is preliminary or final	Chosen from List of Possible Data Elements
Analysis Date	Date on which the analysis was performed	Free-text Entry
Associated Field Activity	Identification code of the associated field activity	Chosen from List of Possible Data Elements
Analytical Procedure ID	Analytical procedure used in determining of the result	Chosen from List of Possible Data Elements
Result Lab Remark Assignment		
Associated Result	Result with which the remark is associated	Chosen from List of Possible Data Elements
Associated Lab Remark	Lab remark (e.g., "Sample or extract held beyond acceptable holding time.")	Chosen from List of Possible Data Elements

Appendix F: Beach Evaluation and Classification List

This appendix provides supplemental discussions, examples, and additional references that may be helpful to beach program managers. It does not create additional requirements beyond those in the main guidance document.

Table F-1 provides an example of information describing (1) the potential for risk to human health presented by pathogens, (2) use of the beach, and (3) other factors that can be used to rank and classify beaches. As indicated in chapter 3, coastal recreation waters adjacent to beaches or similar points of access should be classified in an appropriate tier based on the potential risk to human health presented by pathogens, and the use of the beach. Further ranking of waters that present an equal level of risk may be accomplished by considering information grouped in the category of "other factors" in the following table. The Beach Act also requires that the public be provided an opportunity to review the ranking program through a process that provides for public notice and an opportunity to comment.

Table F-1. Information to Consider When Ranking and Classifying Your Beaches

Category	Information
Potential Risk to Human Health Presented by Pathogens (Available Information)	State water quality reports
	Swimmers report health effects from this beach
	Advisories issued at this beach last year during the bathing season because of exceedance of water quality standard or preemptive standard
	Beach closed to bathing during the season last year because of health concerns or exceedance of water quality standard or preemptive standard
	Suspected sources of human pathogen contamination of the water at this beach
Potential Risk to Human Health Presented by Pathogens (Pollution Threats)	Industrial point sources
	Urban point sources: Publicly owned treatment works (POTWs)
	Urban nonpoint sources: Oil, pesticides, other toxics
	Urban nonpoint sources: Sewage, pathogens
	Urban nonpoint sources: Plastics and other floatables
	Agricultural nonpoint sources: Pesticides and other toxics
	Agricultural nonpoint sources: Nutrients/animal wastes

Table F-1. (continued)

Category	Information
Potential Risk to Human Health Presented by Pathogens (Sanitary Survey)	Annual rainfall for this area
	Number of significant rainfall events during the past year (e.g., more than 1 inch in 24 hours) that were known to contribute to pathogen contamination)
	Type of terrain within 5 miles of the beach
	Average high temperature during the swimming season
	Average temperature during the past 30 days
	Average flow if beach is on a river or an estuary with a flow
	Flow during past 30 days if beach is on a river or an estuary with a flow
	Nearshore water movement if beach is on an ocean, a lake, or other nonflowing waterbody with or without a tide
	Number of point source dischargers within 1 mile of this area (include outfalls)
	Area subject to combined sewer overflows (CSOs) or storm sewer overflows (SSOs)
	Area subject to agricultural runoff during storms
	Location of nearest POTW
	Number of POTWs within 5 miles of beach
	Approximate number of septic systems within 5 miles of beach
	Water treatment level in the area
	Number of animal feeding operations (AFOs, feedlots) or concentrated animal feeding operations (CAFOs) within 5 miles of beach
	Number of aquaculture facilities within 5 miles of beach
	Nature of discharges from AFOs, CAFOs, and aquaculture facilities to a waterbody adjacent to this beach
	Availability of sanitary facilities for the bathing public during the bathing season
	Number of marinas or pleasure craft with toilets
	Wild animals present on or near the beach
	Domesticated animals present on or near the beach
	Approximate number of birds per hour that frequent a typical 50-meter length of this beach or nearshore waters
	Pollution prevention and abatement efforts in this area

Table F-1. (continued)

Category	Information
Potential risk to Human Health Presented by Pathogens (Monitoring Data)	Number of exceedances of water quality standard per sampling station at a beach per month
Use of the Beach (Exposure Considerations)	Approximate area of beach open to bathers (length × width at high tide)
	Average number of days in the bathing season
	Percentage of beach visitors who go in the water
	Average density of bathers at peak season (include weekends and holidays)
	Average density of bathers during off-peak season
	Average density of bathers from the susceptible population (children, elderly)
Other Factors	Importance of the beach to the local economy
	If a program is not now in place at this beach, resources are available for developing a beach monitoring and notification program
	If a program is in place or planned, resources are available for maintaining a beach monitoring and notification program

Appendix G: Conducting a Sanitary Survey

This appendix provides supplemental discussions, examples, and additional references that may be helpful to beach program managers. It does not create additional requirements beyond those in the main guidance document.

Sanitary surveys are frequently associated with water supply systems. They are used to identify sources of pollution and provide information on source controls and identification, persistent problems, and management actions and links to controls. Thus, a sanitary survey can be an effective tool for protecting human health at bathing beaches and can provide information that helps in designing monitoring programs and selecting sampling locations, times, and frequencies.

Using Sanitary Surveys

In the past several years, Delaware has become increasingly concerned about having to close its beaches to swimming for extended periods because of bacterial contamination. Lake water quality and designated uses, such as public swimming, are threatened primarily by high levels of bacteria.

Trap Pond is one of Delaware's most important freshwater recreational resources. Located in the Nanticoke watershed, a Trap Pond is a priority watershed that drains into the Chesapeake Bay. Trap Pond is the recreational focus for Trap Pond State Park. Although the watershed has no point source discharges and little developmental pressure, erosion, pollution transport, and increased nutrient influx were contributing to the lake's surface water and ground water pollution. Increasing bacteria contamination and symptoms of accelerated eutrophication such as algal blooms were becoming increasingly obvious each season. A comparative study found that Saunders Branch, the major tributary to Trap Pond, had elevated bacteria and phosphorus levels.

Sanitary surveys revealed the two probable causes–a direct discharge from an underground septic system and livestock with direct access to the stream. Property owners were notified of the leaking septic systems and corrected the problem, and the bacteria levels decreased immediately in the affected area of Saunders Branch. Livestock accessibility, the second cause, was addressed with a 1-year section 319 grant of $84,419. This grant funded a conservation planner through the Sussex Conservation District and Soil Conservation Service. The planner provided technical assistance to implement animal waste management systems and nutrient management plans on farms throughout the watershed. Some 98 percent of the producers installed manure storage facilities, buffer strips, and other best management practices, and all producers fenced their livestock out of the streams.

(USEPA, 1999a)

G.1 When to Conduct a Sanitary Survey

A sanitary survey should be conducted in suspected high-risk situations to identify or confirm the presence or absence of contamination sources and to aid in beach classification. In addition, sanitary surveys may be performed periodically during a swimming season, when a bacterial exceedance is measured, or more frequently depending on the length of the bathing season (CTDEP, 1992; Figueras et al., 2000; Great Lakes-Upper Mississippi River Board of State Sanitary Engineers, 1990). A sanitary survey also should be conducted as part of any proposal to expand or develop a recreational beach area or when a newly proposed activity would significantly alter the water quality in an existing recreational beach area. The findings of the survey should receive prime consideration in any decision to proceed with development. In some states, such as Maryland, a permit for operation of a bathing beach may not be issued if a detailed sanitary survey reveals sources of pollution that affect or might affect the bathing beach (Maryland Department of Health and Mental Hygiene, 1978). If a significant pollution event occurs during the bathing season, a source identification should be conducted rather than a comprehensive sanitary survey.

G.2 Who Conducts a Sanitary Survey

The *EPA/State Joint Guidance on Sanitary Surveys* recommends that a Registered Sanitarian or a Registered Environmental Health Specialist conduct or supervise the sanitary survey. The Connecticut Department of Environmental Protection recommends that the local health department conduct a sanitary survey of any watershed that drains to a public bathing area (CTDEP, 1992). The Great Lakes-Upper Mississippi River Board of State Sanitary Engineers suggests that the official agency regulating the bathing beach or a person or persons acceptable to that agency should conduct the sanitary survey (Great Lakes –Upper Mississippi River Board of State Sanitary Engineers, 1990).

G.3 Steps for Performing a Sanitary Survey

The survey should identify new sources of microbiological hazards and evaluate the adequacy of the existing sampling program and the corrective measures in place to deal with existing hazards.

The *Guidance Manual for Conducting Sanitary Surveys of Public Water Systems: Surface Water and Ground Water Under the Direct Influence (GWUDI) of Surface Water* (USEPA, 1999) established four steps for conducting a comprehensive sanitary survey:

1. Plan the survey
2. Conduct the survey and site visit
3. Compile the sanitary survey report
4. Review and respond to the report

Examples of how to conduct a sanitary survey are also provided in the *Guidance Manual for Conducting Sanitary Surveys of Public Water Systems* (USEPA, 1999), the *National Shellfish Sanitation Program Model Ordinance* (NSSP, 1997), California's *Draft Guidance for Saltwater Beaches* (CADHS, 2000), California's *Draft Guidance for Freshwater Beaches* (CADHS, 2001). A brief description of the process is provided in the following paragraphs.

G.3.1 Planning the Survey

Before new survey activities are initiated, the previous sanitary survey report as well as any existing data or reports on the area should be reviewed. These materials will help design a thorough and efficient on-site evaluation. Data such as historical data on tides, currents, prevailing winds, rainfall, discharges of wastewater treatment plant effluent, storm water outfalls, combined sewer overflows, and urban and agricultural effluents could be collected. It is important to compile a checklist to ensure that all potential sources of pathogen contamination or other hazards that need to be identified are assessed during an on-site visit. The purpose of an on-site visit is to identify and evaluate all existing and potential sources of microbiological contamination that could affect the safe use of the area. The checklist in appendix F can help target areas to examine as part of the on-site evaluation.

G.3.2 Conducting the Sanitary Survey

For the purposes of this guidance, the significance of rainfall, climate, terrain, flow, and sources of pollution in the watershed and at the beach should be determined to aid in the beach evaluation process.

- **Rainfall and climate**. Pollution can typically be expected to reach a peak after rainfall when storm water runoff washes fecal material into receiving waters (Jagals, 1997). As part of the beach evaluation process, therefore, it can be helpful to identify the annual rainfall for the area, the pattern of rainfall in the 30 days before the survey (has it been below normal, normal, or above normal?), and the number of significant rainfall events (e.g., more than 1 inch in 24 hours) in the past year. The type of terrain, the permeability of the soils, and the storage characteristics of the watershed also can affect the rate at which runoff reaches the beach (Novotny and Olem, 1994). Very hilly or mountainous terrain increases the amount of runoff and the rate at which it reaches the beach. The average high temperature during the swimming season and the temperature pattern during the past 30 days can affect pathogen survival. Microbial growth rates tend to increase as temperatures rise (Auer and Niehaus, 1993).

- **Water flow**. The average flow and the flow during the last 30 days are important factors to consider for beaches on rivers or estuaries. For nonflowing waterbodies (lakes, oceans) with or without a tide, nearshore water movement is important to consider. Water movement affects the concentration of pathogens; waterbodies with little or no flow or water movement usually have higher pathogen concentrations.

- **Sources of pollution in the watershed**. Determining the location and impact of pollution sources in the watershed can also aid in the beach evaluation process. Pollution sources that are closer to the beach or that occur more frequently have a greater effect on the beach than pollution sources that are farther away and occur less frequently. These sources all have the potential to contribute to the bacterial and pathogen load affecting the recreational beach, and therefore it is important to identify them during a sanitary survey. Once the sources have been identified, public health can be protected by enforcing proper discharge levels (Thomann and Mueller, 1987; USEPA, 1994).

- **Water treatment level**. The water treatment level and pollution prevention and abatement efforts in the area also play an important role in beach evaluation. Tertiary treatment removes more pathogens than primary, secondary, or no treatment; therefore, areas where tertiary treatment occurs are at lower risk than areas where primary, secondary, or no treatment occurs (Thomann and Mueller, 1983). Pollution prevention and abatement efforts can help to minimize health risks to bathers. Areas that have excellent pollution prevention and abatement efforts can be of lower risk than areas where few such efforts occur.

- **Sources of pollution at the beach**. Human and animal fecal pollution that occurs at the beach is an important source of pollution. The adequacy of the sanitary facilities for the bathing public should be evaluated. Marinas, pleasure craft with toilets, wild or domestic animals and birds, and failing septic drainfields or tanks also can be direct sources of fecal pollution to recreational waters and the beaches adjacent to them (NRDC, 1999; USDHHS, 1994).

G.3.3 Compiling the Sanitary Survey Report

Final written reports for every sanitary survey should be prepared in a format that is consistent statewide (USEPA, 1999) or that meets the criteria of the particular program for which the sanitary survey is being conducted. The National Shellfish Sanitation Program (USFDA, 1997) recommends that the following components be included in sanitary survey reports for shellfish growing areas:

- An executive summary that includes a description of the area, a location map, and the history of the water quality of the area (if known).

- A pollution source survey, including a summary of the sources, a map or chart documenting the location of the major sources, and an evaluation of the pollution sources and the magnitude of the pollutants they produce.

- Information about physical factors that can affect the distribution and concentration of microorganisms and microbial water quality.

- A description of the hydrographic and meteorological characteristics, including tides, rainfall, winds, and river dischargers, and a summary discussion concerning the actual or potential effect of transport of pollution to the area.

- Water quality studies, including a map of the sampling stations; the sampling plan and justification; the sample data analysis; and presentation and interpretation of the data, including the effects of meteorological and hydrographic conditions on bacterial loading and the variability of the data.

- A conclusion section that includes recommendations for improvement.

The *Guidance Manual for Conducting Sanitary Surveys of Public Water Systems* (USEPA, 1999) suggests that the survey report include the date and time of the survey, the names of survey inspectors, a summary of survey findings with the signatures of survey personnel, a listing of deficiencies based on a regulatory reference, recommendations for improvement in order of priority, and a copy of the survey form. For examples of a sanitary survey report, refer to Bartram and Rees (2000) and NSSP (1997).

With a completed sanitary survey report, a more accurate assessment of public health risk at a beach can be made. Also, informed decisions on how to improve public health at the beach and the implementation of new or improved sampling locations and frequencies can be discussed. Evaluation criteria contained in the sanitary survey checklist in appendix F include the following:

- Annual rainfall for the area
- Amount of rainfall in the past 30 days
- Number of significant rainfall events (e.g., more than 1 inch in 24 hours during the past year) that might have contributed to pathogen contamination
- Average high water temperature during the swimming season
- Water temperature during the past 30 days
- Average flow of beach if the beach is on a river or an estuary
- Average flow during the past 30 days if the beach is on a river or estuary
- Water movement if the beach is on an ocean, a lake, or other nonflowing waterbody with or without a tide
- Number of point source dischargers within 1 mile of this area (include offshore outfalls)
- Area subject to combined sewer overflows (CSOs) or sanitary sewer overflows (SSOs)
- Area subject to agricultural runoff during storms
- Nearest publicly owned treatment works (POTW)
- Number of POTWs within 5 miles of the beach
- Approximate number of septic systems within 5 miles of the beach; estimated age of systems
- Water treatment level in the area
- Number of animal feeding operations (AFOs, feedlots) or concentrated animal feeding operations (CAFOs) within 5 miles of the beach
- Number of aquaculture facilities within 5 miles of the beach
- Nature of discharges from AFOs, CAFOs, and aquaculture facilities to the waterbody adjacent to this beach
- Sanitary facilities during peak season
- Presence of a marina or pleasure craft with toilets
- Wild animals present on or near the beach
- Domesticated animals present on or near the beach
- Approximate number of birds per hour that frequent a typical 50-meter length of this beach or nearshore waters
- Pollution prevention and abatement efforts in this area

G.4 References

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Appendix H: Data Quality and Sampling Design Considerations

This appendix provides additional information on basic data quality planning elements, as well as sampling design considerations. It provides supplemental discussions, examples, and additional references that may be helpful to beach program managers. It does not create additional requirements beyond those in the main guidance document.

H.1 Data Quality

H.1.1 General Considerations

In its *Office of Water Quality Management Plan* (USEPA, 2001c), EPA established a quality policy for Office of Water (OW) Programs. Several key concepts from that document are summarized below because they guide EPA's review of its own quality programs and others.

- *Goal*: The goal of OW is as follows: "Environmental decisions shall be based on data of known and documented quality, such that the decisions are scientifically, and where necessary, legally defensible and able to withstand public scrutiny."

- *Basic tenet:* A basic tenet of OW's quality system is that "the level of effort needed to manage the quality of any activity depends on:
  - The importance of the activity,
  - The risk of decision error,
  - The schedule for completion, and
  - The available resources.

- *Quality policy:* OW's quality policy is based on the goal and basic tenet described above. The *OW Quality Management Plan* provides a succinct statement of priorities and a detailed guide to components of the quality approach. The quality policy stresses the need for systematic, up-front planning and the use of a graded approach to quality management.

- *Graded Approach*: The graded approach to quality management might be the most important part of OW's policy. The basic philosophy behind the graded approach is to recognize that "quality" is not an objective attribute that remains constant. Rather, quality is a subjective attribute of a process or product that must be established in the context of that process or product. Therefore, the quality of the data and the effort expended to manage the quality of the data and the decisions should be based on the end goal of the decision. "Good" quality data are those that enable the user to make the decision at hand with an acceptable risk of error within the required time frame.

H.1.2 Quality System Documentation

An important part of the grant application process is documenting the monitoring program's quality management practices as they pertain to the collection and analysis of water samples. The documentation should address the following:

- Who are the project manager, the sponsoring organization, the responsible individual within that organization, the project personnel, the "customers," and the "suppliers?" How are the customers and suppliers involved?
- What are the project objectives, and what questions and issues will be addressed?
- What are the project schedule, resources, budget, and milestones? Are there any applicable requirements such as regulatory or contractual requirements?
- What types of data does the project require? How will those data support the project objectives?
- How was the quantity of data needed determined? How were the criteria for the quality of the data determined?
- How, when, and from where were the data obtained, including existing data? What are the constraints on the data collection process?
- What activities during data collection will provide the information used to assess data quality (field or laboratory quality control operations, audits, technical assessments)?
- How will the data for the project will be analyzed and evaluated? How will they be assessed to determine how well they serve their intended use and the performance criteria established?

H.1.3 Quality Assurance Project Plan

Typically, the written documentation takes the form of a quality assurance project plan (QAPP). A QAPP typically details the technical activities and quality assurance (QA) and quality control (QC) procedures that should be implemented to ensure the data meet the specified standards. The QAPP should identify who will be involved in the project and their responsibilities; the nature of the study or monitoring program; the questions to be addressed or decisions to be made based on the data collected; where, how, and when samples will be taken and analyzed; the requirements for data quality; the specific activities and procedures to be performed to obtain the requisite level of quality, including QC checks and oversight; and how the data will be managed, analyzed, checked to ensure that it meets the project goals, and reported. The QAPP should be implemented to ensure that data collected and analytical data generated are complete, accurate, and suitable for the intended purpose. EPA has provided requirements and guidance for the preparation of QAPPs in USEPA (1998, 2001b).

H.1.4 Data Quality Objectives

EPA has published a planning tool to help develop DQOs that are included in the quality system documentation. This tool, guidance on the DQO Process, recommends a process that usually consists of the following three activities (USEPA, 2000):

- Define the decision to be made.
- Clarify the information needed for this decision.
- Design the data collection program on the basis of the decision rule and the tolerable limits of decision error.

This process should include preparing a clear statement of the problem, identifying the decision(s) to be made using the data, identifying of the information needed to make the decision(s) (e.g., previously collected data, new environmental measurements), defining the spatial and temporal boundaries of the study, developing a decision rule that will describe a logical basis for choosing an appropriate action based on study results, specifying the limits on decision errors, and optimizing the design for obtaining data. Several iterations of this process might be required to specify the DQOs for a project. Because DQOs are continually reviewed during data collection activities, any needed corrective action can be planned and executed to minimize problems before they become significant. General guidance and examples of planning for monitoring programs are also provided in *Monitoring Guidance for the National Estuary Program* (USEPA, 1991) and *Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls* (USEPA, 1997b).

H.1.5 Standard Operating Procedures

Grant applicants should also document their methods and assessment procedures in the quality system documentation they submit. For routine implementation of these methods, standard operating procedures (SOPs), which can be referenced in and provided with the quality system documentation, provide a tool to assist the person(s) performing the activities. An SOP typically presents in detail the method for a given technical (not administrative) operation, analysis, or action in sequential steps, and it includes specific facilities, equipment, materials and methods, QA and QC procedures, and other factors necessary to perform the operation, analysis, or action. By following the SOP, the operation should be performed the same way every time, that is, it is standardized. Such activities may include, but are not limited to, field sampling, laboratory analysis, software development, and database management. EPA presents examples of the format and content of SOPs in (USEPA, 2001a). The format and content requirements for an SOP are flexible because the content and level of detail in SOPs vary according to the nature of the procedure. SOPs should be revised when new equipment is used, when comments by personnel indicate that the directions are not clear, or when a problem occurs. The grantee should ensure that obsolete documents are removed and that the revised SOPs are used in subsequent tasks.

H.2 Sampling and Monitoring Design Considerations

H.2.1 Improving Usefulness of Monitoring Information

The National Research Council (NRC, 1990a, 1990b) has evaluated marine monitoring programs and practices and has made a series of recommendations to improve the usefulness of monitoring information. EPA (USEPA, 1991) suggested the following steps based on the NRC's findings for designing successful monitoring programs. These steps can be used to develop a beach monitoring program.

Step 1. Develop monitoring objectives

Clear objectives should be developed for each component of the monitoring program. The objectives should include detecting exceedances and notifying the public when an exceedance is detected. Microbiological monitoring of recreational waters, in most cases, is undertaken to establish the degree of allowable microbiological pollution to protect public health and the environment. For beach management programs, recreational waters should attain criteria as protective as those EPA established in *Ambient Water Quality Criteria for Bacteria–1986* (USEPA, 1986). Although an advisory should be considered when a sample exceeds water quality standards, it is ultimately a state or local decision to determine when to issue an advisory or closing.

Step 2. Establish testable hypotheses and select statistical methods

Monitoring program objectives should be translated into statistically testable hypotheses. Establishing testable hypotheses ensures that the results of the monitoring program will be unambiguous and that the objectives of the program can be met. This approach results in the creation of a threshold level for determining when to record an exceedance and notify the public.

Step 3. Select analytical methods and alternative sampling designs

Detailed specifications for the analysis of each environmental variable of the monitoring program should be developed, including field and laboratory protocols and quality assurance/quality control procedures. In addition, alternative spatial and temporal sampling designs should be devised. The sampling designs should specify the number and location of sampling points, sample frequency, and level of sample replication. This information should then be used in the next step to evaluate expected monitoring program performance and to select the most efficient sampling design among the alternatives.

Step 4. Evaluate expected monitoring program performance

Evaluating monitoring program performance might be the most important step in the design and review process (USEPA, 1991). Before the program begins, an evaluation of alternative sampling designs assists in the selection of the most appropriate design for cost-effective sampling that meets the program objectives. During the course of the monitoring effort, performance evaluations provide a systematic procedure for measuring success in terms of the ability to continue to meet program goals. The periodic evaluation process should also identify the need to modify the sampling design and methods. Without this evaluation, there is a risk of collecting and analyzing too few or too many samples. The results of this evaluation should be used to identify the modifications to the initial design necessary to increase monitoring program effectiveness.

Step 5. Implement data analysis

The development of a data management system is an essential task in the design of monitoring programs, and sufficient funds should be provided to cover data analysis. The data management system should be operational before the monitoring program is implemented. In addition to specifying data analysis methods, an expeditious timetable for analyzing the data, and the procedures for reporting and communicating the results, the data management system should be used to assess implementation progress and monitoring program performance. The results of the performance assessment can be used to refine the program objectives and to modify individual study elements to satisfy those objectives.

H.2.2 Sampling Design Considerations

Sampling design considerations that might be helpful when establishing a monitoring program include the following:

- Identify the decision maker and program personnel.
- Clarify monitoring program goals and objectives.
- Describe the monitoring program.
- Identify the type of data needed and the sampling design.
- Establish quality objectives and criteria.

Identify the Decision Maker and Program Personnel

A beach water quality monitoring program requires the efforts of program managers, technical staff, and potentially other interested parties or stakeholders. The team involved in planning and implementing the program might include senior government officials from offices established to protect health or environmental quality; technical experts familiar with the issues and methods to be used; data analysts; data users, including risk assessors and the manager or program leader who will make the advisory or closing decision; and quality assurance specialists. Individuals or organizations that might be directly affected by the decision also should be involved in planning the monitoring program to improve communication and build consensus. The members of this group will be able to offer different perspectives and assist in solving problems. They might be involved in development of the plan at different stages and participate in meetings or other activities.

Some personnel manage or perform the work of the monitoring program, while other personnel who do not actually do the work are needed to provide oversight and ensure the quality of the work being performed. Quality control (QC) is a system of technical procedures and activities developed and implemented to produce measurements of requisite quality. Quality assurance (QA) is an integrated system of management procedures and activities used to verify that the QC system is operating within acceptable limits. QA oversight is important to maintain the credibility of a beach monitoring program. QA personnel should be identified at the planning stage and included during program operation program to assess all aspects of data collection.

Clarify Monitoring Program Goals and Objectives

A clear statement of the purpose of the monitoring program and the program's objectives prevents confusion and the waste of resources. As noted in EPA's monitoring guidance (USEPA, 1997b), monitoring programs can be undertaken for different reasons and to answer different questions. The types, quantity, and quality of the data can vary considerably to meet different goals. A conceptual model of the potential environmental hazard should be prepared. This model can be in the form of a diagram illustrating known or suspected sites of contamination at one or more beaches, sources of microorganisms, and exposure scenarios (e.g., children playing in sand or shallow water, swimming, or surfing). The problem to be investigated needs to be defined. The following are examples of monitoring program goals:

- Determine whether an impairment exists.
- Determine the spatial and temporal extent of the impairment.
- Determine the causes and sources of the impairment.

An example of the first type of program goal is routine monitoring to protect human health by comparing levels of indicator bacteria to the ambient water quality criteria for bacteria (USEPA, 1986) during the swimming season. This information is used to determine whether an advisory should be posted or the beach closed. The results from initial monitoring might spur intensive monitoring involving the collection of water samples at different times (e.g., daily or only after storm events) and from many locations (e.g., waterbodies downstream from the initial location). Intensive monitoring might be needed while establishing a monitoring program to pinpoint the most appropriate locations for the routine sampling effort and the depths, times, and procedures needed to collect the samples. Such monitoring data might be needed during the program to evaluate whether the sampling design continues to protect human health. Intensive monitoring can determine the most appropriate sampling frequency needed to assess standards. It might also be desirable or necessary to identify the point and nonpoint sources that could be responsible for waterbody impairment, or to evaluate the influence of rainfall on the bacterial load at a particular beach. Extensive sampling is needed to develop predictive tools using statistical analysis or mathematical models.

This guidance focuses on routine monitoring for beach advisory or closing decisions. An example of a principal study question is

Could levels of bacteria in the water at Bayside Beach affect swimmers' health?

Examples of alternative actions that might be considered if the answer to this question is "yes" include the following:

Post an advisory at the beach to warn swimmers of the potential hazard.
Close the beach and do not permit swimming until further notice.
Conduct a sanitary survey to identify point and nonpoint sources of bacteria.
Take no action.

The following is an example of a decision statement for this type of program:

Determine whether bacterial indicator levels require taking action to protect human health.

Decision rules developed for this program at a freshwater lake might include the following examples:

If the density of enterococci in any one sample exceeds the EPA instantaneous (single-sample) criterion of 61 per 100 mL, the water is sampled again.

If the density of enterococci in the second sample exceeds the EPA instantaneous criterion, the beach is closed.

If the running geometric mean of enterococcal densities from five sequential samples taken during the previous 30 days is greater than the EPA averaging period criterion of 33 per 100 mL, the beach is closed.

If the density of indicator bacteria does not exceed the criteria under the above conditions, swimmers are not at risk and the beach remains open.

Describe the Monitoring Program

The planning team should discuss what information is needed to make the decision. In the above example, bacterial densities lead to the decision. Also useful are measurements of other environmental factors, such as temperature, nutrients, dissolved oxygen, salinity, turbidity, or water flow, which might provide evidence of a problem or show the seriousness of the exceedance.

The regulatory basis for the decision—in this case, EPA's ambient water quality criteria for bacteria—should be documented. In addition, spatial and temporal boundaries for the monitoring program should be examined. For example, a beach might extend for many miles along the coastline of a jurisdiction, but swimmers have access to only a few hundred feet of shoreline at the end of one road. In addition, the presence of a storm water outfall on the beach might be the focus of sampling.

One or more members of the planning team should document these elements of the program in the monitoring plan. The team also should review available resources, relevant deadlines, the budget, the availability of personnel, and schedule requirements to determine how they will affect sampling at the beach(es) in question. This information should be evaluated along with the proposed sampling design and the boundaries of the monitoring program (see below) to assess how well the program objectives can be met within the various technical and cost limitations.

Identify the Type of Data Needed and the Sampling Design

Various sampling designs have been used for monitoring recreational waters adjacent to bathing beaches. The sampling design specifies the number, location, and types of samples to be collected. It provides the conditions under which they should be collected, the analyses to be performed, and the QA and QC procedures necessary to ensure that the tolerable decision error rates specified in the DQOs.

Because enterococci and *E. coli* are commonly found in the feces of humans and other warm-blooded animals, the presence of enterococci or *E. coli* in water is an indicator of fecal pollution and the possible presence of enteric bacteria that pose a risk to human health. Epidemiological studies have led to established recreational water standards based on the documented relationship between health effects and water quality (chapter 1). According to studies of marine and freshwater bathing beaches, the amount of enterococci or *E. coli* in the water is directly related to the incidence of swimming-associated gastroenteritis (Cabelli, 1983; Dufour, 1984).

Although statistical or probabilistic sampling designs are highly desirable, not every sampling problem can be solved with these designs. Moreover, local limitations in staff and funding might lower the number of samples that can be analyzed during the swimming season. Basic sampling design should address the following seven aspects (Bartram and Rees, 2000):

1. Reasons to sample
2. What to sample
3. How to sample
4. When to sample
5. Where to sample
6. How many samples to take
7. Sampling evaluation

A sampling and analysis plan should include the location of sampling sites, frequency of sampling, duration of the sampling period, and depth of sampling. For each recreational waterbody, the plan also should include other pertinent information, such as the types of containers to be used for sampling, how to package samples for transport, references for analytical methods, how to report data, and requirements for repeat sampling. The plan should be developed in conjunction with the local laboratory that will conduct the bacteriological analyses (CADHS, 1999).

> A study was conducted at two beaches on Lake Erie to evaluate the water sampling design for the collection of several microbiological indicator organisms in relation to day, time, and location of collection. The concentrations of these organisms were generally found to vary significantly by the time and day that collection took place. However, the concentrations did not vary significantly at various locations in the bathing area. Sampling at different locations in the bathing area might be considered for beaches that have poor dispersion of fecal waste sources (Brenniman et al., 1981).

It is difficult to decide the optimum number of samples to take and the most suitable locations to characterize the water quality in the most meaningful way. Sampling marine and estuarine waters requires considering tidal cycles, current patterns, bottom currents, countercurrents, stratification, seasonal fluctuations, dispersion of discharges, multidepth sampling, and many other factors. Sampling lakes and rivers adjacent to beaches requires considering wind and flow and whether the beach is upstream or downstream of pollution sources, as well as time of day (see box). Determining the most appropriate, cost-effective use of the resources available for a monitoring program is also difficult. The following aspects of sampling are presented for consideration when developing a monitoring plan.

Location. Sampling locations are chosen based on historical records, usage, current situations, concentration of bathers, pollution sources, accessibility, and other factors. Areas known to be chronically contaminated, as well as areas that typically have the highest bather density, should be included in the sampling plan. An area close to a storm water outfall might have high counts of bacteria, but it might not be an area commonly used for swimming. Therefore, the priority might be to sample in the area with more swimmers to obtain a better estimate of risk to human health. Ultimately, these decisions are appropriate for the beach manager to make. Table 4-1 in chapter 4 should be consulted for guidance. In addition, other criteria for sampling might be defined, such as obtaining the sample at a specified distance from swimmers and animals and not in the "swash zone" area of low waves near the shore (IITF, 1999), as well as spacing samples at specified intervals for lengthy stretches of beach.

Frequency. Ideally, when first establishing a recreational water quality monitoring program, the optimum sampling frequency is daily and samples of estuarine or marine bathing waters should be obtained at high tide, ebb tide, and low tide to determine the cyclic water quality and deterioration that should be monitored during the swim season (Bordner et al., 1978; see box below). Lakes and rivers might also be sampled at different times, for example, during calm versus windy days or during low-flow versus storm-flow conditions. If a beach monitoring program does not have the resources to sample this often, a minimum frequency of sampling should be established based on historical records, usage, current situations, the potential for health hazards and the number of samples required by the water quality standards being used. Highly populated or high-risk areas, require more frequent sampling, as shown by the tiered approach (Table 4-1). Sampling might be needed under special circumstances, such as at locations where no sanitary facilities are provided at a beach or when toilets at the beach are not open or not operational.

Subsequent sampling also might be needed to determine when to reopen a recreational area after a beach closing. Sampling frequency can be related to the peak bathing period, which is generally in the afternoon, but preferably samples are collected in both the morning and afternoon (Bartram and Rees, 2000), at least for beaches classified as Tier 1. Weekends and holidays should be considered in the sampling program. To characterize the water quality at the beach before the weekend crowd arrives, a

> Water quality data for the years 1979 to 1981 were obtained for a marginally polluted beach in New York. A standard of 2,400 total coliform organisms per 100 mL of sample was used. On a particular day during May through September, one sample per hour was taken for 7 hours. Analysis of the water quality at this location with respect to intra-day variation showed significantly higher mean densities during the first 2 hours of sampling than during the last 2 hours of sampling. During the 3 years studied (1979 –1981), morning coliform densities tended to be significantly greater than the standard, whereas afternoon samples tended to be significantly lower than the standard. These differences were likely due to environmental factors such as wind and local currents. Because such environmental factors vary from location to location, the finding of significant intra-day variation in indicator organism density at this location strongly suggested a need for sampling at different times of the day.
>
> Analysis of the inter-year variability of coliform density at this location showed this variability to be quite low. Analysis using only one-half of the 3 years of data compiled by the New York City Health Department gave a profile of water quality at this location that showed little difference from the analysis using the full data set. This fact, coupled with the previous findings of the study, indicated that sanitary surveys should maximize the number of replicate determinations made per sampling date instead of maximizing the number of days on which samples are taken (Fleisher, 1990).

sample also could be taken on Thursday so that the results are ready by Friday. To characterize the water quality at the beach after the weekend crowd has left, a sample could be taken late Sunday or on Monday. The frequency of sampling might change according to a beach classification.

Sampling Depth. The primary factor for determining the depth of sampling is the users at risk. Samples of ankle- and/or knee-depth water might be more appropriate for children and infants, whereas waist- and/or chest-depth samples might be more appropriate for adults (refer to Table 3-1). Sampling from boats is usually inadequate for beach monitoring because water depths would exceed those common to beach-related recreational activities, especially for young children (CADHS, 1999). Local health agencies, however, might desire to assess water quality away from the shore in additional areas where surfing, windsurfing, or other activities occur.

Sampling Time. The most appropriate time of sampling is that which best estimates water quality conditions during the highest periods of risk. Wave and tidal actions affect bacteria levels, as do the number of bathers during sampling and before and after sampling; the water temperature; and the recent, current, and predicted weather conditions (e.g., wind, rain). Bacteria levels change frequently, based on these types of environmental conditions. This factor should be taken into account when formulating a sampling design and when interpreting sampling results and analyses. If information on the conditions of a beach when the most people are in the shallow waters is of interest, sampling should be conducted during high tide when bacteria levels might be higher near the shore (see Table 4-1). To estimate how water quality is affected by the number of swimmers in the water, the water should be sampled during the time of day when there is the highest bather density at a beach.

In addition, sampling after the weekend might capture the conditions of the water after the highest bather density. Samples could also be taken on Thursday to inform weekend visitors of water quality before they swim on the weekend. (This type of sampling is recommended for use only on a temporary basis if resources prevent routine daily sampling. It should be done only to better understand indicator occurrence patterns, which are used to develop a more minimalistic sampling approach that best represents those patterns.) Ideally, sampling should be done throughout the day and week to look for patterns of bacteria levels. However, it is important to remember that the results of the laboratory test will take about 24 hours.

The final sampling design should be carefully documented in a sampling and analysis plan or incorporated into a QAPP. (Refer to USEPA, 1998 and 2000, for further information on QAPP preparation.) The plan should include a rationale and listing of the location of all sampling sites and stations within a site, the frequency of sampling at each station, the depth of water sample collection, and the duration of the sampling period (e.g., one time only, 2 weeks in July, during the open swimming season). The plan should also include the procedures for obtaining the samples and analyzing them for bacterial indicator(s), procedures for collecting other data from the field, the schedule for repeat sampling, and how and to whom data will be reported. SOPs should be prepared for all activities that need to be performed the same way every time. Each SOP should include details on the method for a given operation, analysis, or action in sequential steps, as well as the facilities, equipment, materials and methods, QA and QC procedures, and other factors required to perform the operation, analysis, or action.

Establish Quality Objectives and Criteria

Data quality standards define the way the sample is collected and analyzed, and they provide performance criteria that, if met, ensure that the data are acceptable and usable by the decision maker. As part of the DQO process, the planning team should establish program and measurement quality objectives to enable the data user to understand any errors or uncertainties associated with the data. Two categories of errors are commonly recognized–sampling error and measurement error. Sampling error is the difference between sample values and in situ “true” values, and it results from unknown biases due to sampling design, including natural variability due to spatial heterogeneity and temporal variability in microorganism abundance and distribution. Measurement error is the difference between sample values and in situ “true” values associated with the measurement process, including bias and imprecision associated with sampling methodology, specification of the sampling unit, sample handling, storage, preservation, identification, instrumentation, and other factors.

The monitoring program should specify methods and procedures to reduce the magnitude and frequency of measurement error. For example, using trained staff to perform the data collection and analyses and following standardized, repeatable procedures for data and sample collection can help eliminate sloppy, inconclusive work. Uncertainty in the data because of sampling and measurement errors or errors introduced during data manipulation could result in identifying a risk to human health when one does not exist (i.e., the true density of bacteria is not greater than the criterion) or not identifying a risk when one does exist (i.e., the true density of bacteria exceeds the criterion). Data entry, transfer, calculation, and reporting mistakes can compound these issues. Data entries and the procedures for calculating results must be carefully checked for accuracy and completeness.

Measurement performance criteria are qualitative and quantitative statements used to interpret the degree of acceptability or utility of the data to the user. These criteria, also known as data quality indicators (DQIs), include the following:

- Precision
- Bias
- Representativeness
- Completeness
- Comparability

Sometimes DQIs for some parameters cannot be expressed in terms of precision and bias (accuracy) or completeness. In these cases a full description of the method by which the data will be obtained should be included in the plan. The various measurement performance criteria that should be established for beach water quality monitoring parameters are discussed in the following subsections.

Precision. Precision is defined as the degree of mutual agreement or consistency between individual measurements or enumerated values of the same property of a sample. Obtaining an estimate of precision provides information on the uncertainty due to natural variation, sampling error, and analytical error. The precision of sampling methods is estimated by taking two or more samples at the same sampling site at approximately 10 percent of the sites. The precision of laboratory analyses is estimated by analyzing two or more aliquots of the same water sample. This data quality indicator is obtained from two duplicate samples by calculating the relative percent difference (RPD) as follows:

$$RPD = \frac{|C_1 - C_2|}{(C_1 + C_2)/2} \times 100$$

where C_1 is the first of the two values and C_2 is the second value. Because the absolute value of the numerator is calculated, the RPD is always a positive number. If it is to be calculated from three or more replicate samples, the relative standard deviation (RSD) is used and is calculated as

$$RSD = \frac{s}{\overline{X}} \ x \ 100$$

where s is the standard deviation and $\overline{x}$ is the mean of repeated samples. The standard deviation or the standard error of a sample mean(s) is calculated as

$$SD = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \overline{X})^2}{n-1}}$$

where X_1 is the measured value of the replicate, $\overline{x}$ is the mean of repeated sample measurements, and n is the number of replicates. Precision can also be expressed in terms of the range of measurement values.

Because of the heterogeneity of populations of bacteria in surface waters, an RPD of less than or equal to 50 percent between field duplicates for microbiological analyses might be considered acceptable. In laboratory analyses, the precision among laboratories following EPA Method 1600 for detecting enterococci from separate aliquots of the same sample was determined to be 2.2 percent for marine water samples and 18.9 percent for fresh surface water samples (USEPA, 1997a). Analysts should be able to duplicate bacterial colony counts on the same membrane within 5 percent and the counts of other analysts within 10 percent; otherwise, procedures should be reviewed and corrected (IITF, 1999).

Accuracy. Accuracy is the degree of agreement between an observed value and an accepted reference or true value. Accuracy is a combination of random error (precision) and systematic error (bias), both of which are due to sampling and analytical operations. Bias is the systematic distortion of a measurement process that causes errors in one direction so that the expected sample measurement is always greater or lesser to the same degree than the sample's true value. Because accuracy is the measurement of a parameter and comparison to a "truth" and the true values of environmental, physicochemical, and biological characteristics cannot be known, use of a surrogate is required.

The accuracy of field measurements is usually evaluated by analyzing samples prepared from known concentrations of the pollutant(s) of interest or by adding known concentrations of the pollutant(s) of interest to field-collected samples (known as "spiked" samples). In studies following Method 1103.1 (USEPA, 1985) to estimate densities of *E. coli*, use of samples prepared from known quantities of freeze-dried and cultured *E. coli* as a surrogate resulted in 97.9 percent recovery of the bacteria from water samples. Based on the mTEC medium, bias was determined to be −2 percent of the true value. This information is helpful in establishing the most appropriate methods to be followed. Accuracy, defined as the similarity of a repeated entity to its original form, such as information, data entry, and calculations, can be controlled by double-checking sources, manual data entries, or electronic data transfers and performing recalculations. Figure H-1 is a graphical representation of the relationship between bias and precision, and accuracy.

Representativeness. Data representativeness is defined as the degree to which data accurately and precisely represent the characteristics of a population, and therefore it addresses the natural variability or the spatial and temporal heterogeneity of a population. It is not quantitative but descriptive in nature, and it can be assessed only by evaluating the sampling design with respect to the particular features of the water at each beach. It is possible to quantitatively estimate sample sizes using estimates of variance and selecting acceptable levels of false positive and false negative error.

In the sampling design, care should be taken to define the area of sample collection and determine whether it is typical and representative of each area of concern. For swimming beaches less than 30 meters in length, a single sample taken from water at the midpoint of the beach site

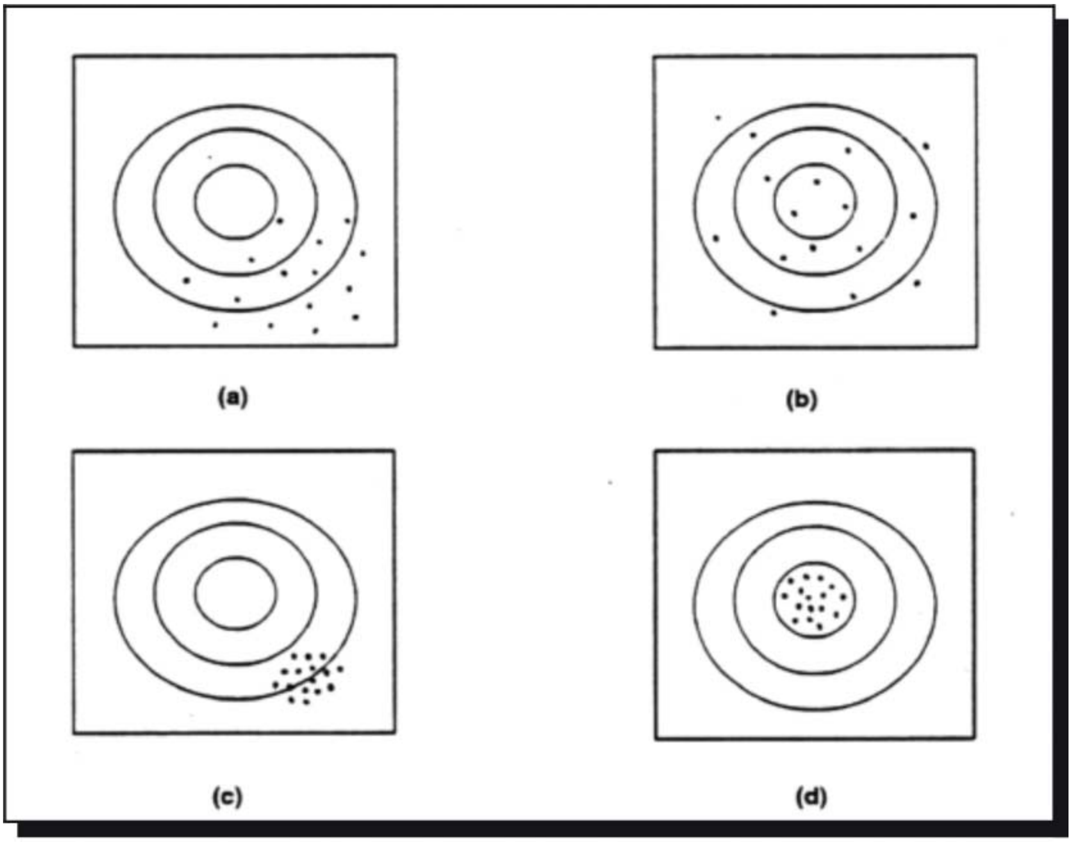

Figure H-1. Graphical representation of the relationship between bias and precision, and accuracy (after Gilbert, 1987). (a): high bias + low precision = low accuracy; (b): low bias + low precision = low accuracy; (c): high bias + high precision = low accuracy; and (d): low bias + high precision = high accuracy.

less than 30 meters in length, a single sample taken from water at the midpoint of the beach site might suffice. For lengthy beaches, establishing the correct number and location of samples is more difficult, because the sampling needs to ensure that the estimated bacterial densities provide a reasonable representation of the potential risk from waterborne pathogens. For example, the monitoring program might decide to sample from the middle of the area where most swimmers congregate and then 15 m on either side of that first sampling station to obtain an average value of bacterial densities for comparison against the standard. Alternatively, each individual sample result might be compared to the standard. At beaches where a known point source of pathogens, such as a storm water outfall, enters the water, the sample might be drawn from stations within 15 m of the point source or where swimmers might be considered to be at greatest risk from exposure.

As noted above, an initial intensive sampling study might be necessary to help decide where and how often samples need to be routinely collected to address bacterial heterogeneity. If sufficient resources are not available to collect and analyze multiple samples along a beach, the monitoring program plan should justify the decision and note the extent of the area that might be affected by an advisory or closing if bacterial densities at a single station exceed the standards.

Completeness. Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and entered into the data management system. Accidental or inadvertent loss of samples during transport or lab activities should be avoided because the loss of the original samples will result in irreparable loss of data. Lack of data entry into the database will reduce the ability to perform analyses, integrate results, and prepare reports. Thus, controlling sample loss by using unbreakable containers, careful sample management (e.g., assigning serial laboratory numbers, completing log books), and tracking samples through analysis and data entry is important. Percent completeness (*%C*) for measurement parameters can be defined as follows:

$$\%C = \frac{V}{T} \times 100$$

where *v* is the number of measurements judged valid and *T* is the total number of measurements. Most monitoring programs should try to achieve a level of completeness in which no less than 95 percent of samples are judged to be valid.

Comparability. Two data sets are considered comparable when the two sets can be considered equivalent with respect to the measurement of a specific variable or group of variables. Comparability of data is not defined quantitatively; it is ensured by similarity in sampling based on geographic, seasonal, and method characteristics; the uniform training and experience of field sampling and laboratory personnel; and the use of standardized, repeatable methods for analysis of bacterial indicator densities. This document should help improve comparability among beach water quality monitoring programs by establishing comparable sampling and analysis procedures so that the meaning of the results can be more easily understood by the public nationwide.

Additional Factors Affecting Sampling Design. By establishing the “rules” for data quality at the planning stage, the number of samples that need to be collected and analyzed is adjusted to obtain data that will be used to judge the quality of the data obtained. For example, a duplicate water sample should be collected from at least 10 percent of the sites in the study to calculate precision. Under some conditions, more frequent collection of duplicate samples might be advised. Monitoring programs need to carefully balance their needs to sample from multiple areas and their resource limitations with the need for data quality. If only one sample is collected from every site for analysis, an agency might cover more territory, but it will not be able to detect errors during sampling, inadvertently reducing the density of bacteria in the sample or showing that the particular patch of water sampled contained an unusually high number of fecal bacteria, but was not representative of the entire area. Thus, inappropriate decisions might be made based on erroneous results.

For the same cost, the number of sites sampled could be reduced while including some QC samples to provide a means to double check the results, both from the field sampling effort and from analyses of duplicate aliquots of single samples in the laboratory. This approach can increase the level of confidence in the data produced and help detect unusual conditions that might lead to errors in decision making.

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Appendix I: Training

This appendix provides supplemental discussions, examples, and additional references that may be helpful to beach program managers. It does not create additional requirements beyond those in the main guidance document.

Training volunteers to do their jobs properly is an essential component of a successful monitoring program. Training is a dynamic process and does not simply begin and end with a kickoff classroom session. For example, follow-up training should occur to resolve specific operating problems discovered in an ongoing program. Even experienced staff benefit from occasional continuing education sessions, which help everyone stay in touch with the program and foster the ideal of team effort.

According to USEPA (1991), training should be planned from three basic perspectives:

1. Training new staff
2. Training experienced staff (teaching the use of new equipment or improved methods)
3. Solving specific operating problems

Each of the three training perspectives should include the presentation of unique material. The training processes involved in presenting this material, however, are similar and consist of the following components:

- Creating a job analysis
- Planning the training
- Presenting the training
- Evaluating the training
- Providing follow-up coaching, motivation, and feedback

I.1 Creating a Job Analysis

The job analysis phase can be the hardest but most important part of training development. The outcome of the job analysis is a list of all the tasks staff should accomplish when sampling a parameter. The tasks should be identified to ensure that procedures are performed consistently throughout the program. This list should include a list of sampling tasks, the required quality level for each task, the job elements that compose each task, and a sampling protocol (standard operating procedure) or job description handout that will be referred to and followed by staff members each time they collect water samples or perform laboratory analyses.

I.2 Planning the Training

Once the job analysis has been completed and the job description prepared, the actual training session should be planned. Training might take place in a group setting or individually. Group training saves money and time, especially when many staff are trained simultaneously. For extensive water sampling efforts throughout a county, however, this approach has drawbacks. Each beach has unique characteristics, and certain circumstances or problems can be addressed only on an individual basis. In practice, it is often best to structure the training program so that there are group sessions as well as individual follow-up sessions.

The training should stress the importance of samples being representative of the waterbody from which they are taken, including the theory behind indicator organisms and quality samples, QA/QC activities and following the protocols specified in SOPs and the monitoring program plan. Ensuring that staff understand how to carry out the protocols to meet those requirements is the primary concern. Training to collect water samples, for example, should also include how to plan sampling activities, how to make field notes describing the sampling site and station, and how to perform on-site inspections. The safety aspects of field sampling and laboratory analysis are an important component as well.

I.3 Presenting the Training

A well-organized, well-paced training session is essential to facilitate understanding and motivate staff. The lesson planning phase provides the trainer with the basic agenda for the session. The trainer, however, is responsible for adapting the lesson to the expectations, knowledge, and experience of the audience. The person presenting the training should know the material and should be organized. Lectures, activities, and discussions should be planned and kept to a timetable. Similarly, demonstration materials, audiovisual equipment, and handouts should be accessible and easily incorporated into the presentation. The trainer should be able to anticipate and respond to problems and questions that might occur during an actual training session. A relaxed presentation that fulfills the education objectives is the basic goal. Although trainers will bring their own styles to the training session, they should incorporate basic public speaking techniques, such as establishing rapport with the audience, enunciating clearly and distinctly, using effective body language and eye contact, and encouraging questions and comments.

Whether in the classroom or in the field, staff should be allowed to demonstrate what they have learned. The trainer should observe closely and offer immediate feedback in the form of positive reinforcement or corrective assistance. This portion of the session is usually when the real learning takes place. During the review portion of the training session, the trainer should summarize what was learned and the staff have an opportunity to ask questions. The session should close with the reassurance that staff will continue to receive training throughout their tenure with the monitoring program.

Volunteer Beach Monitoring Programs Across the Nation

Alabama Coastal Foundation volunteers data are used for trend research by the Alabama Department of Environmental Management, Dauphin Island Sea Lab, and Mobile Bay National Estuary Program.

Alabama Water Watch is a statewide citizen volunteer water quality monitoring program. More than 50 active groups monitor about 250 sites on 100 waterbodies in 20 to 30 counties in Alabama and Georgia. Six chemical parameters are measured, and several groups are beginning to test for pathogen indicators. The program is coordinated from Auburn University, where the central database is maintained.

The Surfrider Foundation is an environmental organization dedicated to the protection and enhancement of the world's waves and beaches through conservation, research, education, and local activism. The Blue Water Task Force, particularly chapters from Southern California coastal counties, analyzes water samples collected at beaches for bacteria and posts results on the Internet.

The Citizen Stewards Program trains volunteers to assist the Casco Bay Keeper in monitoring the water quality of Casco Bay, Maine. Volunteers gather data at more than 100 selected sites along the 500-mile shoreline, collecting surface water and performing tests monthly from April through October. The data are entered into a comprehensive computer database for management and interpretation. Water column profile data are also collected from the BayKeeper’s boat at offshore sites, and water is sampled at closed clam flats to test for bacteria.

The Environmental Quality Laboratory at Coastal Carolina University monitors water and sediment quality in the Waccamaw River and 45 sites from the North Carolina state line to Bucksports, South Carolina, using EPA-approved methods. Monthly physical, chemical, and biological analyses are performed, and occasional measurements of nutrients and heavy metals are taken. Results are interpreted using in situ instantaneous U.S. Geological Survey data on water stage and flow. The sampling plan is designed to identify nonpoint pollution sources. Results are shared with South Carolina's Department of Health and Environmental Control.

The Salt Pond Watchers currently monitor fecal coliform bacteria levels in approximately 30 stations in seven coastal salt ponds on Rhode Island's Atlantic coast. Data are provided to the Rhode Island Department of Environmental Management and local communities to help determine areas unsuitable for fishing and swimming.

In Maine the Clean Water/Partners in Monitoring program provides coordination, information, support, and technical assistance to groups of volunteers and students who want to monitor their local waters. Active programs include water quality, phytoplankton, and marine intertidal diversity monitoring. Training is also provided to certify volunteers to monitor water quality in shellfish-growing areas.

In Hawaii the Hanalei Heritage River Program uses volunteers from the community help take a "snapshot" of the Hanalei's waters by simultaneous sampling all along the bay, up the river, and in its tributaries. This sampling has identified "hotspots" where bacteria counts far exceed standards. The volunteer program provides these data to the Department of Health, which then conducts its own bacterial sampling.

I.4 Evaluating the Training

Training evaluation should encompass the entire training process. It includes the trainee’s perspective, as well as that of the training program designer and trainer, on how effective the session has been. To gain immediate feedback about training, staff should fill out evaluation forms at the end of the session. If possible, it is often effective if a ‘hands-on’ session can be included where trainees can observe staff in action as they collect or process samples. If there are problems or if techniques are not performed according to the desired protocol, trainers might need to apply new methods in subsequent training sessions.

I.5 Providing Follow-up Coaching, Motivation, and Feedback

As stated previously, training should be conducted throughout the life of the monitoring program. Follow-up coaching is an integral part of the training process. Coaching usually occurs on a one-on-one basis to maintain communication between team members, resolve problems, instill motivation, and implement new or improved techniques. The key to follow-up coaching is personal contact to increase staff satisfaction. That personal contact should be maintained throughout the life of the program.

I.6 Volunteer Monitoring Programs

EPA acknowledges that citizen volunteers often can be used to perform some beach monitoring program functions. Using volunteers to collect water samples and transport them to a laboratory for analysis is one way to save on program monitoring costs and, at the same time, establish a partnership with local citizens. Some citizen monitoring programs also perform water quality analyses, and a few determine bacterial indicator levels. Program planning officials, however, need to be aware that establishing a volunteer monitoring program requires a commitment of time and resources to ensure that volunteers are properly trained and managed and that data quality objectives are met. Officials should not view citizen volunteers as unpaid adjunct staff. Typically, their motivation to participate in a monitoring program is not based on a desire to help reduce agency costs; rather, they donate their time and energy to serve as guardians and stewards of their local waters. This recognition should be considered in every aspect of the volunteer monitoring program development process.

The EPA document *Volunteer Water Monitoring: A Guide for State Managers* (USEPA, 1990) lists seven "basic ingredients" for developing a successful volunteer program:

1. Develop and articulate a clear purpose for the use of the data.
2. Produce "data of known quality" that meet the stated data quality objectives.
3. Be aware that volunteer monitoring is cost-effective, but not free.
4. Thoroughly train and retrain volunteers.
5. Give the volunteers praise and feedback (the psychological equivalent of a salary).
6. Use the data volunteers collect.
7. Be flexible, open, and realistic with volunteers.

Including these seven basic ingredients in the development of a volunteer monitoring program has produced many success stories across the United States. The latest edition of the *National Directory of Volunteer Environmental Monitoring Programs* (RISG and USEPA, 1994) documents a total of 772 programs currently in operation. The National Directory also provides a list of volunteer organizations around the country engaged in monitoring rivers, lakes, estuaries, beaches, wetlands, and ground water. The National Directory can be found at http://yosemite.epa.gov/water/volmon.nsf. In addition, EPA's Volunteer Monitoring web site provides information on various monitoring programs as newsletters that contain information on bacterial methods and how they are used by various volunteer groups. This information is currently available at http://www.epa.gov/volunteer/.

A frequent criticism of volunteer monitoring programs is that using the services of volunteers yields data of less certainty than the data obtained when professionals do the job. In general, however, if the seven "basic ingredients" of a successful program are included, data quality should be the same for both groups. Putting this theory to the test for any particular program includes running parallel water sampling tests that compare data collected by professionals those collected by volunteers. Periodic parallel testing serves two purposes. First, it assures the sponsoring agency that volunteers' data are reliable and can be used for the program's purposes. Second, it helps identify areas where the volunteer program can be improved, especially if the results indicate there is a difference in quality between the volunteers' data and the professionals' data.

EPA's volunteer monitoring guide also discusses several other ways to maintain volunteers' interest:

- Sending volunteers regular data reports.
- Keeping volunteers informed about all uses of their data.
- Preparing a regular newsletter.
- Making program officials easily accessible for questions and requests.
- Providing volunteers with educational opportunities.
- Keeping the local media informed of the goals and findings of the monitoring effort.
- Recognizing the efforts of volunteers through certificates, awards, or other means.
- Providing volunteers with opportunities to grow with the program through additional training, learning opportunities, and changing responsibilities.

I.7 References

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Appendix J: Sample Collection

This appendix provides supplemental discussions, examples, and additional references that may be helpful to beach program managers. It does not create additional requirements beyond those in the main guidance document.

J.1 Sample Containers

The sample bottles used to collect water for bacterial density analyses should be able to withstand sterilizing conditions and the solvent action of water. USEPA (1978) suggested wide-mouth borosilicate glass bottles with screw caps or ground-glass stoppers; however, glass bottles can break, causing loss of the sample. Heat-resistant polypropylene bottles may be used if they can be sterilized without producing toxic materials when autoclaved.

Sample bottles should be at least 125-milliliter (mL) volume for adequate sampling and for good mixing. Bottles of 250-mL, 500-mL, and 1,000-mL volume are often used for multiple analyses, such as when determining the density of two or more bacterial indicators. Discard bottles that have chips, cracks, or etched surfaces. Bottle closures should be watertight. Before use, bottles and closures should be cleaned with detergent and hot water, followed by a hot water rinse to remove all traces of detergent. Then rinse three times with laboratory-pure water.

Autoclave glass or heat-resistant polypropylene bottles at 121 °C for 15 minutes. Alternatively, dry glassware may be sterilized in a hot air oven at 170 °C for not less than 2 hours. Ethylene oxide gas sterilization should be acceptable for plastic containers that are not heat-resistant. Sample bottles should be stored overnight before they are used to allow the last traces of gas to dissipate.

Commercially available sterile plastic sampling bags (Whirl-pak) are a practical substitute for polypropylene or glass sample bottles when sampling soil or sediment. The bags are sealed by the manufacturer and opened only at the time of sampling.

If water samples are being collected for the determination of other environmental parameters (e.g., temperature, salinity, turbidity, dissolved oxygen), nonsterile containers may be used. It is important that the sterile and nonsterile containers are clearly labeled and used for the particular sample for which they were intended.

J.2 Sampling Method

A grab sample of water is obtained using a sample bottle that has been prepared as described above. The basic steps for this procedure, derived from Bordner et al. (1978) and IITF (1999), are as follows.

1. Identify the sampling site on a chain of custody tag, if required, or on the bottle label and on a field log sheet.

2. Remove the bottle covering and closure just before obtaining each sample and protect them from contamination. Be careful not to touch the inside of the bottle itself or the inside of the cover.

3. The first sample to be prepared is the trip or field blank (at least one per sampling day for routine sampling is recommended). Open one of the sampling bottles and fill it with 100 mL of sterile buffered dilution solution (see EPA Method 1103.1) when collecting freshwater, estuarine, or marine water samples. Cap the bottle and place it in a cooler.

4. To collect the surface water samples, carefully move to the first sampling location. If wading in the water, try to avoid kicking up bottom material at the sampling station. The sampler should be positioned downstream of any water current to take the sample from the incoming flow.

5. Open a sampling bottle and grasp it at the base with one hand and plunge the bottle mouth downward into the water to avoid introducing surface scum. Position the mouth of the bottle into the current away from the hand of the sampler and away from the side of the sampling platform or boat. The sampling depth should be 15 to 30 centimeters (6 to 12 inches) below the water surface, depending on the depth from which the sample must be taken. If the waterbody is static, an artificial current can be created by moving the bottle horizontally with the direction of the bottle pointed away from the sampler. Tip the bottle slightly upward to allow air to exit and the bottle to fill.

6. Remove the bottle from the waterbody.

7. Pour out a small portion of the sample to allow an air space of 2.5 centimeters (1 to 2 inches) above each sample for proper mixing of the sample before analysis.

8. Tightly close the stopper and label the bottle.

9. Enter specific details to identify the sample on a permanent label. Take care in transcribing sampling information to the label. The label should be clean, waterproof, nonsmearing, and large enough for the necessary information. The label must be securely attached to the sample bottle but removable when necessary. Preprinting standard information on the label can save time in the field. The marking pen or other device must be nonsmearing and maintain a permanent legible mark.

10. Complete a field record for each sample to record the full details on sampling and other pertinent remarks, such as flooding, rain, or extreme temperature, that are relevant to

interpretation of the results. This record also provides a back-up record of sample identification.

11. Place the samples in a suitable container and transport them to the laboratory as soon as possible. Adhering to sample preservation and holding time limits is critical to the production of valid data. Bacteriological samples should be iced or refrigerated at 1 to 4 °C during transit to the laboratory. Use insulated containers such as plastic or styrofoam coolers, if possible, to ensure proper maintenance of storage temperature. Take care to ensure that sample bottles are not totally immersed in water during transit or storage. Examine samples as soon as possible after collection. Do not hold samples longer than 6 hours between collection and initiation of analysis (USEPA, 2000). Do not analyze samples that exceed holding time limits.

12. Collect water samples for analyses of other parameters in separate appropriate containers at the same time and perform analyses as specified in the particular methods.

13. After collecting samples from a station, wash hands and arms with alcohol wipes, a disinfectant lotion, or soap and water, and dry to reduce exposure to potentially harmful bacteria or other microorganisms.

J.3 Sample Handling

In cases where an agency must demonstrate the reliability of its evidence in legal cases involving pollution, it is important to document the chain of possession and custody of samples that are offered for evidence or that form the basis of analytical results introduced into evidence (Bordner et al., 1978). Although the analytical results of the water samples collected at a swimming beach are being used to make a decision for the protection of human health, a decision to close the beach might be unpopular with local businesses and could be contested. It is thus important that the agency collecting the samples and the laboratory performing the analysis prepare written procedures to be followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed. These are known as “chain of custody” (COC) procedures.

The sampling agency should have procedures to ensure the custody and integrity of the samples beginning at the time of sampling and continuing through transport and sample receipt. The laboratory should have procedures for sample receipt, preparation, analysis and storage, data generation and reporting, and sample disposal.

A COC form filled out by the person conducting the sampling should provide information such as the following: sampling location (site ID), time of collection, date of collection, time of near or high tide, air temperature, water temperature, rainfall history, collector’s name and signature, agency, and other notes or comments. A Chain-of-Custody Review List and a Sample Handling, Preparation, and Analysis List are provided at the end of this appendix.

Samples are usually transported to the laboratory by the person collecting the sample or picked up by laboratory personnel. Because of the 6-hour holding time limitation, the laboratory should be conveniently located near the sampling site and should be notified a few days in advance of the sampling effort so that it will be ready to process the samples promptly. COC procedures should be followed at the laboratory for all samples. Laboratory personnel receiving samples should do the following:

1. Check the shipping container for damage and a custody seal. Note whether the custody seal is intact and record any anomalies on the sample log-in form.

2. Open the container and inspect the sample containers, noting any damage or breakage. Immediately take the temperature of the samples. Place a calibrated thermometer or temperature probe in the cooler in a representative location (not directly touching any ice or cold packs and not inside a sample bottle). Record the temperature on the sample log-in form and the COC form enclosed with the sample.

3. Remove the individual containers from the shipping container and inspect each one for damage, leakage, or any other problem. Note the condition of each container, the date received, the project number, the batch number, and the airbill or shipping identification number on the sample log-in form and the COC form.

4. Compare each sample container to those listed on the COC form to ascertain whether all the samples are present and whether all the labels on the sample containers match those on the COC form.

5. If no COC form accompanies the samples, complete a COC form and confirm all sample information with the agency that collected the samples. Document any contact with the agency regarding problems or confirmation on the sample log-in and COC forms.

6. Notify the laboratory manager if any problems with the samples are noted. Sign and date the COC form upon completion of the sample inspection.

7. Assign each sample a sample ID code. For example, the sample ID code should include a sequential log-in number, a sample type code (e.g., U for upstream, S for site, L for laboratory), a code to identify the collecting agency, the sampling date, and the analysis required. Assign replicate samples from the same site the same code with a suffix such as -A,- B, or -C to indicate their replicate status.

8. Record each sample's code on the sample log-in form, the COC form, and the corresponding sample container. Indicate on the form where the samples will be held (e.g., which room in the laboratory). When samples are removed for final disposition, the removal should be documented on the sample log-in form.

9. Record additional information on the sample log-in form, including the collecting agency contact, sample analyses required, and due dates of analyses.

10. Store samples not used immediately at 4 °C.

Table J-1. Chain-of-Custody Review List

Task
Sample custodian designated
Name of sample custodian
Sample custodian's procedures and responsibilities documented
Standard operating procedures (SOPs) developed for receipt of samples
Where are the SOPs documented (laboratory manual, written instructions...)?
Receipt of chain-of-custody record(s) with samples documented
Nonreceipt of chain-of-custody record(s) with samples documented
Integrity of the shipping container(s) documented
Where is security documented?
Lack of integrity of the shipping container(s) documented
Where is nonsecurity documented?
Agreement between chain-of-custody records and sample tags verified and documented
Source of verification and location of documentation
Sample tag numbers recorded by the sample custodian
Where are they located?
Samples stored in a secure area
Where are they stored?
Sample identification maintained
Sample extract (or inorganics concentrate) identification
Samples maintained. How?

Table J-2. Sample Handling, Preparation, and Analysis List

Category	Task
Field Logs	Project name/ID and location
	Sampling personnel identified
	Map
	Geological observations
	Atmospheric conditions
	Field measurements
	Sample dates, times, and locations
	Sample identifications noted
	Sample matrix identified
	Sample descriptions (e.g., odors, colors)
	Number of samples taken per location
	Sampling method/equipment
	Description of any QC samples
	Deviations from the sampling plan
	Difficulties or unusual circumstances
Chain-of-Custody Records	Project name/ID and location
	Sample custodian's procedures and responsibilities documented
	Sample custodians' signatures verified and on file
	Date and time of each transfer
	Carrier ID number
	Integrity of shipping container and seals verified
	Standard operating procedures (SOPs) for receipt on file
	Samples stored in same area
	Holding time protocol verified
	SOPs for sample preservation on file
	Identification of proposed analytical method verified
	Proposed analytical method documentation verified

Table J-2. (continued)

Category	Task
Chain-of-Custody Records	QA plan for proposed analytical method on file
Sample Labels	Sample ID
	Date and time of collection
	Sampler's signature
	Characteristic or parameter investigated
	Preservative used
Sample Receipt Log	Date and time of receipt
	Sample collection date
	Client sample ID
	Number of samples
	Sample matrices
	Requested analysis, including method number(s)
	Signature of the sample custodian or designee
	Sampling kit code (if applicable)
	Sampling condition
	Chain-of-custody violations and identities
Sample Preparation Logs	Parameter/analyte of investigation
	Method number
	Date and time of preparation
	Analyst's initials or signature
	Initial sample volume or weight
	Final sample volume
	Concentration and amount of spiking solutions used
	QC samples included with the sample batch
	ID for reagents, standards, and spiking solutions used
Sample Analysis Logs	Parameter/analyte of investigation

Table J-2. (continued)

Category	Task
	Method number/reference
	Date and time of analysis
	Analyst’s initials or signature
	Laboratory sample ID
	Sample aliquot
	Dilution factors and final sample volumes (if applicable)
	Absorbance values, peak heights, or initial concentrations reading
	Final analyte concentration
	Calibration data (if applicable)
	Correlation coefficient (including parameters)
	Calculations of key quantities available
	Comments on interferences or unusual observations
	QC information, including percent recovery
Instrument Run Logs	Name/type of instrument
	Instrument manufacturer and model number
	Serial number
	Date received and date placed in service
	Instrument ID assigned by the laboratory (if used)
	Service contract information, including service representative details
	Description of each maintenance or repair activity performed
	Date and time of each maintenance or repair activity
	Initials of maintenance or repair technicians
Chemical/Standard Receipt Logs	Laboratory control number
	Date of receipt
	Initials or signature of person receiving chemical
	Chemical name and catalog number

Table J-2. (continued)

Category	Task
	Vendor name and log number
	Concentration or purity of standard
	Expiration date
Standards/Reagent Preparation Log	Date of preparation
	Initials of analyst preparing the standard solution or reagent
	Concentration or purity of standard or reagent
	Volume or weight of the stock solution
	Final volume of the solution being prepared
	Laboratory ID/control number assigned to the new solution
	Name of standard reagent
	Standardization of reagents, titrants, etc. (if applicable)
	Expiration date

J.4 References

Bordner, R., J.A. Winter, and P.V. Scarpino, eds. 1978. *Microbiological Methods for Monitoring the Environment, Water and Wastes.* EPA-600/8-78-017. U.S. Environmental Protection Agency, Washington, DC.

IITF. 1999. *Standard Operating Procedure for Recreational Water Collection and Analysis of* E. coli *on Streams, Rivers, Lakes and Wastewater.* Indiana Interagency Task Force on *E. coli*. LaPorte County Health Department, LaPorte, IN.

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Appendix K: Predictive Tools

This appendix provides supplemental discussions, examples, and additional references that may be helpful to beach program managers. It does not create additional requirements beyond those in the main guidance document.

K.1 Screening Factors for Model Selection

Selection of an appropriate water quality model for helping to determine beach advisories and closings depends on the site conditions of the waterbody of concern. The selection of the appropriate model can be based on the following screening factors:

- ***Combined point and nonpoint sources***. An important screening factor is how the model handles the loadings from point and nonpoint sources. Models based on water quality data implicitly take the point and nonpoint sources into account, whereas models that use continuous simulation of the water quality directly account for the sources. Typically, the sources are part of the input parameters. For example, the rainfall-based alert curves discussed later in this chapter are models based on water quality conditions. Those models do not explicitly account for point and nonpoint sources; instead, the sources affect the water quality parameters used in the model. In the case of the CORMIX and PLUME models (described below), point sources are a component of the model input; the flow and concentration also must be included.

- ***Pathogen source characterization***. Pathogens found at a beach site of interest might be from point sources, including sewage treatment plants, sanitary sewer overflows (SSOs), combined sewer overflows (CSOs), septic systems, and storm water outfalls, or nonpoint sources. Accounting for the different sources of pathogens might require the use and integration of a variety of models. Once pathogen loads from point and nonpoint sources are determined, the next step is the routing of the pathogen through the system using a representative model of the dominant mixing and transport processes to estimate the pathogen concentration at the location of interest.

- ***Dominant mixing and transport processes***. The waterbody type dictates the dominant mixing and transport processes of a pollutant. In rivers and streams the dominant processes are advection and dispersion. In estuaries these processes are influenced by tidal cycles and flows. Waterbody size and net freshwater flow are also important in determining the dominant processes. For discharges in the ocean surf zone, dominant dispersion processes include mixture due to breaking waves and transport from nearshore currents.

- ***Pathogen concentration prediction***. This factor describes the ability of the model to predict the pathogen concentration in the receiving water at the location of interest, which in this case is a beach site. Transformation processes such as bacterial kinetics must also be accounted for in the model to allow for a realistic prediction.

- ***Ability to provide time-relevant analysis, decisionmaking, and guideline establishment***. Timely or time-relevant analysis is needed for an effective advisory. Models applied to predict water quality conditions can be used as a basis for decision making and as management tools. For example, a beach authority can use such tools as a basis for beach advisories following a rainfall event or an accidental sewage spill.

- ***Time-relevant use***. Under this category the input data needed, processing time, and postprocessing abilities of the model are evaluated. Potential predictive tools for beach advisories must be able to predict pathogen concentration at the site of interest in a relatively short. This means that the data input requirements and processing time need to be minimal. Also crucial to the success of the predictive tool is the postprocessing of the output data. Tabular or graphical representation of the output data provides a quick, easy way to interpret results and might serve as a basis for making time-relevant decisions concerning beach advisories.

- ***Evaluation of unplanned and localized spills***. Spills of a pollutant can be caused accidentally by equipment failure or rainfall. In either case, this factor describes how the model handles the additional loading. Models based on water quality data do not account for this increased loading unless samples were collected during rainfall or a spill event and analyzed, and the data were then entered into the model database. Models that account for point sources can easily account for the increased loading by including the spill as an input parameter.

- ***Documented application to beach and shellfish closure***. This factor describes the ability of the model to predict the water quality condition surrounding swimming and shellfish areas. Models can be used as water quality predictive tools and as a basis for decisionmaking. For example, several communities use rainfall models, and the New York City metropolitan area uses the Regional Bypass Model (discussed later in this chapter). These models have proven to be effective tools to protect people from exposure to pathogens following rainfall events or sewage spills.

- ***Ease of use***. The level of user experience is an important factor in determining whether a model is easy to use. Some complex models require a great deal of training and experience; simple methods require only a conceptual understanding of the processes, and results can be readily obtained.

- ***Input data requirements***. Input data requirements are a function of a model's complexity. In general, complex models require more specific and complex input data than simple models. Some of these data might not be readily available, and acquiring such data might require expending resources. Therefore, the objective of the model application can be very important in this step.

- ***Calibration requirements***. Decision making and management alternatives based on modeling results require that the model outcome be acceptable and reliable. Not all models can be calibrated. Models that simulate water quality conditions are calibrated against in-stream monitoring stations. Simple models such as the rainfall alert curves are continuously updated to provide accurate results. This is done by continually updating the model's database.

- ***Pollutant routing***. Pollutant routing addresses how a model deals with the fate and transformation of pollutants. Simpler models might not include processes that describe pollutant transformation. More complex models vary in their description of the processes. The range can be from a gross or a net estimate of the process to a detailed mechanism of the process. The focus is on bacterial processes. In general, most environmental models use the first-order decay rate to represent microbial die-off rate.

- ***Kinetics of pathogen decay***. The survival of pathogens (and pathogen indicators) in the environment is influenced by many variables, such as age of the fecal deposit, temperature, sunlight, pH, soil type, salinity, and moisture conditions. In general, the death rate of pathogens can be estimated as a first-order rate, which is incorporated into water quality models.

Predictive models are effective tools to supplement actual sampling. It is important, however, to consider that models do not provide perfect predictions of actual conditions but instead provide estimates of current conditions. A public health manager should account for inaccuracies in models when making decisions related to public health.

K.2 Predictive Methods Currently Used by Beach Managers

Two approaches were used to identify the predictive tools currently in use by local agencies. First, EPA's National Health Protection Survey of Beaches was used to identify local agencies that currently base their beach advisories on water quality model prediction. Those agencies were contacted regarding the types of models they use and information about the extent of use, model development, and availability.

The second approach was a review of literature and information from previous EPA programs. This approach included reviewing the models and guidelines provided in the CWA section 301(h) program, identifying tools used in the Total Maximum Daily Load (TMDL) program, and reviewing other EPA publications that relate to water quality modeling. The beach closure predictive tools identified were characterized based on modeling or prediction application techniques and on modeling components.

The tools currently in use by local and state agencies vary in their complexity and approach to minimizing exposure to pathogens. The cities of Milwaukee, Wisconsin, and Stamford, Connecticut, and the Delaware Department of Natural Resources and Environmental Control (DNREC) used regression analysis to relate rainfall to pathogen concentration. Models developed using this approach are site-specific because they are derived from locally observed water quality and rainfall data.

Simulation of water quality conditions under a variety of scenarios of untreated or partially treated sewage also can be used. Comparison of the simulated water quality conditions to the established criteria can serve as the basis for a beach closure. The metropolitan Boston area in Massachusetts is undertaking such a project. A predictive model that can predict water quality conditions resulting from bypasses of sewage at preselected locations was developed for the New York-New Jersey Harbor. Beaches surrounding the discharge locations are closed whenever the predicted pathogen concentrations exceed the water quality criteria.

Closure of beaches based on water quality modeling is also practiced in Virginia and Washington. Computer models that predict pathogen concentration by simulating the dominant mixing and transport processes in the receiving water range from simple to very complex. The Virginia Department of Health uses a simple mixing and transport model to predict water quality conditions surrounding wastewater treatment plant outfalls. The state of Washington uses a more complex model, CORMIX, to predict water quality conditions surrounding wastewater treatment plant outfalls. Rhode Island is also developing predictive models for its beaches. *Review of Potential Modeling Tools and Approaches to Support the Beach Program* (USEPA, 1999) provides a detailed description of these tools and their attributes, limitations, data requirements, and availability. A summary of the capabilities and applicability of these models is provided in table K-1.

Table K-1. Evaluation of Model Capabilities and Applicability

Model	Combined PS/NPS [a]	Real Time and Decision Making	Spills	Application to Beach or Shellfish Closure	Ease of Use	Input Data Required	Calib.	Developing Guidelines	Pollutant Routing
Rainfall-based	xxx	xxx	0	xxx	xxx	x	xx	xx	0
Bypass	x (PS)	xxx	xxx	xxx	xxx	xxx	x	xx	xxx
SMTM	x (PS)	xx	xx	xx	xx	x	x	0	x
PLUMES	x (PS)	x	xx	xx	xx	x	x	x	x
CORMIX	x (PS)	x	x	x	xx	x	x	x	x
JPEFDC	xx (NPS/PS)	x	xxx	xxx	x	xxx	xx	x	xxx

0 Not applicable. x Low applicability.
xx Medium applicability. xxx High applicability. [a] Point Source/Nonpoint Source.

K.3 Rainfall-Based Alert Curves

K.3.1 Objectives

The objective of a rainfall-based alert curve model is to establish a statistical relationship between rainfall events and bacterial indicator concentrations. This relationship can then serve as a management tool for developing operating (advisory and closures) guidelines based on predicted pathogen concentrations that suggest the need to restrict or prohibit contact uses of recreation waters. Several agencies have developed beach operating rules based on analysis of site-specific relationships between rainfall and water quality monitoring data. Delaware (DNREC, 1997) and Connecticut (Kuntz, 1998) have successfully used this approach (USEPA, 1999).

K.3.2 Benefits

The use of rainfall-based alert curves are highly recommended as predictive tools to determine the need for beach advisories or closings. They are recommended because of their simplicity, ease of development and use, economic feasibility, and virtually instantaneous run time. A great advantage of rainfall-based alert curves is that they can be easily translated to decision logic that a beach manager can use without prior advanced training or a high level of technical skill.

K.3.3 Limitations

It is important to update these models with changes in watershed or weather pattern. Weather patterns are typically cyclical, so predictive models must reflect this variance or acknowledge this limitation.   For example, rainfall-based alert curves may not be appropriate for use along the arid southern California coast because of an "impact lag" effect where discharges from storm water outfalls can continue for several weeks following substantial rain events.

K.3.4 Overview of Rainfall-Based Alert Curves Technical Approach

Rainfall-based alert curves are developed in three phases: collecting data, analyzing data (linking the rainfall events to bacterial indicators), and developing operating rules for advisories or closings of recreational waters. Although EPA is currently supporting continued efforts in research and development of these techniques, the Agency recommends that state, tribal, and local beach managers consider developing scientifically based and easy-to-use site-specific decision rules based on the technical approaches summarized below:

- Rainfall-based models are site-specific, and their development requires relatively large sets of monitoring data for both rainfall and water quality. The overall relationship can be described by a statistical regression/estimation model. Depending on the number of rainfall stations considered and the number of rainfall characteristics (amount, duration, lag time), the relationship might require a more complex multiple-regression model. Because of the statistical nature of these types of models, they cannot distinguish between point sources and nonpoint sources of pathogens and do not explicitly incorporate advection, transport, and decay processes. Also, because their use is limited to assisting in the development of decision rules for advisories and closings of recreational waters, they do not attempt to provide the spatial and vertical distribution of pathogens.

- Frequency of exceedance analysis is another rainfall-based method that can be used to develop rainfall-based alert curves. An exceedance is defined as any time the observed pathogen concentration exceeds the action level, such as the state water quality standard, specified by a responsible agency. The objective of this method is to determine the minimum amount of rainfall that causes the pathogen concentration to exceed the action level. This amount can be determined by dividing cumulative rainfall amounts over a period of 24 hours or more into segments that range from no rainfall to an upper limit that is representative of the rainfall record, types of storms, and season. For each rainfall amount category, the observed pathogen concentration or the geometric mean of multiple samples is compared to the action level.

- After establishing a relationship between rainfall amounts and pathogen concentrations, developing decision rules for advisories and closings is the next step. An advisory or closing threshold is determined based on the least amount of rainfall that would result in an exceedance of the action level. This method applies to situations where historical rainfall data and water quality records exist. Decision rules also should be developed to include seasonal variation in rainfall.

K.3.5 Case Studies

Rainfall-based alert curves based on regression analysis have been used for preemptive beach closures in Milwaukee, Wisconsin; Stamford, Connecticut; Sussex County, Delaware; and the Boston, Massachusetts, area. In the cases of the city of Milwaukee, city of Stamford, and the Delaware Department of Natural Resources and Environmental Control, the approach taken was regression analysis to relate rainfall to pathogen concentration. Models developed based on this approach are site-specific because they are derived from locally observed water quality and rainfall data as well as beach location/configuration relative to pathogen sources.

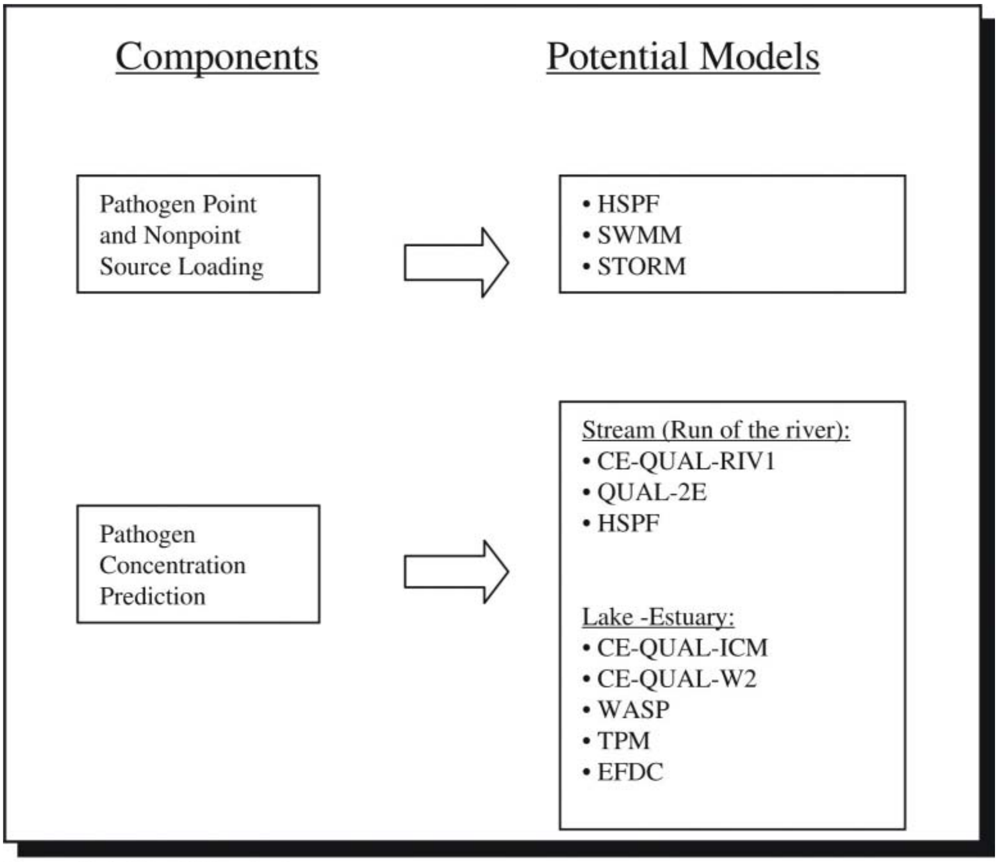

Figure K-1. Predictive tool summary.

K.4 Other Predictive Tools to Supplement Sampling

Supplemental Sampling

The overall objective of beach closure predictive tools is to minimize the population's exposure to pathogens. The tools currently in use by local agencies vary in their complexity and approach to minimizing exposure but are generally simple, reliable tools. Figure K-1 shows other predictive tools that can be used to determine the need for a beach closing. The listed models are divided into two categories—watershed pathogen loading models and pathogen concentration prediction models. The latter category is divided into two additional groups to reflect the waterbody types: (1) rivers and streams and (2) lakes and estuaries. Currently, there are no readily available models that address the coastal nearshore environment; therefore, surf zone models are not included in this appendix.

Pathogen Loading Estimates

Watershed loading models that can be used to estimate pathogen loadings to receiving waters are presented in table K-2. Three considerations are taken into account in the table—real-time prediction, source type, and land use type.

Table K-2. Watershed-scale Loading Models

Model Type	Model Name	Real- time Prediction		Source Type			Land Use Type	
		Data Needs	Processing Time	PS	NPS	CSO	Urban	Rural
Watershed-scale loading	HSPF: Hydrological Simulation Program–Fortran	x	x	xx	x		x	xxx
	SWMM: Storm Water Management Model	x	x	x	x	xx	xx	x
	STORM: Storage, Treatment, Overflow, Runoff Model	x	x	x	x	x	xx	

x Low data requirements/applicability.
xx Medium data requirements/applicability.
xxx High data requirements/applicability.

Potential sources of pathogens include point sources (including CSOs) and nonpoint sources. Models differ in their ability to account for these various source types. Models that simulate nonpoint sources are capable of describing the pathogen buildup processes during dry weather and washoff processes related to rainfall-generated runoff. Accounting for various land uses is very important in estimating nonpoint source loadings because the processes of buildup and washoff are land-use-specific. CSO loading is a function of the hydraulic routing and the storage capacity in the publicly owned treatment works, consisting of the treatment plant and collection system. Therefore, a model's ability to deal with the complex land uses in the watershed is an important factor in model selection and applicability. The key loading models suited for real-time prediction summarized in table K-2 are briefly described below.

HSPF: Hydrological Simulation Program—Fortran. HSPF is a comprehensive watershed-scale model developed by EPA. The model uses continuous simulation of water balance and pollutant buildup and washoff processes to generate time series of runoff flow rates, as well as pollutant concentration at any given point in the watershed. Runoff from both urban and rural areas can be simulated using HSPF; however, simulation of CSOs is not possible. Because of the comprehensive nature of the model, data requirements for HSPF are extensive and using this model requires highly trained personnel.

SWMM: Storm Water Management Model. SWMM is a comprehensive watershed-scale model developed by EPA. It can be used to model several types of pollutants on either a continuous or storm event basis. Simulation of mixed land uses is possible using SWMM, but the model's capabilities are limited for rural areas. SWMM can simulate loadings from CSOs. The model requires both intensive data input and a special effort for validation and calibration. The output of the model is time series of flow, storage, and contaminant concentrations at any point in the watershed.

STORM: Storage, Treatment, Overflow, Runoff Model. STORM is a watershed loading model developed by the U.S. Army Corps of Engineers for continuous simulation of runoff quantity and quality. The model was primarily designed for modeling storm water runoff from urban areas, but it also can simulate combined sewer systems. It requires relatively moderate to high calibration and input data. The simulation output is hourly hydrographs and pollutographs.

Pathogen Concentration Prediction

Loading models, depending on the simulation type, provide estimates of either the total water and pollutant loading or a time series loading of water and pollutants. Pathogen concentration prediction is the process of describing the response of the waterbody to pollutant loadings, flows, and ambient conditions. Because the response is specific to the waterbody, different types of models are required for accurate simulation, as shown in table K-3. The models are divided into two categories on the table—rivers and streams, and lakes and estuaries.

Rivers and Streams. Prediction of pathogen concentration in rivers and streams is dominated by the processes of advection and dispersion and the bacterial indicator degradation. One-, two-, and three-dimensional models have been developed to describe these processes, as shown in table K-3. Waterbody type and data availability are the two most important factors that determine model applicability. For most small and shallow rivers, one-dimensional models are sufficient to simulate the waterbody's response to pathogen loading. For large and deep rivers and streams, however, the one-dimensional approach falls short of describing the processes of advection and dispersion. Assumptions that the pathogen concentration is uniform both vertically and laterally are no longer valid. In such cases two- or three-dimensional models that include a description of the hydrodynamics are used. The river and stream models summarized in table K-3 are briefly described below.

Table K-3. Potential Pathogen Fate and Transport Models

Model Name	Time-Relevant Prediction		Waterbody Type	
	Data Needs	Processing Time	Rivers and Streams	Lakes and Estuaries
HSPF: Hydrological Simulation Program—Fortran	xx	x	x	N/A
CE-QUAL-RIV1: Hydrodynamic and Water Quality Model for Streams	xx	xx	x	N/A
CE-QUAL-ICM: A Three-Dimensional, Time-Variable, Integrated-Compartment Eutrophication Model	xxx	xxx	x	xx
CE-QUAL-W2: A Two-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model	xxx	xx	xx	x
WASP5: Water Quality Analysis Simulation Program	xx	xx	xx	xx
EFDC: Environmental Fluid Dynamics Computer Code	xx	xx	xx	xx
QUAL2E: Enhanced Stream Water Quality Model	x	x	x	N/A
TPM: Tidal Prism Model	x	x	N/A	x

x Low applicability.
xx Medium applicability.
xxx High applicability.

HSPF: Hydrological Simulation Program—Fortran . HSPF is a comprehensive watershed-scale model developed by EPA. The receiving water component allows dynamic simulation of one-dimensional stream channels, and several hydrodynamic routing options are available. The model output is time series of runoff flow rate, as well as pollutant concentration at any given point in the watershed. Because of the model's comprehensive nature, the data requirements for HSPF are extensive and running the model requires highly trained personnel.

CE-QUAL-RIV1: Hydrodynamic and Water Quality Model for Streams. CE-QUAL-RIV1 is a dynamic, one-dimensional model for rivers and estuaries consisting of two codes—one for hydraulic routing and another for dynamic water quality simulation. CE-QUAL-RIV1 allows simulation of unsteady flow of branched river systems. The input data requirements include the river geometry, boundary conditions, initial in-stream and inflow boundary water quality concentrations, and meteorological data. The model predicts time-varying concentrations of water quality constituents.

Lakes and Estuaries. Predicting the response of lakes and estuaries to pathogen loading requires an understanding of the hydrodynamic processes. Shallow lakes can be simulated as a simplified, completely mixed system with an inflow stream and an outflow stream. However, simulating deep lakes or estuaries with multiple inflows and outflows that are affected by tidal cycles is not a simple task. Pathogen concentration prediction is dominated by the processes of advection and dispersion, and these processes are affected by the tidal flow. The size of the lake or the estuary, the net freshwater flow, and wind conditions are some of the factors that determine the applicability of the models. The lake and estuary models summarized in table K-3 are briefly described below.

ASP5: Water Quality Analysis Simulation Program. WASP5 is a general-purpose modeling system for assessing the fate and transport of pollutants in surface water. The model can be applied in one, two, or three dimensions and can be linked to other hydrodynamic models. WASP5 simulates the time-varying processes of advection and dispersion while considering point and nonpoint source loadings and boundary exchange. The waterbody to be simulated is divided into a series of completely mixed segments, and the loads, boundary concentrations, and initial concentrations must be specified for each state variable.

CE-QUAL-ICM: A Three-Dimensional Time-Variable Integrated-Compartment Eutrophication Model. CE-QUAL-ICM is a dynamic water quality model that can be applied to most waterbodies in one, two, or three dimensions. The model can be coupled with three-dimensional hydrodynamic and benthic-sediment model components. CE-QUAL-ICM predicts time-varying concentrations of water quality constituents. The input requirements for the model include 140 parameters to specify the kinetic interactions, initial and boundary conditions, and geometric data to define the waterbody to be simulated. Model use might require significant expertise in aquatic biology and chemistry.

EFDC: Environmental Fluid Dynamics Computer Code. EFDC is a general three-dimensional hydrodynamic model developed by Hamrick (1992). EFDC is applicable to rivers, lakes, reservoirs, estuaries, wetlands, and coastal regions where complex water circulation, mixing, and transport conditions are present. EFDC must be linked to a water quality model to predict the receiving water quality conditions. HEM-3D is a three-dimensional hydrodynamic eutrophication model that was developed by integrating EFDC with a water quality model. Considerable technical expertise in hydrodynamics and eutrophication processes is required to use the EFDC model.

CE-QUAL-W2: A Two-Dimensional, Laterally Averaged Hydrodynamic and Water Quality Model. CE-QUAL-W2 is a hydrodynamic water quality model that can be applied to most waterbodies in one dimension or laterally averaged in two dimensions. The model is suited for simulating long, narrow waterbodies like reservoirs and long estuaries, where stratification might occur. The model application is flexible because the constituents are arranged in four levels of complexity. Also, the water quality and hydrodynamic routines are directly coupled, allowing for more frequent updating of the water quality routines. This feature can reduce the computational burden for complex systems. The input requirements for CE-QUAL-W2 include geometric data to define the waterbody, specific initial boundary conditions, and specification of approximately 60 coefficients for the simulation of water quality.

QUAL2E: The Enhanced Stream Water Quality Model. QUAL2E is a steady-state receiving water model. The basic equation used in QUAL2E is the one-dimensional advective-dispersive mass transport equation. Although the model assumes a steady-state flow, it allows simulation of diurnal variations in meteorological inputs. The input requirements of QUAL2E include the stream reach physical representation and the chemical and biological properties for each reach.

TPM: Tidal Prism Model. TPM is a steady-state receiving water quality model applicable only to small coastal basins. In such locations the tidal cycles dominate the mixing and transport of pollutants. The model assumes that the tide rises and falls simultaneously throughout the waterbody and that the system is in hydrodynamic equilibrium. Two types of input data are required to run TPM. The geometric data that define the system being simulated are the returning ratio, initial concentration, and boundary conditions. The physical data required are the water temperature, reaction rate, point and nonpoint sources, and initial boundary conditions for water quality parameters modeled.

K.5 References

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