DEPARTMENT OF
ECOLOGY
State of Washington

Quality Assurance Project Plan

Beach Environmental Assessment, Communication, and Health (BEACH) Program: Monitoring Washington State Marine Beaches

December 2014

Publication No. 14-03-128

Publication Information

Each study conducted by the Washington State Department of Ecology (Ecology) must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

This Quality Assurance Project Plan is available on Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1403128.html

Data for this project will be available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search Study ID EPABEACH

Ecology's Activity Tracker Code for this study is 02-502.

Author and Contact Information

Debby Sargeant and Julie Lowe
P.O. Box 47600
Environmental Assessment Program
Washington State Department of Ecology
Olympia, WA 98504-7710

Communications Consultant: phone 360-407-6834.

Washington State Department of Ecology - www.ecy.wa.gov

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Yakima 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

Cover photo: Surfing at Westport, WA; Swimming at Twanoh State Park; Scuba diving in Puget Sound; Beach sign. (BEACH Program photo files)

Any use of product or firm names in this publication is for descriptive purposes only and does not imply endorsement by the author or the Department of Ecology.

Accommodation Requests:
To request ADA accommodation including materials in a format for the visually impaired, call Ecology at 360-407-6834. Persons with impaired hearing may call Washington Relay Service at 711. Persons with speech disability may call TTY at 877-833-6341.

Quality Assurance Project Plan

Beach Environmental Assessment, Communication & Health (BEACH) Program: Monitoring Washington State Marine Beaches

December 2014

Approved by:

Signature:	Date: December 2014
Debby Sargeant, Author / BEACH Program Manager, EAP	
Signature:	Date: December 2014
Julianne Ruffner, BEACH Program Specialist, EAP	
Signature:	Date: December 2014
Carol Maloy, Marine Monitoring Unit Supervisor, EAP	
Signature:	Date: December 2014
Robert F. Cusimano, Western Operations Section Manager, EAP	
Signature:	Date: December 2014
Bill Kammin, Ecology Quality Assurance Officer	

Signatures are not available on the Internet version.
EAP: Environmental Assessment Program

1.0 Title Page and Table of Contents

Table of Contents

Page

1.0 Title Page and Table of Contents 2

2.0 Abstract 5

3.0 Background 5
- 3.1 Study area and surroundings 6
  - 3.1.1 Logistical problems 9
  - 3.1.2 History of study area 9
  - 3.1.3 Parameters of interest 10
  - 3.1.4 Results of previous studies 10
  - 3.1.5 Regulatory criteria or standards 12

4.0 Project Description 13
- 4.1 Project goals 13
- 4.2 Project objectives 13
- 4.3 Information needed and sources 13
- 4.4 Target population 14
- 4.5 Study boundaries 14
- 4.6 Tasks required 14
- 4.7 Practical constraints 14
- 4.8 Systematic planning process 14

5.0 Organization and Schedule 15
- 5.1 Key individuals and their responsibilities 15
- 5.2 Special training and certifications 16
- 5.3 Organization chart 16
- 5.4 Project schedule 17
- 5.5 Limitations on schedule 17
- 5.6 Budget and funding 17

6.0 Quality Objectives 18
- 6.1 Decision Quality Objectives (DQOs) 18
- 6.2 Measurement Quality Objectives (MQOs) 18
  - 6.2.1 Targets for precision, bias, and sensitivity 19
  - 6.2.2 Targets for comparability, representativeness, and completeness 20

7.0 Sampling Process Design (Experimental Design) 21
- 7.1 Study design 21
  - 7.1.1 Field measurements 21
  - 7.1.2 Sampling location and frequency 21
  - 7.1.3 Parameters to be determined 21
- 7.2 Maps or diagram 22
- 7.3 Assumptions underlying design 22
- 7.4 Relation to objectives and site characteristics 22
- 7.5 Characteristics of existing data 22

8.0 Sampling Procedures 23
8.1 Field measurement and field sampling SOPs 23
8.2 Containers, preservation methods, holding times 23
8.3 Invasive species evaluation 23
8.4 Equipment decontamination 23
8.5 Sample ID 23
8.6 Chain-of-custody, if required 23
8.7 Field log requirements 24
8.8 Other activities 24

9.0 Measurement Methods 25
9.1 Field procedures table/field analysis table 25
9.2 Lab procedures table 25
9.3 Sample preparation method(s) 25
9.4 Special method requirements 25
9.5 Lab(s) accredited for method(s) 26

10.0 Quality Control (QC) Procedures 27
10.1 Table of field and laboratory QC required 27
10.2 Corrective action processes 27

11.0 Data Management Procedures 27
11.1 Data recording/reporting requirements 27
11.2 Laboratory data package requirements 28
11.3 Electronic transfer requirements 28
11.4 Acceptance criteria for existing data 28
11.5 EIM/STORET data upload procedures 28

12.0 Audits and Reports 28
12.1 Number, frequency, type, and schedule of audits 28
12.2 Responsible personnel 29
12.3 Frequency and distribution of report 29
12.4 Responsibility for reports 29

13.0 Data Verification 29
13.1 Field data verification, requirements, and responsibilities 29
13.2 Lab data verification 29
13.3 Validation requirements, if necessary 29

14.0 Data Quality (Usability) Assessment 30
14.1 Process for determining whether project objectives have been met 30
14.2 Data analysis and presentation methods 30
14.3 Treatment of non-detects 30
14.4 Sampling design evaluation 30
14.5 Documentation of assessment 30

15.0 References 31

16.0 Figures 33

17.0 Tables 33

18.0 Appendices 33

Appendix B. BEACH Field Data Form 35
Appendix C. Glossaries, Acronyms, and Abbreviations 36

List of Figures and Tables

Page

Figures

Figure 1. BEACH Program Monitoring Study Area including the 51 CORE Monitoring Stations. 8

Figure 2. Percent of BEACH Program-sampled beaches that met the swimming criteria each year. 11

Tables

Table 1. Organization of project staff and responsibilities. 15

2.0 Abstract

The Washington State Beach Environmental Assessment, Communication and Health (BEACH) Program supports a public marine recreational beach monitoring and notification program throughout the Puget Sound and coast of Washington. Select Washington marine beaches are tested for the fecal bacteria Enterococci to determine possible health risk to the public from water contact recreation. During the swimming season, water samples are collected at high-use, high-risk, marine beaches that are primarily used for swimming, wading, surfing, or SCUBA diving. The public is notified when bacteria levels are high and it is unsafe to swim in the water.

Washington's BEACH Program is primarily funded through a U.S. Environmental Protection Agency (EPA) grant. The ongoing monitoring program is co-managed by the Washington State Departments of Ecology and Health. The BEACH Program distributes grant funding for monitoring, beach notification, and public education to local health jurisdictions (LHJs), universities, tribes, and volunteer non-profit organizations throughout the Puget Sound and Washington coast. Monitoring and program activities are coordinated on a regional basis by BEACH Program staff.

This QAPP supersedes the original QAPP for BEACH Program monitoring, written in 2004 (Schneider, 2004).

3.0 Background

The BEACH Program supports a marine recreational beach monitoring and notification program throughout the Puget Sound and coast of Washington. Washington marine beaches are tested for the fecal bacteria Enterococci to determine possible health risk to the public from water contact recreation. During the swimming season, water samples are collected at high-use, high-risk, marine beaches primarily used for swimming, wading, surfing, and SCUBA diving. The public is notified when results exceed the BEACH Program Guidance thresholds described in Schneider (2002). BEACH Program monitoring is an ongoing monitoring program that began in 2004. This QAPP supersedes the original QAPP for BEACH Program monitoring, written in 2004 (Schneider).

Washington's BEACH Program is primarily funded through a U.S. Environmental Protection Agency (EPA) grant. In 2000, the Clean Water Act was amended, adding the Beaches Environmental Assessment and Coastal Health Act (BEACH Act). Congress authorized EPA to award grants to states for the development and implementation of BEACH programs that reduce the risk of disease to users of the nation's marine recreational waters. States use the grant money to develop and implement programs to support microbiological testing and monitoring of marine recreational waters. The grants also support communication programs to notify the public of potential exposure to disease-causing microorganisms.

In 2012, EPA revised Recreational Water Quality Criteria threshold limits (EPA, 2012). The revised criteria are directly based on health risks to humans swimming in the water. In 2014, EPA notified the states that receive BEACH Act grants that they have until 2016 to revise their

State Water Quality Standards for bacteria to meet the 2012 Water Quality Criteria threshold limits (EPA, 2014). In the future, this QAPP may be amended to reflect changes to the Recreational Water Quality threshold limits.

The BEACH Program is co-managed by the Washington State Departments of Ecology and Health, (Ecology) and (Health). The program distributes grant funding for monitoring, beach notification, and public education to local health jurisdictions (LHJs), universities, tribes, and volunteer non-profit organizations throughout Puget Sound and the coast. Monitoring and program activities are coordinated on a regional basis by BEACH Program staff.

In addition to routine beach monitoring, the program helps to identify sources of bacterial pollution at beaches with high bacteria levels. BEACH Program staff also participate in public education and outreach activities to educate the public about sources of bacterial pollution and what they can do to avoid polluting the water. Staff also educate the public about health risks associated with swimming in contaminated waters and minimizing those risks.

3.1 Study area and surroundings

The study area includes public marine beaches in Puget Sound and the coast. The number of monitored beaches varies from year to year, depending on available funding. The BEACH program sampled 46-71 beaches per year from 2004-2014. Coastal counties currently participating in the program are: Clallam, Grays Harbor, Island, Jefferson, King, Kitsap, Mason, Pierce, Skagit, Snohomish, Thurston, and Whatcom.

The Makah Tribe in Clallam County currently obtains funding directly from EPA to administer their BEACH Program. They monitor five coastal beaches weekly throughout the year. Data from their program is entered into the BEACH database and EIM by Ecology staff.

In 2004, the BEACH program developed a list of 51 core beaches (Table 1 and Figure 1). Core beaches are considered to be the highest-use and highest-risk beaches in Washington. The BEACH Program tries to consistently monitor core beaches, as funding allows, to determine long-term water quality trends.

Table 1. BEACH Program list of Core beaches.

County	Beach	Beach Identification
Clallam	Cline Spit County Park	WA422935
Clallam	Salt Creek Recreation Area	WA496627
Grays Harbor	Westhaven State Park, Half Moon Bay	WA673259
Grays Harbor	Westhaven State Park, South Jetty	WA620402
Grays Harbor	Westport - The Groynes	WA353465
Island	Freeland County Park / Holmes Harbor	WA600271
Island	Windjammer Lagoon	WA913096
Island	Windjammer Park	WA896421
Jefferson	Fort Worden State Park	WA515591
King	Alki Beach Park	WA614011
King	Carkeek Park	WA121922

County	Beach	Beach Identification
King	Dash Point State Park	WA686013
King	Golden Gardens	WA339253
King	Lincoln Park	WA160611
King	Redondo County Park	WA676420
King	Richey Viewpoint	WA726327
King	Richmond Beach Saltwater Park	WA705527
King	Saltwater State Park	WA667355
King	Seahurst Park	WA347545
Kitsap	Arness County Park	WA192208
Kitsap	Eagle Harbor Waterfront Park	WA381199
Kitsap	Evergreen Park	WA324660
Kitsap	Fay Bainbridge Park	WA325280
Kitsap	Illahee State Park	WA843240
Kitsap	Indianola Dock	WA175620
Kitsap	Lions Field	WA581265
Kitsap	Pomeroy Park - Manchester Beach	WA369081
Kitsap	Silverdale Waterfront Park	WA177646
Mason	Potlatch State Park	WA521828
Mason	Twanoh State Park	WA205748
Mason	Walker County Park	WA113345
Pierce	Dash Point Metro Park	WA261743
Pierce	Owen Beach / Point Defiance Park	WA473944
Pierce	Purdy Sandspit County Park	WA370745
Pierce	Sunnyside Beach Park	WA872803
Pierce	Titlow Park	WA465917
Pierce	Waterfront Dock / Ruston Way	WA288467
Skagit	Bayview Boat Launch	WA595244
Skagit	Bayview State Park	WA211931
Snohomish	Edmonds Marina Beach Dog Park	WA207419
Snohomish	Edmonds Marina Beach Park	WA980702
Snohomish	Edmonds Underwater Park	WA928351
Snohomish	Howarth Park	WA587438
Snohomish	Jetty Island	WA765635
Snohomish	Kayak Point County Park	WA294978
Snohomish	Picnic Point County Park	WA233925
Thurston	Burfoot County Park	WA467079
Whatcom	Birch Bay County Park	WA486271
Whatcom	Birch Bay State Park	WA382349
Whatcom	Larrabee State Park, Wildcat Cove	WA542379
Whatcom	Port Of Bellingham Marine Park	WA266896

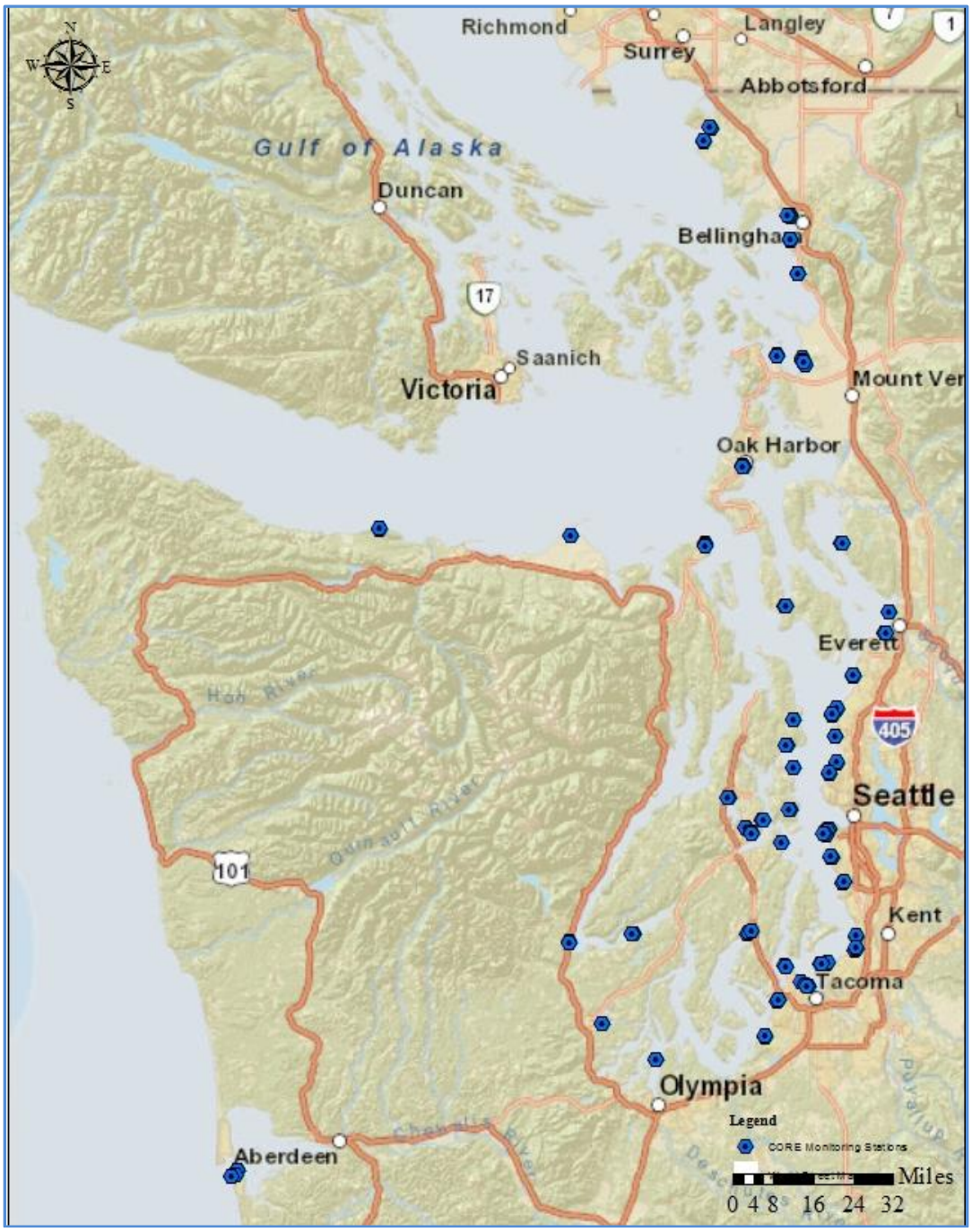


Figure 1. BEACH Program Monitoring Study Area including the 51 CORE Monitoring Stations.

.

3.1.1 Logistical problems

Logistical problems may include volunteer sampler availability, beach access due to tidal variation, and timing of field work due to fecal bacteria 6-hour holding time.

For beaches sampled by volunteers (Snohomish and Skagit county beaches and Fort Worden State Park in Jefferson County), it may be difficult to find volunteers to resample beaches with initial high bacteria counts. Beaches sampled by volunteers include a weekly sample schedule. The sample schedule should also include volunteers on call for resample events.

Beach sampling should be scheduled in advance of the sampling season (May through September). Schedules should include sample timing windows for beaches with tidal issues, whether it is low or high tide. For example, it is unsafe to sample some muddy beaches at low tide and it's difficult to access some beaches at higher tides.

In addition, ample time must be allowed to conduct all sampling and deliver the samples to the laboratory by the appropriate time and within six hours of sample collection.

3.1.2 History of study area

In 2000, the Clean Water Act was amended, adding the Beaches Environmental Assessment and Coastal Health Act (BEACH Act). Congress authorized EPA to award grants to states for the development and implementation of BEACH programs that reduce the risk of disease to users of the nation's marine recreational waters. States use this grant money to develop and implement programs to (1) support microbiological testing and monitoring of marine recreational waters and (2) notify the public of potential exposure to disease-causing microorganisms.

Prior to funding and implementation of the BEACH Program, only two counties in Washington (Island and Kitsap) had marine recreational swimming beach monitoring and notification programs. King and Skagit counties also monitored marine beaches, but did not have notification procedures in place. Washington did not have a standardized bacteria monitoring program for marine swimming beaches. In 2001, Ecology applied for and received a BEACH Act Grant from EPA in December 2001.

A group of stakeholders, named the BEACH Committee, convened during the spring of 2002 to plan Washington's BEACH Program. This committee developed both the Draft: Beach Environmental Assessment, Communication, and Health (BEACH) Program Guidance (Schneider, 2002) and the original BEACH Program Quality Assurance Project Plan (QAPP) (Schneider, 2004).

Implementation of the BEACH Program began as a pilot project in 2003. Five counties−Grays Harbor, Island, Kitsap, Pierce, and Skagit−conducted weekly monitoring. The 2003 Beach Program Pilot Project was evaluated and recommendations were incorporated into the Beach Program Guidance.

Today, the BEACH Program is jointly administered by the Departments of Ecology and Health. The Program distributes grant funding to local health jurisdictions (LHJs), universities, tribes, and volunteer non-profit organizations throughout the state.

Monitoring takes place at high-use, high-risk beaches and is dependent upon funding. Monitoring and notification of marine water quality provides information to the public about the relationship between water quality and human health and safety.

3.1.3 Parameters of interest

The fecal bacteria indicator, Enterococcus is the primary parameter of interest. EPA recommends monitoring for the fecal indicator Enterococci in marine and freshwater, or *E.coli* in freshwater to determine if water is safe for primary contact recreation. Studies show a link between illness and fecal contamination in recreational waters (EPA, 2012).

3.1.4 Results of previous studies

The BEACH Program has been monitoring beaches throughout Puget Sound and the coast since 2004. Data for this project is available on Ecology's Environmental Information Management (EIM) website at http://ecyeim/search/MonitoringProgramDefault.aspx?StudyMonitoringProgramUserId=BEACH&StudyMonitoringProgramUserIdSearchType=Equals.

In-depth data analysis has not been conducted on the BEACH data set. Current annual assessment includes determining if beaches are passing or failing swimming criteria. Figure 2 presents the percentage of beaches that meet the swimming criteria by year.

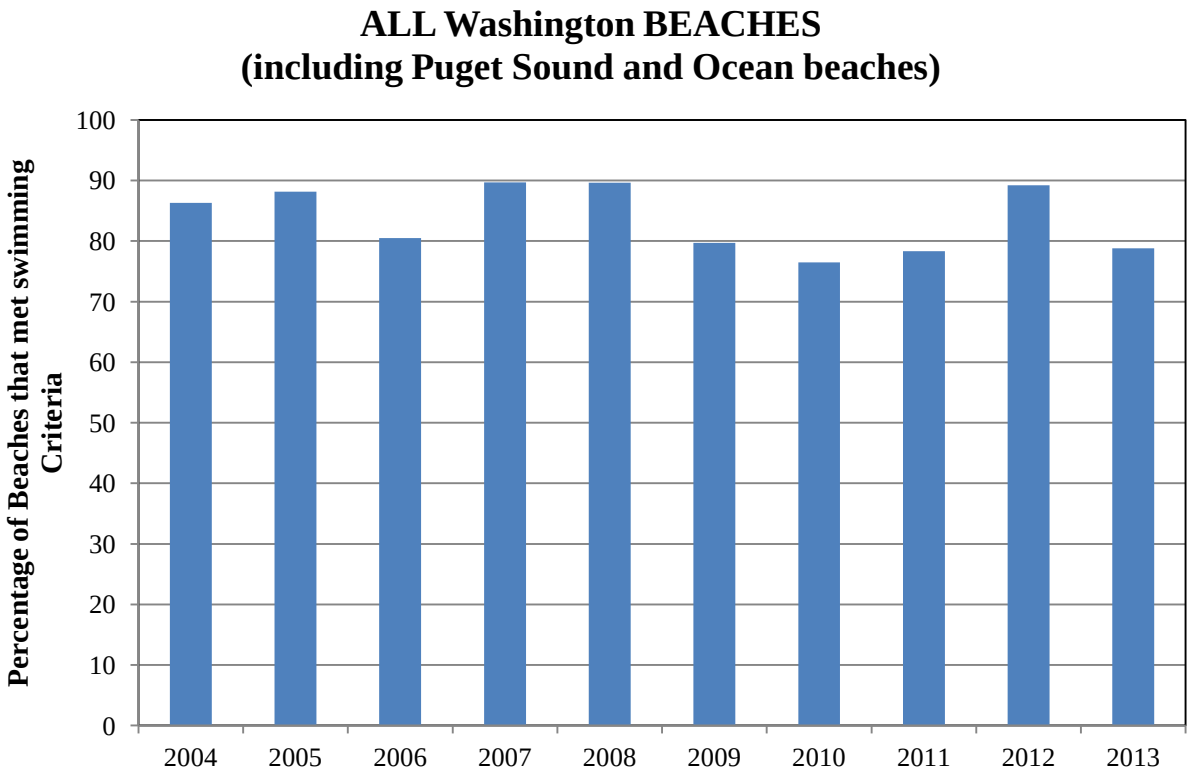


Figure 2. Percent of BEACH Program-sampled beaches that met the swimming criteria each year.

3.1.5 Regulatory criteria or standards

Currently the BEACH Program's water quality decision criteria are based on EPA's ambient water quality criteria (EPA, 1986), not the Washington State Water Quality Standard for fecal coliform. The fecal indicator Enterococcus is used because this indicator has a better correlation between indicator levels and illness rates than either fecal coliform or *E. coli*. The current Washington State Water Quality Standards for primary contact recreation in marine water bacteria is for fecal coliform, and the criteria and indicator are based on protecting shellfish for human consumption.

Numeric criteria for the BEACH Program are as follows:

- Geometric Mean (GM) shall not exceed 35 Enterococci/100 mL; based on results from a minimum of five weekly samples (including all samples).

The minimum beach swimming advisory level or Beach Action Value (BAV) protective bacterial standard for marine recreational beaches used for primary contact recreation is as follows:

- The beach arithmetic average (of the three samples collected at a single beach) for the sample day should not exceed 104 Enterococci/100 mL.

The critical warning level (Beach Swimming Closure) protective bacteriological standard for marine recreational beaches used for primary contact recreation is as follows:

- The beach arithmetic average for the sample day should not exceed 276 Enterococci/100 mL.

Appendix A presents the BEACH Program decision flow chart to post a beach "Beach Swimming Advisory" or a "Beach Swimming Closure".

BEACH Program staff do not have authority to take closure actions. Closure action or other emergency action may only be taken by the local health officer under RCW 70.05.070, Local health Officer - Powers and Duties.

In addition, *WAC 246-260-180, Bathing beaches* states that no bathing beach shall be maintained or operated when such water is determined by the local health officer to be so polluted or subject to pollution as to constitute a menace to health if used for bathing. Where bathhouse and toilet facilities are provided for use of bathers, they shall be constructed, maintained, and operated in a sanitary manner approved by the health officer.

4.0 Project Description

The BEACH Program supports a marine recreational beach monitoring and notification program throughout the state. Marine beaches are tested for the fecal bacteria Enterococci to determine possible health risk to the public from water contact recreation. During the swimming season, water samples are collected at high-use, high-risk marine beaches primarily used for swimming, wading, surfing, and SCUBA diving. Public notification occurs when results exceed the BEACH Program Guidance thresholds. (Schneider, 2002).

In addition to routine beach monitoring, the program helps to identify sources of bacterial pollution at beaches with high bacteria levels. BEACH Program staff also participate in public education and outreach activities to educate the public about sources of bacterial pollution and health risks associated with swimming in contaminated waters.

4.1 Project goals

The primary goal of this monitoring project is to:

- Determine possible health risk to the public from marine water contact recreation.
- Identify sources of bacterial contamination to marine swimming beaches.

4.2 Project objectives

To accomplish monitoring project goals, Enterococcus bacteria samples will be collected at high-use, high-risk marine beaches primarily used for swimming, wading, surfing, and SCUBA diving. Samples will be collected weekly or bi-weekly during the high-use season, generally May through mid-September.

Bacteria results will be reviewed immediately after laboratory analysis to determine if marine water is safe for primary contact recreation. If the average beach results are greater than 104 Enterococcus/100 mL, beach notification procedures will be initiated. The BEACH Program's recommended decision process for notification is presented in Appendix A.

When beaches have consistently high bacteria levels that require beach swimming advisories or closures, BEACH Program staff will work with local jurisdictions to identify sources of bacterial contamination. Bacterial source identification may require additional sampling, such as bacteria sampling of tributaries or discharges to the beach, or adding bacteria sampling sites along the beach shoreline.

4.3 Information needed and sources

This project has been ongoing since 2004. At this time, no additional information is needed.

4.4 Target population

The target population is fecal Enterococcus bacteria at high-use, high-risk marine swimming beaches in the state.

4.5 Study boundaries

Study boundaries include the Puget Sound and Washington Coast (Figure 1).

Beaches sampled for this project may be in the following WRIAs:

- 1 Nooksack
- 3 Lower Skagit/Samish
- 5 Stillaguamish
- 6 Island
- 7 Snohomish
- 8 Cedar/Sammamish
- 9 Duwamish/Green
- 10 Puyallup/White
- 12 Chambers/Clover
- 13 Deschutes
- 14 Kennedy/Goldsborough
- 15 Kitsap
- 16 Skokomish/Dosewallips
- 17 Quilcene/Snow
- 18 Elwha/Dungeness
- 19 Lyre/Hoko (Makah BEACH Program)
- 22 Lower Chehalis

4.6 Tasks required

Not applicable.

4.7 Practical constraints

See Section 3.1.1.

4.8 Systematic planning process

Not applicable.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Project staff and their responsibilities are described in Table 1, and 2014 BEACH local partners are described in Table 2.

Table 1. Organization of project staff and responsibilities.

Staff	Title	Responsibilities
Rob Pedersen EPA, Region 10 Phone: 206-553-1646	EPA BEACH Program Lead	Clarifies scope of the project and provides technical assistance.
Janette Knittel EPA, Region 10 Phone: 206-553-0483	EPA Contract Manager	Administers EPA Beach Monitoring and Notification Program Development Grant and provides technical assistance.
Mary Knackstedt EPA Grant Coordinator Department of Health Office of Shellfish and Water Protection Phone: 360-236-3319	NEP Contract Manager	Provides QAPP review and NEP project oversight.
Debby Sargeant MMU, WOS, EAP Phone: 360-407-6139	Project Manager	Writes the QAPP. Administers all aspects of the BEACH project including sampling and notification oversight, review of data, data interpretation, and data entry into EIM. Responsible for all reports.
Julianne Ruffner MMU, WOS, EAP Phone: 360-407-6154	Beach Specialist	Provides local partners with technical assistance for sampling, data entry, and beach notification. Conducts QA review of data. Assists Project Manager with duties as needed.
Carol Maloy MMU, WOS, EAP Phone: 360-407-6742	Unit Supervisor for the Project Manager	Provides internal review of the QAPP and approves final QAPP.
Robert F. Cusimano WOS, EAP Phone: 360-407-6596	Section Manager for the Project Manager	Provides internal review and approves final QAPP.
William R. Kammin EAP Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP.

EPA: Environmental Protection Agency
BEACH: Beach Environmental Assessment, Communication, and Health
EAP: Environmental Assessment Program
EIM: Environmental Information Management database
MMU: Marine Monitoring Unit
NEP: National Estuary Program
QAPP: Quality Assurance Project Plan
WOS: Western Operations Section

Table 2. 2014 BEACH Program Local Partners.

Name	Title/Organization
Andy Brastad Carol Creasey	Clallam County Health and Human Services
Aaron Parker	Makah BEACH Program Manager
Jeff Nelson Rob King	Grays Harbor County Public Health
Maribeth Crandell	Island County Health Department
Mike Dawson	Jefferson County Public Health
Jamie Landry	Port Townsend Marine Science Center
Teri Barclay	Public Health Seattle and King County
Jim Zimny Dayna Chang	Kitsap County Health District
Debbie Riley Carol Spaulding	Mason County Environmental Health
Ray Hanowell Lindsay Tuttle	Tacoma-Pierce County Health Department
Susan Wood Catherine Buchalski	WSU Skagit County Beachwatchers
Chrys Bertolotto Joan Douglas	WSU Snohomish County Beachwatchers
Sue Davis	Thurston County Public Health
Tom Kunesh	Food Safety and Living Environment Program Supervisor, Whatcom County Health Department
Eleanor Hines	Northwest Straits Chapter, Surfriders

5.2 Special training and certifications

BEACH Program samplers include BEACH Program staff, local government, tribal staff, and volunteers. All samplers undergo sample training from BEACH Program staff or their respective group coordinator, following the procedures outlined in the BEACH Program Bacteria Sampling SOP, EAP092.

5.3 Organization chart

See Tables 1 and 2.

5.4 Project schedule

Table 3 describes the annual schedule for the BEACH Program activities including site selection, monitoring period, data entry, data reporting, and analysis.

Table 3. Annual Schedule for BEACH Program Activities.

Task	Timeline	Responsible Party
Finalize annual beach sampling list	March each year	BEACH Program Staff, LHJ, volunteer coordinators
Volunteer Training	April/May each year	BEACH Program Staff
Weekly or biweekly collection of bacteria and field data	May through early September	Volunteers, Coordinators or LHJ, or Ecology staff
Data Entry	Friday each week during beach season	Laboratories, non-profit organizations, universities, or volunteers
Data Verification	Upon receipt of final laboratory analytical report	BEACH Program Staff
EIM Data Loaded	November 30 each year	BEACH Program Staff
EIM Data Entry Review	December 30 each year	BEACH Program Staff
Data reporting to EPA and EIM Completion	January 31 each year	BEACH Program Staff
Data analysis	January 30 each year	BEACH Program Staff
Report to EPA	March 30 each year	BEACH Program Staff

LHJ: Local Health Jurisdiction

5.5 Limitations on schedule

Not applicable.

5.6 Budget and funding

Funding for the BEACH Program is provided by an EPA grant as part of the Beaches Environmental Assessment and Coastal Health Act of 2000, regulatory authority 40 CFR PART 31. In addition, the BEACH Program has received National Estuary Program (NEP) grant funds since 2011. The BEACH Program will receive NEP funds through 2015. The NEP funding is directed toward sampling additional beaches, and conducting bacterial source investigation and remediation.

The budget for the BEACH Program varies by year, depending on:

- EPA's grant award for the year.
- Additional funds obtained to sample beaches and conduct source control investigations, e.g., NEP funding.

6.0 Quality Objectives

Quality objectives are statements of the precision, bias, and lower reporting limits necessary to meet project objectives. Precision and bias together express data accuracy. Other considerations of quality objectives include representativeness and completeness. Quality objectives apply equally to laboratory and field data collected by Ecology, to data used in this study collected by entities external to Ecology, and to other analysis methods used in this study.

6.1 Decision Quality Objectives (DQOs)

The Washington BEACH Program's recommended decision process for notification of swimming beaches with high bacteria results is described in Appendix A. The BEACH Program has limited authority to make beach closure decisions. However, we will make recommendations to local health jurisdictions for closures, based on bacteria data results, nearby sewage spills, combined sewer overflow discharge, or other pollution problems that could adversely affect public health.

6.2 Measurement Quality Objectives (MQOs)

Field sampling procedures and laboratory analyses inherently have associated uncertainty, which results in data variability. Measurement quality objectives (MQOs) state the acceptable data variability for a project. *Precision* and *bias* are data quality criteria used to indicate conformance with MQOs. The term *accuracy* refers to the combined effects of precision and bias (Lombard and Kirchmer, 2004).

Precision is a measure of the variability in the results of replicate measurements due to random error. Random error is imparted by the variation in concentrations of samples from the environment as well as other introduced sources of variation, e.g., field and laboratory procedures. Precision for field replicate samples will be expressed as the relative standard deviation (RSD) for the group of duplicate pairs (Table 4).

Bias is defined as the difference between the sample value and true value of the parameter being measured. Bias affecting measurement procedures can be inferred from the results of quality control (QC) procedures. Bias in field measurements and samples will be minimized by strictly following BEACH Program's measurement, sampling, and handling protocols, including the Standard Operating Procedures (SOP) for BEACH Program Bacteria Sampling SOP, EAP092 (Sargeant, 2014). Field sampling precision and bias will be addressed by submitting field duplicate samples.

Table 4 outlines analytical methods, expected precision of sample duplicates, and method reporting limits. The targets for precision of field duplicates are based on values described in Mathieu (2006). The reporting limits of the methods listed in the table are appropriate for the expected range of results and the required level of sensitivity to meet project objectives.

Table 4. Approved BEACH Program Bacteria Laboratory Methods, Holding Times, measurement quality objectives, and lowest concentration of interest.

Parameter	Method	Holding Time/ Maximum Transport Time	Field/Lab Duplicate	Detection Limits
Enterococci				
MPN/ multiple well	ASTM 6503-99, SM9230B; and Enterolert Method® SM 9230D	6 hrs	50% RSD	10 MPN/100 mL
MF	EPA Method 1600 or SM 9230C	6 hrs	50% RSD	1 cfu/100 mL
Fecal Coliform				
MPN	SM 9221E	6 hrs	50% RSD	1.8 MPN/100 mL
MF	SM 9222D	6 hrs	50% RSD	1 cfu/100 mL
Escherichia Coli				
MPN	EPA Method 1104, SM 9221F, SM 9223B Colilert Method®	6 hrs	50% RSD	1.8 MPN/100 mL
MF	EPA Method 1603	6 hrs	50% RSD	1 cfu/100 mL

MPN: Most probable number
MF: Membrane filter
ASTM: American Society for Testing and Materials International
SM: Standard Methods
RSD: Relative standard deviation

6.2.1 Targets for precision, bias, and sensitivity

6.2.1.1 Precision

Precision is a measure of the variability in the results of replicate measurements due to random error. Random error is imparted by the variation in concentrations of samples from the environment as well as other introduced sources of variation, e.g., field and laboratory procedures. Precision for field replicate samples will be expressed as the relative standard deviation (RSD) for the group of duplicate pairs (Table 4).

6.2.1.2 Bias

Bias is defined as the difference between the sample value and true value of the parameter being measured. Bias affecting measurement procedures can be inferred from the results of QC procedures. Bias in field measurements and samples will be minimized by strictly following Ecology's measurement, sampling, and handling protocols. Field sampling precision bias will be addressed by submitting replicate samples (Table 4). Laboratories used for this project will assess bias through the use of laboratory replicates and QC procedures described in section 10.1.

6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance. It is commonly described as detection limit. Targets for laboratory measurement sensitivity required for the project are listed in Table 4.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

BEACH Program monitoring will follow SOP EAP092, BEACH Program Bacteria Sampling (Sargeant, 2014). Bacteria sampling sites for all beaches are documented with a GPS and maps of sampling sites are provided to our sampling partners. Sampling sites remain consistent between years.

6.2.2.2 Representativeness

The study is designed to have enough sampling sites at sufficient sampling frequency to meet study objectives. Bacteria values are known to be highly variable over time and space. Sampling variability can be somewhat controlled by strictly following standard procedures and collecting QC samples, but natural spatial and temporal variability can contribute greatly to the overall variability in the bacteria value.

6.2.2.3 Completeness

EPA has defined completeness as a measure of the amount of valid data needed to be obtained from a measurement system (Lombard and Kirchmer, 2004). The goal for this study is to correctly collect and analyze 100% of the samples for each of the sites. However, problems occasionally arise during sample collection that cannot be controlled; thus, a completeness of 95% is acceptable. Potential problems are laboratory issues, site access problems, or sample container shortages.

7.0 Sampling Process Design (Experimental Design)

7.1 Study design

The study objectives will be met by characterizing bacterial marine water quality during the swimming season (May through September) at select beaches. Three samples will be collected at each beach on a weekly or biweekly basis. The arithmetic average of results of the three samples will be compared to the beach action value (BAV), > 104 Enterococci/100 mL to make swimming advisory decisions. When results exceed 104 Enterococci/100 mL the decision criteria in Appendix A will be followed.

Beach water quality stations are sited to capture bacterial source inputs such as freshwater and stormwater discharges. Sampling stations are geo-referenced using a GPS unit and stored in the BEACH Program database. Additional sampling may occur during bacterial source investigations.

7.1.1 Field measurements

In addition to bacteria sampling, samplers collect field data including weather conditions, air and water temperature, wind speed and direction, tidal information, and data on the presence of people, birds, pets, and wildlife. Samplers record this information each time a beach is sampled. Field data will be collected using BEACH Program Field Data Forms or similar forms approved by the BEACH Program. Appendix B includes an example of the BEACH Program Field Data Form.

7.1.2 Sampling location and frequency

Beach sampling will occur weekly or biweekly during the swimming season, generally Memorial Day through Labor Day. Three bacteria samples will be collected at each beach, according to the SOP EAP092 for BEACH Program Bacteria Sampling (Sargeant, 2014). Samplers may collect additional samples of freshwater or stormwater discharges to the beach.

Sampling will occur early in the week. This allows for obtaining results before weekend recreational use of the beach and for re-sampling, if necessary.

7.1.3 Parameters to be determined

Marine beaches will be sampled for Enterococci bacteria. Table 4 describes possible sample parameters. Additional types of fecal bacteria samples may be obtained for source identification, such as fecal coliform or *E.coli*.

7.2 Maps or diagram

Figure 1 describes the study area and core beaches included in the study.

7.3 Assumptions underlying design

Not applicable.

7.4 Relation to objectives and site characteristics

Not applicable.

7.5 Characteristics of existing data

The BEACH Program sampling has been ongoing since 2004, using the same parameters at many of the same beaches.

8.0 Sampling Procedures

8.1 Field measurement and field sampling SOPs

Marine and freshwater samples will be collected, using Ecology's BEACH Program Bacteria Sampling SOP EAP092. Field notes will be obtained using the BEACH Program Field Data Form or similar forms approved by the BEACH Program (Appendix B).

8.2 Containers, preservation methods, holding times

As described in the BEACH Program Bacteria Sampling SOP (EAP092), sample containers are 100, 250, or 500 mL pre-autoclaved polypropylene bottles. After collection, the sample is labeled with the appropriate tag and immediately placed on ice in a cooler to preserve the sample during shipment to the laboratory. The sample must be delivered to the laboratory within six hours of sample collection. We will obtain sample bottles from the laboratory for the next sample event. Sample bottles should not be used after 6 months.

8.3 Invasive species evaluation

Marine beach sites are not in areas of extreme concern. BEACH sampling will follow the SOP to minimize the spread of invasive species, SOP EAP070 (Parsons et al., 2012). For more information regarding invasive species of concern, please see Ecology's website on minimizing the spread of invasive species at www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html.

8.4 Equipment decontamination

If equipment such as thermometers, refractometers, or sampling poles are used, they should be thoroughly rinsed with fresh water after sampling, to minimize metal corrosion.

8.5 Sample ID

Specific sample IDs are provided for each beach site. Sample IDs are stored in the BEACH database and noted on maps provided to samplers. Each sample is tagged with a label that provides the sample id, sample date and time, type of analysis performed, and whether the sample is from marine or fresh water.

8.6 Chain-of-custody, if required

Once collected, samples will be stored in coolers in the sampling vehicle. When field staff are not in the sampling vehicle, it will be locked to maintain chain-of-custody. When samples are delivered to the laboratory for analysis, a chain-of-custody sheet may be required.

8.7 Field log requirements

Field notes will be obtained using the BEACH Program Field Data Form or similar forms approved by the BEACH Program (Appendix B). Data forms must be filled out for each beach and day sampled.

8.8 Other activities

Volunteer samplers will be trained by BEACH Program staff before the beginning of each beach sample season. Training will consist of equipment training, sampling protocols, and data entry into the Secure Access Washington (SAW) system.

9.0 Measurement Methods

9.1 Field procedures table/field analysis table

Table 5 shows the field and laboratory measurement methods required to meet the goals and objectives of this project.

Table 5. Measurement methods (field and laboratory).

Analyte	Sample Matrix	Number of Samples	Expected Range of Results	Method	Method Detection Limit
Field Measurements (optional)					
Salinity	Water	Optional	0-33 ppt	Refractometer	n/a
Temperature	Water	Optional	5-35°C	Thermometer	n/a
Laboratory Procedures					
Enterococci	Water	3 per beach per sample event	<10 - > 2000 MPN/100 mL	See Table 4	
E. Coli	Water	As needed	1 – 10,000 cfu/100 mL	See Table 4	
Fecal Coliform	Water	As needed	1 – 10,000 cfu/100 mL	See Table 4	

9.2 Lab procedures table

See Table 5.

9.3 Sample preparation method(s)

Bacteria samples must be collected in pre-sterilized polypropylene bottles. Bottles should not be used after six months.

9.4 Special method requirements

No special method is required; however, special notification procedures are required. The laboratory is required to notify the BEACH Program or the LHJ immediately, when the average of the marine Enterococci beach results are greater than 104 MPN/100 mL. This enables BEACH Program staff and the LHJ to initiate the public notification process as soon as possible.

9.5 Lab(s) accredited for method(s)

All bacteria analysis will be performed by a laboratory accredited for that method. The following accredited laboratories are used by the BEACH Program and BEACH Program partners:

- Avocet, Bellingham
- Clallam County Environmental Laboratory, Port Angeles
- Edge Analytical Laboratories Microbiology Lab, Bellingham
- Everett Environmental Laboratory, Everett
- Grays Harbor County Water Testing Lab, Montesano
- King County Environmental Laboratory, Seattle
- Lab/Cor Inc., Bremerton
- Twiss Analytical Laboratories Inc., Poulsbo
- Thurston County Health Department Laboratory, Olympia
- Water Management Laboratories Inc., Tacoma

10.0 Quality Control (QC) Procedures

10.1 Table of field and laboratory QC required

Field and laboratory QC is described in Table 6. Laboratories will conduct annual proficiency testing for bacteria. For the Enterolert method, positive and negative bacteria controls will be run with each new lot media.

Table 6. Quality control samples, types, and frequency.

Parameter	Field		Laboratory		
	Blanks	Replicates	Check Standards	Analytical Duplicates	Matrix Spikes
Enterococci	n/a	10%	n/a	1/20 samples	n/a
E. Coli	n/a	10%	n/a	1/20 samples	n/a
Fecal Coliform	n/a	10%	n/a	1/20 samples	n/a

10.2 Corrective action processes

QC results may indicate problems with data during the course of the project. The lab will follow prescribed procedures to resolve the problems. Options for corrective actions might include:

- Rejecting the results
- Resampling the beach sites
- Qualifying the results

11.0 Data Management Procedures

11.1 Data recording/reporting requirements

BEACH Program staff manages water quality field and laboratory results via the BEACH Program database.

Samplers will record all field data on the BEACH Program Field Data Form or similar form approved by the BEACH Program (Appendix B). Field Data Forms must be filled out for each beach and day sampled.

The local sampling lead is responsible for entering data from the Field Data Form. Contract laboratories are responsible for entering the laboratory data. Field and laboratory data must be entered into the BEACH Program database by Friday each week.

Final laboratory analytical reports will be mailed, faxed, or electronically transmitted to either the BEACH Program or LHJs. Final reports must be sent to the BEACH Program for data verification as soon as possible. Analytical reports must contain final data, the method(s) used for analysis, and all quality assurance and quality control performed.

BEACH Program staff will verify the data within two weeks of data entry. Once data is verified in the BEACH Program Database, data from this program is available to the public via the BEACH Program website through both Ecology and Ecology's Environmental Information Management (EIM) Database. All records are kept on file for a minimum of 5 years.

11.2 Laboratory data package requirements

Final laboratory analytical reports will be mailed, faxed or electronically transmitted to either the BEACH Program or LHJs. Final reports must be sent to the BEACH Program for data verification as soon as possible. Analytical reports must contain final data, the method(s) used for analysis and all quality assurance and quality control performed.

11.3 Electronic transfer requirements

Not applicable.

11.4 Acceptance criteria for existing data

Not applicable. No special criteria are necessary to assess the usability of existing data.

11.5 EIM/STORET data upload procedures

All bacteria data will be entered into EIM and STORET, following all existing Ecology business rules and the EIM User's Manual for loading, data quality checks, and editing.

12.0 Audits and Reports

12.1 Number, frequency, type, and schedule of audits

To ensure field work consistency, improve adherence to SOPs, and to share information, staff will conduct one audit per year. The field audit will consist of staff accompanying local beach samplers during their routine beach sampling. Each year, a field audit will be conducted with a different local partner.

12.2 Responsible personnel

See section 12.1.

12.3 Frequency and distribution of report

After data is verified in the BEACH Program Database, data from this program will be available to the public via the BEACH Program website through both Ecology and Ecology's Environmental Information Management (EIM) Database.

An annual report is submitted to EPA every April, describing BEACH Program activities for the previous year.

12.4 Responsibility for reports

The BEACH Program Manager will be the lead on the EPA annual report.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

The field lead will verify initial field data before leaving each site. This process involves checking the data sheet for omissions or outliers. If measurement data are missing or a measurement is determined to be an outlier, the measurement will be repeated.

13.2 Lab data verification

Laboratory staff will perform the laboratory verification following standard laboratory practices. After the laboratory verification, staff will perform a secondary verification of each data package. This secondary verification will entail a review of all parts of the laboratory data package with special attention to laboratory QC results. Staff will bring any discovered issues to the laboratory manager for resolution.

13.3 Validation requirements, if necessary

Not applicable.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining whether project objectives have been met

After all laboratory and field data are checked, staff will examine the entire data package to determine if all the criteria for MQOs, completeness, representativeness, and comparability have been met. If the criteria have not been met, the BEACH Program Manager will decide if affected data should be qualified or rejected based upon the decision criteria from the QAPP. The BEACH Program Manager will decide how any qualified data will be used in the technical analysis.

14.2 Data analysis and presentation methods

The arithmetic average of the bacteria samples for the beach and day (generally three samples) will be calculated. This value will be compared to the BEACH Programs swimming criteria (Appendix A) and the Washington State Water Quality Standards when applicable.

14.3 Treatment of non-detects

For bacteria values below the detection limit, we will use a conservative value of the detection limit minus one. For bacteria values above the detection limit we will use the upper detection limit plus one.

14.4 Sampling design evaluation

The BEACH Program Manager will decide whether the data package meets the MQOs, criteria for completeness, representativeness, and comparability, and whether meaningful conclusions can be drawn from the data. If so, the sampling design will be considered effective.

14.5 Documentation of assessment

In the annual report to EPA, the BEACH Program Manager will include a summary of the data quality assessment findings.

15.0 References

APHA (American Public Health Association), American Water Works Association, and Water Environment Federation, 2012. Standard Methods for the Examination of Water and Wastewater 22nd Edition. American Public Health Association, Washington, D.C.

EPA, 1986. Ambient Water Quality Criteria for Bacteria – 1986. EPA 440/5-84-002. United States Environmental Protection Agency, Office of Water, Washington, DC. http://water.epa.gov/scitech/swguidance/standards/upload/2001_10_12_criteria_ambientwqc_bacteria1986.pdf

EPA, 2012. Recreational Water Quality Criteria. EPA 820-F-12-058. United States Environmental Protection Agency, Office of Water, Washington, DC. http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/upload/RWQC2012.pdf.

EPA, 2014. National Beach guidance and Required Performance Criteria for Grants, 2014 Edition. EPA-823-B-14-001. United States Environmental Protection Agency, Office of Water, Washington, DC. http://www2.epa.gov/sites/production/files/2014-07/documents/beach-guidance-final-2014.pdf.

Lombard, S. and C. Kirchmer, 2004. Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies. Washington State Department of Ecology, Olympia, WA. Publication No. 04-03-030. https://fortress.wa.gov/ecy/publications/SummaryPages/0403030.html

Mathieu, N., 2006. Replicate Precision for Twelve Total Maximum Daily Load (TMDL) Studies and Recommendations for Precision Measurement Quality Objectives for Water Quality Parameters. Washington State Department of Ecology, Olympia, WA. Publication No. 06-03-044. https://fortress.wa.gov/ecy/publications/SummaryPages/0603044.html

Parsons, J., D. Hallock, K. Seiders, W.J. Ward, C. Coffin, E. Newell, C. Deligeannis, and K. Welch, 2012. Standard Operating Procedures to Minimize the Spread of Invasive Species, Version 2.0. Washington State Department of Ecology, Olympia, WA. SOP Number EAP070. www.ecy.wa.gov/programs/eap/quality.html

Sargeant, D., 2014. Standard Operating Procedures for BEACH Program Bacteria Sampling, Version 1.0. Washington State Department of Ecology, Olympia, WA. SOP Number EAP092. www.ecy.wa.gov/programs/eap/quality.html

Schneider, L., 2002. DRAFT: Beach Environmental Assessment, Communication, and Health (BEACH) Program Guidance. Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA. Publication No. 02-03-050. https://fortress.wa.gov/ecy/publications/SummaryPages/0203050.html

Schneider, L., 2004. Quality Assurance Project Plan: BEACH Program. Washington State Department of Ecology, Olympia, WA. Publication No. 04-03-205. https://fortress.wa.gov/ecy/publications/SummaryPages/0403205.html

WAC 173-201A. Water Quality Standards for Surface Waters in the State of Washington Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/laws-rules/ecywac.html

16.0 Figures

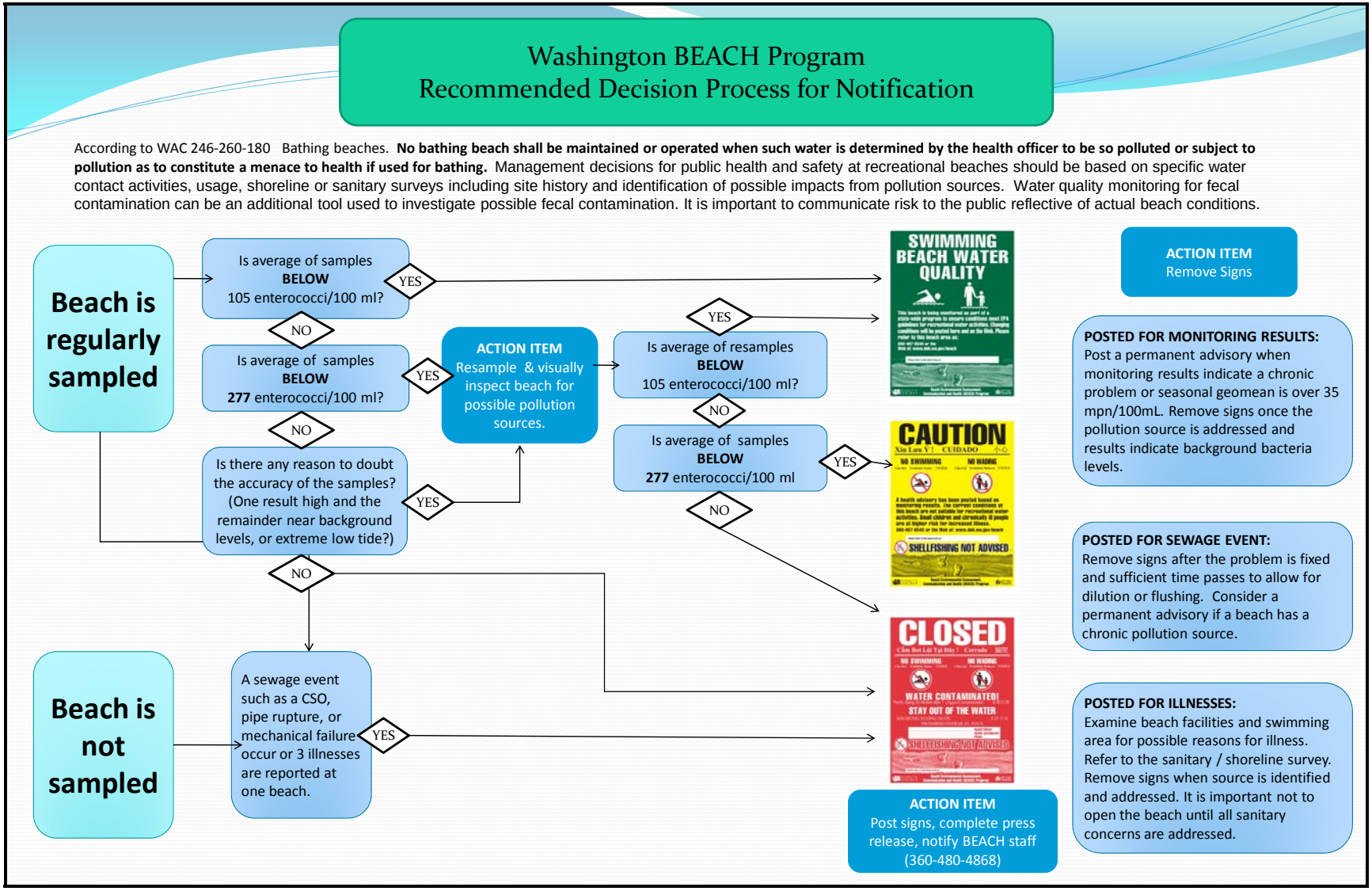
See Table of Contents for list of figures included in the report.

17.0 Tables

See Table of Contents for list of tables included in the report.

18.0 Appendices

Appendix A. WA BEACH Program Recommended Decision Process for Beach Notification



Appendix B. BEACH Field Data Form

Beach Name:
Stations:
Duplicate Sample Station:

Sampled Date	____/____/_____ ___:___							
Sampled By				Tide Height	Feet			
Tide Phase	LowTide	¼Flood	MidFlood	¾Flood	HighTide	¼Ebb	MidEbb	¾Ebb
Wind Direction	*from the*	N	NW	W	SW	S	SE	E	NE
Wind Speed	Calm	1-3mph	4-8mph	9-12mph	13-18mph	19-25mph	25+	
Recent Rain	24hours	48hours	72hours	4-7days	>1week			
Weather	Clear/Sun	Hazy	PartCloudy	Cloudy	LightShowers	Rain		

People in Water		Comments:
People on Beach		
Dogs on Beach		
Birds on Beach		
Air Temp	°F	
Water Temp	°F	*Please manually enter Beach Wrack info in the Comments section of the website*
Salinity		Beach Wrack Y / N *length* FT x *width* IN x *depth* IN

Speed MPH	Description	Land Observation
0	Calm	Smoke rises vertically
1-3	Light air	Wind direction shown by smoke
4-8	Light breeze	Wind felt on face, leaves rustle
8-12	Gentle breeze	Leaves and twigs constantly move, flags begin to flutter
13-18	Moderate breeze	Dust blows, small branches on trees move
19-25	Fresh breeze	Small trees sway

Appendix C. Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

Anthropogenic: Human-caused.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Designated uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Enterococcus: A genus of bacteria that inhabit the intestinal tract of warm-blooded animals and remain viable (alive and capable of infecting another organism) in water for a variable period of time. The presence of Enterococcus in water indicates fecal contamination by a warm-blooded animal; harmful bacteria, viruses, or protozoa associated with fecal contamination may also be present.

***Escherichia coli (E. coli*):** A species of bacteria that inhabit the intestinal tract of warm-blooded animals and remain viable (alive and capable of infecting another organism) in water for a variable period of time. While *E. coli* are normally harmless and live in the intestines of healthy people and animals a few strains may cause illness. The presence of *E. coli* in water indicates fecal contamination by a warm-blooded animal; harmful bacteria, viruses, or protozoa associated with fecal contamination may also be present.

Fecal coliform (FC): That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform bacteria are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Geometric mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or

discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in Section 502(14) of the Clean Water Act.

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

Point source: Source of pollution that discharges at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or
(2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Primary contact recreation: Activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing.

Sediment: Soil and organic matter that is covered with water (for example, river or lake bottom).

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Streamflow: Discharge of water in a surface stream (river or creek).

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Thalweg: The deepest and fastest moving portion of a stream.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

90th percentile: An estimated portion of a sample population based on a statistical determination of distribution characteristics. The 90th percentile value is a statistically derived estimate of the division between 90% of samples, which should be less than the value, and 10% of samples, which are expected to exceed the value.

Acronyms and Abbreviations

APHA	American Public Health Association
ASTM	American Society for Testing and Materials International
BAV	Beach Action Value
BEACH Act	Beaches Environmental Assessment and Coastal Health Act of 2000
BMP	Best management practice
cfu	Colony forming unit(s)
Health	Washington State Department of Health
e.g.	For example
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
FC	(See Glossary above)
FIB	Fecal indicator bacteria
GM	Geometric mean
GPS	Global positioning system
i.e.	In other words
LHJ	Local Health Jurisdiction
MF	Membrane filter
MPN	Most probable number
MQO	Measurement quality objective
NEP	National Estuary Program
QA	Quality assurance
QC	Quality control
RCW	Revised code of Washington
RM	River mile
RPD	Relative percent difference
RSD	Relative standard deviation
SAW	Secure Access Washington
SOP	Standard operating procedure
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area

Units of Measurement

°C	degrees centigrade
Ft	feet
g	gram, a unit of mass
kg	kilograms, a unit of mass equal to 1,000 grams
mg/L	milligrams per liter (parts per million)
mL	milliliter
ppt	parts per thousand
s.u.	standard units
ug/g	micrograms per gram (parts per million)
ug/Kg	micrograms per kilogram (parts per billion)
ug/L	micrograms per liter (parts per billion)
uS/cm	microsiemens per centimeter, a unit of conductivity

Quality Assurance Glossary

Accreditation: A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data. For Ecology, it is "Formal recognition by (Ecology)…that an environmental laboratory is capable of producing accurate analytical data." [WAC 173-50-040] (Kammin, 2010)

Accuracy: The degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms precision and bias be used to convey the information associated with the term accuracy. (USGS, 1998)

Analyte: An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella. (Kammin, 2010)

Bias: The difference between the population mean and the true value. Bias usually describes a systematic difference reproducible over time, and is characteristic of both the measurement system, and the analyte(s) being measured. Bias is a commonly used data quality indicator (DQI). (Kammin, 2010; Ecology, 2004)

Blank: A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process. (USGS, 1998)

Calibration: The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured. (Ecology, 2004)

Check standard: A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards, but should be referred to by their actual designator, e.g., CRM, LCS. (Kammin, 2010; Ecology, 2004)

Comparability: The degree to which different methods, data sets, and/or decisions agree or can be represented as similar; a data quality indicator. (USEPA, 1997)

Completeness: The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator. (USEPA, 1997)

Continuing Calibration Verification Standard (CCV): A QC sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run. (Kammin, 2010)

Control chart: A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system. (Kammin, 2010; Ecology 2004)

Control limits: Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean. (Kammin, 2010)

Data Integrity: A qualitative DQI that evaluates the extent to which a data set contains data that is misrepresented, falsified, or deliberately misleading. (Kammin, 2010)

Data Quality Indicators (DQI): Commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity. (USEPA, 2006)

Data Quality Objectives (DQO): Qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.
(USEPA, 2006)

Data set: A grouping of samples organized by date, time, analyte, etc. (Kammin, 2010)

Data validation: An analyte-specific and sample-specific process that extends the evaluation of data beyond data verification to determine the usability of a specific data set. It involves a detailed examination of the data package, using both professional judgment, and objective criteria, to determine whether the MQOs for precision, bias, and sensitivity have been met. It may also include an assessment of completeness, representativeness, comparability and integrity, as these criteria relate to the usability of the data set. Ecology considers four key criteria to determine if data validation has actually occurred. These are:

- Use of raw or instrument data for evaluation.
- Use of third-party assessors.
- Data set is complex.
- Use of EPA Functional Guidelines or equivalent for review.

Examples of data types commonly validated would be:

- Gas Chromatography (GC).
- Gas Chromatography-Mass Spectrometry (GC-MS).
- Inductively Coupled Plasma (ICP).

The end result of a formal validation process is a determination of usability that assigns qualifiers to indicate usability status for every measurement result. These qualifiers include:

- No qualifier, data is usable for intended purposes.
- J (or a J variant), data is estimated, may be usable, may be biased high or low.
- REJ, data is rejected, cannot be used for intended purposes (Kammin, 2010; Ecology, 2004).

Data verification: Examination of a data set for errors or omissions, and assessment of the Data Quality Indicators related to that data set for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a data set. (Ecology, 2004)

Detection limit (limit of detection)**:** The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero. (Ecology, 2004)

Duplicate samples: Two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis. (USEPA, 1997)

Field blank: A blank used to obtain information on contamination introduced during sample collection, storage, and transport. (Ecology, 2004)

Initial Calibration Verification Standard (ICV): A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples. (Kammin, 2010)

Laboratory Control Sample (LCS): A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples. (USEPA, 1997)

Matrix spike: A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias due to interference or matrix effects. (Ecology, 2004)

Measurement Quality Objectives (MQOs)**:** Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness. (USEPA, 2006)

Measurement result: A value obtained by performing the procedure described in a method. (Ecology, 2004)

Method: A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed. (EPA, 1997)

Method blank: A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample,

and the same preparation process is used for the method blank and samples. (Ecology, 2004; Kammin, 2010)

Method Detection Limit (MDL): This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero. (Federal Register, October 26, 1984)

Percent Relative Standard Deviation (%RSD): A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$\%RSD = (100 * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples (Kammin, 2010)

Parameter: A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all "parameters." (Kammin, 2010; Ecology, 2004)

Population: The hypothetical set of all possible observations of the type being investigated. (Ecology, 2004)

Precision: The extent of random variability among replicate measurements of the same property; a data quality indicator. (USGS, 1998)

Quality Assurance (QA): A set of activities designed to establish and document the reliability and usability of measurement data. (Kammin, 2010)

Quality Assurance Project Plan (QAPP): A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives. (Kammin, 2010; Ecology, 2004)

Quality Control (QC): The routine application of measurement and statistical procedures to assess the accuracy of measurement data. (Ecology, 2004)

Relative Percent Difference (RPD): RPD is commonly used to evaluate precision. The following formula is used:

$$[Abs(a-b)/((a + b)/2)] * 100$$

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

Replicate samples: Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled. (USGS, 1998)

Representativeness: The degree to which a sample reflects the population from which it is taken; a data quality indicator. (USGS, 1998)

Sample (field): A portion of a population (environmental entity) that is measured and assumed to represent the entire population. (USGS, 1998)

Sample (statistical): A finite part or subset of a statistical population. (USEPA, 1997)

Sensitivity: In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit. (Ecology, 2004)

Spiked blank: A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method. (USEPA, 1997)

Spiked sample: A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency. (USEPA, 1997)

Split Sample: The term split sample denotes when a discrete sample is further subdivided into portions, usually duplicates. (Kammin, 2010)

Standard Operating Procedure (SOP): A document which describes in detail a reproducible and repeatable organized activity. (Kammin, 2010)

Surrogate: For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis. (Kammin, 2010)

Systematic planning: A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning. (USEPA, 2006)

References for QA Glossary

Ecology, 2004. Guidance for the Preparation of Quality Assurance Project Plans for Environmental Studies. https://fortress.wa.gov/ecy/publications/SummaryPages/0403030.html]

Kammin, B., 2010. Definition developed or extensively edited by William Kammin, 2010. Washington State Department of Ecology, Olympia, WA.

USEPA, 1997. Glossary of Quality Assurance Terms and Related Acronyms. U.S. Environmental Protection Agency. http://www.ecy.wa.gov/programs/eap/quality.html

USEPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4. U.S. Environmental Protection Agency. http://www.epa.gov/quality/qs-docs/g4-final.pdf

USGS, 1998. Principles and Practices for Quality Assurance and Quality Control. Open-File Report 98-636. U.S. Geological Survey. http://ma.water.usgs.gov/fhwa/products/ofr98-636.pdf