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ECOLOGY
State of Washington

Quality Assurance Project Plan

White Salmon River
Fecal Coliform Bacteria
Compliance Monitoring

September 2009

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Quality Assurance Project Plan

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Fecal Coliform Bacteria
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SWRO – Southwest Regional Office.
DSU – Directed Studies Unit.
WOS – Westside Operations Section.
EAP – Environmental Assessment Program.
EIM – Environmental Information Management system.

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Abstract

The White Salmon River and its tributaries, Rattlesnake Creek, Gilmer Creek, and Trout Lake Ditch, are listed under Section 303(d) of the federal Clean Water Act as not meeting Washington State water quality standards for fecal coliform bacteria. Fecal coliform data collected by the Underwood Conservation District and the Washington State Department of Ecology (Ecology) from 1992 – 2001 were used for the listing.

Land use changes over the past decade have decreased potential agricultural sources of fecal coliform in the watershed. In 2007, Ecology established water quality monitoring stations on the White Salmon River and Rattlesnake Creek. Both stations met the fecal coliform water quality standard between October 2007 and September 2008.

The main goal of the study outlined in this Quality Assurance (QA) Project Plan is to monitor 303(d) listed waters within the White Salmon River watershed for fecal coliform bacteria. The data will be used to determine if these waters now meet water quality criteria.

The secondary goal is to collect data which will be used to recommend corrective actions, if needed, within the watershed. If data indicate water quality standards are still not being met, it is hoped that these actions will lead to water quality improvements that could be accomplished in place of a Total Maximum Daily Load (TMDL) effort.

Each study conducted by Ecology must have an approved QA Project Plan. After completion of the study, a final report describing the study results will be posted to the Internet.

Background

The White Salmon River is a largely rural stream that originates in the Gifford Pinchot National Forest in south-central Washington along the south slope of Mount Adams in Skamania and Yakima Counties. It flows south for 45 miles before entering the Bonneville Reservoir in Underwood, Washington. The White Salmon River is located in Water Resource Inventory Area (WRIA) 29 and drains approximately 386 square miles of Skamania, Yakima, and Klickitat Counties. Principal tributaries include Trout Lake, and Buck, Mill, Dry, Gilmer, and Rattlesnake Creeks.

The majority of the watershed is forest range and cropland. Cropland is located mostly in the lower elevations. Agricultural enterprises include cow-calf operations, hay and pasture (both irrigated and dryland), cereal grains, fruit production, and irrigated agriculture. The cities of White Salmon, Bingen, and Underwood make up the largest urban areas in the watershed.

Anadromous fish passage is currently blocked at River Mile (RM) 3.3 by Condit Dam. The dam operators are currently being required to provide fish passage and are planning the removal of the dam in 2010 (Ecology, 2005). This will result in an additional 13 miles of the White Salmon River mainstem and several tributaries being accessible again to anadromous fish. Additional fish barriers include a falls near the town of Husum and the 20-foot falls at RM 16. River Mile 16 is likely the upper extent of current anadromous fish potential; however, there is some historical evidence of anadromous fish reaching the Trout Lake Valley.

Data collected by the Underwood Conservation District and the Washington Department of Ecology (Ecology) from 1992 – 2001 demonstrated elevated fecal coliform levels in the White Salmon River basin (Ecology, 2008). The White Salmon River and its tributaries Trout Lake Ditch, and Gilmer and Rattlesnake Creeks, are listed under Section 303(d) of the federal Clean Water Act as not meeting Washington State water quality standards for fecal coliform bacteria.

Since the time of the 2004 listing, land use changes have decreased potential agricultural sources of fecal coliform in the watershed UCD, 2007. In addition, stakeholders within the basin have implemented water quality improvement projects for the White Salmon mainstem and between three and ten tributaries.

In 2007, Ecology established water quality monitoring stations on the White Salmon River and Rattlesnake Creek. Both stations met the fecal coliform water quality standard between October 2007 and September 2008.

Water Quality Standards

The Washington State water quality standards, set forth in Chapter 173-201A of the Washington Administrative Code (WAC), include designated beneficial uses, waterbody classifications, and numeric and narrative water quality criteria for surface waters of the state. This section provides Washington State water quality information and those standards applicable to the White Salmon River watershed.

Portions of White Salmon River watershed are listed on the 2008 Section 303(d) list for fecal coliform (Ecology, 2008). The applicable water quality criteria are summarized in Table 1.

Table 1. Washington State water quality standards for fecal coliform bacteria in the White Salmon River watershed.

Parameter	2006 Classification	2006 Criteria
Fecal Coliform	Primary Contact Recreation	Shall not exceed a geometric mean value of 100 cfu/100 mL, and not more than 10% of all samples exceed 200 cfu/100 mL.

Logistical Considerations

Ecology staff conducted a reconnaissance survey on August 5, 2009 to verify accessibility of site locations. A Global Positioning System (GPS) receiver verified station coordinates.

All sampling locations are located at bridge crossings where nearby parking is available. All stations are located near each other and within a day's drive of Ecology's Operation Center in Lacey where samples can be picked up by Manchester Environmental Laboratory. No logistical problems are anticipated.

Project Description

The primary goals of the *Compliance Monitoring Study* are to:

1. Evaluate whether the current Section 303(d) fecal coliform listings of the White Salmon River and the three tributaries are still warranted.
2. Conduct a systematic review and water quality assessment.

The secondary goal of this *Compliance Monitoring Study* is to collect data which will be used to recommend corrective actions, if needed, that promote compliance of the water quality standards within the watershed.

The project goals will be met by the following objectives:

1. Collect, analyze, and interpret data to determine if Washington State water quality standards for fecal coliform are being met.
2. Collect credible water quality data that will be used for fecal coliform source identification, if necessary.
3. Review data for representativeness, comparability, and usability.

Fecal coliform samples will be collected within the listed segments of the White Salmon River and the tributaries, Rattlesnake Creek, Gilmer Creek, and Trout Lake Ditch. Sampling will occur twice per month, October 2009 through September 2010.

During the project, additional sites and/or samples will be added or sampled at the project manager's discretion to provide information that will help meet the goals and objectives of the study. The project manager will immediately review laboratory results to determine the possible need for source identification sampling to verify unexpected laboratory results or to isolate specific fecal coliform sources.

Staff have set a sampling and analysis goal of 100% completeness. However, there are many reasons for missing samples in a monitoring program. These include inclement weather or flooding, hazardous driving or monitoring conditions, illness, and unavailability of staff. Apart from weather, unforeseen occurrences are random relative to water quality conditions. These occurrences will not affect long-term data analyses, except for effects from potential reduction in sample size. Routinely missed samples could bias interpretation of the data, so sampling events will be rescheduled when missed in order to maintain integrity of the study. Field monitoring data loss due to equipment failure may occur; backup equipment will be available to minimize this problem.

Organization and Schedule

The following people are involved in this project (Table 2). All are employees of the Washington State Department of Ecology.

Table 2. Organization of project staff and responsibilities.

Staff	Title	Responsibilities
Tonnie Cummings Water Cleanup/Technical Assistance Unit, WQP Southwest Regional Office Phone: (360) 690- 4664	EAP Client, TMDL Lead	Provides internal review of the draft QAPP. Reviews and approves the draft and final reports.
Kim McKee Water Cleanup/Technical Assistance Unit, WQP Southwest Regional Office Phone: (360) 407-6407	EAP Client's Unit Supervisor	Clarifies scope of the project. Provides internal review of the draft QAPP. Reviews and approves the draft and final reports.
Garin Schrieve Water Quality Program Southwest Regional Office Phone: (360) 407-0643	EAP Client's Section Manager	Approves QAPP.
Scott Collyard Directed Studies Unit WOS, EAP Phone: (360) 407-6455	Project Manager and Principal Investigator	Writes the QAPP. Conducts QA review of data, analyzes and interprets data, prepares data for upload to EIM. Writes the draft report and final report.
Markus Van Prause Directed Studies Unit WOS, EAP Phone: (360) 407-6000	EIM Data Engineer and Field Assistant	Uploads data into EIM. Collects samples and records field information. Assists with writing the draft and final report.
George Onwumere Directed Studies Unit WOS, EAP Phone: (360) 407-6730	Project Manager's Unit Supervisor	Reviews and approves the final QAPP, draft technical memo, and draft report. Approves the project budget.
Robert F. Cusimano WOS, EAP Phone: (360) 407 - 6596	Project Manager's Section Manager	Approves the QAPP, technical memo, and draft report.
Stuart Magoon Manchester Environmental Laboratory, EAP Phone: (360) 871-8801	Director	Approves the final QAPP.
William R. Kammin EAP Phone: (360) 407-6964	Ecology Quality Assurance Officer	Reviews and approves the final QAPP.

EAP – Environmental Assessment Program.
WQP – Water Quality Program.
WOS – Western Operations Section.
EIM – Environmental Information Management system.
QAPP – Quality Assurance Project Plan.

Project Schedule

The project schedule is located in Table 3.

Table 3. Proposed schedule for completing field and laboratory work, data entry into EIM, and reports.

Field and laboratory work	Due date	Lead staff
Field work completed	September 2010	Markus Von Prause
Laboratory analyses completed	October 2010	
Environmental Information System (EIM) database		
EIM user study ID	SCOL0002	
Product	Due date	Lead staff
EIM data loaded	November 2010	Markus Von Prause
EIM Quality Assurance	December 2010	Scott Collyard
EIM complete	June 2011	Markus Von Prause
Final report		
Author lead / support staff	Scott Collyard / Markus Von Prause	
Schedule		
Draft due to supervisor	February 2011	
Draft due to client/peer reviewer	March 2011	
Draft due to external reviewer(s)	April 2011	
Final (all reviews done) due to publications coordinator (Joan)	May 2011	
Final report due on web	June 2011	

Sampling Schedule

The tentative field sampling schedule is listed below. Some dates will likely change due to unanticipated circumstances.

- October 12, 2009
- October 26, 2009
- November 9, 2009
- November 23, 2009
- December 7, 2009
- December 21, 2009
- January 4, 2010
- January 18, 2010
- February 1, 2010
- February 18, 2010
- March 1, 2010
- March 29, 2010
- April 12, 2010
- April 26, 2010
- May 10, 2010
- May 24, 2010
- June 7, 2010
- June 21, 2010
- July 5, 2010
- July 19, 2010
- August 2, 2010
- August 30, 2010
- September 13, 2010
- September 27, 2010

Laboratory Costs

The total laboratory cost for this project is approximately $5,566.

These costs were calculated using the Manchester Laboratory's price list for Fiscal Year 2009.

Compliance monitoring by MF*: 202 samples @ $23/sample =	$4,646.00
Source identification monitoring by MF*: 40 samples @ $23/sample =	$920.00
Total laboratory costs (including pre-planning 50% discount) =	$5,566.00

*Membrane Filter Method (APHA, AWWA, and WEF, 1998)

Quality Objectives

Quality objectives are statements of the precision, bias, and lower reporting limits necessary to address project objectives. Precision and bias together express data accuracy. Other considerations of quality objectives include representativeness and completeness.

- *Precision* is a measure of data consistency. It is expressed as the relative standard deviation (RSD) and derived from replicate sample analyses. It is subject to random error. RSD is determined by dividing the standard deviation of a sample by the mean for the same sample and then multiplying by 100%. For this project, an RSD will be calculated for each pair of replicate samples.
- *Bias* is a measure of the systematic error between an estimated value for a parameter and the true value. Systemic errors can occur through poor technique in sampling, sample handling, or analysis. Although staff will not evaluate bias for most of our data, the field lead will minimize the bias through strict adherence to standard operating protocols (SOPs). Field staff will follow the SOPs listed in this plan (Ward, 2007; Gallagher and Stevenson, 1999). Care will also be taken to prevent contamination, a frequent problem with bacteria sampling. Table 4 lists the measurement quality objectives (MQOs) for this project.
- *Representativeness* for the project will be assured through the use of standardized protocols.
- The objective for sampling *completeness* is 100%. Completeness will be assessed by examining: (1) the number of samples collected compared to the sampling plan, (2) the number of samples shipped and received at Manchester Laboratory in good condition, (3) the laboratory's ability to produce usable results for each sample, and (4) sample results accepted by the project manager.

Table 4. Measurement quality objectives.

Analysis	Precision of Paired replicates (RSD)	Lower Reporting Limit	Bias
Fecal Coliform MF[1]	184 %[2]	1 cfu/100 mL	N/A
Discharge	5 %[3]	0 cfs[4]	N/A

[1] Analyzed by *Membrane Filter* Method (APHA, AWWA, and WEF, 1998).
[2] Evaluation of fecal coliform precision is subject to judgment of the project manager (Mathieu, 2006). If there are more than 10 paired means of greater than 20 cfu/100 mL, then cumulative distributions of the replicates will be evaluated according to page 9 of Mathieu (2006): 90% of pairs less than 50% RSD, and 50% of pairs less than 20% RSD.
[3] Based on Butkus (2005). For estimating variation, *not* necessarily for rejection.
[4] Velocity range of Marsh-McBirney Flo-Mate Model 2000 is -0.5 to 19.99 ft/s: www.marsh-mcbirney.net/manuals/Model_2000_Manual.pdf

MQOs will vary for parameters based on their measurability in the natural environment. Increasing the number of replicates will improve precision estimation and confidence in decision-making. For example, we have planned a 20% replicate sampling rate (Tables 5) for fecal coliform sampling because this parameter inherently has large variability.

Sampling Process Design (Experimental Design)

Compliance Sampling

The intent of this study is to collect fecal coliform data at a high enough frequency and a long enough time span to (1) obtain a reasonable level of confidence in the results, and (2) meet the objectives of this project.

Water samples from sampling stations will be analyzed by the membrane filtration (MF) method to remain consistent with the Section 303(d) listing data. A field replicate MF sample will be collected at a minimum of one per sampling trip (Table 5). This provides a 20% field duplication rate for MF.

Table 5. Frequency and distribution of field replicate fecal coliform samples.

Station	Oct		Nov.		Dec.		Jan.		Feb.		Mar.		April		May		June		July		Aug.		Sept.	
29-TLC-0.3	2	1	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1
29-WS-22.5*	1	2	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	2	1	1	1	1	2
29-TLD-2.6	1	1	2	1	2	1	1	1	2	1	2	1	1	1	2	1	2	1	1	1	1	1	2	1
29-GC-0.4	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	2	1	1
29-WS-12.0	1	1	2	1	2	1	1	1	2	1	2	1	1	1	2	1	2	1	1	1	2	1	1	1
29-RSC-0.1	1	1	1	1	1	2	1	2	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1
29-WS-1.43	2	1	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1

* An instantaneous discharge measurement will be taken monthly here. Also, a replicate discharge measurement will be taken during one summer month and one winter month.

Compliance Sampling Locations

Sampling sites were selected based on (1) the Underwood Conservation District historic sampling stations, and (2) segments currently listed as impaired for fecal coliform (Ecology 2008). Underwood Conservation District fecal coliform results from 1992 – 1996 are presented in Figure 1.

Descriptions and locations of Ecology's seven monitoring stations are presented in Table 6 and Figure 2.

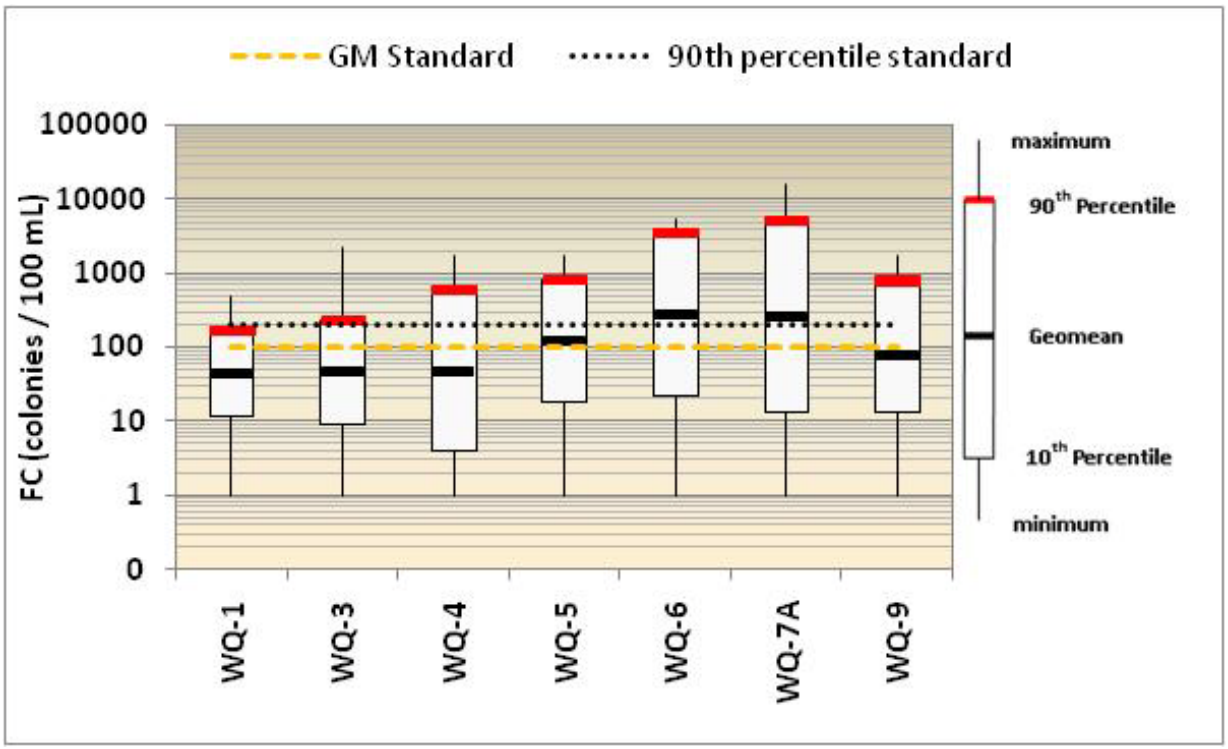

Figure 1. Underwood Conservation District fecal coliform (FC) results (1992 – 1996).

Table 6. Ecology monitoring station descriptions.

Station ID[1]	Description	Underwood Station ID.	Latitude	Longitude
29-TLC-.030	Trout Lake Creek Station @ River Mile 0.30 near Old Creamery Bridge	WQ-9	45.99512	-121.50808
29-WS-22.55	White Salmon River @ River Mile 22.5 near Sunnyside Road	WQ-6	45.96415	-121.46938
29-TLD-2.6	Trout Lake Ditch	WQ-7A	45.93791	-121.48448
29-WS-12	White Salmon River @ River Mile 12 near boat launch	WQ-4	45.8506	-121.5044
29-GC-0.20	Gilmer Creek @ River Mile 0.2 near mouth	WQ-5	45.85778	-121.5044
29-RSC-0.1	Rattlesnake Creek @ River Mile 0.1 near mouth	WQ-3	45.79717	-121.48505
29-WS-1.43	White Salmon River @ River Mile 1.43 below dam	WQ-1	45.74884	-121.5222

[1]Station IDs are identified as WRIA-waterbody-river mile.

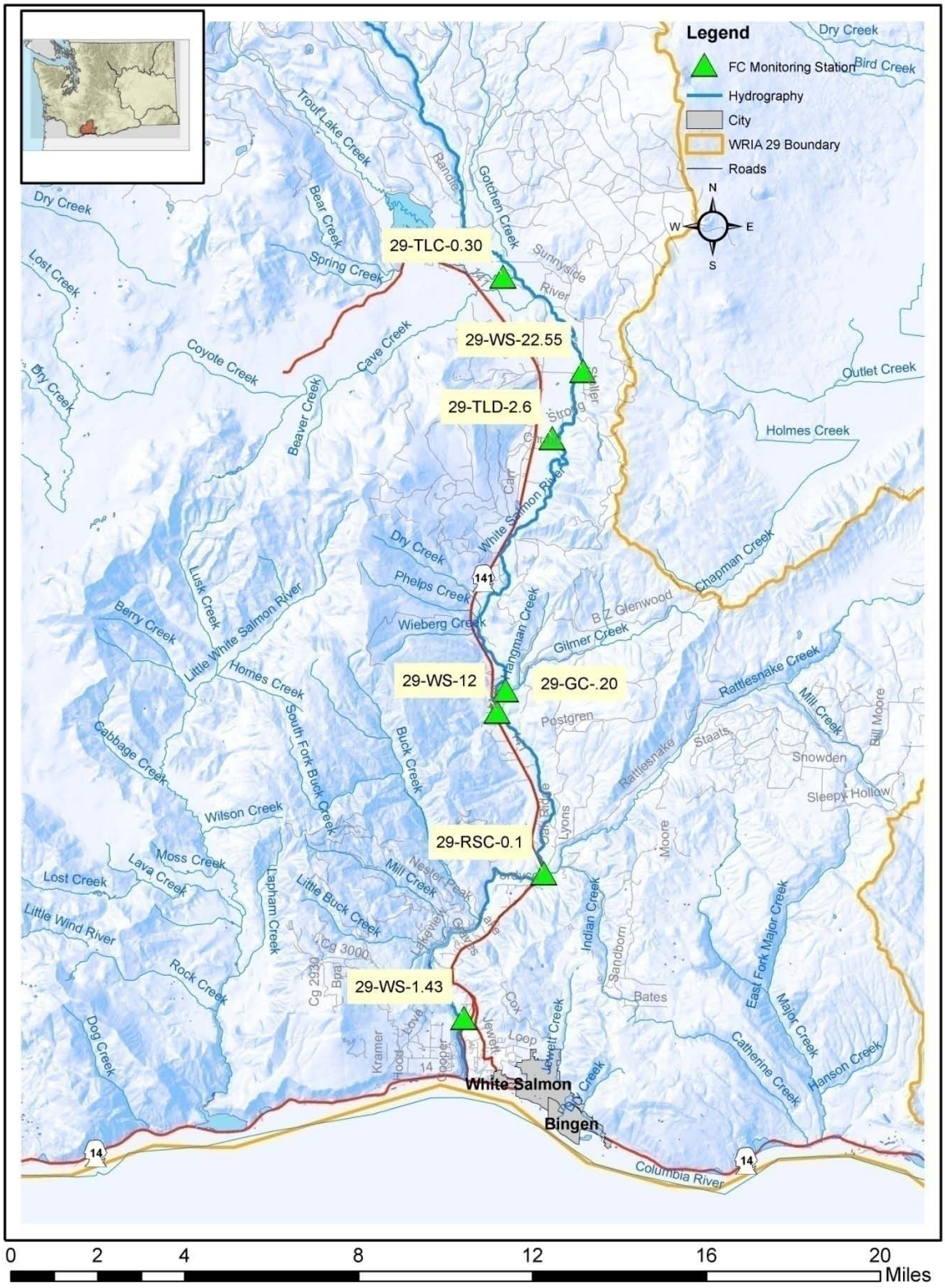

Figure 2. Ecology's fecal coliform compliance monitoring stations.

Source Identification Monitoring

The project manager will immediately review laboratory results to determine the possible need for source identification sampling to verify unexpected laboratory results or provide source identification and resolution. The decision to add source identification sampling stations will largely be determined by downstream compliance sampling station results. For example, if fecal coliform samples routinely do not meet water quality standards during the 2009-10 study, source identification stations may be added upstream of compliance stations. Potential source identification sampling stations are listed in Table 7. If needed, additional sampling stations may be added on private property. This is dependent on landowner approval. A field replicate MF sample will be collected for source identification sampling at a rate of 20%.

Manchester Environmental Laboratory (MEL) will be notified two weeks prior to the addition of compliance sampling locations.

Source Identification Locations

Potential source identification sampling locations are presented in Table 7 and Figure 3. These locations were selected based on public access to waterways within one mile upstream of the compliance monitoring stations.

Table 7. Potential source identification sampling locations.

Station ID[1]	Station Description	Latitude	Longitude
29-TLC-1.53	Trout Lake Creek Station @ Mt. Adams Recreation Rd.	45.99893	-122.5280
29-WS-25	White Salmon River @ River Mile 25 @ Schmid Rd.	45.98808	-121.48815
29-WS-23.75	White Salmon River @ River Mile 23.75 by Sunnyside Rd.	45.97846	-121.47409
29-WS-21	White Salmon River @ River Mile 21 by Strong Rd.	45.9462	-121.97861
29-WS-14.39	White Salmon River @ River Mile 14.39 near Wieberg Creek	45.87844	-121.51804
29-GC-0.44	Gilmer Creek @ River Mile 0.44 by BZ Glenwood Rd.	45.875180	-121.51804
29-RSC-0.43	Rattlesnake Creek @ River Mile 0.43 near Indian Creek	45.77938	-122.47774
29-WS-2	White Salmon River @ River Mile 2 by Power House Rd.	45.75433	-121.52814

[1]Station IDs are identified as WRIA-waterbody-river mile.

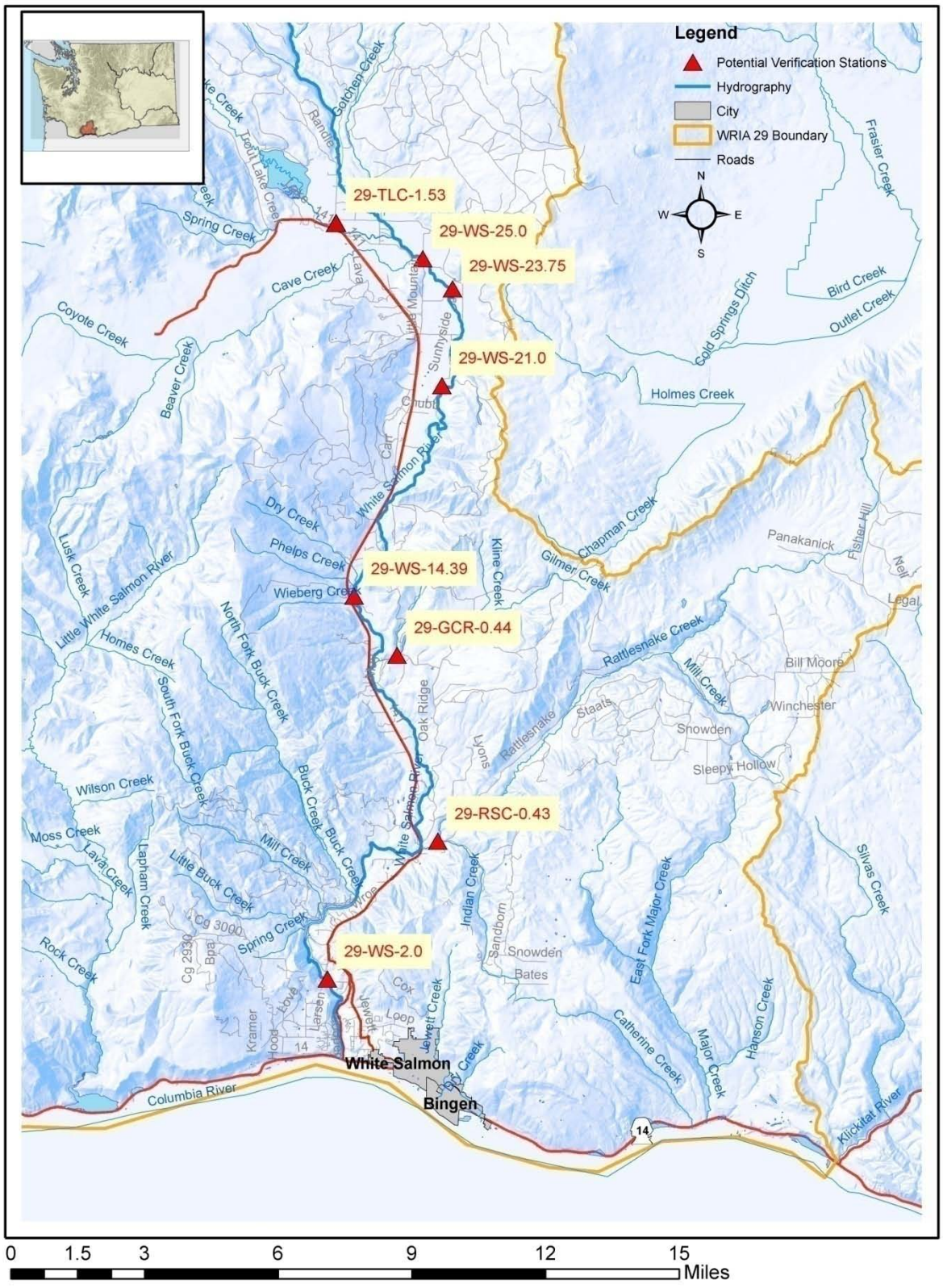

Figure 3. Potential Ecology source identification monitoring stations.

Sampling Procedures

Safety

Staff will adhere to safety measures contained in Ecology's Environmental Assessment Program Safety Manual. Field operations will be discontinued any time personnel determine that driving conditions, site access, or sampling conditions are unsafe for that site.

Sampling

Fecal coliform sampling will be performed according to Ecology's Environmental Assessment Program standard operating procedures. The *Standard Operating Procedure (SOP) for the Collection of Fecal Coliform Bacteria Samples, Version 1.3* (Ward, 2007) will be used.

Bacteria grab samples will be collected directly into pre-cleaned 250-mL containers supplied by the laboratory and described in MEL (2006). Samples will be collected from the stream center of flow (thalweg) whenever possible. Samples will be labeled, transferred to a cooler, placed in crushed or cube ice, and kept at between 0°C and 4°C. All samples will be delivered to MEL no later than 20 hours after collection. Analysis will be performed within 24 hours of collection.

Following each field sampling event, samples will be delivered to Ecology's Operation Center in Lacey for shipment to MEL. Sampling staff will use chain-of-custody records, as described in the *Lab Users Manual* (MEL, 2008). These include field log books and the Laboratory Analyses Required form.

Streamflow Measurements

Instantaneous discharge measurements will be taken twice monthly at one station (29-WSRM-22.55) according to field methods described by the American Fisheries Society (Gallagher and Stevenson, 1999) and according to methods in the meter manufacturer's operating manual. Replicate discharge measurements will be recorded in accordance with Ecology's quality control procedures (Table 9). Discharge data will be used for analyzing fecal coliform data.

Measurement Procedures

Laboratory analyses will be performed in accordance with the *MEL Lab Users Manual*, (MEL, 2008). This manual indicates that the reporting limits listed in Table 8 can be achieved by using analytical methods. The laboratory staff will consult the project manager if there are any changes in procedures over the course of the project, or if other difficulties arise.

Table 8. Summary of laboratory analysis procedures for fecal coliform bacteria.

Method	Estimated Range (cfu/100 mL)	Detection Limit (cfu/100 mL)	Holding Time	Preservation	Container
MF[1]	< 1 to > 5000	1	24 hrs	Chill (4 °C)	250-mL glass or poly autoclaved

[1] *Membrane Filter* method (APHA, AWWA, and WEF, 1998).

The field crew will communicate with MEL staff to ensure that laboratory resources are available. The project team will follow normal MEL procedures for sampling event notification and scheduling. With adequate communication, sample quantities and processing procedures should not overwhelm the laboratory capacity. When laboratory-sample load capacities are heavy, rescheduling of individual surveys may be necessary.

Quality Control Procedures

Quality control procedures used during field sampling and laboratory analyses will provide estimates toward understanding accuracy of the monitoring data. All samples will be analyzed at MEL following standard QC procedures outlined in the laboratory Quality Assurance Plan and Users Manual (MEL, 2006 and 2008). The laboratory's data quality objectives are documented in MEL (2006).

The results of the laboratory Quality Control sample analyses should be used in determining compliance with MQOs (Table 4). Variation will be described for field and laboratory results by examining replicate samples and comparing to MQOs. Laboratory Quality Control data for fecal coliform duplicates will be compared to the MQOs for precision.

Two types of variation in fecal coliform data will be examined:

- Sampling and analysis (field + laboratory) – from *field duplicates*.
- Analysis alone – from *duplicate laboratory analyses*.

Results (relative standard deviation) for replicate pairs of fecal coliform measurements will be compared to the MQOs (Table 4). Replicate samples and measurements will be obtained at frequencies indicated in Table 9.

Table 9. Frequency of quality control procedures.

Analysis	Meter Calibration	Field Replicate	Lab Method Blank	Lab Duplicates
Fecal Coliform (MF)	N/A	1/5 samples	1/run	1/5 samples
Discharge	1/use	1/6 samples	N/A	N/A

N/A – Not applicable.

MEL protocols (MEL, 2006) also call for the measurement of *blanks* at a rate described in Table 9. Positive blank response can be due to a variety of factors related to the procedure, equipment, or reagents. Unusually high blank responses indicate laboratory contamination (Lombard and Kirchmer, 2004).

Flow meters used in measuring stream discharge will be checked and calibrated at the start of each sampling day and will follow manufacturer's procedures. Replicate discharge measurements will be used to describe the variability. Both the initial value and the replicate value will be reported, regardless of the magnitude in relative standard deviation (consistent with Butkus, 2005).

Data Management Procedures

Laboratory Data

Procedures for laboratory data reduction, review, and reporting are outlined in the MEL Users Manual (MEL, 2006). Laboratory staff will be responsible for the following functions:

- Fecal coliform data verification.
- Proper transfer of data to the Laboratory Information Management System (LIMS).
- Reporting data to the project manager.

The Environmental Information Management (EIM) data engineer will subsequently enter data into Ecology's EIM system after data verification and validation. The project manager will perform the following functions:

- Review data for errors (quarterly) and make procedural adjustments as necessary.
- Apply corrective measures to minimize errors and validate the quality of the data.

Major changes will require notification of those who have signed this QA Project Plan. The project manager may approve data that do not meet MQOs (Table 4), but only after consultation with these signatories, and only with appropriate data qualification.

Laboratory Reports

MEL will report all laboratory results to the project manager within 30 days of sample delivery. The reports will include narratives, numerical results, data qualifiers, and costs.

High fecal coliform densities (≥ 200 cfu/100 mL) will be reported to Ecology's Southwest Regional Office (SWRO) and the project manager in accordance with the Environmental Assessment Program's official Bacteria Notification Policy (1-03). All other data will be made available to the SWRO for release after quality control and EIM entry are completed.

Field Data

Field data will be recorded by pencil onto a notebook with waterproof pages. The project manager will review the field data monthly, then calculate discharge. The project manager will review calculated data for errors and make procedural adjustments as necessary. Field data will be entered into a Microsoft Excel® spreadsheet for later integration with laboratory data before exporting to Ecology's EIM database. Data entry and validation will be performed by staff within Ecology's Environmental Assessment Program. All entered data will be validated by an internal, independent reviewer. Errors found will be identified, flagged, and corrected by the project manager. The EIM data engineer will upload all data into the EIM database.

If verification stations are identified and sampled during the study, station information will be collected following Table 6.

Final Study Report

A technical memo and final study report will compare measured fecal coliform geometric mean values (GMVs) and 90th percentiles to water quality standards. Current fecal coliform levels will be reported to better characterize water quality conditions in the Salmon Creek watershed.

Estimation of univariate statistical parameters may be generated using Microsoft Excel® or other appropriate computer software. These parameters may include arithmetic mean, geometric mean, median, standard deviation, and range of data by station and sampling survey, and graphical presentation of the data.

The technical memo and study report will also synthesize data and information from other available sources.

If water quality standards are not met, the final study report will include suggestions for geographical areas that would most benefit from Best Management Practices (BMPs) and consequently lead to water quality improvements.

Audits and Reports

MEL will submit laboratory reports, QA worksheets, and chain-of-custody records to Environmental Assessment Program staff. Any problems and associated corrective actions will be reported by the laboratory to the project manager. The project manager is responsible for periodic audit updates to the sampling team and client as well as for the final report.

Documentation from MEL should include any quality control results associated with the data in order to evaluate the accuracy of the data and to verify that the quality objectives are met.

Data Verification and Validation

Data Verification

Data verification involves examining the data for errors, omissions, and compliance with quality control (QC) acceptance criteria. MEL is responsible for performing the following functions:

- Reviewing and reporting QC checks on instrument performance such as initial and continuing calibrations.
- Reviewing and reporting case narratives. This includes comparison of QC results with method acceptance criteria such as precision data, surrogate and spike recoveries, laboratory control sample analysis, and procedural blanks.
- Explaining flags or qualifiers assigned to sample results.
- Reviewing and assessing MEL's performance in meeting the conditions and requirements set forth in this QA Project Plan.
- Reporting the above information to the project manager or lead.

After field staff record measurement results, the results are verified by the project manager to ensure that:

- Data are consistent, correct, and complete, with no errors or omissions.
- Results of QC samples accompany the sample results.
- Established criteria for QC results were met.
- Data qualifiers are properly assigned where necessary.
- Data specified in the Sampling Process Design were obtained.
- Methods and protocols specified in the QA Project Plan were followed.

MEL is responsible for verifying all analytical results. Reports of results and case summaries provide adequate documentation of the verification process. MEL analytical data will be reviewed and verified by comparison with acceptance criteria according to the data review procedures outlined in the *Lab Users Manual* (MEL, 2008). Appropriate qualifiers will be used to label results that do not meet quality assurance requirements.

Field results will also be verified by field staff before leaving the site after measurements are made. Detailed field notes will be kept to meet the requirements for documentation of field measurements. The field lead is responsible for checking that field data entries are complete and error free. The field lead will check for consistency within an expected range of values, verify measurements, ensure measurements are made within the acceptable instrumentation error limits, and record anomalous observations.

Data Validation and Usability

Data usability assessment follows verification. This involves a detailed examination of the data package using professional judgment to determine whether the MQOs have been met. The project manager examines the complete data package to determine compliance with procedures outlined in the QA Project Plan and Standard Operating Procedures. The project manager is also responsible for the data usability assessment by ensuring that the MQOs for precision, bias, and sensitivity are met.

Part of this process is an evaluation of precision. Precision will be assessed by calculating relative standard deviations (RSDs) for field and laboratory duplicates. Laboratory duplicates will yield estimates of precision performance at the laboratory only. Field replicates will indicate overall variability (environmental + sampling + laboratory). Acceptable precision performance is outlined in the MQOs (Table 4).

The project manager will assess completeness will be assessed by examining (1) number of samples collected compared to the sampling plan; (2) number of samples shipped and received at MEL in good condition; (3) MEL's ability to produce usable results for each sample; and (4) sample results accepted by the project manager.

To analyze data for its usability, the project lead will consider precision, completeness, and documentation of adherence to protocols. Data will also be examined for extremes (i.e., against historical records and against the distributions of these project data). Extreme values will require logical explanations. Identified sources of bias will be described in the final project report.

The data will be used to determine whether freshwater quality criteria have been met. The data may also be used for suggesting potential BMP actions if water quality criteria are not met. The project manager will make this determination by examining the data and all of the associated quality control information. This includes fecal coliform target geometric mean, 90^{th} percentile values, and required percent reductions.

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Appendix. Glossary, Acronyms, and Abbreviations

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards, and are not expected to improve within the next two years.

90th percentile: A statistical number obtained from a distribution of a data set, above which 10% of the data exist and below which 90% of the data exist.

Anadromous: Sea-run.

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.

Compliance Monitoring: The objective of compliance monitoring is to assess whether a specific 303(d) listed segment or waterbody is in compliance with water quality standards or whether a specific segment or waterbody is in compliance with the prescribed TMDL target limits.

Fecal coliform: 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 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.

Parameter: Water quality constituent being measured (analyte).

Source Identification Monitoring: The purpose for this site-specific monitoring is to isolate specific pollution sources identified through TMDL characterization monitoring.

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

Total Maximum Daily Load (TMDL): A water cleanup plan. A distribution of a substance in a waterbody designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

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.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

BMP	Best management practices
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
GPS	Global Positioning System
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
QA	Quality assurance
RM	River mile
RSD	Relative standard deviation
SOP	Standard operating procedures
TMDL	(See Glossary above)
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
mL	milliliters