Quality Assurance Project Plan

Union River
Fecal Coliform
Total Maximum Daily Load
Effectiveness Monitoring

by
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Environmental Assessment Program
Washington State Department of Ecology
Olympia, Washington 98504-7710

July 2008

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Ecology's Project Tracker Code for this study is 08-022.

303(d) Listings Addressed in this Study:
Union River LLID: 1228405474456 (MF56EG): Fecal coliform

Waterbody Number: WA-15-2010

Additional Waterbodies:
Bear Creek LLID: 1228051474927
Belfair Creek LLID: 1228326474519
Courtney Creek LLID: 1228276474693
Little Mission Creek LLID: 122876747286
Mission Creek LLID: 122871347308

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NWRO - Northwest Regional Office
WQP - Water Quality Program

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Abstract

The Washington State Department of Ecology (Ecology) is required under Section 303(d) of the federal Clean Water Act to (1) develop and implement Total Maximum Daily Loads (TMDLs; water cleanup plans) for impaired waters, and (2) evaluate the effectiveness of the water cleanup plans in achieving the needed improvement in water quality.

The Union River has been impaired[1] based on high fecal coliform bacteria concentrations. A 2001 TMDL study attributed the pollution to nonpoint sources such as septic systems, stormwater, bio-solids land applications, small farms, and wildlife. Cleanup activities have been implemented in the expectation that the Union River will meet load allocation targets set by the TMDL and thereby meet water quality criteria.

The main purpose of the study outlined in this Quality Assurance (QA) Project Plan is to evaluate the effectiveness of implementation efforts in meeting fecal coliform target concentrations in the Union River. Monthly fecal coliform sampling will be conducted at five TMDL target stations in the Union River watershed during May 2008 – April 2009.

Another purpose of the study is to evaluate waters in the vicinity. Various waters in the Union River vicinity have exhibited elevated fecal coliform concentrations. Therefore we will also sample five added stations for fecal coliform during the same year-long period to determine if these waters meet water quality criteria.

All ten sampling sites are located in Mason County.

Each study conducted by Ecology must have an approved QA Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completion of the study, a final report describing the study results will be posted to the Internet.

[1] Exceeded the Washington State water quality criteria

Background and Project Description

The Union River is a largely rural stream that is listed under Section 303(d) of the federal Clean Water Act as not meeting Washington State water quality standards for fecal coliform bacteria. The impaired reach is situated below the intake from the City of Bremerton domestic water supply reservoir (Union River Reservoir). The reservoir location is shown on page 3 (Figure 1) of Garland and Lawrence (2003; www.ecy.wa.gov/pubs/0310066.pdf).

The Union River originates from above this reservoir. The main stream and its major tributaries, Bear Creek, Hazel Creek, Courtney Creek, Belfair Creek, East Fork, and Northeast Fork, combine to make up over 16 miles of stream corridor. In addition, there are several smaller tributaries that contribute to the river's flow.

The Union River drainage has supported chum salmon (fall and summer runs), coho salmon, coastal cutthroat trout, pink salmon (SaSI, 2007), winter steelhead (SaSI, 2007; Hard et al., 2007), fall Chinook salmon, (SaSI, 2007; Ruckelshaus et al., 2006), and sockeye salmon (Gustafson et al., 1997). The Hood Canal Coordinating Council's plan for the recovery of *threatened* summer chum salmon was adopted in May 2007 (HCCC, 2007).

The Union River flows southwest and discharges into the northern tip of lower Hood Canal (Figure 1). Fecal coliform contamination into tributaries of this part of Hood Canal has contributed to the closure of shellfish harvesting here (MSA, 2005; WDOH, 2006).

This effectiveness monitoring project serves as a check of past and ongoing work to cleanup the Union River so that it can meet water quality standards for fecal coliform bacteria. Cleanup work has been conducted by local governments, stakeholders, and the Washington State Department of Ecology (Ecology).

History of Data Collection and Cleanup

Union River Impairment Detected

During the 1990s, monitoring by several agencies indicated that the Union River violated the Washington State water quality standard for fecal coliform (Ward et al., 2001; Sweet et al., 2002; Garland and Lawrence, 2003). Historical fecal coliform data for streams in the Union River vicinity can be found in Ecology's Environmental Information Management database (www.ecy.wa.gov/eim); see Table 1 below.

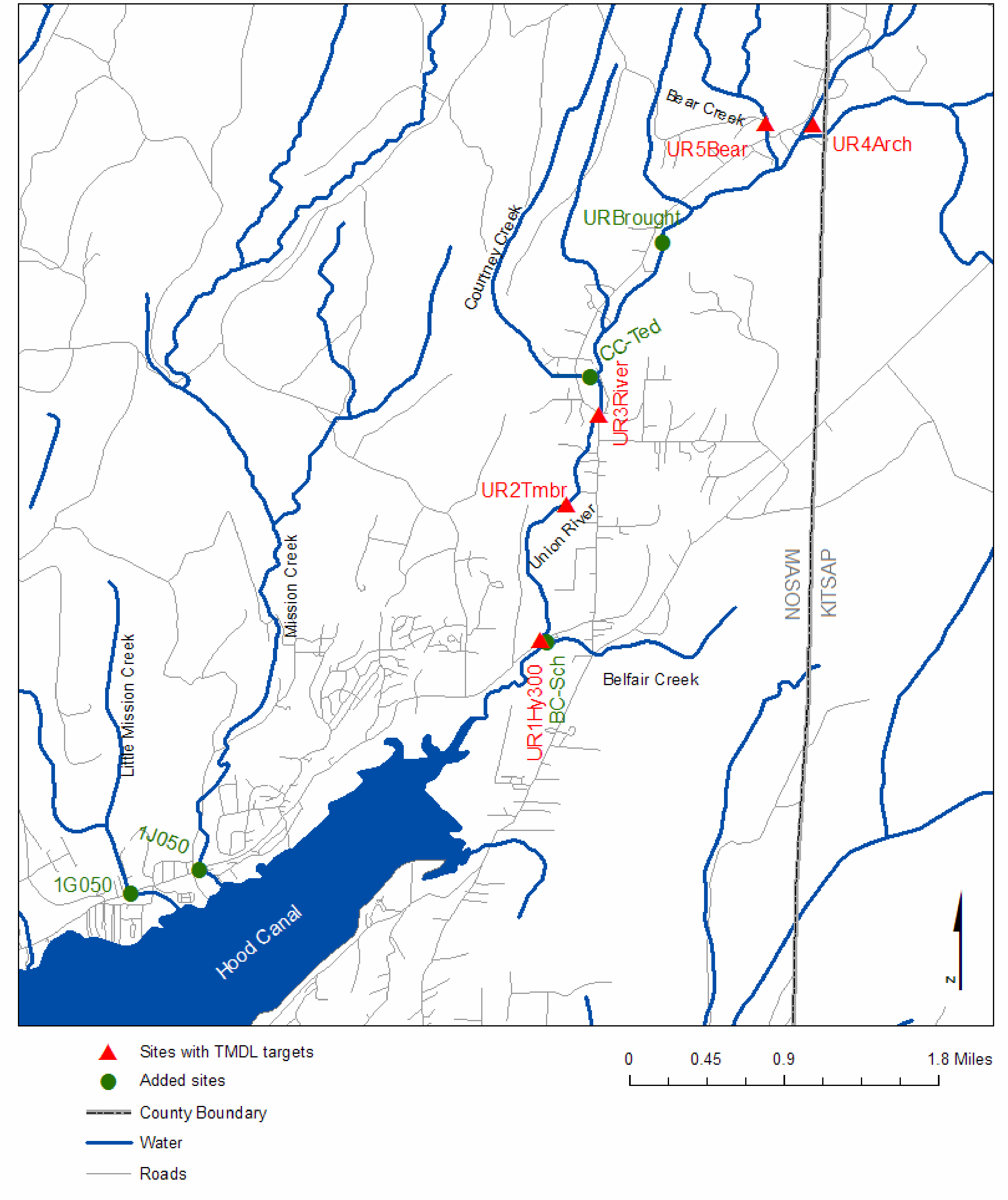

Figure 1. Fecal coliform monitoring stations: 5 for comparison to Union River TMDL targets and 5 added for comparison to Washington State water quality criteria.

Table 1. Regional stream fecal coliform bacteria data in EIM.

Study Name	User Study ID
Statewide River and Stream Ambient Monitoring-WY2000 to present	AMS001
Statewide River and Stream Ambient Monitoring-WY1989 through WY1999	AMS001D
Baseline Assessment of Lower Hood Canal Streams	G0000106
Upper Union River Restoration	G0100200
Kitsap County Health District Surface Water Trend Monitoring	KITSAPWQ
Union River TMDL	URTMDL
Upper Union River Restoration	G0100200

WY = Water year

Union River Cleanup Plans

A Total Maximum Daily Load (TMDL) study was conducted by Ward et al. (2001). The main study objective was to recommend a strategy for cleaning up fecal coliform pollution from the river sufficiently to meet water quality criteria. This was done by estimating pollution loads and concentrations along the river, modeling an acceptable loading capacity, and then recommending load allocations. Fecal coliform pollution was attributed to these nonpoint sources:

- Septic systems
- Stormwater
- Bio-solids land applications
- Small farms
- Wildlife

Union River Cleanup Implementation

Ecology prepared the *Union River Fecal Coliform Total Maximum Daily Load Submittal Report* (Sweet et al., 2002). This report outlined on-going and planned activities that would reduce fecal coliform pollution to the Union River. The report was submitted to EPA.

Based on the 2001 TMDL study and the 2002 submittal report, and additional sampling by Ecology's Northwest Regional Office, Ecology then prepared the *Union River Fecal Coliform Water Cleanup Detailed Implementation Plan* (Garland and Lawrence, 2003). The Detailed Implementation Plan includes an extensive description of the study area, surroundings, and historical data. Many projects have contributed to the cleanup of fecal coliform bacteria (Table 2).

Additional efforts are likely to contribute to reductions in fecal coliform contamination. Examples include the Hood Canal Dissolved Oxygen Program (Fagergren et al., 2004) and work to recover *threatened* summer chum salmon (HCCC, 2007).

Table 2. Summary of past, ongoing, and planned implementation projects to reduce fecal coliform bacteria in the Union River watershed.

Project	Responsible Parties	Scheduled Completion
Upper Union River Restoration Project (Pollution Identification and Correction)	Kitsap County Public Works, Kitsap County Health District, Kitsap Conservation District, Washington State Dept. of Ecology	Dec. 2004
Port of Bremerton Industrial Park stormwater improvements	Port of Bremerton Surface & Stormwater Management Utility, Washington State Dept. of Ecology	Aug. 2005
Olympic View Landfill Closure	Kitsap County Health District, Washington State Dept. of Ecology	June 2005
Lower Union River Restoration Study	Mason Conservation District, Mason County Dept. of Health Services, Hood Canal Salmon Enhancement Group, University of Washington Sea Grant, Mason County Public Works, Washington State Dept. of Ecology	Nov. 2005
Belfair sanitary sewer improvements	Mason County Dept. Utilities/Waste Management	2006
Belfair stormwater improvements	Mason County Public Works	2006
Mason County's On-site Sewage System Management Plan (MCPHD-EHD, 2007)	Mason County Public Health Dept. Environmental Health Division, Jefferson County Public Health	Dec. 2007
Kitsap Surface Water Quality Trend Monitoring	Kitsap County Public Works, Kitsap County Health District	Ongoing
Kitsap Self-Help On-Site Sewage Repair Program	Kitsap County Health District, Washington On-Site Sewage System Association, Volunteers	Ongoing
Highway runoff stormwater management	Washington State Dept. of Transportation, Kitsap County Public Works, Mason County Public Works	Ongoing
On-Site Septic System Repair and Replacement Local Loan Program	Kitsap County, Mason County, Washington State Dept. of Ecology	Ongoing
Northwest Region Sampling Investigations	Washington State Dept. of Ecology	Ongoing
South Kitsap Industrial Area sewer service	Port of Bremerton, Kitsap County Public Works, Port Orchard	2009

Other Data from the Union Creek Vicinity

Recent Ecology sampling in the Union River watershed shows high fecal coliform concentrations in Lower Belfair Creek near Belfair, a stream draining the Belfair Urban Growth Area (Ecology, 2003). Little Mission Creek and Mission Creek, nearby tributaries to lower Hood Canal, have also exhibited elevated concentrations of fecal coliform bacteria (Ecology, 2008a; HCSEG, 2006). Little Mission Creek is categorized as impaired for fecal coliform bacteria (Ecology, 2008b).

Water Quality Standards

Washington State Surface Water Quality Standards (WAC 173-201A) have recently changed. In November 2006, Ecology adopted revised surface water quality standards (Ecology, 2006). On February 11, 2008, the US Environmental Protection Agency approved revisions. Therefore the standards have changed since the 2001 TMDL study. The historic standards were based on the class designation of each given waterbody. The revised standards are based on designated beneficial uses of the waterbody. These changes do not effectively change the criteria for fecal coliform bacteria in the waters discussed in this plan. However, we will describe the applicable historic and current standards for clarity.

Historic Applicable Standards

The *Union River Fecal Coliform Total Maximum Daily Load Study* (Ward et al., 2001) was designed to address impairments of characteristic uses caused by fecal coliform levels above standards. These impairments were detected during November 1997 through November 2006. At that time, based on a Class AA status, the characteristic uses designated for protection in the Union River watershed were as follows:

"Characteristic uses. Characteristic uses shall include, but not be limited to, the following:

- *(i) Water supply (domestic, industrial, agricultural).*
- *(ii) Stock watering.*
- *(iii) Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting. Other fish migration, rearing, spawning, and harvesting. Clam, oyster and mussel rearing, spawning, and harvesting. Crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing, spawning, and harvesting.*
- *(iv) Wildlife habitat.*
- *(v) Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment).*
- (vi) *Commerce and navigation."*

[WAC 173-201A-030(1)(b)]

The Washington State water quality standards described criteria for fecal coliform. Although different criteria applied for freshwater and marine waters, the TMDL only discussed the freshwater criteria.

For Class AA freshwaters:

"Freshwater – fecal coliform levels shall both not exceed a geometric mean value of 50 colonies/100 mL and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 100 colonies/100 mL." [WAC 173-201A-030(1)(c)(i)(A)]

The water quality standards describe the averaging periods in the calculation of the geometric mean for the fecal coliform criteria:

"In determining compliance with the fecal coliform criteria in WAC 173-201A-030, averaging of data collected beyond a thirty-day period,… shall not be permitted when such averaging would skew the data set as to mask noncompliance periods." [WAC 173-201A-060(3)]

Current Applicable Standards

The characteristics of Hood Canal are relevant to the standards for Hood Canal and to the standards for its freshwater tributaries. Hood Canal is designated as *extraordinary quality marine waters* (WAC 173-201A-210, Table 612). For fecal coliform concentrations, Hood Canal marine water designated uses are defined as *Primary Contact Recreation* (WAC 173-201A-210).

"Fecal coliform organism levels in Primary Contact Recreation marine waters must not exceed a geometric mean value of 14 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 43 colonies/100 mL." [WAC 173-201A-210]

We do not anticipate sampling in marine waters (where salinity is greater than 10 ppt through the water column).

Fresh water use designations are defined in WAC 173-201A-600.

"Use designations — Fresh waters.
(1) All surface waters of the state not named in Table 602 are to be protected for the designated uses of: Salmonid spawning rearing, and migration; primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting; commerce and navigation; boating; and aesthetic values.

(a) Additionally, the following waters are also to be protected for the designated uses of: Core summer salmonid habitat; and extraordinary primary contact recreation:

- *(i) All surface waters lying within national parks, national forests, and/or wilderness areas.*
- *(ii) All lakes and all feeder streams to lakes (reservoirs with a mean detention time greater than fifteen days are to be treated as a lake for use designation).*
- *(iii) All surface waters that are tributaries to waters designated core summer salmonid habitat; or extraordinary primary contact recreation.*
- *(iv) All fresh surface waters that are tributaries to extraordinary quality marine waters (WAC 173-201A-610 through 173-201A-612)."*

Since Hood Canal is designated as *extraordinary quality marine waters*, the fresh waters that are tributary to Hood Canal (except those specified in table 602 of WAC 173-201A) are designated for fecal coliform standards as *Extraordinary Primary Contact Recreation*:

"Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100 colonies/100 mL." [WAC 173-201A-200, Table 200 2(b)].

Waterbodies that do not meet these applicable water quality standards, despite the presence of technology-based pollutant controls, are listed as impaired under Section 303(d) of the Clean Water Act. The listing requires development of a TMDL intended to provide guidance for the protection of beneficial uses within the basin.

The TMDL may be apportioned between point sources (wasteload allocations) and nonpoint or background sources (load allocations) of pollution. The allocations may be implemented through NPDES permits, state waste discharge permits, grant projects, watershed action plans, and other nonpoint source control activities. There are nonpoint sources, but no point source discharges, to the Union River.

Local efforts for bacteria pollution control are evident as water quality continues to improve in the Union River watershed.

Study Objectives

This study has two goals:

- To gather support for the fecal coliform bacteria TMDL implementation actions.
- To support systematic review and improvement of water quality.

This study has two objectives:

- To determine if fecal coliform targets set by the 2001 TMDL study and described in the 2003 Detailed Implementation Plan have been met.
- To determine if Washington State water quality standards for fecal coliform are being met in select freshwater streams.

Monitoring of fecal coliform bacteria is needed to assess how the Union River's conditions match the temporal and spatial goals set by the TMDL and to a assess the status of nearby waters of concern. To meet these needs, fecal coliform concentrations will be estimated monthly from all sites from May 2008 – April 2009. Final results will be reported in a technical memo, and final report including a table displaying geometric mean values (GMV) and 90th percentile values for each station.

These statistics will be generated on an annual and seasonal basis, depending on the availability of data. Only data from sites within the Union River effectiveness monitoring study area that meet all quality control requirements will be used in this evaluation.

We 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, and illness or unavailability of monitoring staff. Routinely missed samples could impart bias in expressions generated from final data. Sampling events will be rescheduled when missed in order to maintain integrity of the characterization effort. Field monitoring data loss due to equipment failure may occur; backup equipment will be available to minimize this problem. 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.

Sampling Locations

Sites for TMDL Effectiveness Monitoring

Based on the TMDL study (Ward and others, 2001), the Detailed Implementation Plan describes fecal coliform target limits for each of five stations in the Union River watershed. This study will evaluate whether these five stations (Figure 1, Table 3) meet these targets (Table 4).

Additional Sites for Water Quality Criteria Monitoring

This study will also monitor five additional freshwater stream stations in the Union River vicinity (Figure 1, Table 3) to evaluate fecal coliform levels relative to Washington State's water quality criteria. *Extraordinary Primary Contact Recreation* criteria (WAC 173-201A-200) apply to all of these waters. These criteria (Table 4) require a geometric mean of all measurements to be less than 50 cfu/100 mL. They also require 90 percent of all measurements to be less than 100 cfu/100 mL.

TMDL sites have allocation targets for cleanup that were specified by the Detailed Implementation Plan (Garland and Lawrence, 2003). Added sites will be evaluated relative to state water quality standards.

The first 5 stations in Table 4 have TMDL target limits that were described by the Detailed Implementation Plan (Garland and Lawrence, 2003). The last 5 stations will be evaluated relative to state water quality criteria.

All 10 stations are located in Mason County.

Logistical Considerations

We conducted a reconnaissance survey on January 4, 2008 to verify accessibility of site locations. A Global Positioning System (GPS) receiver verified station coordinates.
All sample locations are located at bridge crossings or near parking. All stations are located close to each other and within a short distance to Ecology's Manchester Environmental Laboratory. This facilitates direct delivery of samples within hours of collection. No logistical problems are anticipated.

Table 3. Monitoring stations.

Station	Description	Type	Latitude, Longitude (NAD83)
UR1HY300	Union River at Highway 300	TMDL	47.4522, -122.8339
UR2Tmbr	Union River at Timberline Dr	TMDL	47.4638, -122.8312
UR3River	Union River at Old Belfair Hwy	TMDL	47.4714, -122.8275
UR4Arch	Union River at Archery Range	TMDL	47.4964, -122.8019
UR5Bear	Bear Creek at Bear Creek Rd	TMDL	47.4964, -122.8078
1G050	Little Mission Creek at Highway 300	Added	47.4298, -122.8838
1J050	Big Mission Creek at Highway 300	Added	47.4320, -122.8755
BC-Sch	Belfair Creek at mouth	Added	47.4520, -122.8331
CC-Ted	Courtney Creek at mouth	Added	47.4745, -122.8286
URBrought	Union River at private bridge (T23N,R1W,Sec16, SW of NW)	Added	47.4860, -122.8201

Table 4. Fecal coliform targets for each station.

Station	Geometric Mean (cfu/100 mL)	10% of Samples Cannot be Over (cfu/100 mL)
UR1HY30	44	100
UR2Tmbr	50	54
UR3River	50	51
UR4Arch	50	57
UR5Bear	50	62
1G050	50	100
1J050	50	100
BC-Sch	50	100
CC-Ted	50	100
URBrought	50	100

Organization

Ecology employees involved in this project are listed in Table 5. All persons listed on the signature approval page are responsible for reviewing and approving the final Quality Assurance Project Plan.

Table 5. Organization of project staff and responsibilities.

Name/unit & section/ regional office/phone	Title	Responsibilities
Glenn Merritt Directed Studies Unit WOS, EAP (360) 407-6777	Interim Project Manager and Principal Investigator	Writes the QAPP.
Scott Collyard Directed Studies Unit WO Section, EAP (360) 407-6000	Project Manager and Principal Investigator	Conducts QA review of data, analyzes and interprets data, prepares data for upload to EIM, and writes the draft report and final report.
Mark Von Prause Directed Studies Unit WOS, EAP (360) 407-6000	EIM Data Engineer	Uploads data into EIM.
Dave Garland Watershed Unit WQP-NWRO (425) 649-7031	EAP Client and Field Assistant	Clarifies scope of the project, provides internal review of the QAPP, and approves the final QAPP. Helps to collect samples and field information. Helps deliver samples to the laboratory.
Kevin Fitzpatrick Watershed Unit, WQP-NWRO (425) 649-7033	Client's Section Manager	Approves the QAPP.
Craig Homan Watershed Unit WQP-NWRO (425) 649-7031	Field Assistant	Collects samples and records field information. Transports samples Manchester Laboratory.
George Onwumere Directed Studies Unit WOS, EAP (360) 407-6730	Project Manager's Unit Supervisor	Reviews the QAPP and draft technical memo. Approves the QAPP and project budget.
Bob Cusimano EAP (360) 407-6596	Western Operations Section Manager	Approves the QAPP and technical memo.
Stuart Magoon EAP, Manchester Environmental Laboratory (360) 871-8801	Director	Approves the final QAPP.
William R. Kammin EAP (360) 407-6964	Ecology Quality Assurance Officer	Reviews the draft QAPP and approves the final QAPP.

EAP – Environmental Assessment Program
EIM – Environmental Information Management system
QAPP – Quality Assurance Project Plan
WQP-NWRO – Water Quality Program- Northwest Regional Office
WOS – Western Operations Section

Schedule

Project Schedule

The project schedule is in Table 6.

Table 6. Proposed schedule for completing field and laboratory work, data entry into EIM, and reports.

Field and laboratory work	
Field work	Monthly: May 2008- April 2009
Laboratory analyses completed	May 2009
Environmental Information System (EIM) system	
EIM data engineer	Mark Von Prause
EIM user study ID	GMER0004
EIM study name	Union River FC TMDL Effectiveness Monitoring
Data due in EIM	August 2009
Final report	
Author lead	Scott Collyard
Schedule	
Draft due to supervisor	August 2009
Draft due to client/peer reviewer	September 2009
Draft due to external reviewer	October 2009
Final report due on web	January 2010

Sampling Schedule

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

- May 5, 2008
- June 2, 2008
- July 7, 2008
- August 4, 2008
- September 8, 2008
- October 6, 2008
- November 3, 2008
- December 1, 2008
- January 5, 2009
- February 2, 2009
- March 2, 2009
- April 6, 2009

Experimental Design

The intent of this 2008-2009 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. To mimic the 2001 TMDL study, field sampling will be performed monthly during May 2008 through April 2009. Sampling will be timed as closely as feasible to low tides to avoid tidal effects at locations bordering Hood Canal.

Water samples from TMDL target stations will be analyzed by the Most Probable Number (MPN) method (Table 7) because this is the method that was used for the TMDL study (Ward et al., 2001). A field duplicate MPN sample will be collected each month at a location specified (Table 7). This provides a 20% field duplication rate for MPN.

Table 7. Allocation of fecal coliform samples (by MPN) at the TMDL target stations.

Station ID	May 2008	June 2008	July 2008	Aug. 2008	Sept. 2008	Oct. 2008	Nov. 2008	Dec. 2008	Jan. 2009	Feb. 2009	Mar. 2009	Apr. 2009
UR1HY300	2(s)	1	1	1	1(s)	2	1	1	1(s)	1	2	1
UR2Tmbr*	1(s)	2(s)	1(s)	1(s)	1(s)	1(s)	2(s)	1(s)	1(s)	1(s)	1(s)	2(s)
UR3River	1	1(s)	2	1	1	1(s)	1	2	1	1(s)	1	1
UR4Arch	1	1	1(s)	2	1	1	1(s)	1	2	1	1(s)	1
UR5Bear	1	1	1	1(s)	2	1	1	1(s)	1	2	1	1(s)
MPN Total	6	6	6	6	6	6	6	6	6	6	6	6
MF by split	2	2	2	2	2	2	2	2	2	2	2	2

(s) Indicates where one 500-mL water sample will be split at the laboratory into 250 mL for analysis by MF and 250 mL for analysis by MPN.
* An instantaneous discharge measurement will be taken monthly here. Also, a duplicate discharge measurement will be taken during one summer month and one winter month.

To save expense, the Membrane Filter (MF) method will be used to analyze samples from the added sites (Table 8). A field duplicate MF sample will also be collected each month at a station specified (Table 8). This provides a 20% field duplication rate for MF.

Table 8. Allocation of fecal coliform samples (by MF) at the additional sampling stations.

Station ID	May 2008	June 2008	July 2008	Aug. 2008	Sept. 2008	Oct. 2008	Nov. 2008	Dec. 2008	Jan. 2009	Feb. 2009	Mar. 2009	Apr. 2009
BC-Sch	2	1	1	1	1	2	1	1	1	1	2	1
15G050	1	2	1	1	1	1	2	1	1	1	1	2
15J050	1	1	2	1	1	1	1	2	1	1	1	1
CC-Ted	1	1	1	2	1	1	1	1	2	1	1	1
URBrought	1	1	1	1	2	1	1	1	1	2	1	1
MF Total	6	6	6	6	6	6	6	6	6	6	6	6

To compare between MPN and MF methods, one 500-mL sample each month from the TMDL target stations will be divided at the laboratory into 2 separate 250-mL samples for separate analyses: one by MPN *and* another by MF (Table 7). The sampling locations for these divided samples (called splits) will consist of one consistent, non-tidal, downstream location (UR2Tmbr) and another location that rotates among the other 4 stations.

There will be 72 MPN samples from the TMDL-target stations. Of these, 24 bottles will be split into MF samples at the laboratory.

Among the four stations that are close to Hood Canal (UR1HY300, BC-Sch, 15G050, and 15J050), *in-situ* conductivity will be measured concurrently with fecal coliform sampling. These data will be examined to ensure that fecal coliform samples have been collected from freshwater and not marine water.

There will be 72 MF samples from these added stations. No splits will be collected.

Costs

Total project costs (laboratory plus travel) are approximately **$ 6,024** ($5,304 +$720).

Laboratory

These costs were calculated using the Manchester Laboratory's price list for FY2009.

Fecal Coliform by MPN: 72 samples @ $43/sample =	$ 3,096
Fecal Coliform by MF: 96 samples @ $23/sample =	$ 2,208
Total laboratory costs (including pre-planning 50% discount)	**$ 5,304**

Travel

Approximately $468 will be required for *per diem* expenses. Lodging will not likely be needed, but length of field days might exceed 11 hours for each round-trip by staff from Ecology's Northwest Regional Office in Bellevue. These costs were developed using Ecology's rates ($39 *per diem*) for Mason County travel, in effect since October 1, 2007. Additionally, about $252 might be needed as fare for ferry service between the study area and Ecology's Northwest Regional Office (about $21 round-trip x 12 trips). Total travel costs should be about **$720**.

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, each sample for which an RSD will be calculated will consist of paired duplicates.

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 we will not evaluate bias for most of our data (except for conductivity), we will minimize the bias through strict adherence to standard operating protocols (SOPs). Field staff will follow the SOPs listed in this plan (Ward, 2007a; Ward, 2007b; Gallagher and Stevenson, 1999). Care will also be taken to prevent contamination, a frequent problem with bacteria sampling. The bias of the field conductivity meter will be calibrated before each day of sampling and checked following each day of sampling, using a standard solution of known conductivity.

Table 9 lists the measurement quality objectives (MQOs) for this project.

Table 9. Measurement quality objectives.

Analysis	Precision of Paired Duplicates (RSD)	Lower Reporting Limit	Bias
Discharge	5 %[1]	0 cfs[2]	N/A
Fecal Coliform MF[3]	184 %[4]	1 cfu/100 mL	N/A
Fecal Coliform MPN[5]	184 %[4]	1 cfu/100 mL	N/A
Conductivity	10 %[6]	0.1 µS/cm @ 25° C	5 µS/cm @ 25° C

[1] Based on Butkus (2005). For estimating variation, *not* necessarily for rejection.
[2] 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
[3] Analyzed by *Membrane Filter* Method (APHA, AWWA, and WEF, 1998)
[4] Fecal coliform precision measured by Ward et al. (2001); 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.
[5] Analyzed by *Most Probable Number* Method (APHA, AWWA, and WEF, 1998).
[6] Consistent with Onwumere (2006).

Measurement quality objectives 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% duplicate sampling rate (Tables 7 and 8) for fecal coliform sampling because this parameter has inherently large variability.

For the effectiveness monitoring portion of this 2008-2009 project, we will seek to collect *representative* samples through the use of stations and targets identified by the TMDL technical study (Ward et al., 2001). We will also use the same methods and frequency of sampling as the TMDL study. Furthermore, this study will span a year in duration, as did the 2001 TMDL study.

Representativeness generally for the project will be assured through the use of standardized protocols. We will assure that samples represent freshwaters by measuring conductivity and ensuring that it measures less than 17,000 µS/cm @ 25° C where fecal coliform samples are collected.

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) 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.

Field Procedures

Safety

Staff should adhere to the Environmental Assessment Program's Safety Manual (EAP, 2006). 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, 2007a) will be used.

Bacteria grab samples will be collected directly into pre-cleaned containers supplied by the laboratory and described in MEL (2005). These will be 250-mL bottles for standard samples and 500-mL bottles samples to be split into separate analyses at the laboratory. 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 Manchester Laboratory no later than 20 hours after collection. Analysis will be performed within 24 hours of collection.

Following each field sampling event, staff will drive to Manchester Laboratory and directly deliver samples to laboratory sample management staff. Sampling staff will use chain-of-custody records, as described in the Lab Users Manual (MEL, 2005). These include field log books and the Laboratory Analyses Required form.

Measurements

Flow

Instantaneous discharge measurements will be taken once monthly at one station (UR2Tmbr) 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. One duplicate discharge measure will be recorded during a summer month, and one duplicate discharge estimate will be measured during a winter month.

Conductivity (or Salinity)

A conductivity grab sample from about 6 inches below the surface will be measured in the field according to Ecology's Environmental Assessment Program standard operating procedures. The *Standard Operating Procedure (SOP) for the Collection and Analysis of Conductivity Samples, Version 1.3* (Ward, 2007b) will be used. One duplicate grab sample will be measured per month at station UR1HY300.

The conductivity measurements will be used to confirm that samples are being collected from freshwaters, not marine waters. Freshwater standards for fecal coliform bacteria apply to waters of salinity < 10 ppt (< 17,000 µS/cm at 25° C) through the water column. Conductivity units (µS/cm at 25° C) can be converted to salinity units (ppt) based on *Standard Methods* (APHA, AWWA, and WEF, 1998). This conversion is available online (www.fivecreeks.org/monitor/sal.html).

Laboratory Measurement Procedures

Laboratory analyses will be performed in accordance with the *Manchester Environmental Laboratory Users Manual*, (MEL, 2005). This manual indicates that the reporting limits listed in Table 9 can be achieved by using analytical methods listed in Table 10. The laboratory staff will consult the project manager if there are any changes in procedures over the course of the 2008-2009 project, or if other difficulties arise.

The field crew will communicate with the laboratory to ensure that laboratory resources are available. The project team will follow normal Manchester Laboratory procedures for sample 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.

Table 10. Summary of laboratory analysis procedures for fecal coliform bacteria.

Method	Estimated Range (cfu/100 mL)	Detection Limit (cfu/100 mL)	Holding Time[3]	Preservation	Container[4]
MF[1]	< 1 to > 5000	1	24 hrs	Chill (4 °C)	250 mL glass or poly autoclaved
MPN[2]	< 1 to > 5000	1	24 hrs	Chill (4 °C)	250 mL glass or poly autoclaved

[1] *Membrane Filter* method (APHA, AWWA, and WEF, 1998)
[2] *Most Probable Number* method (APHA, AWWA, and WEF, 1998)
[3] Holding time as required by Standard Methods for the Examination of Water and Wastewater (APHA, AWWA, and WEF, 1998).
[4] Split samples will be collected in 500 mL bottles.

Quality Control Procedures

Quality control (QC) procedures used during field sampling and laboratory analysis will provide estimates toward understanding accuracy of the monitoring data. All samples will be analyzed at the Manchester Laboratory following standard QC procedures outlined in the laboratory manual and the laboratory quality assurance plan (MEL, 2005 and 2007). The laboratory's data quality objectives are documented in MEL (2007).

The results of the laboratory QC sample analyses should be used in determining compliance with measurement quality objectives (Table 9). Variation will be described for field and laboratory results by examining replicate samples and comparing to measurement quality objectives. Laboratory QC data for fecal coliform duplicates will be compared to the Measurement Quality Objectives for precision.

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

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

Results (relative standard deviation) for duplicate pairs of fecal coliform measurements will be compared to the measurement quality objectives (Table 9). Duplicate samples and measurements will be obtained at frequencies indicated in Table 11.

Table 11. Frequency of quality control procedures.

Analysis	Meter Calibration	Field Duplicates	Field Sample Splits	Lab Method Blank	Lab Duplicates
Discharge	1/use	1/6 samples	N/A	N/A	N/A
Fecal Coliform (MF)	N/A	1/5 samples	1 MF per 3 MPN	1/run	1/5 samples
Fecal Coliform (MPN)	N/A	1/5 samples	1 MF per 3 MPN	1/run	1/5 samples
Conductivity	1/use[1]	1/4 records	N/A	N/A	N/A

[1] The conductivity meter will be calibrated before daily measurements.
The calibration will be checked after daily measurements.
N/A = not applicable.

Field sample splits will be collected as described in Tables 7 and 11. Fecal coliform analysis results can vary by method. These splits will help to describe the relationship between MF results and MPN results. Generally, the mean of paired samples results should be within 95% of each other. However, results for both methods need to be reported separately, regardless of this comparison.

Manchester Laboratory protocols (MEL 2005) 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 manufacturers procedures. *Duplicate discharge* measurements will be used to describe the variability. Both the initial value and the duplicate value will be reported, regardless of the magnitude in relative standard deviation (consistent with Butkus, 2005).

Quality control of field conductivity measurements will be performed according to methods of Ward (2007b). The meter will be *calibrated* daily prior to use. Daily measurements will be *checked* by measuring a solution of known conductivity following field sampling activities.

Data Management Procedures

Laboratory Data

Procedures for laboratory data reduction, review, and reporting are outlined in the Manchester Laboratory Users Manual (MEL, 2005). Laboratory staff will be responsible for the following functions:

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

The Environmental Information Management data engineer will subsequently enter data into Ecology's EIM system. 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 Quality Assurance Project Plan. The project manager may approve data that do not meet measurement quality objectives (Table 9), but only after consultation with these signatories, and only with appropriate data qualification.

Laboratory Reports

Manchester Environmental Laboratory 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 bacteria densities (≥ 200 cfu/100 mL) will be reported to Ecology's Northwest Regional Office (NWRO) 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 NWRO 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.

Final Study Report

A technical memo and final study report will compare observed fecal coliform bacteria geometric mean values (GMVs) and 90th percentiles to target concentrations. Current fecal coliform levels will be reported to better characterize current water quality conditions in the 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.

Audits and Reports

Manchester Laboratory 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 team and client as well as for the final report.

Documentation from the lab 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 Usability Assessment

Data Verification

Data verification involves examining the data for errors, omissions, and compliance with quality control (QC) acceptance criteria. Manchester Environmental Laboratory (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 sampling plan.
- Reporting the above information to the project manager or lead.

After measurement results have been recorded, the results are verified 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 Quality Assurance 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, 2005). Appropriate qualifiers will be used to label results that do not meet quality assurance requirements. An explanation for data qualifiers is provided.

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 should 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 Usability Assessment

Data usability assessment follows verification. This involves a detailed examination of the data package using professional judgment to determine whether the method quality objectives (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 duplicates will indicate overall variability (environmental + sampling + laboratory). Acceptable precision performance is outlined in the MQOs (Table 6).

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. We expect to have highly variable fecal coliform data because the TMDL study found this parameter to be highly variable in the Union River vicinity. Identified sources of bias will be described in the final project report.

The data will be used to determine whether TMDL targets have been met and whether freshwater quality criteria have been met. The project manager will make this determination by examining the data and all of the associated quality control information. This includes target geometric mean, 90th percentile values, and required percent reductions.

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Appendix. Glossary and Acronyms

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.

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.

Extraordinary primary contact: Waters providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas.

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.

Load allocation (LA): The portion of a receiving waters' loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

Loading capacity: The greatest amount of a substance that a waterbody can receive and still meet water quality standards.

Margin of safety: Required component of TMDLs that accounts for uncertainty about the relationship between pollutant loads and quality of the receiving waterbody.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

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.

Point source: Sources of pollution that discharge 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: Such 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 is 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.

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.

Thalweg: The deepest and fastest moving portion of a stream

Total Maximum Daily Load (TMDL): A distribution of a substance in a waterbody designed to protect it from 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.

Wasteload allocation (WLA): The portion of a receiving water’s loading capacity allocated to existing or future point sources of pollution. Wasteload allocations constitute one type of water quality-based effluent limitation.

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.

cfs	Cubic feet per second
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management System
GIS	Geographic Information System software
MEL	Manchester Environmental Laboratory
MF	Membrane Filter
MPN	Most Probable Number
MQO	Measurement quality objectives
NWRO	Northwest Regional Office
ppt	Parts per trillion
QA	Quality assurance
QC	Quality control
TMDL	Total Maximum Daily Load (water cleanup plan)
WAC	Washington Administrative Code