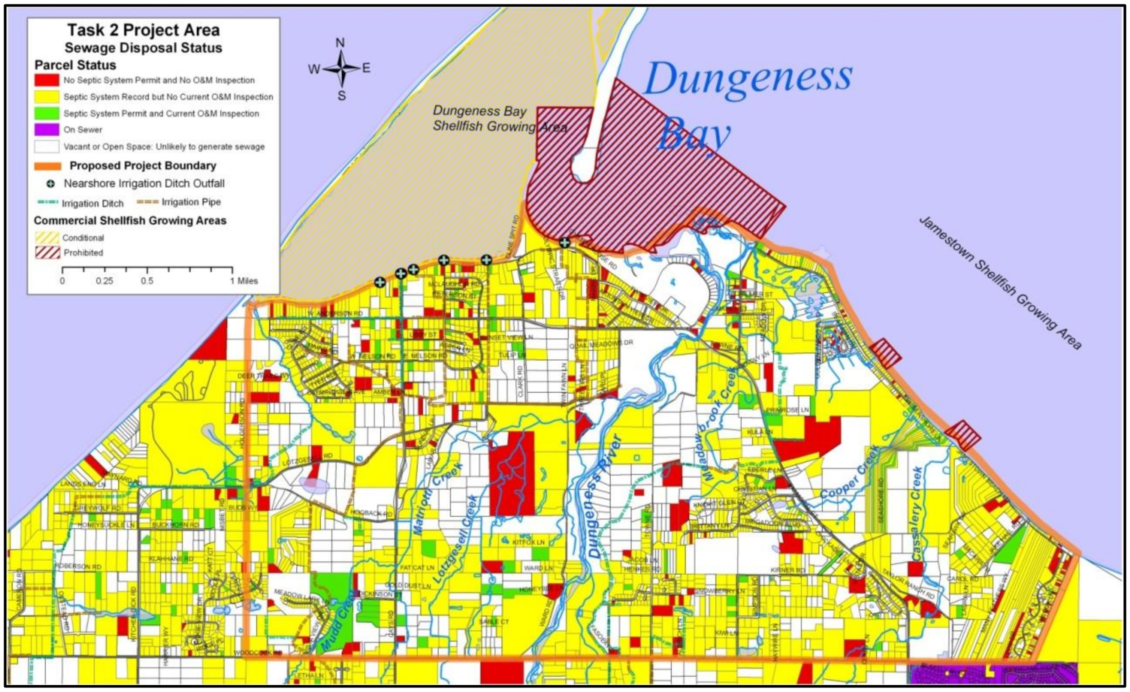

Quality Assurance Project Plan

Clallam Marine Recovery Area (MRA) Septic Solutions

Task 2, Targeted Survey Septics of Concern
Subtask 2E, Water Quality Monitoring

G1100174

April 19, 2013

Prepared by:
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Environmental Health Section

With assistance from:
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Publication Information

Recipients of funding from Washington State Department of Ecology (Ecology) used for water quality monitoring are required to follow an approved Quality Assurance Project Plan. The Plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, recipients submit water quality data to Ecology's Environmental Information Management (EIM) system. Data is then available to the public online at http://www.ecy.wa.gov/eim.

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Quality Assurance Project Plan

Clallam Marine Recovery Area (MRA)

Septic Solutions

G1100174

Task 2, Targeted Survey Septics of Concern
Subtask 2E, Water Quality Monitoring

April 2013

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2.0 Abstract

This monitoring project has two objectives, to (A) assess the current status of fecal coliform and nutrient concentrations in the lower Dungeness River and several area streams through ambient monitoring, and (B) study the potential effectiveness of septic system repair in improving surface water quality in an adjacent stream. The study area is the lower portion of the Dungeness watershed, within the Marine Recovery Area designated by Clallam County in 2007 and within a shellfish protection district formed after the downgrade of commercial growing areas in Dungeness Bay in 2000. Clallam County Environmental Health is the lead agency, to be assisted by staff and volunteers from Streamkeepers of Clallam County and the Jamestown S'Klallam Tribe.

3.0 Background

The Dungeness watershed has been the focus of both ground and surface water quality studies for several decades. Background information presented here is excerpted or derived from these reports:

- Dungeness River and Matriotti Creek fecal coliform TMDL (Sargeant 2002).
- Dungeness Bay fecal coliform TMDL (Sargeant 2004).
- An initial shellfish closure response plan, a.k.a, Detailed Implementation Plan, was integrated with Water Cleanup Plans associated with both TMDLs into a "Clean Water Strategy" (Streeter and Hempleman 2004). This Strategy has guided the activities of the Dungeness Clean Water Work Group since it was prepared. Status reports on its implementation are submitted annually by Clallam County to DOH.
- Microbial source tracking found evidence that many animal groups, including humans, contribute to bacterial contamination in Dungeness watershed and Bay (Woodruff et al 2009a).
- Effectiveness monitoring, including monthly sampling at dozens of sites over a two-year period for both fecal coliform and nutrients (Woodruff et al 2009b).
- Ecology conducted a fecal coliform TMDL effectiveness monitoring project (Ecology 2009, 2010).
- Clallam County's groundwater quality monitoring of rural domestic wells showed a prevalence of elevated nitrates in the mid-lower Dungeness watershed, but low levels of nitrates in domestic wells within the lowest portion of the watershed (Soule 2011).

Study area and surroundings

The study area is coincident with the study areas of the TMDLs from 2000-04 and 2009, and monitoring projects of 2005-08 (described further below), but more focused on downstream sites within the Dungeness watershed due to limitations of staff capacity and funding. Key contaminants of concern include fecal coliform bacteria and nutrients. Figure 1 shows the study area and planned monitoring sites.

Dungeness Bay is located in Clallam County near Sequim, Washington, on the northeast coast of the Olympic Peninsula. The outer edge of Dungeness Bay is defined by Dungeness Spit, extending in a narrow five-and-a-half-mile curve into the Straits of Juan de Fuca. Inner Dungeness Bay is divided from the outer bay by Graveyard Spit (which extends south from Dungeness Spit) and Cline Spit (which extends north from the mainland). A relatively narrow opening between these two spits allows tidal waters to flow between inner and outer Dungeness Bay. (Streeter and Hempleman, 2004)

The Bay has traditionally been rich in littleneck clams. Native people have harvested shellfish here throughout tribal memory. In the 1900s, the Bay was a profitable source of commercial farmed oyster harvest which provided local jobs. Recreational harvest has been popular with residents and tourists, and contributes to the image of the Dungeness as a beautiful and pristine area. (Streeter and Hempleman, 2004)

Land uses in the lower Dungeness valley include commercial, residential, and agricultural. Sequim has become increasingly urbanized in recent decades, and residential land use is becoming more predominant. The city of Sequim is on a sewer system while residential and commercial businesses in the rural area use on-site septic systems (OSS).

OSS failures can contribute to the elevated fecal coliform levels in freshwater tributaries to the Bay and the Bay itself. Citizen education, regular OSS inspections, and system repairs continue to reduce these nonpoint sources. Recently, the Clallam County Department of Community Development and the Environmental Health Division (Clallam County), and the Jamestown S'Klallam Tribe (JSKT) decommissioned eight on-site systems from the mouth to river mile 1.0 for river restoration purposes.

The climate in this region of the Olympic Peninsula is drier because it lies in the rain shadow of the Olympic Mountains. Precipitation varies from 15 inches near Sequim to 80 inches in the headwaters of the Dungeness River. Due to the low rainfall, the lower Dungeness valley contains around 100 miles of irrigation water conveyance to support appx. 11,000 acres in agricultural production. Like small streams, this network of irrigation ditches is another conduit for fecal coliform to enter Dungeness Bay and its tributaries. Agricultural best management practice implementation and technical assistance from Clallam Conservation District have reduced fecal coliform inputs to the irrigation system.

Recent projects conducted by the Clallam Conservation District and the Sequim-Dungeness Water Users Association have replaced many open irrigation ditches with buried pipelines, often capping the end of the pipelines to eliminate irrigation water discharges to the Bay and its tributaries. These projects reduce the amount of water diverted from the Dungeness River, help prevent pollutants from entering the irrigation system, and when totally enclosed, eliminate tailwater discharges at the end of the system.

Major tributaries to Dungeness Bay

The Dungeness River flows north into the outer Dungeness Bay just east of the opening between Graveyard and Cline Spits. The river is 32 miles long and drains 172,517 acres. The upper two-thirds of the watershed are within national forest and national park areas. The river contributes the vast majority of freshwater to the Bay.

Several tributaries that enter the Dungeness River, or directly into the Bay; most are included in this study:

- Matriotti Creek is 9.3 miles long and flows into the Dungeness River on the left bank at RM 1.9.
- Hurd Creek is approximately one mile long and flows into the Dungeness River on the right bank at RM 2.7 (not included in this study).
- Meadowbrook Creek flows north into the Bay 0.4 miles east of the Dungeness River mouth. Meadowbrook Slough is approximately 0.5 miles long and flows into Meadowbrook Creek just before the creek enters the bay. In recent history,

Meadowbrook Creek and Slough merged with the lowest reach of the Dungeness River flowing north; however, for several years the River has been discharging on the west side of its delta and Meadowbrook has discharged directly to the Bay.

- Golden Sands Slough discharges into outer Dungeness Bay southeast of Meadowbrook Creek. The slough is a series of constructed channels in an estuarine wetland area. Water in the slough tends to be saline and stagnate (Sargeant, 2002).
- Cooper Creek discharges into Dungeness Bay just southeast of Golden Sands Slough. The creek is fed by wetlands, and the upland area is undeveloped. The lower portion of the stream channel has been straightened, and the mouth is controlled by a tide gate.
- Cassalery Creek is approximately 4.2 miles long and discharges to Dungeness Bay southeast of Cooper Creek.
- One ditch located toward the base of Dungeness Spit sometimes discharges to inner Dungeness Bay. Road-side ditches act as stormwater conveyance and may also be used for occasional flushing of irrigation pipelines under the control of the Cline Irrigation District. (These conveyances are not included in this study.)

Impairment determinations – Fecal coliform bacteria

Fecal coliform (FC) concentrations in Matriotti Creek were found to exceed water quality standards in 1991. Matriotti Creek was placed on Washington’s 303(d) list of impaired waters in 1996. Dungeness Bay continued to meet water quality standards through 1996.

In 1997, the Washington State Department of Health (DOH) reported increasing levels of FC bacteria in Dungeness Bay near the mouth of the Dungeness River. Bacteria levels continued to increase in later monitoring activities with higher levels of bacteria occurring in inner Dungeness Bay. As a result, DOH closed 300 acres in 2000 near the mouth of the Dungeness River to shellfish harvest. In 2001, 100 more acres were added to the closure area.

Since 2003, DOH has gradually upgraded the classification of several stations in Dungeness Bay from “prohibited” to "conditionally approved," meaning that shellfish harvest is open from February through October but closed in the rainy season—from November through January. Four sites, near or relatively close to the mouth of the River, remain closed year round. (DOH 2012)

Total Maximum Daily Load (TMDL) studies

TMDL studies were conducted for both the lower Dungeness River watershed (Sargeant, 2002) and Dungeness Bay (Sargeant, 2004b). The main objective for both studies was to recommend sufficient targets and load reductions for FC bacteria. This was done by estimating pollutant loads and concentrations for tributaries to the bay, modeling an acceptable loading capacity, and recommending load allocations.

The *Dungeness River and Matriotti Creek Fecal Coliform Bacteria Total Maximum Daily Load Study* (Sargeant, 2002) measured FC concentrations in several freshwater tributaries to Dungeness Bay from 1999-2000. The purpose of the study was to determine the freshwater sources contributing high FC levels to the bay. The study area included the lower Dungeness

River, Hurd Creek, Matriotti Creek, Meadowbrook Creek, and Meadowbrook Slough. The results of the study set target reductions for FC concentrations in these and other tributaries to the bay.

Rensel Associates conducted bacteria sampling in Dungeness Bay and ditches discharging into Dungeness Bay from October 2001 to 2002. A circulation and bathymetry study was also conducted and resulted in a final technical report in April 2003 (Rensel, 2003). The Rensel study was summarized and used as the basis for the *Dungeness Bay Fecal Coliform Bacteria Total Maximum Daily Load Study* (Sargeant, 2004a). The TMDL addressed FC bacteria in inner and outer Dungeness Bay, irrigation ditches to the inner Dungeness Bay, and the Dungeness River. Target reductions for FC concentrations were set for the Dungeness River and irrigation ditches discharging to inner Dungeness Bay.

TMDL study findings include:

- More stringent load reductions are needed in several upstream tributaries to meet the marine FC criterion at the Dungeness River, including the Dungeness River (mouth to RM 0.3), Matriotti Creek, Hurd Creek, Meadowbrook Creek, Meadowbrook Slough, Golden Sands Slough, and Cooper Creek.
- There are no permitted point source discharges in the study area.
- Elevated FC levels are found in several freshwater tributaries flowing into the bay.
- FC pollution is attributed to nonpoint sources, including on-site septic systems, pet and livestock waste, stormwater runoff, and wildlife.
- The critical period for inner Dungeness Bay is November through February, and the critical period for the outer Dungeness Bay near the mouth of Dungeness River is March through July.

Post-TMDL data collection and analysis

Clallam County and the Jamestown S'Klallam Tribe conducted FC sampling at many of the freshwater TMDL target sites from 2001 to 2004. These data, and data collected by Ecology's ambient monitoring program, were compared to the initial TMDL FC data collected in 1999 and 2000. The results of this analysis were presented in the *Dungeness River and Matriotti Creek Post-Total Maximum Daily Load Data Review* (Sargeant, 2004b).

The purpose of the 2004 post-TMDL analysis was to determine whether FC bacteria levels were improving in the tributaries to the bay and if the cleanup actions implemented had been effective. The analysis found significant improvement in some areas and seasons. The 2001- 2004 data showed that further reductions are necessary even though the trend during certain critical seasons was showing a decrease in FC concentrations. The Matriotti Creek sites showed the greatest decline and may have contributed to a slight decline in FC concentrations in the Dungeness River. Meadowbrook Creek showed a slight increase in FC concentrations (Sargeant, 2004a).

Recent FC data collection

Clallam County received a Centennial Clean Water Fund grant from Ecology in 2005. The Jamestown S'Klallam Tribe received an EPA Targeted Watershed Grant (TWG) in 2005. Portions of both grant funds were for FC monitoring in the Dungeness watershed (Streeter, 2005).

Clallam County and the Tribe combined efforts to monitor 58 sites monthly in the Dungeness watershed for FC in 2005-08. Some of these sites were selected to fill gaps in ambient water quality information. Many of the TMDL study sites were also monitored to continue evaluating the effectiveness of TMDL implementation. Twenty-two of these sites were sampled monthly from September 2005 to August 2008. Irrigation ditches included in the *Dungeness Bay TMDL* study were also sampled when water was flowing at the site. Seven of 12 TMDL target sites were monitored consistently between 1999 and 2009 (and are included in this study as well).

Extensive FC data sets resulting from this monitoring have been analyzed and reported in publications by Battelle (2009b) and Ecology (2010). Both reports present multiple diagrams and illustrations of trends by parameter and sub-area; the reader is referred to the online reports to view specific figures of interest:

- Battelle 2009b: "Effectiveness Monitoring of Fecal Coliform Bacteria and Nutrients in the Dungeness Watershed, Washington;" www.jamestowntribe.org/jstweb_2007/programs/nrs/FINAL_EM_RPT(Oct_09)v_2.pdf

- Ecology 2010: "Dungeness Bay and Dungeness River Watershed Fecal Coliform Bacteria Total Maximum Daily Load Water Quality Effectiveness Monitoring Report;" http://www.ecy.wa.gov/pubs/1003032.pdf

DOH continues to conduct monthly sampling in Dungeness Bay to monitor FC pollution in shellfish growing areas as part of the National Shellfish Sanitation Program (DOH, 2009). Thirteen DOH sites in the inner and outer Dungeness Bay area are still sampled monthly (Figure 2). Analyses of these data were used in Ecology's effectiveness monitoring report (Ecology, 2010) to determine whether marine surface water quality standards were being met annually; during wet and dry seasons; and to evaluate FC concentration trends since the *Dungeness Bay TMDL* study.

Analyses of DOH data found evidence of a reduction in FC pollution from 2003-2011 (DOH, 2012). This trend in pollutant reduction was found in 12 of 13 sites in the Dungeness shellfish growing area. Site 111 was the only site that did not show a significant reduction in FC concentration. Although the general trend for all sites indicates a significant decline in marine FC concentrations since 2005, and all stations technically meet the NSSP standards, some areas are "Conditionally Approved" (closed Nov–Feb) rather than "Approved" because water quality in general is consistently poor in winter months. (Shown in Figure 2.)

At the request of the Jamestown S'Klallam Tribe in 2008, DOH reclassified 725 acres of previously unclassified intertidal waters for commercial shellfish harvest (DOH, 2008). The reclassified Jamestown growing area is located southeast of the Dungeness River estuary along the shoreline and includes the DOH sampling sites 193, 182, 102, 101, 100, and 99. DOH sampled four tributaries for FC as part of this survey, including three TMDL target sites: Meadowbrook Creek, Golden Sands Slough, and Cooper Creek. Cassalery Creek was also sampled during this survey.

DOH shoreline surveys conducted in 2007 and 2008 found elevated FC levels in both Golden Sands Slough and Cassalery Creek. Further evaluation in Golden Sands Slough found problems with on-site septic system and direct sewage discharge to the slough. As a result, DOH prohibited commercial shellfish harvest at a 140-meter radius and 121-meter radius around the mouths of Golden Sands Slough and Cassalery Creek, respectively (shown in Figure 2).

Nutrient data collection and analysis

There are no water quality criteria for nutrients in streams; however, when nutrients are found at high levels, they can have a negative impact on aquatic systems. Anthropogenic alterations within a watershed generally lead to higher nutrient concentrations resulting from both point and non-point sources.

The chemical speciation of nutrients becomes an important factor both for evaluation of ecological impacts and as a tracer of source contaminants. For example, Ammonia is generally found in areas with low oxygen availability (i.e. groundwater) and is rapidly oxidized to nitrate in contact with surface waters. Its presence in surface waters, even at low levels, could indicate close proximity to potential sources such as septic systems or agricultural runoff.

Targeted Watershed Initiative funding from EPA obtained by the Jamestown S'Klallam Tribe for 2005-08 sampling included collection of nutrient (nitrogen and phosphorus) data from all sites. From these data (over 830 nutrient observations) Battelle (2009b) provided a characterization of nutrients in the watershed including descriptive statistics and general trends. Findings include:

- For a general reference, nutrient data were compared to historic data (nitrate and phosphate) collected at another location in the upper Dungeness River between 1959 and 1970.

- For the most part, recent nutrient levels in the lower Dungeness watershed were not very different than historic values, although a direct site comparison could not be made. There were, however, several trends in the data that warrant further investigation.

- Ammonia concentrations were slightly elevated at all Dungeness tributaries and Bell Creek compared to those detected in the River or Johnson Creek.

    - In addition, ammonia levels were an order of magnitude higher at Golden Sands Slough, another freshwater station close to the Bay.
    - There were minimal seasonal changes noted in ammonia concentrations, another possible indication of septic system influence since septic system input generally

varies less by season than other anthropogenic nutrient sources incorporated into seasonal runoff.

- Total inorganic nitrogen (TIN) was higher in Matriotti Creek, Bell Creek, Golden Sands Slough and the irrigation ditches compared to other water bodies and stations.
  - TIN is an indicator of a number of possible anthropogenic inputs.
  - Overall, the TIN data was higher during the wet season compared to the dry season, a possible indication of anthropogenic runoff.

- PO4 and TP concentrations showed a similar trend of elevated concentrations in Bell Creek, Golden Sands Slough and the irrigation ditches, with higher concentrations during the wet seasons compared to the dry season.

- There was no significant correlation between nutrients (NH4, NO3, NO2, TIN, TN, PO4, and TP), freshwater FC concentrations, and daily rainfall determined for the days of sample collection. The lack of a statistically significant correlation may be indicative of varying sources of FC and nutrients; however analysis of rainfall patterns over a longer duration might demonstrate a correlation.

Logistical Considerations

For the current project, sampling sites are relatively near each other in the lower watershed, and located at bridge crossings or adjacent roadways. Permissions from land owners are required for some sites and will be obtained for the full year prior to the first field visit.

Both analytical laboratories will be notified of the sampling schedule and ship/delivery dates. No logistical problems are anticipated.

A reconnaissance survey was conducted on April 11, 2013, to verify accessibility of sampling sites and availability of staff gages. Sampling methods were reviewed and practiced by potential field team leaders.

4.0 Project Description

In 2010, Clallam County Environmental Health (CCEH) obtained a Centennial Clean Water grant to address degraded water quality in the lowest and most sensitive parts of the Dungeness watershed, with a focus on potential contamination from onsite septic systems (OSS) and improving the rate of OSS inspections (see cover illustration). The area is within a designated Marine Recovery Area where shellfishing is closed in some parts due to seasonal or year-round bacterial problems. Two fecal coliform TMDLs have been completed as discussed in the Background section, above. A microbial tracking study showed that human waste is partly responsible for the bacterial contamination in Dungeness Bay.

Additional concerns for the project area include increasing ulvoid mats in the nearshore, and increasing numbers of known OSS problems requiring expensive repairs or replacement due to unsuitable soils.

The CCEH Centennial grant, "Septic Solutions in the Clallam County Marine Recovery Area," involves multiple activities and is identifying OSS pollution problems and working to have them fixed through:

- Field surveys investigating all septic systems without a permit record,
- outreach and technical assistance,
- improving compliance with new enforcement tools,
- water quality monitoring, and
- determining the feasibility of replacing individual systems in problematic soils with clustered larger OSS or a community sewer system.

Project goals

It is the long-term goal of the grant project to improve water quality in Dungeness Bay and lower watershed streams, resulting in re-opening of closed shellfish beds by DOH, achievement of TMDL targets tracked by Ecology, and improved salmon habitat in the nearshore.

Target population

The "population" of surface water streams is what will be sampled with this project. Specifically, streams in the lower Dungeness watershed subject to TMDLs for fecal coliform as well as streams potentially impacted by adjacent failing (and subsequently repaired) onsite septic systems.

Project objectives

The objectives of Subtask 2E are to conduct:

A. Ambient monitoring: Update the water quality status with regard to fecal coliform bacteria as well as nutrients for freshwater stream sites in the lower Dungeness watershed, many of which were used in TMDL studies over the past 14 years.
B. Event-specific monitoring: Document stream water quality before and after septic system repair. (Note that this objective depends on the availability of cases where a septic system repair is adjacent to a study-area stream, and that up- and down-stream sampling is possible. The CCEH database shows 5-15 repair cases per year in the Dungeness watershed; a fraction of this number is likely adjacent to a stream. In order to statistically indicate improvement we would ideally have 10 cases, or repair events.)

Information needed and sources

In addition to the written resources available and listed in prior sections, this monitoring effort will depend on collaboration by members of the Clean Water District Work Group (CWWG) as described in the activities listed above. Current CCEH staff is less familiar as other partners are with the long-term monitoring strategy for the District. At regular CWWG meetings we solicited input on sampling site priorities in the watershed, the coordination of field efforts, equipment calibration, and other activities. Specifically, Clallam County Environmental Health has enlisted the assistance of:

- Streamkeepers of Clallam County (coordinator paid by the County Public Works Department; volunteers)
- Jamestown S'Klallam Tribe natural resources staff (salaried)

Study boundaries

The study area is the same as that for the TMDLs from 2000-04 and monitoring projects of 2005-08 (described in the previous section) but somewhat more focused on downstream sites due to limitations of staff capacity and funding. See Figure 1.

Tasks required

The monitoring project will include these general activities:

- collecting samples for bacteria and nutrients.
- identifying streams adjacent to failing or poorly maintained OSS for before and after sampling.
- compiling results, assessing data and conducting preliminary analysis.
- submitting data to Ecology's EIM system.

Specific activities include (excerpted from grant contract G1100174):

- Working with the Dungeness Clean Water Workgroup to re-assess and adapt (if needed) the long-term water quality monitoring strategy for the Sequim-Dungeness Clean Water District/MRA (Streeter 2005) based on the findings of Ecology's TMDL effectiveness monitoring and other studies (and supplemental data analysis, if warranted).
- Collecting at least one year of monitoring data in accordance with the long-term sampling strategy (i.e., monthly fecal coliform and nutrient sampling at ten stations on TMDL and 303-d listed streams for one year, with flow monitoring at select stations).
- Event-specific monitoring of bacteria and nutrients above and below failing or poorly maintained OSS which are potentially impacting surface waters, before and after the septic repair or replacement (to document any resulting water quality improvements).
- Managing all monitoring data collected or acquired under this agreement in order to be available to secondary users and meet the "ten-year rule." The ten-year rule means that data documentation is sufficient to allow an individual not directly familiar with the specific monitoring effort to understand the purpose of the data set, methods used, results obtained, and quality assurance measures taken ten years after data are collected.
- Submitting all data to Ecology through the Environmental Information Management System (EIM). Data must be submitted by following instructions on the EIM website, currently available at www.ecy.wa.gov/eim.

Practical constraints

All streams in this study are small ("high" flow <100 cfs) except for the Dungeness River; attempts to measure flow in the River will be limited to field visits when the flow according to Ecology's gage is <300 cfs.

Constraints on the accessibility of any monitoring site were determined during a reconnaissance field day scheduled for April 11, 2013.

Field days will preferably be Tuesdays or Wednesdays, due to the need to calibrate Hydrolabs before and after field events, and also to be sure we can submit FC samples to the CCEH Lab before 3pm Thursday (for analysis by EOB Friday).

Systematic planning process used

The County's grant contract indicates that CCEH will "work with the Dungeness Clean Water Workgroup to re-assess and adapt the long-term water quality monitoring strategy for the Sequim-Dungeness Clean Water District/MRA based on the findings of Ecology's TMDL effectiveness monitoring and other studies, and supplemental data analysis, if warranted." A systematic and thorough re-assessment was not completed by CCEH; however, input from members of the Clean Water District Work Group (CWWG) – which includes the authors and/or project participants/ assistants of subject studies – was instrumental.

The CWWG meets quarterly to consider implementation of the Water Cleanup Plan prepared after the Dungeness Bay shellfishing classification was downgraded in 2000. Members are knowledgeable of historic water quality conditions and informed of new data whenever monitoring projects are conducted in the watershed. The preparation of this QAPP would have been impossible without discussions at CWWG meetings and with individual members regarding site priorities, sampling methods, and availability of field assistants.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities (project team, decision-makers, stakeholders, lab, etc.)

Clallam County Environmental Health (CCEH) is the grant recipient and lead agency responsible for QAPP preparation and supervision of all monitoring activities including data submittal to EIM. Lead staff is Ann Soule, assisted by Sue Waldrip and possibly Adar Feller.

Assisting CCEH with project planning and/or in the field is:

- Staff from the Jamestown S'Klallam Tribe natural resources department (Lori DeLorm and Chris Burns)
- Staff from Streamkeepers of Clallam County (Ed Chadd)

- Streamkeeper volunteers (one to four)

There will be two field crews on each sampling day, each with a Hydrolab water quality sonde and Marsh-McBirney flow meter; potential team leaders include Ann Soule, Ed Chadd, Sue Waldrip, and Lori DeLorm. Hydrolab calibration will be conducted before and after a sampling day (within 24 hours) by their respective owners (County and Tribe).

CCEH must use environmental laboratories accredited by Ecology to analyze water samples for all parameters that require bench testing. We intend to use:

- UW Marine Chemistry Lab for nutrient samples (Katherine Krogslund, manager)
- CCEH Water Laboratory for FC samples (Belinda Pero, manager)

Staff from CCEH or Streamkeepers will be responsible for shipment of nutrient samples to UW and delivery of FC samples to the CCEH lab.

A report of the monitoring results is not listed as a deliverable for this grant; however, CCEH staff will summarize the work in the final grant project report—an essential deliverable for grant closure.

5.2 Organization chart

N/A

5.3 Project schedule

The original required performance from the grant contract follows, with strike-thru adjustments to the schedule reflecting lack of staff capacity until winter 2013:

1. Submit a Quality Assurance Project Plan to the DEPARTMENT by ~~December 31, 2011~~ March 29, 2013.
2. Water samples collected and analyzed for bacteria and nutrients by ~~June 30, 2013~~ March 7, 2014.
3. Water data submitted to the DEPARTMENT'S EIM system by ~~September 30, 2013~~ March 25, 2014.

A tentative sampling schedule follows:

2013	April	23 – Tues.	2013	October	29 – Tues.
	May	21 – Tues.		November	13 – Wed.
	June	4 – Tues.		December	3 – Tues.
	July	24 – Wed.	2014	January	14 – Tues.
	August	13 – Tues.		February	12 – Wed.
	September	10 – Tues.		March	4 – Tues.

5.4 Limitations on schedule

The primary limitation is whether monthly sampling for one year can be completed and data can be entered and submitted to EIM (and reported) before the grant expires on March 31, 2014. Field personnel have been identified and equipment is available.

Also, field days are limited by the need to submit FC samples to the CCEH Lab by 3pm Thursday, and also by the need to calibrate the day before and after a field day. County furloughs for 2014, if any, are not yet scheduled but could impact tentatively chosen field days for 2014.

5.5 Budget and funding

The source of funding for this project is a Centennial Clean Water Fund grant from Ecology, G1100174. The grant project budget follows:

Clallam Marine Recovery Area Septic Solutions		
TASKS	TOTAL PROJECT COST	TOTAL ELIGIBLE COST (TEC)
1 – Project Administration/Management	$15,750	$15,750
2 – Targeted Survey of Septics of Concern	$148,748	$148,748
3 – Enforcement Effectiveness	$30,000	$30,000
4 – Assessment of Alternative Wastewater Solutions in Dungeness	$105,500	$105,500
Total	$299,998	$299,998
The DEPARTMENT's Fiscal Office will track to the Total Eligible Cost.		
MATCHING REQUIREMENTS		
DEPARTMENT Share: 75% of TEC		$224,999
RECIPIENT Share: 25% of TEC		$74,999

The budget developed for planning Task 2E, Monitoring, follows:

Task 2, Subtask E - Water quality monitoring	
STAFF	
QAPP development	2,625
Event-specific sampling	8,400
Ambient monitoring	3,360
Data management	1,800
Indirect	4,046
LAB EXPENSES	
Event-specific lab tests - FC	3,220
Event-specific lab tests - nutrients	1,890
Event-specific lab tests - total N & P	1,750
ambient lab tests - FC	5,750
ambient lab tests - nutrients	3,375
ambient lab tests - total N & P	3,125
contingency on lab fees	1,582
SUPPLIES	
Office supplies incl. shipping	100
Travel	1,500
Equipment maintenance (Marsh-McBirney)	750
TOTAL	43,273

6.0 Quality Objectives

Field sampling procedures and laboratory analyses inherently have associated error. Measurement quality objectives state the allowable error for a project. Precision and bias provide measures of data quality and are used to assess agreement with measurement quality objectives.

Table 6.1 outlines field and analytical methods, expected precision for replicates, method detection limits and/or resolution, and the expected range of results. The targets for precision of replicates are based on historical performance by each laboratory.

Table 6.1. Measurement Quality Objectives (MQOs)

Parameter	Bias	Precision – Field Duplicates	Precision – Lab Duplicates	Sensitivity	Expected Range of Results
	Deviation from true value	Median RSD (all replicates)	Relative Percent Difference (RPD)	Method Detection Limit (MDL), (and upper end of range for field methods)	Units of Concentration
FIELD MEASUREMENTS					
Water Temperature	(see text)	0.2 C[2]	n/a	-5 – 50 C	0 – 30 C
Specific Conductance		5% RSD	n/a	0 – 100,000 uS/cm	20 – 200 uS/cm
pH		0.20 s.u. [2]	n/a	0 – 14 s.u.	3 – 8 s.u.
Dissolved Oxygen		5% RSD	n/a	0 – 50 mg/L	0.1 – 20 mg/L
Salinity		5% RSD	n/a	0 – 70 PSS	0 – 35 PSS
Streamflow		10% RSD	n/a	0.01 cfs	0.01 – 400 cfs
LABORATORY ANALYSES					
Fecal coliform	10%	See note 1[3]	40%	1 cfu/100 mL	<1 – 2000 cfu/100 mL
NO3	15%	10% RSD[3]	20%	0.08 uM	0–15 mg/L
NO2	20%	10% RSD[3]	20%	0.01 uM	0 – 1 mg/L
NH4 and NH3	20%	10% RSD[3]	20%	0.07 uM	0 – 1 mg/L
PO4 and OP	20%	10% RSD[3]	20%	0.03 uM	0 – 1 mg/L
SiOH4	15%	10% RSD[3]	20%	0.76 uM	0–50 mg/L
Total N	10%	10% RSD[3]	20%	1.08 uM	0.005 – 15 mg/L
Total P	10%	10% RSD[3]	20%	0.04 uM	0.005 – 3 mg/L

1. 50% of duplicate pairs <20% RSD; 90% of duplicate pairs <50% RSD.
2. Median absolute difference for all duplicate measurement pairs.
3. For nutrients, duplicate pairs less than 5x the reporting limit are excluded from median calculation. For bacteria, duplicate pairs less than 20 cfu/100mL are excluded. (Mathieu, 2006)

For nutrients, field duplicates and blanks will be shipped and analyzed in the same batch as regular samples. Lab duplicates (if done) will be charged the same as samples. Check samples are run with every run / data set. (UW Labs, 2013)

6.2.1.1 Precision

Precision is a measure of the variability in the results of replicate measurements due to random error. Random error is imparted by the variation in concentrations of samples from the environment as well as other introduced sources of variation, e.g., field and laboratory procedures. Precision for replicates will be expressed as percent relative standard deviation (%RSD) and assessed following the MQOs outlined in Table 6.1. At least two replicate samples will be collected for each sampling event, and at least one duplicate measurement will be made for field measurements.

6.2.1.2 Bias

Bias is a measure of the systematic error (difference) between the population mean (or an estimated value) and true value of the parameter being measured. Field and laboratory QC procedures, such as blanks, check standards, and spiked samples, provide a measure of any bias affecting measurement procedures. Bias from the true value is very difficult to determine for the set of parameters measured in this project; however, staff will minimize bias in field measurements and samples by strictly following measurement, sampling, and handling protocols.

Project staff will assess bias in field samples by submitting field blanks. Field staff will prepare blanks in the field by filling the bottles directly with deionized water, and handling and transporting the samples to the labs in the same manner that the rest of the samples are processed.

For field measurements, project staff will minimize bias by calibrating and/or checking equipment using NIST-traceable standards before and after each run. More detailed information is found in Section 10 on Quality Control Procedures. Staff will assess any potential bias from instrument drift in probe measurements using criteria expressed in Table 10.2.

6.2.2 Targets developed for:

6.2.2.1 Comparability

It is important for results from this project to be comparable to results generated by previous projects in the Dungeness watershed. To help ensure comparability, standardized sampling techniques and methods, and analysis and data reduction, are being used. In addition, laboratories for analysis were chosen to be consistent with those used for the EPA Targeted Watershed Grant monitoring (Streeter 2005; Woodruff et al 2009b). The same analytical methods are available and will also be used.

6.2.2.2 Representativeness

Sampling will be conducted monthly for one year, ensuring representativeness across the year. For logistical and practical reasons, field work will need to be conducted during the morning and early afternoon time frame on Tuesdays and Wednesdays; however, streamflow status and weather will not deter going into the field.

6.2.2.3 Completeness

A sampling and analysis goal of 90% completeness is set for this project. There are many reasons for missing sampling activities in a monitoring program. These include: (1) inclement weather or flooding, (2) hazardous driving or monitoring conditions, and (3) illness or unavailability of monitoring staff.

Routinely missed sampling events could impart bias in expressions generated from final data. If a sampling event is missed, it will be rescheduled within the same month in order to maintain representativeness. 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.

7.0 Sampling Process Design (Experimental Design)

7.1 Study Design

As mentioned throughout the QAPP, there are two separate elements to the monitoring for this project:

(A) Ambient, and
(B) Event-specific.

Ambient monitoring will commence as soon as possible after QAPP approval and continue once per month for twelve months. Event-specific monitoring will be conducted when failing or other septic systems suspected of impacting surface water are identified, repair is planned, and appropriate sampling locations are determined. The number of septic repair events adjacent to streams with up- and down-stream sampling accessibility can't be predicted.

7.1.1A AMBIENT MONITORING – Sampling location and frequency

Sampling will be monthly for one year at sites listed in Table 7.1 (also see Figure 1). Ten sites constitute the core ambient sites and will be included in any given month's site visits. Six others are optional with high priority, and several others are low priority, to be included depending on availability of resources (field staff as well as budget for lab analyses).

Table 7.1, Ambient sampling sites

Stream site list indicating priority ("Core" and "Optional", etc.) for monthly monitoring, with site notes. Also indicated is whether a staff gage has been present in the past, whether the site was part of the 2009 TMDL study and recommended by Ecology (Ecology, 2010) for future monthly monitoring of fecal coliform, and whether it was part of Streamkeepers quarterly monitoring in 2011.

Site ID	Description	Prior-ity	Gage	TMDL-RM/ID	SK 2011-RM/ID	Notes
Dungeness River						
DUN0.1	Downstream of bridge	OPT		0.1		
DUN0.8	@ ECY flow gage	CORE	Yes	0.8	(0.7?)	
DUN3.0	@ Mary Wheeler Park d/s of Woodcock bridge & ECY DR3.2 site	OPT – High	See notes	3.2		No flow station but statistically same as Dun11.0 (TWG) @ USGS flow station.
Matriotti Creek						
MAT0.1	Near mouth	CORE	Yes	0.1	0.1	
MAT0.3, 0.4, 0.7	Access points between RM 0.1 and 2.0	OPT				May be used for investigative sampling of septic repairs.
MAT2.0 or MAT1.9	@ Cays Rd near Fat Cat Lane	CORE	Yes G5	1.9		Naming and site description issues—need to confirm if u/s or d/s of Mudd Creek
MAT3.2	@ MacLeay Rd	CORE	Yes	3.2	3.2	
MAT3.5, 3.7	Access points at CM 3.5 and 3.7	OPT				Investigative sampling to follow up on TWG-era septic repair in the area; new recent repair nearby
MAT4.8	@ Spath Rd	OPT – High				Good reference site, esp. for nutrient baseline
Hurd Creek						
	(no sites included)	N/A				No history of water quality issues.
Meadowbrook Creek						
MC0.1	@ Three Crabs Rd	CORE	Yes	0.2	0.1	Tidal influence affects flow, document tide and monitor on outgoing when possible
MC2.0	@ Sequim-Dungeness Way	CORE			2	History of problems but recently within limits

Site ID	Description	Prior-ity	Gage	TMDL-RM/ID	SK 2011-RM/ID	Notes
MC3.1	@ headwaters	OPT – High				As funding allows
Golden Sands Slough						
GSS0.0	@ Three Crabs Rd	CORE		GOLD SANDS	0.0	Tidally influenced; document tide and monitor on outgoing when possible
Cooper Creek						
COOP0.1	@ end of Three Crabs Rd	CORE		0.1		Upstream side of road
Cassalery Creek						
CASS0.0	@ mouth	OPT – High				May have to sample d/s of culvert
CASS0.6	@ Jamestown Rd	CORE	Yes	CASSA LERY	0.6	recent septic repair just u/s of site, history of problems
CASS1.6	@ Clary Ln	CORE			1.6	d/s of confluence w/ trib
Bell Creek						
BELL0.16	Old TWG site in cow pasture	OPT				Sample if possible at old location, include nutrients
BELL0.2	@ Schmuck Rd	OPT – High	Yes		0.2	
BELL0.8	@ WSDOT restoration site	OPT	Recon		0.8	Has seasonal spikes possibly tied to irrigation use
BELL4.2	@ Bell Creek Ln	OPT – High	Recon		4.2	Statistically effective as an u/s site because lower d/s sites show occasional spikes
Johnson Creek						
JOHN0.1	@ John Wayne Marina Parking Lot	OPT	Recon		0.0	JSKT to monitor quarterly full suite
JOHN2.0	Reconnaissance	OPT			2.0	JSKT to monitor quarterly full suite
Other						
THORN DIT	Thornton Road ditch at bluff above inner bay	OPT		THORN DIT		Outfall?
BD7	Irrigation ditch upland from bluff	OPT		BD7		

7.1.1B EVENT-SPECIFIC MONITORING – Sampling location and frequency

Sampling locations and timing will be determined when failing septic systems, and repair strategies, are identified. It is hoped that 3-5 events, and up to 10, will be identified and sampled before the grant expiration (10 is the number of events that would allow statistical evaluation of water quality improvement). Generally speaking, upstream/upgradient as well as downstream/downgradient locations relative to an identified failing system will be determined and sampled three times (on different days, but at a consistent time of day—such as 9-10am) prior to system repair and three times after system repair. Sampling will include flow measurement; if there is a significant (>15%) flow change from the initial sampling date, staff will return on a different date to collect samples.

7.1.2 Parameters to be determined

All site visits, whether ambient or event-specific, will include sampling for fecal coliform as well as nutrients, with analysis performed by accredited laboratories listed elsewhere.

7.1.3 Field measurements

All site visits (both ambient and event-specific) will include the following data collected in the field:

- Flow measurement, staff gage reading, or both
- Electronic meter measurements (Hydrolab) for
  - water temperature (degrees C)
  - specific conductivity (mS/cm)
  - dissolved oxygen (mg/L)
  - pH
  - salinity (ppt)
  - turbidity (NTU)

7.2 Maps or diagram

Figure 1 shows all ambient monitoring sites listed in Table 7.1. Event-specific monitoring sites will be determined after an OSS repair is reported and scheduled.

7.3 Assumptions underlying design

The study area has been the target of several water quality investigations in the past two decades, both of surface and ground water. Specific sites were prioritized based on their history of problems, mostly related to fecal coliform. Several upstream (and distant) sites are considered optional for this study due to limitations of funding and staff resources.

In prioritizing study sites it was assumed that sites with no history of fecal coliform issues are unlikely to have major nutrient issues related to human or animal waste.

7.4 Relation to objectives and site characteristics

The study design supports project objectives to obtain baseline conditions for fecal coliform and nutrients in the lowest portion of the Dungeness watershed. Some upgradient sites will be included; others are optional. Several sites on Bell Creek, outside the Dungeness watershed area, are optional as well due to funding limitations and the need to focus on the specific target area for the overall project.

The site locations don't present challenges of access, physical hazards, chemical hazards, or other environmental factors.

7.5 Characteristics of existing data

Existing data is high quality and fairly recent and plentiful for core study sites as well as optional sites. This is thanks to Ecology TMDL studies and efforts of Clean Water District members, especially the Jamestown S'Klallam Tribe and Streamkeepers. This project addresses a needed update of water quality conditions in the lower Dungeness.

8.0 Sampling Procedures

8.1 Field measurement and field sampling SOPs

The following table summarizes methods to be used for the various parameters in this project. Sample container, preparation, and holding times are found as well. Detailed SOPs are found at the citations given below.

Table 8.1. Field and laboratory methods; sample container, preparation, and holding times

Parameter	Field Method	Field Method Citation	Instrument/ Container type	Sample Preparation	Min. Quantity, Holding time (per lab)
FIELD MEASUREMENTS					
Water Temperature	Multimeter: Hydrolab or YSI	Chadd 2013	Thermistor	In situ	
pH	Multimeter: Hydrolab or YSI	Chadd 2013	Gel probe	In situ	
Dissolved Oxygen	Multimeter: Hydrolab or YSI	Chadd 2013	Membrane electrode	In situ	
Specific Conductivity (25°C)	Multimeter: Hydrolab or YSI	Chadd 2013	Electrode	In situ	
Salinity	Multimeter: Hydrolab or YSI	Chadd 2013	Electrode	In situ	
Turbidity	Multimeter (Hydrolab) or Turbidimeter (Hach)	Chadd 2013	Ratio turbidimeter	In situ or if manual grab, 4°C, dark	If grab sample, 100 mL, 48 hr
Streamflow	Wade-across: Marsh-McBirney or Swoffer	Chadd 2013	Electronic current/ depth meter	In situ	
LABORATORY ANALYSES					
[CCEH Lab] Fecal coliform	Manual grab	Chadd 2013	Sterilized poly ≥125 mL	4°C, dark	100 mL, 24 hr
[UW] Nutrients (dissolved): NO_3, NO_2, NH_4, PO_4, $Si(OH)_4$	Manual grab	Joy 2006	60 mL HDPE narrow mouth, acid washed	Surfactant-free cellulose acetate filter, 4°C, dark	40 mL, 48 hr
[UW] Total N and P	Manual grab	Joy 2006	60 mL PP wide mouth, acid washed	4°C, dark	40 mL, 7 days
[MEL] NO_3, NO_2, NH_3 (all dissolved), TPN (Total Persulfate Nitrogen)	Manual grab	Joy 2006	125 mL clear w/m poly bottle	H_2SO_4 to pH<2; 6°C, dark	125 mL, 48 hr
[MEL] TP (Total Phosphorus)	Manual grab	Joy 2006	60 mL clear n/m poly bottle	1:1 HCl to pH<2; 6°C, dark	50 mL, 28 days
[MEL] OP (Orthophosphate) (dissolved)	Manual grab	Joy 2006	125 mL amber w/m poly bottle	0.45 µm filter; 6°C, dark	125 mL, 48 hr

8.2 Measurement and sample collection – narrative

<u>In-Situ Sampling Procedures</u>: A basic schema of sampling and measurement procedures is presented in Section 8.1 above. The cited method sources, hereby incorporated by reference into this document, give full explanations relating to:

- collection of samples and associated field QC samples
- analytical methods for measurements/analyses done in the field as well as the laboratory
- required equipment and in-situ calibration and maintenance procedures
- required content and format of field log entries
- sampling equipment and methods for its preparation and decontamination

8.3 Containers, preservation methods, holding times

See Table 8.1.

8.4 Invasive species evaluation

To avoid cross-contamination of invasive species between sites, samplers will follow the Streamkeepers of Clallam County Anti-Contamination Protocol (Chadd 2013), which is compliant with WA Dept. of Ecology SOPs EAP070 and EAP071.

8.5 Equipment decontamination

This project does not expect to be sampling substances with high levels of contaminants. For the routine sampling being performed here, it is sufficient to rinse sampling equipment (but not sample bottles) with sample water between locations (EPA 2011). Samplers will follow the Streamkeepers of Clallam County Safety SOP (Chadd 2013).

8.6 Sample ID

Bottles will be labeled as follows:

- Fecal coliform: pre-numbered bottles, numbers indicated on log sheet, left column
- Nutrients: bottles will be labeled with station code indicating stream plus stream-miles (e.g., Dun0.8), plus R or B for Replicate or Blank (or a different code if blind QC is necessary).
    - At each site, nutrient samples will be taken separately for dissolved nutrients and for Total N and P.

Each bottle sampled will be entered into the Clallam County Water Resources database with a unique Batch ID, and each result from each Batch will have a unique Result ID.

The following figure shows an example of the log sheet that will be sent to laboratories along with samples:

Clean Water District Monitoring Date: ___/___/___ Weather Observations: ______________________ Tour ID:

Chief sampler (incl initial):______________ Other samplers: ______________________ Tides: High_____ Low____

Hydrolab ID: __________ Flow meter ID: __________ Laboratory(s): ______________________

NOTE: At sites indicated for replicates on the Sampling Plan, take replicates for ALL parameters and fill out a separate row.

Bottle #	Station Name, Code, or Description (If sampling nutrients, use a separate sheet and label bottles per lab instruction; first bottle should be "Temperature Control")	Time (military)	Enter "FR" if a field rep	Wade-across flow? Y/N	Stage gage height (ft)	Samples taken with Hydrolab:						Samples taken with clean "turbidity generic" 100+ mL bottles:	Fecal lab dilution factor	Samples taken with Bacteria 125 mL bottles:	Comments **Stream conditions—turbid? **Problems sampling **Unusual situations *(Continue on back if needed; indicate stream & location.)*
						Wtr Temp °C	Specific Cond. (SpC) mS/cm	Dissolved Oxygen mg/L	pH	Salinity (PSU) ppt	Turbidity NTU	Turbidity NTU (all 3 readings, separated by slashes)		Fecal/ lab rep counts per 100 mL	

Lab samples submitted by (incl. initials): ____________ Date: ______ Time: ______ Rec'd by: ____________ Date: ______ Time: ______

8.7 Chain-of-custody

Each lab will receive a version of the above log sheet, which has a line at the bottom for chain of custody.

8.8 Field log requirements

The field log for this project will consist of the above log sheet containing the primary data, plus the additional log sheets listed below, describing the overall sampling event and calibration/drift check results. Any corrections will use strikeouts and be initialed and dated.

- Episode cover sheet—one per monthly sampling event
  http://www.clallam.net/streamkeepers/assets/applets/EpisodeCover.pdf
- Tour cover sheet—one per sampling team per event
  http://www.clallam.net/streamkeepers/assets/applets/TourCoverGeneric.pdf
- Flow data sheet: page 2 of the following:
  http://www.clallam.net/SK/doc/QtrFldFrmBas.pdf
- Turbidity grab sample form—if samples are processed offsite:
  http://www.clallam.net/SK/doc/TurbGrabs.pdf
- Instrument calibration activity & pre/post checks:
  http://clallam.net/streamkeepers/assets/applets/Hydrolab_Cal_data_sheet.pdf
- DO meter check vs. Winkler titrations:
  http://clallam.net/streamkeepers/assets/applets/DO_Winkler__Lab__datasht.pdf

8.9 Other sampling-related activities

At sites with stream gages, samplers will record stage height simultaneous with discharge measurements. At some point, discharge may be correlated with stage at these sites.

9.0 Measurement Methods

9.1 Lab Measurement Methods

The matrix for all analytes is non-potable water. Analytical methods are summarized in Table 9.1. Fecal coliform analyses will be performed by Clallam County Environmental Health Laboratory (CCEH Lab) in Port Angeles, WA, accreditation # M421-12. Nutrient analyses will be performed by UW School of Oceanography Marine Chemistry Laboratory (UW Lab) in Seattle, WA, accreditation # A521-12; Washington Dept. of Ecology Manchester Environmental Laboratory (MEL) in Port Orchard, WA, accreditation # S750-12a, is a backup lab for nutrient analyses. (Having a backup is necessary because concerns of the County's and UW's legal departments have delayed the establishment of a contract, to date.)

UW Lab analysis for “nutrients” includes Nitrate (NO3), Nitrite (NO2), Ammonia (NH4), Phosphate (PO4), and Silicate (SiOH4); UW Lab analysis for Total N and P are done simultaneously as described in Valderrama 1981. MEL analyzes and bills separately for each ion/analysis, and will analyze for NH3 rather than NH4, and Orthophosphate (OP) rather than Phosphate (PO4).

At least 10 and up to 15 sites will be visited during each sampling event, monthly for one year (tentative schedule listed in section 5.3). Nutrient samples will be shipped to UW Labs or MEL (or both) on the day of sampling. All FC samples will be delivered to the CCEH Lab same day. The total number of samples (each for FC, nutrient, and total N/P) is between 120 and 180, not including QC samples (up to 80 additional) or lab comparison samples.

Table 9.1. Analytical Procedures

Analysis	Method Reference	EPA/Standard method #	NELAC Code	Detection Limits (sensitivity/ MDL)	Expected Range of Results*
Clallam County Environmental Health Water Laboratory					
Fecal coliform		SM 9222 D (m-FC)-97	20210008	1 cfu/100 mL	<1 – 2000 cfu/100 mL
UW Marine Chemistry Laboratory					
NO_3	UNESCO (1994)	EPA 353.4_2_1997	10068209	0.08 uM 0.0058 mg/L	0 – 15 mg/L
NO_2	UNESCO (1994)	EPA 353.4_2_1997	10068209	0.01 uM 0.0001 mg/L	0 – 1 mg/L
NH_4	UNESCO (1994)	EPA 349	WM920220	0.07 uM 0.0051 mg/L	0 – 1 mg/L
PO_4	UNESCO (1994)	EPA 365.5_1.4_1997	WM920270	0.03 uM 0.0001 mg/L	0 – 1 mg/L
$SiOH_4$	UNESCO (1994)	EPA 366	WM920240	0.76 uM 0.0271 mg/L	0 – 50 mg/L
Total N	Valderrama (1981)	SM 4500-P J	WM920270	1.08 uM 0.0078 mg/L	0 – 15 mg/L
Total P	Valderrama (1981)	SM 4500-P J	WM920270	0.04 uM 0.0014 mg/L	0 – 3 mg/L
Manchester Environmental Laboratory					
NO_3		SM4500NO3I	20118552	0.003ug/L	0 – 15 mg/L
NO_2		SM4500NO3I	20118552	0.003ug/L	0 – 1 mg/L
NH_3		SM4500NH3H	20112203	0.002ug/L	0 – 1 mg/L
PO_4 (OP)		SM 4500-PG	20125137	0.0006ug/L	0 – 1 mg/L
Total N (TPN)		SM 4500-NB	WM901050	0.005ug/L	0 – 15 mg/L
Total P		SM 4500-PH	20125013	0.002ug/L	0 – 3 mg/L

*Note that UW Lab will report in micrograms/Liter (ug/L)

9.2 Sample preparation method

See Table 8.1.

9.2 Field Measurement Methods

Instruments and methods to be used for field work are described in Section 8.1 above. Instruments will be calibrated in accordance with manufacturers' instructions.

9.3 Special method requirements

Dissolved nutrient samples will be filtered in situ.

10.0 Quality Control (QC) Procedures

10.1 Table of lab and field QC required

Table 10.1 summarizes basic QC procedures for the field and laboratory. An “event” is a sampling event, normally all the same day, involving 10-15 site visits and collection of one sample per site – plus QC samples. Internal blanks, dupes, and spikes conducted for nutrients by UW and MEL labs will be obtained by CCEH for documentation purposes.

Table 10.1. QC Samples, Types, and Frequency

<table>
<tr><th rowspan="2">Parameter</th><th colspan="2">FIELD</th><th colspan="4">LABORATORY</th></tr>
<tr><th>Blanks</th><th>Replicates</th><th>Check Stds</th><th>Method Blanks</th><th>Analytical Dupes</th><th>Matrix Spikes</th></tr>
<tr><td>Fecal coliform</td><td rowspan="3">1 per event (min. 5%)</td><td>2 per event (min. 10%)</td><td>None</td><td>2 per </=10 samples</td><td>1 per </= 10 samples</td><td>n/a</td></tr>
<tr><td>Nutrients</td><td rowspan="2">1 per event (min. 5%)</td><td>2 per run</td><td>n/a</td><td>None</td><td>None</td></tr>
<tr><td>Total N & P</td><td>1 per run</td><td>n/a</td><td>None</td><td>None</td></tr>
</table>

10.2 Corrective action processes

UW Lab indicated that analytical QC criteria listed above for nutrients and Total N/P will always be met. Standards and check standards are run at the beginning of each run; if they are not within the QC range then they are discarded and begun again. (UW Labs, 2013)

For CCEH Lab fecal coliform analyses, QC is performed using “Standard Methods 9020B Intralaboratory Quality Control Guidelines.” (Pero, 2013)

10.3 Additional QC notes

Streamkeepers of Clallam County maintains rigorous protocols for all steps in the process of monitoring area streams, from documentation to calibration to SOPs to training. Some details from their protocols may be useful here. (Chadd, 2011)

<u>Training:</u> Streamkeepers offers training to volunteers, based on the procedures in the Volunteer Handbook (Chadd, 2013). Volunteers see the procedures demonstrated and have the opportunity to practice them, under supervision of staff or experienced volunteers. Training participation is recorded in Streamkeepers’ database. New volunteers are then assigned to teams with experienced volunteers guiding them through procedures. Usually several outings are required before new volunteers feel comfortable performing procedures on their own. Only volunteers trained in a given procedure will be allowed to attach their initials to data gathered under that procedure. The Streamkeepers database connects all data with a sampler, whose training history is recorded in a separate table in that database.

Data Qualifiers: To be unqualified (i.e., acceptable without qualification for submission for the State Water Quality Report), data must be gathered in accordance with established monitoring procedures, be fully documented, and pass all QC screens. Data qualified with a flag will use codes established by the WA Dept. of Ecology; the most common flags are:

- **J-variants** (laboratory-data estimate): Apply if laboratory identifies sample as an estimate, or if established QC procedures have not been followed or documented (for example, field duplicates were not taken), or one or more QC screens have not passed (for example, field duplicates were outside precision targets), but project managers believe the data to be reasonably trustworthy for un-official purposes.
- **EST** (field-data estimate): For measurement data; apply if established procedures have not been followed or documented, or one or more QC screens have not passed, but project managers believe the data to be reasonably trustworthy for un-official purposes.
- **REJ** (reject): Apply if established procedures have not been followed and/or documented, or one or more QC screens have not passed, and program managers believe the data to be untrustworthy for any purposes.

Bracketing Qualifiers Based on QC Controls: For each QC control performed, qualifiers indicated by a QC test will be applied to all data governed by that test. In general, instruments will be calibrated (or checked if not able to be calibrated) prior to the sampling session and checked subsequent to the sampling session. Both pre- and post-sampling checks must meet QC criteria in order for data gathered in between to be considered acceptable.

Post-Period Drift Check Is Sufficient: Instrument drift away from accuracy is presumed to progress in a single direction, either above or below the accuracy target. Therefore, in a case where an instrument was checked for accuracy only subsequent to a sampling episode, if the instrument passes its QC post-check, it is presumed that the instrument performed to specifications prior to that check (Katznelson, 2011), so long as no substantive maintenance or replacement of instrument parts was performed in between. This situation is to be avoided, because samplers run the risk of downgrading an entire set of data due to not having checked instrument accuracy at the outset.

Accuracy Tests: Accuracy of water quality measurements is estimated by performance evaluation measurements of the equipment; see Tables 6.1 and 6.2 for criteria.

Precision Tests: Precision of water quality measurements is estimated by analysis of replicate samples taken in the field at one site per team per sampling period. The variation between these sample and replicate values is a measure of variability due to short-term environmental factors, instrument operation, and sampling procedure. See Tables 6.1 and 6.2 for acceptance criteria and control limits based on comparing replicates with their paired samples.

QC qualifiers are then applied to all samples in the grouping covered by that replicate/sample pair—for example, the entire group of samples taken by that team during that sampling period. These qualifiers are only applied if they downgrade already-applied QC qualifiers; for example, if program managers have already applied a “REJ” qualifier to a result, a downgrade value of “J” based on replicate/sample comparison will not change the “REJ” designation for that result.

Table 10.2. Field and Lab Equipment QA/QC Measures

RSD in the table below refers to the relative standard deviation or RSD (also known as the coefficient of variation), which, when n = 2 (as when comparing a sample with a replicate), is defined as follows:

RSD = abs(difference/sum) x sqrt(2), where abs = absolute value and sqrt = square root

Parameter measured	**Office prep (beginning of each sampling period)**	**Mainten-ance measures (office & field)**	**Field prep/ checks**	**Post-sampling accuracy (bias) checks**	**Accuracy qualification per post-check**	**Replicates for precision control**	**Precision qualification (per rep/ sample difference)**
Temperature	2-pt. (~0° & 20°C) check vs. NIST-traceable thermo-meter	Keep sensor clean		2-pt. calibration check vs. NIST-traceable thermo-meter	"J" if >±0.2°C "REJ" if >± 0.5°C	1 replicate per team per sampling period	"J" if >±0.2°C; "REJ" if >± 0.5°C
Dissolved Oxygen	Side-by-side testing vs. replicated Winkler titrations	Membrane & fluid replacement & electrode cleaning as needed	Check/rinse probe; in-situ saturated air calibration near stream temperature , with pressure adjustment; drift check of meter following measurements	Side-by-side testing vs. replicated Winkler titrations	"J" if difference >±0.5 mg/L; "REJ" if difference >±1 mg/L (Meter listed at ±0.3 mg/L & Winkler listed at ±0.2 mg/L (Hallock & Ehinger, 2003)	1 replicate per team per sampling period	"J" if >± 0.3 mg/L; "REJ" if >± 0.55 mg/L
Conductivity	Calibration with NIST-traceable standard	Electrode cleaning solution	Check /rinse electrodes	Post-season check against NIST-traceable standard	"J" if >±10% of standard value; "REJ" if >±15% of standard value	1 replicate per team per sampling period	"J" if RSD >5%; "REJ" if RSD >10%
pH	2-point calibration with NIST-traceable standards	Clean/ replace probe as needed if performance fails		2-point check with NIST-traceable standards	"J" if post-checks bracketing range of field values are >±0.2 pH unit; "REJ" if >±0.5 pH**	1 replicate per team per sampling period	"J" if >±0.2 pH unit; "REJ" if >±0.5 pH unit

Parameter measured	Office prep (beginning of each sampling period)	Mainten-ance measures (office & field)	Field prep/ checks	Post-sampling accuracy (bias) checks	Accuracy qualification per post-check	Replicates for precision control	Precision qualification (per rep/ sample difference)
**If one or more post-check vs. a buffer is outside the acceptable range, values taken with the meter might still be acceptable. For example, if the field reading was 6.8, and the drift checks showed the meter within specs with the 7 buffer but off by 0.3 with the 4 buffer, the calibration curve would be such that the 6.8 reading would be well within the meter's accurate range. Curve calculations from drift readings can determine this issue.							
Turbidity	2-pt. calibration with NIST-traceable standards	Keep sampling well & outsides of vials dry and clean; avoid scratching vials		2-pt. check with NIST-traceable standards	"J" if post-checks bracketing range of field values show difference > both 0.5 and 5% of standard value; "REJ" if difference > both 1.0 and 10% of standard value	1 replicate per team per sampling period	"J" if difference > 1 NTU (the field MDL) and > 5% RSD; "REJ" if difference > 1 NTU (the field MDL) and >10% RSD
Fecal Coliform	Verification of colonies once a month; annual proficiency testing with state	Checks of medium, filters, funnels, thermo-meter, rinse & dilution water	Sterilized bottles, 4 oz. (125 mL) minimum; observe holding specs	Pre- and post-sample blanks; control blanks for 1/10 of samples	Adjust/flag data as needed per blank results	Field and lab replicates for 1/10 of samples	"REJ" if >± 10 and Base 10 log-transformed values >± 0.6 (RSD > 85%)

Special note for QC of Bacterial Laboratory Samples: Both field and lab replicates are taken with approximately 10% of samples. Rather than randomly choosing samples for field and laboratory duplicates, we intend to choose samples likely to have high counts, on the notion that replicated samples with no counts provide little information (Lombard, 2007). If data is qualified by the laboratory or adjusted due to blanks, replicates, spikes, or blind standards, these adjustments are documented along with the data and flagged appropriately. The following acceptance criteria and control limits are based on comparing field and laboratory replicates with their paired samples:

Table 10.3. Streamkeepers QC Measures for Bacterial Samples

Control measure used: variance between sample and field or lab replicate
If absolute difference ≤ 10 or difference between base-10 logs ≤ 0.6 (Relative Standard Deviation ≤ 85%): No qualifier
Otherwise, qualify per the following, using best professional judgment of program manager and laboratory analyst: --Flag that sample as "REJ" (unacceptable); --If other rep/sample pairs from that day's analysis were within tolerance, do not flag the other data, unless there is reason to question the entire batch; --If no other rep/sample pairs in that batch, use best professional judgment of laboratory and monitoring program managers to decide whether to flag other data. --If other rep/sample pairs from that day's analysis exceeded tolerance, consider flagging all the data from that day, or possibly from the team(s) which collected those samples.

Side-by-Side Sampling—External: As possible, Streamkeepers volunteers or staff participate in Ecology's Side-by-Side Sampling program (http://www.ecy.wa.gov/programs/eap/fw_riv/SxSIndex.html), whereby water-quality monitors test water bodies at the same time Ecology tests them as part of their monthly Ambient Monitoring Program. This program affords both parties the opportunity for additional validation of their data.

Other General QC Measures:

- Clear, user-friendly, and detailed instructions for all procedures, minimizing judgment calls
- Equipment checked for damage prior to sampling
- Multiple observers when possible
- Each sampling team has an experienced leader
- Staff review of data, including comparing values year-to-year
- Values compared to external data from other agencies, such as stream gage data

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11.0 Data Management Procedures

11.1 Data recording/reporting requirements

Data collection, quality control, management, and reporting will be coordinated by the Clallam County Streamkeepers program.

Recording Field Data: Field data will be collected on custom-designed data sheets. The primary field data sheet is shown above in Section 8.6, and ancillary data sheets (Episode and Tour cover sheets, flow-data sheet) are on Streamkeepers' website at http://www.clallam.net/SK/monitoringusables.html. Field samplers record and initial data on these sheets. When all data have been collected at a site, the team leader looks over the sheets for completeness, legibility, and obvious errors, and gets further information from team members as appropriate. Any problems with data collection are noted in a "Comments" section of the data sheet. The team leader initials and dates this review, then initials and dates again when turning the sheets in to the office. Then staff initials and dates receipt and QC review of the data. This latter review is a thorough process that includes troubleshooting for decimal and rounding errors, data entered into the wrong field, incomplete data, etc.

Requirements for Laboratory Data Packages: The microbiology and chemical laboratories will report sample results, including field and laboratory replicates, on report forms provided by Streamkeepers or of their own making. They will indicate their QC review and approval of the data presented. Laboratories will not be required to submit internal QA/QC documentation, such as blanks, spikes, and blind standards, used to determine the adequacy of the analytical procedures, providing their procedures met all internal laboratory QA/QC requirements; but they will be required to keep all such internal records for a minimum of five years.

Transferring Data to Electronic Form: Once data sheets have been received and reviewed at the Streamkeepers office, volunteers enter the data into the Clallam County Water Resources (CCWR) database (Microsoft Access software). Detailed procedures are provided to the volunteers, both in written form and in one-on-one training, and staff are available to volunteers as they perform data entry. Volunteers subsequently check the database entries against the field sheets, and then later perform an additional troubleshooting double-check.

Automated Data Checks: Our intention is to program the CCWR database to automatically perform some of the statistical checks described in the "Quality Control" section above, and in some cases to downgrade data automatically as appropriate (leaving a record of the downgrade). In other cases the database will display a message instructing program managers to examine data and apply downgrades as appropriate. These automated routines will ensure compliance with QC procedures. Until this automation takes place, data downgrades are done manually by QC officers.

Final Sign-Off of Data: Once all of the above checks have been performed, Streamkeepers program managers do a final review of data, including examination of outliers, and sign off that the data are ready for publication.

Management and Storage of Database: The CCWR database is managed by the Streamkeepers of Clallam County program, in the Department of Public Works-Roads. It is stored on Clallam County's network drive, which is backed up daily. The database itself is actually two files: CCWR_data consists exclusively of data tables, while CCWR_user comprises data-entry forms, database queries, reports, lookup tables, metadata, and other database objects. This structure provides stable storage for the data.

Retrieval of Data: Data can be retrieved from the CCWR database in a variety of ways. A number of custom-made reports and queries have been designed, which report out virtually all the environmental data in the database. Data can also be retrieved via user queries. A variety of CCWR data is also available on the Streamkeepers website: http://www.clallam.net/SK/studies.html.

11.2 Lab data package requirements

Lab documentation should always include all QC results associated with the data, a case narrative discussing any problems with the analyses, corrective actions taken, changes to the referenced method, and an explanation of data qualifiers.

The Clallam County Environmental Health Laboratory reports results directly on data sheets provided for the project. Outside laboratories will report results and QC information on their standard forms.

11.3 Electronic transfer requirements

All laboratories will be requested to report data and QC information on electronic spreadsheets.

11.4 Acceptance criteria for existing data

Existing data are covered under other Quality Assurance Project Plans and will be submitted to Ecology per these Plans if they have not already been.

11.5 EIM data upload procedures

Data from this project will be uploaded from the Clallam County Water Resources database to Ecology's EIM database after completion of monitoring and data assessment.

12.0 Audits and Reports

12.1 Number, frequency, type, and schedule of audits *and*
12.2 Responsible personnel

The Streamkeepers coordinator will be responsible for day-to-day compliance with this document, including assuring that quality of the data is acceptable and that corrective actions are implemented in a timely manner. QC review and signoff will be conducted after each sampling period.

The project manager will review the data and metadata in consultation with the Streamkeepers coordinator at some point early in the project and at the end of the project, to assure that procedures have been followed as outlined in this document.

Laboratories participate in performance and system audits of their own procedures; these are available on request.

12.3 Frequency and distribution of report *and*
12.4 Responsibility for reports

The Streamkeepers coordinator will upload data to Ecology's EIM database at the end of the project. CCEH will summarize the monitoring and results to include in the final grant report deliverable.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

Field team leaders will verify data before turning in data sheets. The Streamkeepers coordinator will examine the data and metadata for errors or omissions as well as completeness and compliance with QC acceptance criteria, and will apply data qualifiers as needed.

13.2 Lab data verification

Laboratory results are reviewed and verified by qualified and experienced lab staff, with findings documented in a case narrative.

13.3 Validation requirements, if necessary

The complete data package, along with the laboratories' written reports, will be assessed for completeness and reasonableness.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining whether project objectives have been met

The project manager, in consultation with other staff and laboratories working on this project, will comment in the project final report on whether the data are of sufficient quality and quantity to have achieved the project goals.

14.2 Data analysis and presentation methods

Acceptable data will be uploaded to Ecology's EIM database. In the event that grant funding and time are available at the end of sampling, staff or a subcontractor may perform simple analyses to update trends at ambient sites, and/or compare event-specific OSS sites before and after repair. Potentially, we could pool all before/ after pairs together and do a Wilcoxon signed rank or t-test (if distribution is normal) to determine whether OSS repairs resulted in decreased FC in the watershed.

14.3 Treatment of non-detects

Non-detects will be reported at the MDL for the given analyte (see table in Section 9), with the qualifier "U" indicating that the analyte was not detected at or above the reported result.

14.4 Sampling design evaluation *and*
14.5 Documentation of assessment

These will be included in the monitoring summary for inclusion in the final grant project report.

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16.0 Figures

Figure 1: Study area, showing monitoring sites

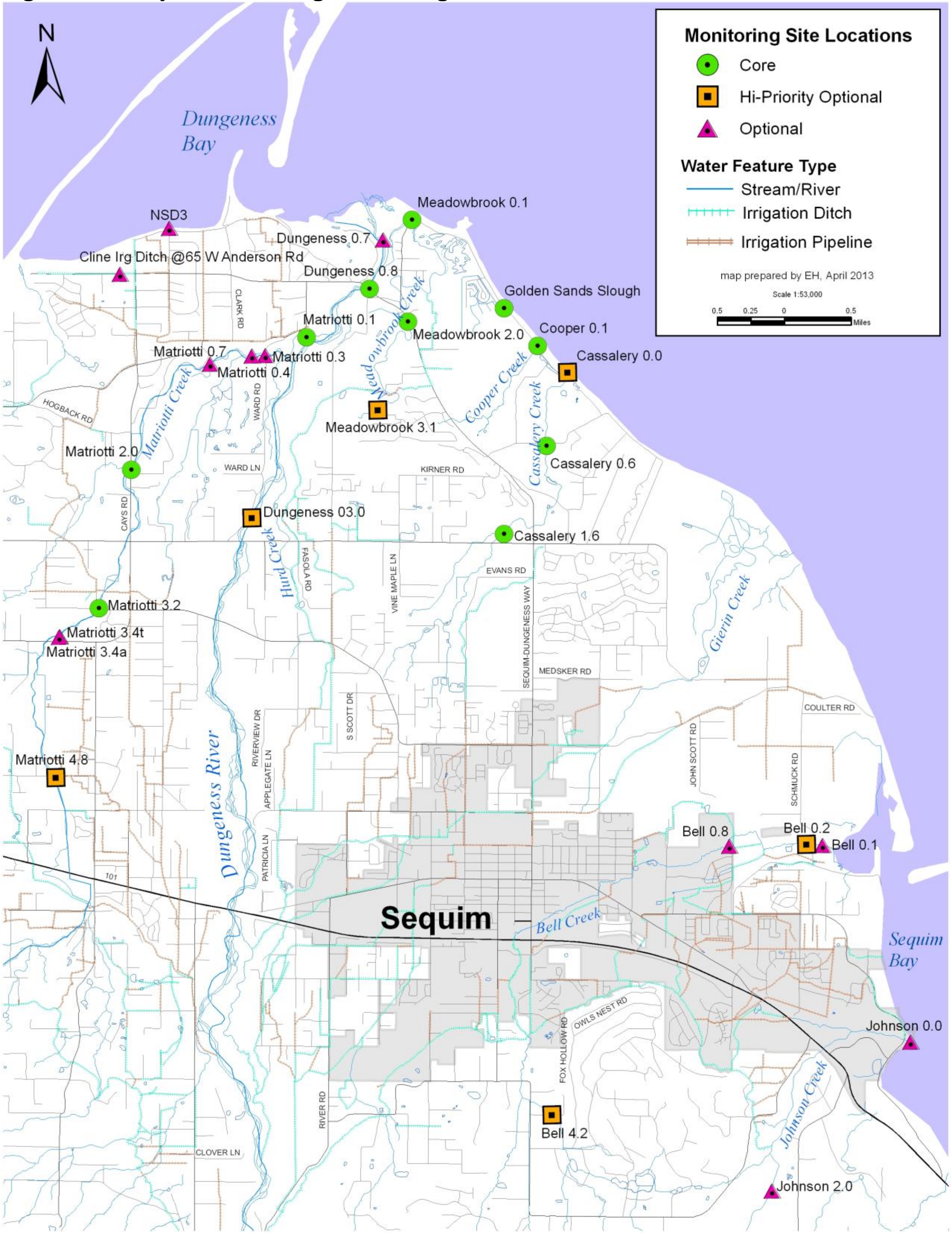
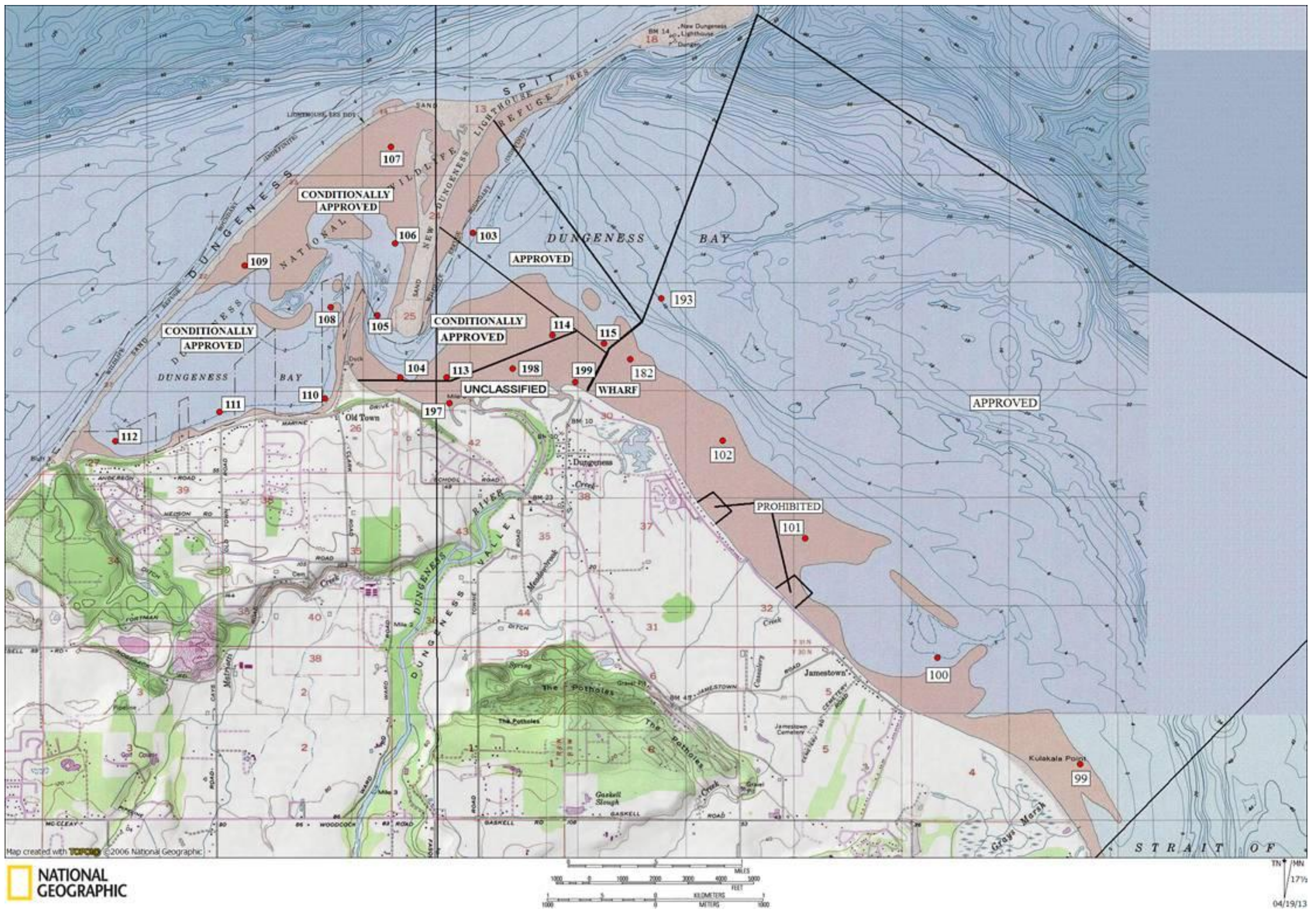


Figure 2: DOH marine monitoring stations in Dungeness Bay and Jamestown growing areas(Schultz, 2013).



17.0 Appendices

Appendix A – Glossary, Acronyms, and Abbreviations

Quality Assurance Glossary

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

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

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

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

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

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

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

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

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

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

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

Dataset - A grouping of samples, usually organized by date, time and/or analyte. (Kammin, 2010)

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

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

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

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

Data verification - Examination of a dataset for errors or omissions, and assessment of the Data Quality Indicators related to that dataset for compliance with acceptance criteria (MQO's). Verification is a detailed quality review of a dataset. (Ecology, 2004)

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

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

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

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

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

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

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

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

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

Method blank - A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples. (Ecology, 2004; Kammin, 2010)

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

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

Percent relative standard deviation, %RSD = (100 * s)/x where s = sample standard deviation, and x = sample mean

(Kammin, 2010)

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

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

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

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

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

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

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

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

Where a and b are 2 sample results, and abs() indicates absolute value

(RPD can be used only with 2 values. More values, use %RSD) (Ecology, 2004)

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

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

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

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

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

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

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

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

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Glossary – General Terms

Ambient: Background or away from point sources of contamination.

Baseflow: The component of total streamflow that originates from direct groundwater discharges to a stream.

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.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Eutrophic: Nutrient rich and high in productivity resulting from human activities such as fertilizer runoff and leaky septic systems.

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.

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. This includes, but is 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 is considered a nonpoint source. 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 is a nonpoint source.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

Parameter: A physical chemical or biological property whose values determine environmental characteristics or behavior.

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

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

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.

Reach: A specific portion or segment of a stream.

Riparian: Relating to the banks along a natural course of water.

Salmonid: Any fish that belong to the family *Salmonidae*. Any species of salmon, trout, or char is considered a salmonid. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

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

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

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

Total Maximum Daily Load (TMDL): 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.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

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.

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 standard, 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 exists and below which 90% of the data exists.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

BMP	Best management practices
e.g.	For example
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
GIS	Geographic Information System software
GPS	Global Positioning System
i.e.	In other words
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
QA	Quality assurance
RM	River mile
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedures
SRM	Standard reference materials
TMDL	(See Glossary above)
TOC	Total organic carbon
TSS	(See Glossary above)
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resources Inventory Area
WSTMP	Washington State Toxics Monitoring Program
WWTP	Wastewater treatment plant

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
ft	feet
g	gram, a unit of mass
m	meter
mg	milligram
mg/L	milligrams per liter (parts per million)

mg/L/hr	milligrams per liter per hour
mL	milliliters
mmol	millimole or one-thousandth of a mole. A mole is an S1 unit of matter.
NTU	nephelometric turbidity units
psu	practical salinity units
s.u.	standard units
ug/L	micrograms per liter (parts per billion)
um	micrometer
uM	micromolar (a chemistry unit)
umhos/cm	micromhos per centimeter
uS/cm	microsiemens per centimeter, a unit of conductivity