Quality Assurance Project Plan

for

Stormwater Sampling in Clarks Creek, Puyallup River Drainage (WRIA 10): Measuring Oxygen-Demanding Sources

Northwest Indian Fisheries Commission Cooperative Agreement
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This quality assurance project plan (QAPP) has been prepared according to guidance provided in *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5, EPA/240/B-01/003, U.S. Environmental Protection Agency (EPA), Quality Assurance Division, Washington, DC, March 2001 [Reissued May 2006]) to ensure that environmental and related data collected, compiled, and/or generated for this project are complete, accurate, and of the type, quantity, and quality required for their intended use. Tetra Tech will conduct work in conformance with the quality assurance program described in the quality management plan for Tetra Tech's Fairfax Group and with the procedures detailed in this QAPP.

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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
cm	centimeters
DO	Dissolved oxygen
DQI	Data quality indicators
DQO	Data Quality Objectives
EIM	Environmental Information Management
EPA	Environmental Protection Agency
g	grams
GRTS	Generalized Random Tessellation Design
m	meter(s)
µS/cm	microSiemens per centimeter
mg/L	milligrams per liter
MS4	Multiple Separate Storm Sewer System
NPDES	National Pollution Discharge Elimination System
NPS	Nonpoint source
ODEQ	Oregon Department of Environmental Quality
PDF	Portable Document Format
QA	Quality assurance
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QAPP	Quality assurance project plan
QC	Quality control
QCO	Quality Control Officer
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard Operating Procedure
TMDL	Total Maximum Daily Load
TOL	Task Order Leader
TOM	Task Order Manager
Tt	Tetra Tech, Inc.
Tt TOL	Tetra Tech Task Order Lead (analogous to Project Manager)
WWTP	Waste Water Treatment Plant

DISTRIBUTION

This document will be distributed to the following U.S. Environmental Protection Agency (EPA), Tetra Tech, and state regulatory staff members who are involved in this project, as well as to all responsible subcontractors.

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1.0 PROJECT/TASK ORGANIZATION

The purpose of this document is to present the quality assurance project plan (QAPP) for conducting a stormwater monitoring survey and estimates of sediment oxygen demand at several locations in the Clarks Creek drainage (Puyallup, WA). Results from this survey will be used in an HSPF model to determine response of dissolved oxygen concentrations following storm events as well as the influence of aquatic macrophyte beds and influence of this biological community on sediment oxygen demand. A sampling team comprised of scientists from Tetra Tech's (Tt) Seattle, WA office will perform in-stream data collection. Tt will coordinate collection and handling of data, analysis, and interpretation of field-collected data with the assistance of sampling team personnel.

This QAPP provides general descriptions of the work to be performed to collect in-stream data, the objectives to be met, and the procedures that will be used to ensure that the data are scientifically valid and defensible and that uncertainty has been reduced to a known and practical minimum. The QAPP describes procedures used to prepare for the field effort, conduct field sampling using standard protocols, and post-process field data.

The organizational aspects of a program provide the framework for conducting tasks. The organizational structure can also facilitate project performance and adherence to quality control (QC) procedures and quality assurance (QA) requirements. Key project roles are filled by those persons responsible for ensuring the collection of valid data and the routine assessment of the data for precision and accuracy, as well as the data users and the person(s) responsible for approving and accepting final products and deliverables. The project organization chart, presented in Figure 1-1, includes relationships and lines of communication among all participants and data users. The responsibilities of these persons are described below.

Lisa Chang is the U.S. Environmental Protection Agency (EPA) Task Order Manager (TOM). She will provide coordination of the technical and QA resources of the Agency and its contractors in executing this project. As the TOM, she will have the following responsibilities:

- Reviewing and approving the project work plan, QAPP, and other materials developed to support the project
- Providing oversight for study design, site selection, and adherence to design objectives
- Reviewing and approving all contract deliverables for the program, including draft, interim, and final reports
- Coordinating with contractors, reviewers, and others to ensure technical quality and contract adherence

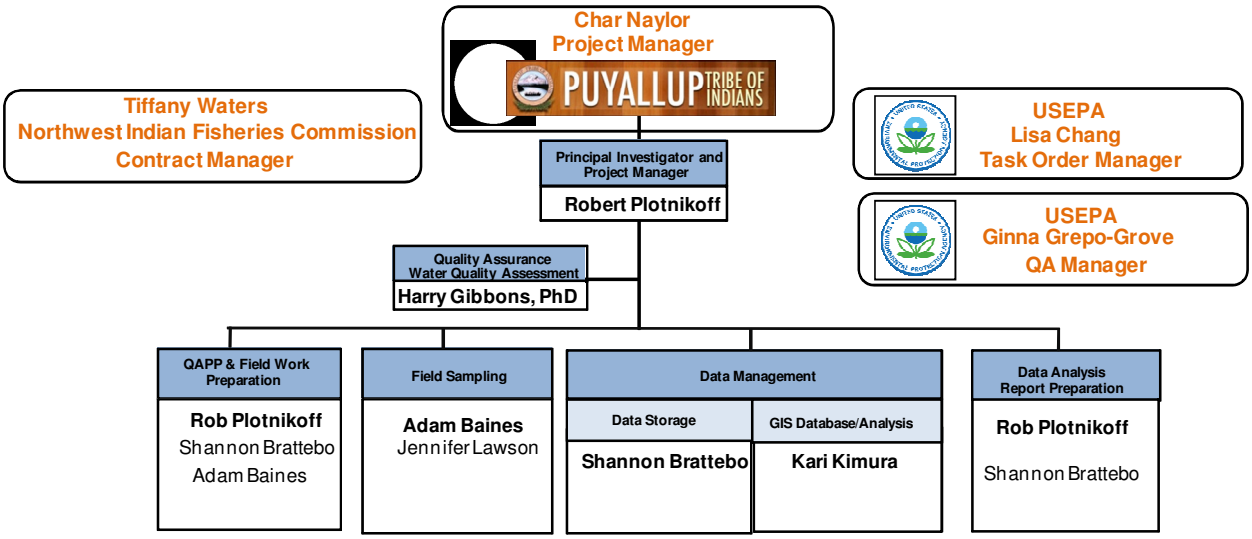

Figure 1-1. Project Organization

The local EPA Region 10 Quality Assurance Manager (QAM) is Ginna Grepo-Grove, who will be responsible for reviewing and approving the QAPP and any other deliverables, as requested by the TOM. Additional EPA Region 10 QAM responsibilities include the following:

- Reviewing and evaluating field procedures
- Conducting procedural reviews and supplemental training, as required, at the initiation of field activities
- Conducting external performance and system audits of the procedures
- Participating in EPA QA reviews of the study (QAM from EPA Region 10)

The Tt Project Manager, Robert Plotnikoff, will participate in study design and implementation activities. Other specific responsibilities of the (Tt PM) include the following:

- Coordinating project assignments in establishing priorities and scheduling
- Reviewing and evaluating field procedures with the field team and conducting procedural reviews and supplemental training at the initiation of field activities
- Ensuring completion of high-quality projects within established budgets and schedules
- Providing guidance, technical advice, and performance evaluations to those assigned to the project
- Implementing corrective actions and providing professional advice to staff
- Preparing or reviewing preparation of project deliverables, or both, including the QAPP and other materials developed to support the project
- Providing support to EPA in interacting with the project team, technical reviewers, and others to ensure that technical quality requirements are met in accordance with study design objectives

The Tt Quality Assurance Officer (QAO) for this project is Harry Gibbons, whose primary responsibilities with assistance of others, as necessary, include the following:

- Overseeing development of and approving the QAPP

- Reviewing and approving the project QAPP
- Providing support to EPA and the Tt Project Manager in preparing and distributing the work plan and QAPP
- Monitoring QC activities (with the assistance of the QAOs) to determine conformance to the approved QAPP and work plan

The Field Task Manager (Task 3) is Adam Baines. He will participate in study design and implementation of specific field sample and data collection activities. He will coordinate and participate in the overall sampling efforts throughout the field data sample collection period. Other specific oversight responsibilities of the Field Task Manager include the following:

- Assisting in the development of the project QAPP
- Verifying adherence to the project QAPP
- Verifying the completeness and accuracy of appropriate field calibration and data records
- Overseeing the receipt and inspection of sampling equipment and supplies, including instrumentation, custody documents, and sample containers
- Verifying the completeness and accuracy of appropriate field calibration and data records
- Verifying the completeness and accuracy of chain-of-custody documentation
- Verifying the integrity of the sample custody processes in place for the program, regardless of whether that entails monitoring records and shipping, courier service, or hand-delivery
- Controlling and monitoring access to samples while in their custody

Additional technical staff will be responsible for conducting specific tasks during the project (e.g., performing field sampling and collecting physical, chemical, and biological water quality data) at the direction and discretion of the Project Manager (PM). The Project Manager will supervise the technical staff participating in the project, including implementing the QC program, completing assigned work on schedule with strict adherence to procedures established in the approved QAPP, and completing required documentation. The Project Manager will direct the work of the field sampling team including collection, preparation, and shipment of samples and completion of field-sampling records. To perform the required work effectively and efficiently, the field-sampling team will include scientific staff with specialization and technical competence in field-sampling activities, as required to ensure the highest quality data are collected without incident. They must perform all work in adherence with the project work plan and QAPP, including maintenance of field sample documentation. Where applicable, custody procedures are required to ensure the integrity of the samples with respect to preventing contamination and maintaining proper sample identification during handling. Where field samples are collected the sampling team is responsible for the following:

- Receiving and inspecting the sample containers
- Receiving, inspecting, calibrating, and maintaining field instrumentation
- Completing, reviewing, and signing appropriate field records
- Assigning tracking numbers to each sample (sample identification numbers)
- Controlling and monitoring access to samples while in their custody
- Verifying the completeness and accuracy of chain-of-custody documentation
- Initiating shipment and verifying receipt of samples at their appropriate destinations
- Verifying the results of sample measurements collected for compliance with the requirements of the reference methods and this QAPP

Additional oversight will be provided by the QA Officers (QAOs), who are responsible for performing evaluations to ensure that QC is maintained throughout the sampling process, that the data collected will be of optimal validity and usability, and that limitations of the data set are minimized as much as is possible given the challenges of the routine field investigation. The QAO is any senior technical staff

assigned the responsibility of providing a second-level review of all documentation and records developed during the sample and data collection process. The QC evaluations will include double-checking work as it is completed and providing written documentation of these reviews (minimally initialing and dating documents as they are reviewed) to ensure that the standards set forth in the QAPP are met or exceeded. QCOs may be assigned at the task or subtask level allowing teams to efficiently divide work processes or tasks required and exchanging project documentation for review prior to departure from a sampling station. In this regard, QCOs ensure that all required data and information are recorded for each sampling station prior to physically leaving the collection site. Other QA/QC staff, such as technical reviewers and technical editors selected as needed, will provide peer review oversight on the content of work products and ensure that work products comply with the client's specifications.

Technical staff involved with the program will be responsible for reading and understanding this QAPP and complying with and adhering to its requirements in executing their assigned tasks relative to this project.

Although no formal field audits are anticipated for the project, Tt will perform at least one site visit and one procedural review with the field team and will minimally review the logistical support program established during the first sampling event. In addition, the local EPA QAM may reserve the right to audit at any time during the field data and sample collection program. Such an audit may entail a review of the data collection program to ensure that the data collected will be of optimal validity and usability, and that limitations of the data set are minimized as much as is possible given the logistical considerations and challenges of the data collection requirements. It is optimal to conduct field audits, where funding is available, during the first sampling events such that the QAO or designee can conduct procedural reviews if necessary to ensure compliance with EPA methods and standard operating procedures (SOPs), where applicable, and to introduce any unique aspects of this field program. The field audit would generally include verification of compliance with the QAPP as well as adherence to the requirements established in this document.

2.0 PROBLEM DEFINITION/BACKGROUND

The Clarks Creek watershed is located in the lower Puyallup River Basin, not far from Commencement Bay (southern end of Puget Sound) and the northwest corner of Pierce County, WA. The Clarks Creek drainage occupies and area of approximately 16.3 square miles. The headwaters of the Clarks Creek surface drainage network starts approximately one-third of a mile south of Maplewood Springs and flows 3.6 miles through Pierce County, the City of Puyallup, and Puyallup Tribal lands before discharging into the Puyallup River.

Clarks Creek watershed is part of an extensive plateau of glacial deposits that border the Puget Sound. Clarks Creek and adjacent tributaries are fed by swale and wetland-dominated stream channels and ravines flowing between the rolling terrain of northern-aligned ridges that descend from the southern part of the watershed. Elevations in the watershed range from sea level at the mouth in Puget Sound to 120 meters on adjacent bluffs and 210-245 meters in the upper foothills.

The Clarks Creek watershed has approximately equal proportions of area in the City of Puyallup and unincorporated areas of Pierce County. In addition, residences within the city limits are generally on sewer, while those in the county use on site wastewater disposal. Land uses in the Clarks Creek watershed consist mostly of single family residences (47 percent of the watershed) scattered with vacant forest land, pastures, lawns, and hobby farms. Most of this area is not sewered and relies on onsite wastewater disposal. The land use becomes more urban closer to the City of Puyallup, Tacoma, and South Hill Mall. Commercial development is mostly concentrated along the major transportation corridors such as the Meridian Avenue and SR-12 interchange.

It is important to note that in many portions of Clarks Creek downstream of DeCoursey Park managed lawns associated with single-family residences extend up to the edge of the creek. This may be associated with a variety of impacts including direct input of lawn fertilizers, lack of riparian shade, and reduced filtering of pollutant loads in storm runoff. Stormwater conveyance of these pollutants are suspected of causing an oxygen-demand in the creek.

Stormwater reaching Clarks Creek is also regulated under the NPDES system as Municipal Separate Storm Sewer Systems (MS4s). Pierce County is a Phase I community under the MS4 program, while the City of Puyallup is a Phase II community. The County has developed both a stormwater manual and a best management practices manual to control stormwater discharges to the creek. The City of Puyallup's Engineering and Collection Division is responsible for stormwater infrastructure, drainage and flood protection, improving surface water quality, incorporating current development standards, and stormwater management.

3.0 PROJECT/TASK DESCRIPTION

Task 001: Preparation of a QAPP Document and for Field Work

Development of a QAPP that will outline how in-stream data will be collected and analyzed. This QAPP clearly outlines a monitoring plan for agency review.

The QAPP is developed in accordance with EPA's *Requirements for Quality Assurance Project Plans (EPA QA/R-5)* <http://yosemite.epa.gov/R10/OEA.NSF/webpage/QA+Reference+Documents> and Ecology's Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies (July, 2004) <http://www.ecy.wa.gov/biblio/0403030.html>.

Task 001 involves the preparation of necessary technical documentation prior to implementation of actual monitoring activities. A portion of the documentation will require field site visits in order to finalize the QAPP report and will be accomplished under the following sub-task activities:

1) Tetra Tech Surface Water Group (TT SWG) will develop and submit the draft Quality Assurance Project Plan (QAPP) for review by the Puyallup Tribe of Indians and U.S. EPA Region 10 Task Leads. The QAPP will use U.S. EPA's format as described in the EPA QA/R-5 Guidance.
2) The location of sampling stations for both stormwater monitoring events and sediment oxygen demand events will be identified. These sites will be agreed upon by the Puyallup Tribe of Indians Contract Manager and the Tetra Tech Project Manager.
3) TT SWG will determine if permission from private landowners is required to access any of the sites proposed for stormwater monitoring activities.

Deliverables:

1) A Quality Assurance Project Plan (QAPP will be developed, reviewed, and revised).
2) The location of sampling stations (using GIS coordinates) will be recorded in the QAPP.

Task 002: Field Work

Task 002 includes mobilization for field work. Initial field work will include sediment oxygen demand measurements and will be followed by stormwater monitoring. The following sub-tasks will be completed by Tetra Tech SWG:

1) Sediment oxygen demand chambers will be deployed on 2 separate events during the summer of 2011. The chambers will measure conditions at 3 locations on Clarks Creek with 3 replicates per station.
2) Outfalls to select locations on Clarks Creek and the receiving water above and below the outfalls will be sampled during 4 storm events. This work will be conducted when the next storm season begins in October 2011.
3) Field sampling will generate several coolers filled with stormwater samples. Sample bottle will be labeled and catalogued carefully, following strict Chain-of-Custody procedures and development of paperwork that serves in logging the transport condition of samples.

Deliverables:

1) Results from 2 deployments of sediment oxygen demand chambers will generate results from 3 locations on Clarks Creek.
2) Water quality data from 4 locations on Clarks Creek will be characterized during 4 separate storm events.

Task 003: Data Management

A large volume of stormwater samples will be collected and field data generated during Task 002. All of the information recorded at station visits will be kept in electronic form and in spreadsheets by TT SWG for eventual storage in a relational database like Microsoft Access®. Task 003 will involve development and storage of data generated for this project and to provide easy access for other users.

1) Unique identifiers will be developed for each of the stormwater and sediment monitoring stations. Spatial delineation and identifiers will be developed for storage in ArcGIS as companion information to stations.
2) Both field measurements and laboratory results will be compiled in an electronic spreadsheet for easy access to data generated for stormwater sampling events and sediment oxygen demand estimates.
3) Storm events will vary according to storm intensity and duration. Summary statistics will be generated for upstream, downstream, and outfall data for each event and reviewed for patterns that relate pollutant delivery to setting and potential sources.

Deliverables:

1) Spreadsheets will be developed that include stormwater sampling and sediment oxygen demand results.
2) Summary statistics will be generated from this data for inclusion in Task 004 the Data Analysis Report.

Task 004: Data Analysis/Report Preparation

Tetra Tech SWG will prepare a summary report of stormwater monitoring results and format data for use in the HSPF modeling effort currently underway by Dr. Jon Butcher. The content of the report will include summary statistics describing water quality conditions during stormwater events from Task 003 and record all relevant information that would enable adequate interpretation of results. The following sub-tasks will be used to construct a final report:

1) Changes to water quality at Clarks Creek locations downstream of outfalls sampled in this study will be described from upstream/downstream result comparisons. Relationships that exist between pollutant delivery to the streams and characteristics of rainstorm events will be determined.
2) Sediment oxygen demand (SOD) will be described from 3 mainstem locations on Clarks Creek (2 events) and rates of oxygen demand associated with stream setting characteristics. SOD will be estimated from these locations to determine the magnitude of influence this process has on oxygen concentration reduction at locations within the drainage,
3) A draft report will be prepared that describes methods and results from stormwater monitoring work completed in Clarks Creek. The draft report will be submitted to the Puyallup Tribe, Dr. Jon Butcher (Tetra Tech), and U.S EPA Region 10 for review. TT SWG will review and complete revisions and finalize the report.
4) All data generated from this project will be submitted to EPA's STORET system by TT.

Deliverables:

A Final Report will be developed that includes all field data and laboratory results collected from stormwater events. Relationships to physical settings within the drainage will be observed to aid in interpretation of sampling results.

3.1 Field Tasks

The following tasks for this project have been developed:

Task 1. Evaluate Stormwater quality conditions from select storm drains discharging into Clarks Creek in the study area beginning from the upstream 12th Ave. SW site to the downstream W. Pioneer Avenue site. Four sites have been identified that will be visited for stormwater quality characterization in outfalls. Stormwater outfalls have been identified at each site and a final selection of specific outfalls will be made following a reconnaissance visit.

Output: Will determine water quality characteristics of stormwater delivered to Clarks Creek from storms of varying duration and intensity.

Task 2. Characterize receiving water conditions in Clarks Creek downstream of the select storm drains and collect compare to water quality conditions immediately above the influence of each stormwater outfall. Four sites have been identified that will be visited for stormwater quality characterization in receiving water; 2 locations at each site on Clarks Creek.

Output: Will determine if stormwater input to Clarks Creek results in a measurable change to downstream water quality. Will determine if storm characteristics including combinations of duration and intensity result in measurable change of pollutants downstream of each storm outfall.

3.2 Objectives

Information in this Stormwater Sampling Workplan (SSW) is organized to provide sampling and analysis methods that will generate data and interpretations necessary to address the following objective(s):

1. To determine the influence stormwater has on Clarks Creek receiving water quality at locations between 12th Avenue SW upstream and West Pioneer Avenue downstream.

Outcome: Will be able to determine the type and magnitude of changes from stormwater to water quality in Clarks Creek.

2. To use results from stormwater characterization and influence on receiving water quality in future management for where current stormwater conveyance is directed.

Outcome: Will be able to determine if stormwater has measurable impacts on receiving water and identify alternate solutions for stormwater management.

3.3 Stormwater Sampling

The proposed project describes a monitoring strategy that evaluates parameters that cause depression in dissolved oxygen concentrations in the mainstem of Clarks Creek. Parameters that are known to cause dissolved oxygen sag in surface water include: nutrients (phosphorus and nitrogen input), organics associated with inorganic materials like suspended sediment, and a direct measurement of oxygen-demanding media that strip dissolved oxygen from solution in surface water.

a) Task 1: Stormwater Outfall Monitoring

Purpose: Determine volume and concentration of stormwater input from four outfalls into Clarks Creek. Oxygen-demanding parameters will be measured that are used to interpret differences between upstream/downstream sampling results described in Section 2.3(b).

Sampling of four outfalls within the study area will occur during 4 storm events within the term of the project. Storm water samples will be characterized as wet season/dry season results where wet season which is defined as October 1st through March 31st and dry season as April 1st through September 30th. Samples will be collected from the outflow of select stormwater pipes in order to determine water quality characteristics of nutrients, dissolved oxygen concentrations, and other parameters that describe oxygen demand. Samples will be collected manually. The grab samples will be delivered to an accredited Washington Laboratory that has met analytical performance standards established by the Washington Department of Ecology.

Storm Design Conditions

For the purposes of defining a single storm event, the minimum amount of rainfall should be forecast to be at least 0.2 inches in a 24-hour period and the event must be preceded by a dry period of at least 4 hours. Two of the 5 storm events should have a minimum amount of rainfall of at least 0.5 inches. To account for the variability of each sampling event, storm conditions, and outfall discharge, each sampling event will last for four hours or for the duration of the storm. Samples will be collected at defined time intervals, i.e. one sample every hour. Flow volume will be estimated at each outfall pipe at the time of sampling. Flow data will be used to calculate volume and load for eventual use in the existing modeling effort to characterize dissolved oxygen (DO) conditions.

b) Task 2: Clarks Creek Receiving Water Monitoring

Purpose: Determine how inflow of stormwater affects parameters that influence dissolved oxygen concentrations in the receiving water.

Grab samples will be collected in Clarks Creek at two points, upstream and downstream, of each monitored stormwater outfall to characterize nutrients, dissolved oxygen, and other oxygen-demand indicators during storm events. Grab samples will be collected in Clarks Creek just upstream of each stormwater outfall as well as downstream of each outfall. Collecting nutrient samples, dissolved oxygen, and oxygen demand indicator data from these two locations will provide information on how the stormwater input loading of these parameters explains the level of oxygen demand currently predicted by the dissolved oxygen model.

Sampling of upstream/downstream locations within the Clarks Creek study area will occur during 4 to 5 storm events per year. Storm water samples will be characterized as wet season/dry season results where wet season which is defined as October 1st through March 31st and dry season as April 1st through September 30th. Samples will be collected from the outflow of select stormwater pipes in order to determine water quality characteristics of nutrients, dissolved oxygen concentrations, and other parameters that describe oxygen demand. In addition, sediment oxygen demand chambers will be deployed below the outfall locations in the Clarks Creek channel. A direct measurement of the effects sediment oxygen demand has on overlying surface water. Samples will be collected manually. The grab samples will be delivered to an accredited Washington Laboratory that has met analytical performance standards established by the Washington Department of Ecology.

For the purpose of defining a single storm event, the minimum amount of rainfall should be forecast to be at least 0.2 inches in a 24-hour period and the event must be preceded by a dry period of at least 4 hours. Two of the 5 storm events should have a minimum amount of rainfall of at least 0.5 inches. To account for the variability of each sampling event, storm conditions, and outfall discharge, each sampling event will last for four hours or for the duration of the storm. Samples will be collected at defined time intervals and based on minimum rainfall triggers as reported in Table 3-1. Flow volume will be estimated at each outfall pipe at the time of sampling. Flow data will be used to calculate volume and load for eventual use in the existing modeling effort to characterize dissolved oxygen (DO) conditions.

Flow measurements and field parameters (e.g., temperature, pH, conductivity, and dissolved oxygen) will also be collected during each sampling event.

Table 3-1. Criteria that trigger storm event sampling.

Storm Condition (rainfall triggers in a 24-hr period)	**Duration of the Storm** <24 hrs or >24 hrs	**Sample Collection Interval**					
		Sample #1	Sample #2	Sample #3	Sample #4	Sample #5	Sample #6
0.2 inches	> 24 hrs	1 hr	2 hrs	3 hrs	4 hrs	5 hrs	6 hrs
0.2 inches	< 24 hrs	30 min	1 hr	2 hrs	3 hrs	4 hrs	5 hrs
0.6 inches	> 24 hrs	1 hr	2 hrs	3 hrs	4 hrs	5 hrs	6 hrs
0.6 inches	< 24 hrs	30 min	1 hr	1.5 hrs	2 hrs	2.5 hrs	3 hrs

Note: The rainfall triggers are guides for selecting the variety of storm conditions that can commonly occur in Puget Sound. However, some of these design conditions may not occur during this project due to the unpredictable nature of climate events and unforeseen logistical issues.

Several criteria and storm characteristics have been suggested by the Washington Department of Ecology for determining timing and frequency for grab, composite, or sequential sampling routines. Most of the listed criteria in Table 3-2 are standard definitions for determining when a storm event qualifies for sampling (e.g., Rainfall Volume through Inter-event dry period). The remaining criteria suggest the minimum number of samples collected at fixed stations that should be useable in calculating pollutant loads for determining compliance with a stormwater permit (e.g., No. of annual chemistry samples per site that meet all criteria and No. of annual chemistry samples per site that don't meet annual rainfall volume criteria). These criteria serve as guidelines for mobilizing a sampling effort, but need to consider typical rainfall patterns in the area (as in the case of sampling select locations in Clarks Creek).

Table 3-2. Storm event criteria that initiates sampling and sample retention.

Criteria	Wet Season
Period	October 1st through April 30th
Rainfall Volume	0.20" minimum, no fixed maximum
Rainfall Duration	No fixed minimum or maximum
Antecedent Dry Period	≤ 0.02" rain in the previous 24 hours
Inter-event dry period	6 hours
No. of annual chemistry samples per site that meet all criteria	7-9
No of annual chemistry samples per site that don't meet rainfall volume criteria	0-3

Storm event duration is a key to mobilization of pollutants and is used to partition the type of storm that needs to be characterized as part of a monitoring program. The wet season in Puget Sound has storm events that can last more than 24 hours and this was a demarcation for categorizing storm event duration (Table 3-3). One of the important attributes in storm event sampling is to capture pollutant loading characteristics at various stages of the hydrograph and the criteria listed in Table 3-3 force sampling effort over longer periods of time, when necessary.

Table 3-3. Duration of storm event and collection criteria.

Storm Event Duration	< 24 hrs	> 24 hrs
Minimum storm volume to sample	75 percent of the storm event Hydrograph	75 percent of the hydrograph of the first 24 hours of the storm
No. of Aliquots	7 to 9 accepted[1]	7 to 9 accepted[1]

[1] Applicable when using a composite sampling routine.

Criteria from Table 3-2 will be used to determine timing for storm event sampling and the goals for generating storm event samples that can be used in further technical analysis will be determined from elements of Table 3-3. Some general guidelines have been established in this project to alert the sample team when a candidate storm event is likely. Forecasting stormwater sampling events will use the following indicators:

a. The probability of precipitation is greater than 50 percent
b. The forecasted rainfall is greater than 0.2 inches in 24 hours
c. For purposes of sample timing within the week, a candidate rainfall should begin between Monday 12:00 and not be forecast later than Thursday 22:00 (this time period allows for sample delivery to a contract laboratory within holding times for some parameters).

The following web sites will be consulted in order to determine when an eligible storm event is likely to occur:

a. National Weather Service
http://www.wrh.noaa.gov/sew/
b. University of Washington Forecast Models
http://www.atmos.washington.edu/mm5rt/

Storm events will be characterized in the Puyallup, WA region by contacting the local meteorologist and determining characteristics of the most common and second most common storm events. Storm events will be characterized based on intensity (no. of inches of rainfall per storm) and duration (longevity of the storm event). A frequency curve will be constructed using these characteristics so that the two most common types of storm events in the Puyallup, WA region can be targeted for sampling.

c) Optional Task 3: Alternate Sampling Strategy (Automated Stormwater Sampling)

Automated stormwater sampling can be established as an alternate method for characterization of the outfall discharge into Clarks Creek and for upstream/downstream sample collection of water about each outfall location. Water level triggers for sampling will be used by investigating existing gauging data at sites on Clarks Creek and how water level has responded to presence of storm events. Water level gauging will be accomplished using capacitance probes, pressure transducers or bubblers that activate the ISCO sequential sampling device and begin the water sampling intervals (Table 3-1). A scheme will be established for each ISCO sequential sampler that activates a collection scheme when the water level in Clarks Creek rises based on stormwater input. Use of automated samplers may be limited to one or two select locations as the need for multiple units (one for outfall, one for upstream, and one for downstream) at a site may be cost-prohibitive and may not yield results that differ from those grab samples collected by field staff.

There are some limitations for use of the automated sequential sampler that are as follows:

- Holding times may be exceeded for select parameters (e.g., fecal coliform bacteria)
- False starts may occur using the triggering devices for the automated sampler
- Equipment failure may occur and not be detected until inspection by field staff
- Field staff are not on-site to note general conditions at a sample site for use in analyzing and interpreting data results

The selection of an automated sampling device for use in this project may be more appropriate once more is known about stormwater outfall volumes following an event and the response of Clarks Creek at select locations during a storm event.

3.4 Water Quality Constituents to Monitor (Primary Monitoring Program)

Nitrogen and phosphorus parameters, field measured parameters, suspended sediments, dissolved organic carbon, and biochemical oxygen are important influences on the dissolved oxygen concentrations in Clarks Creek. Results from collection and analysis of water samples will enable partitioning of pollutants or parameters that depress oxygen concentrations in Clarks Creek and the points of origin. By recording water velocity and/or flow measurements, the relative influence these parameters have on oxygen concentration reduction can be described. Direct measurement of sediment oxygen demand (SOD) has on overlying surface water will also be measured using SOD chambers.

Field measured parameters include temperature, dissolved oxygen concentration, pH, and specific conductance. All of these can be used to indicate sources of contamination in the same way dissolved oxygen concentrations are usually used as a surrogate to indicate increased concentrations of nutrient loading, especially phosphorus, present in the drainage.

4.0 DATA QUALITY OBJECTIVES AND CRITERIA

Data quality objectives (DQOs) are qualitative and quantitative statements that clarify the intended use of the data, define the types of data needed to support the decision, identify the conditions under which the data should be collected, and specify tolerable limits on the probability of making a decision error due to

uncertainty in the data (if applicable). Data users develop DQOs to specify the data quality and quantity needed to support specific decisions.

4.1 Project Quality Objectives

The quality of an environmental monitoring program can be evaluated in three steps: (1) establishing scientific assessment quality objectives, (2) evaluating program design to evaluate whether the objectives can be met, and (3) establishing assessment and measurement quality objectives that can be used to evaluate the appropriateness of the methods being used in the program. The quality of a data set is some measure of the types and amount of error associated with the data.

Data, or decision, quality objectives determine when data will be used to select between management alternatives or to determine compliance with a standard. Management decisions for improving predictive capacity of the dissolved oxygen model will require generation of an adequate quantity of data influenced by numbers, locations, and frequency of samples from sites that reflect changes that occur from stormwater input to the creek. A set of data eventually used to make management decisions will meet various standards or comply with minimum requirements of a statistical evaluation and have the ability to distinguish between two environmental conditions (e.g., impaired or not-impaired) with an acceptable level of uncertainty.

Sources of error or uncertainty in statistical inference are commonly grouped into two categories:

Sampling error: The difference between sample values and in situ *true* values from unknown biases due to sampling design. Sampling error includes natural variability (spatial heterogeneity and temporal variability in population abundance and distribution) not specifically accounted for in a design (for design-based inference), and variability associated with model parameters or incorrect model specification (for model-based inference).

Measurement error: The difference between sample values and in situ *true* values associated with the measurement process. Measurement error includes bias and imprecision associated with sampling methodology, specification of the sampling unit, sample handling, storage, preservation, identification, instrumentation, and the like.

The data requirements for this project encompass aspects of database management to reduce sources of errors and uncertainty in the use of the data.

4.2 Measurement Performance Criteria

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

- Precision
- Accuracy
- Representativeness
- Completeness
- Comparability

Type and Frequency of Laboratory Quality Control Samples
For samples analyzed at a commercial laboratory, the type and frequency of the quality control samples to be analyzed are summarized in Table 4-1. Additional quality control sampling will be conducted in the field and is detailed in Section 11.0 Quality Control Procedures.

Table 4-1. Laboratory quality control samples.

Type of Quality Control Sample	Description
Method Blank	Reagent grade sample matrix analyzed to provide an indication of laboratory contamination.
Check Sample	Generally purchased, prepared independently from analytical standards and used to provide an indication of the accuracy of the analytical determination.
Laboratory Duplicate	A second aliquot of a sample, processed in exactly the same manner.
Matrix Spike	An aliquot of a sample to which known quantities of analytes are added, processed in exactly the same manner.
Field Duplicate	A split sample, labeled in a similar manner as regular samples, submitted to laboratory, and processed in exactly the same manner.

For samples analyzed at a commercial laboratory, the frequencies of the quality control samples to be analyzed are summarized in Table 4-2.

Table 4-2. Frequency of laboratory quality control samples.

Parameter	Matrix	Check Standards	Method Blanks	Analytical Duplicates	Matrix Spikes	Field Duplicates
Total Phosphorus	Water	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	Minimum 10% of samples
Soluble Reactive Phosphorus	Water	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	Minimum 10% of samples
Ammonia	Water	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	Minimum 10% of samples
Nitrate+Nitrite-N	Water	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	Minimum 10% of samples
Total Kjeldahl Nitrogen	Water	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	Minimum 10% of samples
Total Suspended Solids	Water	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	Minimum 10% of samples
Volatile Suspended Solids	Water	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	Minimum 10% of samples
Dissolved Organic Carbon	Water	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	Minimum 10% of samples
Biochemical Oxygen Demand	Water	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	Minimum 10% of samples

Parameter	Matrix	Check Standards	Method Blanks	Analytical Duplicates	Matrix Spikes	Field Duplicates
Fecal Coliform	Water	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples	Minimum 10% of samples

NA ~ not applicable

Precision

Precision is a measure of the scatter in the data due to random error that is expected primarily from sampling and/or analytical procedures. Laboratory duplicates for assessment of precision will be analyzed at a frequency of about 10 percent of the total number of samples submitted to the laboratory or at least one per sample batch. In addition, field duplicates will be collected for approximately 10 percent of samples submitted to the laboratory. For sample results which exceed the reporting detection limit (RDL), the relative percent difference (RPD) will be less than or equal to 20 percent.

For laboratory sample results with values less than 5 units, the precision criterion will be less than or equal to 1.5 units rather than the RPD to account for the effect of smaller values on percent differences. No criteria are presented for duplicates which are below the RDL, as these data are provided for informational purposes only. For instance, where one result is below the RDL, professional judgment will be used in determining the compliance of the data to project requirements.

Precision is a measure of internal method consistency. It is demonstrated by the degree of agreement between individual measurements (or values) of the same property of a sample, measured under similar conditions.

Sampling method consistency and adherence to SOPs (Standard Operating Procedures) will be assessed during field audits and documented in a Field Sampling QA Report. In the event that the field audit identifies problems requiring attention, the Tetra Tech Project Manager and/or the EPA QA Manager will immediately consult with the EPA Task Order Manager. The corrective action system for this project is described in Section 17.0.

Bias

Bias provides an indication of the accuracy of the analytical data, as provided by both method blanks and percent recovery of target analytes from reagent and field sample matrix. Check samples will be used to provide compliance criteria for bias. The percent recovery of the matrix spikes and standard reference materials will be less than or equal to +/- 20 percent.

Method blank samples will be analyzed with each batch of samples. Results for method blank samples should be less than the minimum detection limit for each parameter.

Accuracy

Accuracy is defined as the degree of agreement between an observed value and an accepted reference or true value. Accuracy is a combination of random error (precision) and systematic error (bias), introduced during sampling and analytical operations. Bias is the systematic distortion of a measurement process that causes errors in one direction, so that the expected sample measurement is always greater or lesser to the same degree than the sample's true value.

Methods to ensure accuracy of field measurements include instrument calibration and maintenance procedures. Sample handling procedures and procedures for verification of data influence the accuracy of results.

The Tetra Tech Project Manager will ensure the contract laboratory accuracy by meeting %Recovery (Rec) values specified by EPA methods and listed in Table 4-3.

In addition, performance of field equipment and operation of meters will be evaluated by meeting relative percent difference goals for each of the parameters (Table 4-4). Accuracy for field measurements cannot be measured directly, but can be evaluated based on description of equipment performance.

Table 4-3. Measurement quality objectives for laboratory analysis.

	Precision		Bias/Accuracy			
Parameter	**Analytical Duplicate Samples**	**Field Duplicate Samples**	**Check Standard (LCS)**	**Matrix Spikes**	**Method Blanks**	**Lowest Concentrations of Interest**
	Relative Percent Difference (RPD)	**Relative Percent Difference (RPD)**	**% Recovery Limits**	**% Recovery Limits**	**Units**	**Units of Concentration**
Surface Water						
Total Phosphorus	±20 [a]	±20 [a]	±10	±20	< RL	Reporting Limit [b], µg/L
Soluble Reactive Phosphorus	±20 [a]	±20 [a]	±10	±20	< RL	Reporting Limit [b], µg/L
Ammonia	±20 [a]	±20 [a]	±10	±20	< RL	Reporting Limit [b], µg/L
Total Nitrogen (Total Kjeldahl Nitrogen)	±20	±20	±10	±20	< RL	Reporting Limit [b], µg/L
Nitrate-nitrite	±20	±20	±10	±20	< RL	Reporting Limit [b], µg/L
Total Suspended Solids	±20 [a]	±20 [a]	N/A	N/A	N/A	mg/L
Volatile Suspended Solids	±20 [a]	±20 [a]	N/A	N/A	N/A	Reporting Limit [b], µg/L
Dissolved Organic Carbon	±20	±20	±10	±20	< RL	mg/L
Biochemical Oxygen Demand	±20 [a]	±20 [a]	±10	N/A	N/A	Reporting Limit [b] mg/L as $CaCO_3$
Fecal Coliform	±20 [a]	±20 [a]	±5	±20	< RL	mg/L

[a]For sample results with values of less than 5 units, the precision criterion will be less than or equal to 1.5 units rather than the RPD to account for the effect of smaller values on percent differences.
[b]The Required Reporting Limit (or Minimum Detection Limit) is listed in Table 5.6-1.

Table 4-4. Measurement quality objectives for field measurements.

	Precision (from replicate measurements	Bias/Accuracy	Lowest Values of Interest
Parameter	**Relative Percent Difference (RPD)**	**(% Recovery) (deviation from true value)**	**Units of Measurement**
Dissolved Oxygen (LDO)[a]	10	N/A	Minimum detection limit [b]
Conductivity	5	N/A	Minimum detection limit [b]
pH	5	N/A	4.0 units
Temperature	5	N/A	0 ^{o}C
Creek Level	0.5 inches	N/A	0.5 inches
SOD	10	N/A	Minimum detection limit [b]

[a] Luminescent Dissolved Oxygen Probe.
[b] The Minimum Detection Limit is listed in Table 5.6-1.

Representativeness
Representativeness is defined as "the degree to which the data accurately and precisely represent a characteristic of a population parameter, variation of a property, a process characteristic, or an operational condition" (Stanley and Verner 1985; Smith et al. 1988). At one level, representativeness is affected by problems in any or all of the other attributes of data quality.

Sample representativeness will be addressed at two distinct steps in the data collection process. During sample collection, the use of generally accepted sampling procedures in a consistent manner throughout the project will ensure that representative samples are obtained. During sub-sampling within the laboratory, samples will be mixed by inverting several times to ensure that the analytical sub-sample is representative of the sample container contents.

a) Stormwater Outfall Water Quality

Representativeness will be achieved through collection of samples aimed at capturing the complexity and dynamics of each storm event. Locations at which sampling of stormwater outfall occurs will characterize water quality in storms that differ in duration and intensity.

b) Clarks Creek Water Quality

Data will be gathered to characterize water quality constituents from stormwater events during dry and wet seasons of the year. Sample collection will be conducted less frequently during the dry season as ambient conditions remain similar throughout this period of time. Sample collection will increase in frequency during wet season portions of the year in order to characterize ambient conditions and the influence from stormwater events. Stormwater samples will be collected manually and at equal time intervals in order to characterize storm events that present combinations of duration and intensity (i.e., distribution of precipitation quantity with time). Additional detail is provided for description of storm events in Western Washington and the characteristics that will be described by stormwater monitoring (see Section 7.2).

Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and entered into the data management system. To optimize completeness, every effort is made to avoid sample and/or data loss. Accidents during sample transport or lab activities that cause the loss of the original samples will result in irreparable loss of data, which will reduce the ability to perform analyses, integrate results, and prepare reports.

Completeness requirements are established and evaluated from two perspectives. First, valid data for individual indicators must be acquired from a minimum number of sampling locations in order to make subpopulation estimates with a specified level of confidence or sampling precision. The objective of this study is to complete sampling at 95% or more of the sites.

These objectives are estimated as the percentage of valid data obtained versus the amount of data expected based on the number of samples collected or number of measurements conducted. Where necessary, supplementary objectives for completeness are presented in the parameter-specific sections of this QAPP.

Comparability

Two data sets are considered to be comparable when there is confidence that the two sets can be considered equivalent with respect to the measurement of a specific variable or group of variables. Comparability is dependent on the proper design of the sampling program and on adherence to accepted sampling techniques, SOPs (Standard Operating Procedures), and QA (Quality Assurance) guidelines.

Data comparability generated throughout the Clarks Creek study will be ensured through application of standardized sampling procedures and convergence with methods and practices of existing monitoring programs (e.g., Washington Department of Ecology), analytical methods (e.g., state-accredited laboratories), units of measurement, and detection limits. The sampling results will be tabulated in a database for comparison between sampling events and sampling sites.

Method detection limits and laboratory methods for surface water quality variables analyzed in the Clarks Creek project are listed in Table 4-5.

Table 4-5. Reporting limits and analytical methods for surface water, stormwater, and sediment data.

Water Quality Parameter	Units	Minimum Reporting Limit	Accuracy	Method
Surface Water				
Total Phosphorus, TP	µg/L	2.0	±2	EPA 365.1
Soluble Reactive Phosphorus, SRP	µg/L	1.0	±2	EPA 365.1
Nitrate+Nitrite-N	µg/L	10	±10%	EPA 353.2
Total Nitrogen (Total Kjeldahl Nitrogen)	mg/L	0.2	±10%	EPA 351.1
Ammonia-N	µg/L	10.0	±10%	EPA 350.1
Total Suspended	mg/L	0.5	±10%	SM2540D

Solids				
Volatile Suspended Solids	mg/L	0.5	±10%	SM1810200
Dissolved Organic Carbon	mg/L	0.250	±10%	SM5310C
Biochemical Oxygen Demand (5-day)	mg/L	2.00	±10%	SM5210B
Fecal Coliform	cfu/100 mL	1cfu/100 mL	±20%	SM9222D
Temperature	ºC	0.5	±0.5	[a] Thermometer
		0.01	±0.1	[a] HydroLab MS5
Dissolved Oxygen	mg/L	0.2 (test kit) 0.01 (meter)	±0.4 (test kit) ±0.2 (meter)	Bioluminescence Probe (LDO) HydroLab MS5
pH	pH units	0.1	±0.2	HydroLab MS5
Conductivity	µmhos/cm	5	±1	HydroLab MS5
[b] Creek level	inches	0.5	±0.5	Staff Gage/Pressure Transducer
Sediment				
Sediment Oxygen Demand	$g/m^2/day$	0.2 (Winkler Method)	±0.4	ECY EAP036 SOP[c]

Note:
[a] Calibration checks of the HydroLab® will be checked with a field thermometer twice during the monitoring year using a NIST-approved calibration thermometer.
[b] Select locations will be continuously monitored for level (pressure transducer) in order to estimate flow for determining loading estimates of pollutants diminishing dissolved oxygen concentrations in receiving water.
[c] EAP036 Benthic Flux Chamber Standard Operating Procedure (http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_036BenthicFluxChambers.pdf)

5.0 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

This QAPP and supporting materials will be distributed to all participants. The local Project Manager, Rob Plotnikoff, will conduct a procedural review before the field team is mobilized for sampling. The procedural review will include the requirements of the QAPP and referenced SOPs, as well as instrument manufacturers' operation and maintenance instructions. It will be performed concurrently with a check that all equipment and sampling gear are fully functional and ready for deployment. In addition, there will be discussions and demonstrations of sampling method(s) to be used and discussions regarding specific health and safety concerns. Each sampling team will consist of, at a minimum, one sample collector and a second field investigator who will serve as the QC Officer (QCO). The QCO will ensure strict adherence to the project protocols, check all documentation for completeness and correctness, and verify that no transcription errors or omissions have been made in preparing sample custody records and other project documentation.

6.0 DOCUMENTATION AND RECORDS

Thorough documentation of all field sample collection is necessary for proper processing of data and, ultimately, for interpreting study results. Field sample collection will be documented in writing, on forms included in (to be included in Appendix A), as well as on the following forms and labels:

- A field log notebook for general observations and notes
- A Field Data Record Form that contains information about observations and measurements made and samples collected at the site
- Checklists for each sampling event, sampling point, and sampling time.

The Tt Project Manager will maintain files, as appropriate, as repositories for information and data used in preparing any reports and documents during the project and will supervise the use of materials in the project files. The following information will be included:

- Any reports and documents prepared
- Contract and Task Order information
- Project QAPP
- Results of technical reviews, data quality assessments, and audits
- Communications (memoranda; internal notes; telephone conversation records; letters; meeting minutes; and all written correspondence among the project team personnel, subcontractors, suppliers, or others)
- Maps, photographs, and drawings
- Studies, reports, documents, and newspaper articles pertaining to the project
- Special data compilations
- Spreadsheet data files: physical measurements, analytical chemistry data (hard copy and disk)

Copies of the field log books and physical characterization/water quality data sheets and sampling checklists will be supplied to the Field PMs at the close of each sampling event. These data will be used in conjunction with inspection checklists to compile the sampling event reports. Formal reports that are generated from the data will be subject to technical and editorial review before submission to the Puyallup Tribe, and will be maintained at Tt's Seattle, Washington, office in the central file (disk and hard copy). The data reports will include a summary of the types of data collected, sampling dates, and any problems or anomalies observed during sample collection.

When visiting a sampling station, the sample collector will record the following information on water-proof field sheets. Detailed information on field observations should include the following:

- Date
- Time
- Names of sampling personnel
- Number/type of samples collected
- Weather
- Descriptions of any photographs taken
- On-site field measurement (e.g., temperature, water level)
- Color of water
- Unusual conditions (changes in land uses, presence of oil sheens, odors, nuisance conditions).

If any change(s) in this QAPP are required during the study, a memo will be sent to each person on the distribution list describing the change(s), following approval by the appropriate persons. The memos will

be attached to the QAPP. All written records relevant to the sampling and processing of samples will be maintained at Tt's Seattle, Washington office in the central file. Unless other arrangements are made, records will be maintained for a minimum of 3 years following expiration of the contract.

7.0 SAMPLING DESIGN

Stormwater introduction into Clarks Creek has been identified as one of several factors that have been consuming oxygen and reduced oxygen concentrations in the water column during portions of the year. Following several years of intensive evaluation of existing data and identification of potential causes for the 303(d) listings for low dissolved oxygen concentrations local, federal, tribal, and state governments have been focused on identifying how stormwater influences water quality in this drainage.

7.1 Sampling Design and Rationale

The sampling design and rationale presented are intended to provide information that can be used to contribute to data gaps in the current modeling effort and will enhance the predictive capacity so that implementation plans are more likely to be effective. The proposed monitoring strategy addresses the impact potential sources of non-point stormwater contributions would have in diminishing dissolved oxygen concentrations and explain how much each of the suspected factors that diminish DO has on this continuing water quality impairment.

Stormwater Outfall Monitoring. Evaluate Water Quality conditions discharging from select stormwater outfalls at four locations in the study area.

STORMWATER OUTFALL STRUCTURES

Locations: Outlet of the stormwater pipe discharging to the edge or into Clarks Creek.

A. Parameters:
   The stormwater outlet drains an area in the Clarks Creek drainage. The characteristics of the water quality draining from the stormwater pipe are dependent on the land uses and human activities in that area of the drainage. The list of parameters recommended for analysis will be broad enough to capture any unique signatures of the drainage area when stormwater runoff occurs. Data from these monitoring efforts serve as a base of information for use in the current dissolved oxygen model enhancing the performance and reducing the number of assumptions made in constructing the model.

   Parameters will be measured from water samples collected immediately from the stormwater outfall pipe. The location of these structures had been mapped by the City of Puyallup and a schematic used to find candidate sites where stormwater outfall and public access intersected. Continuous field monitoring may be conducted at the outlet of the stormwater pipe structure in order to describe the response in stormwater quality as the event progresses. Flow measurements will be recorded by calibrating a flow rating curve with pressure transducer readings. The pressure transducer readings will be converted into flow estimates following collection and download of this data. Periodic check for actual flow measurements will be made during sample collection for other water quality parameters.

B. Reasons for Monitoring Design and Parameter Analysis:
   Requirements for maintenance of water quality conditions in waters of the state often will require that a TMDL model be constructed in order to inform on milestones for improvement ; identify specific pollutant loads that will bring the stream segment into compliance with water quality criteria for the State. Some of the data needed to improve the dissolved oxygen model has not been generated and instead has used assumed values to satisfy model data needs. The additional

effort proposed to collect actual stormwater outfall data and describe receiving water conditions is only a positive step in completing the current management strategy.

Clarks Creek Receiving Water Monitoring. Determine effects of stormwater outfall drainage into Clarks Creek.

CLARKS CREEK (Conveyance from the stormwater pipe to receiving water)
The stormwater outfalls are directed toward Clarks Creek in four locations that will be monitored in this study. The physicochemical characteristics of the receiving water will be evaluated for any changes that occur resulting from stormwater outfall discharge. Some of the factors that may ameliorate or exacerbate water pollution impacts are water velocity in the creek, incoming stormwater volume, channel shape, and timing when stormwater discharge enters the stream channel. The upstream/downstream locations isolate the stormwater outfall discharge impacts and determine if there are persistent conditions that occur at multiple stormwater outfall locations or if each location where stormwater enters the creek is different.

7.2 Sampling Locations and Frequencies

The two types of monitoring described in Section 7.1 require collection of physicochemical field data and water samples for laboratory analysis. The following description of proposed study sites and design for sampling (at discrete sites) are presented in descriptive and map form (Figure 7-1). The proposed discrete sites for sampling will be field-verified prior to final location. Once selections are made for sites they will be monumented using a GPS locational unit.

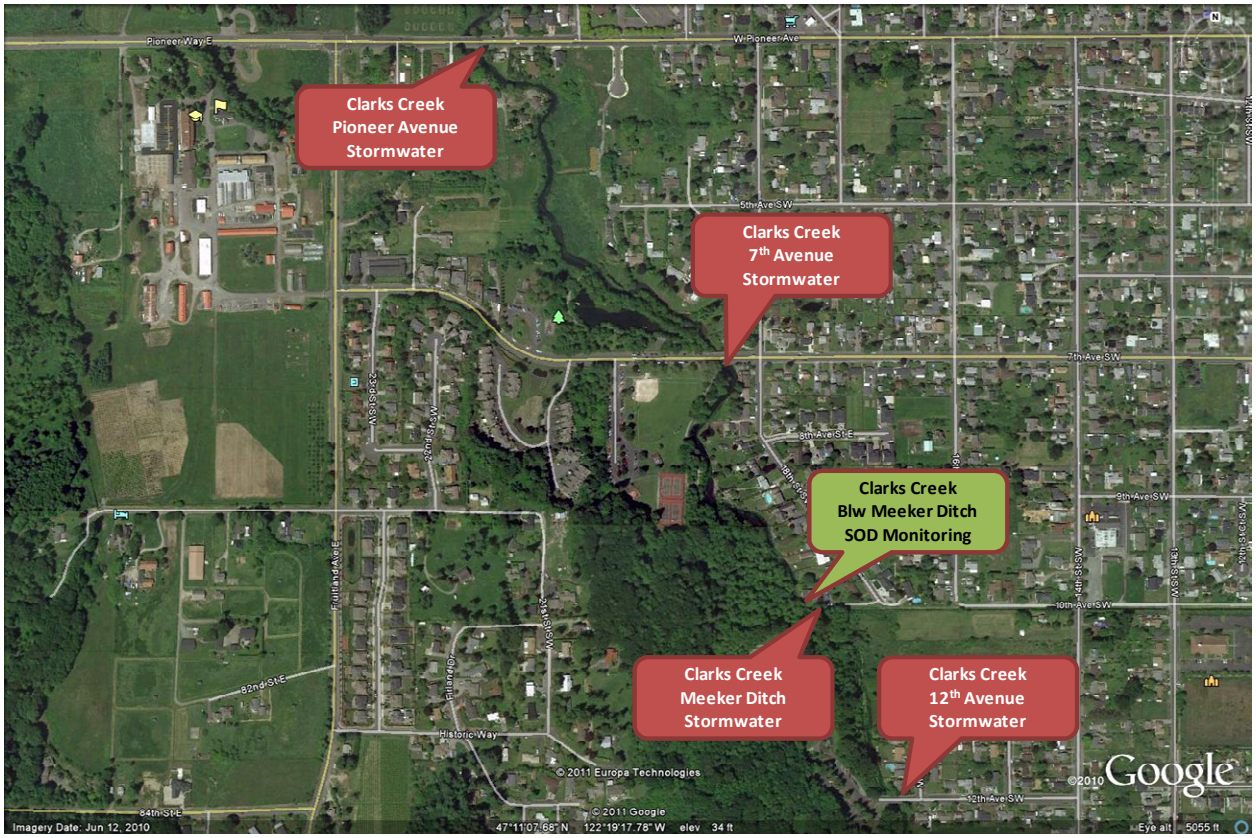

Figure 7-1. Proposed sample sites and locations for collection of stormwater outfall, surface water, and sediment oxygen demand data.

The remaining sample sites (Figure 7-2) will be used to measure sediment oxygen demand on two separate visits prior to beginning of a storm season (October 1st).

Figure 7-2. Proposed remaining sample sites and locations for collection of sediment oxygen demand data.

Stormwater Outfall Locations

A. Frequency of Sample Collection:

Sample collection timing and frequency is determined by the occurrence of storm events. Ideally, monitoring will be completed at 4 storm events; each with varying intensities of rainfall and longevity of the storm event. Monitoring based on these 2 factors provides some level of detail in understanding of pollutant delivery under varying storm conditions. The period of monitoring is established from wet season, October 1st through March 31st and the dry season, April 1st through September 30th of each calendar year the project is implemented.

Stormwater outfalls at each location have multiple pipes except at the Clarks Creek-Ball Park site (Figure 7-1). A single pipe will be identified and consistently sampled at each site with selection based on likelihood that noticeable flow is discharged during storm events.

Grab samples will be collected in order for sample integrity to be maintained and for making observations about environmental conditions when an investigator is present. Information gathered about physical characteristics of the water, water velocity from the stormwater outfalls, and surrounding information that might explain why specific water quality problems might arise are reasons why being present and sampling affords a greater opportunity to construct information for the critical feedback loop.

Clarks Creek Sampling

A. Upstream of Discharge

a. Surface Water Sample Collection

The upstream site for monitoring surface water quality will serve as the control for determining if the stormwater outfall discharge is a cause for changes in downstream water quality. The monitoring frequency for characterizing each storm event will be 6 visits at each upstream site and with uniformly spaced collection times. Additional monitoring effort will be conducted at both the upstream and downstream site; including placement of Sediment Oxygen Demand (SOD) Chambers that will be placed at select sites outside of storm events so that continuous monitoring of water quality conditions inside a chamber will be recorded with a HydroLab® unit. Procedures for deploying and operating the sediment oxygen demand chambers will follow the description in Murphy and Hicks (1986). Additional parameters that will be collected during surface water grab sampling and from within the SOD Chambers are:

- Water Temperature
- Dissolved Oxygen concentration
- Conductivity
- pH

These additional parameters are important for understanding how the receiving water assimilates effects from additional pollutant input. Conversely, the receiving water may, at times, have higher concentrations of nutrient input that uses up the assimilative capacity. By generating a greater amount of information about water quality characteristics, identification of pollutant sources will assist in making drainage-level management decisions to assure the Clarks Creek implementation plan goals are met.

B. Downstream of Discharge

a. Surface Water Sample Collection

Comparison between upstream and downstream (of the stormwater outfall pipe) water quality characteristics will evaluate the effect stormwater discharge has on receiving water. The upstream/downstream sample design with each site located in close proximity to the outfall pipe will isolate effects from other potential pollutant sources. Water quality parameter measurements will be sampled identical to those described for the upstream site above. In addition, water velocity (flow) measurements will be conducted using either a calibrated pressure transducer calibrated using an existing flow-rating curve or by estimating flow at the time of sample collection. The total pollutant loads originating from upstream of the stormwater outfall pipe will be combined with mainstem Creek loads and the resulting load compared against the downstream estimate. This analytical exercise is intended to reveal the advent of a cumulative effect for each pollutant in a downstream direction.

7.3 Order (Timing) of Sampling

Non-point source pollutants enter streams at different rates during each season throughout the year with transfer and distance of travel influenced primarily by climatic events. Each of the tasks addresses potential source and pathway for introduction of pollution into Clarks Creek and accounts for optimal time of year when pollution is either detectable or loading is greatest to surface water. In some cases, a division of the year that differentiates wet- from dry seasons is used as a contrast to estimate the magnitude of pollution load introduced during a time period. Distinguishing seasons and differences in pollution load are used as a guide to suggest abatement of pollution by adjusting existing BMPs (best management practices). The suggested monitoring interval is has been determined from previous studies to characterize the temporal differences that occur for timing and location of pollutant entry into Clarks Creek.

The following are descriptive examples for sampling dates and frequencies for satisfying study objectives in each of the tasks:

Stormwater Outfall Sampling

- Sampling Intervals from the stormwater outfall pipes; Rainfall Events and No. of Visits
  October 1st – March 31st (3-4 visits)
  April 1st – September 30th (2-3 visits)

Clarks Creek Sampling

- Clarks Creek upstream/downstream sampling:
- October 1st – March 31st
- Surface Water Temperature (grab)
- Dissolved Oxygen concentration (grab)
- Conductivity (grab)
- pH (grab)

- April 1st – September 30th
- Surface Water Temperature (grab)
- Dissolved Oxygen concentration (grab)
- Conductivity (grab)
- pH (grab)
- SOD Chambers (2 deployments at 3 sites x 3 replicates; non-storm event)

8.0 SAMPLING METHODS

Sampling methods focus on characterization of surface water chemistry (e.g., dissolved oxygen and pH) and some of the physical properties (e.g., temperature and conductivity). The collection of samples prescribes collection periods, handling procedures, and identification procedures that minimize and identify systematic error in the Clarks Creek project. Performance expectations of the samplers described in this section records information that can be used for data verification and validation.

Achieving accuracy in data generation begins with a sampling procedure that is well conceived, described, and carefully implemented (WSDOE 2001). The sampling locations, sample types, sampling equipment, and methods were briefly described in *Section 2.0 Project Description*. This section of the QAPP discusses the details of the sample collection method and the sample handling and labeling procedures (U.S. EPA 1990).

8.1 Sampling Schedule

Stormwater structure and Creek sampling will occur over a six month Index Period; characterizing the variety of storm events through several water quality collection events will capture pollutant loading from intensity and length of individual storms. Measurements will be taken at pre-determined locations for characterizing water quality in each component of the study area and during specific periods of the year (e.g., optimal times for characterizing water quality conditions) based on information reported in Table 8-1.

Table 8-1. Monitoring schedule and timing/frequency for collection of samples.

Sampling Routine	Jan.	Feb	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Task #1	Stormwater Outfall Monitoring **(Wet Season)**			Stormwater Outfall Monitoring **(Dry Season)**						Stormwater Outfall Monitoring **(Wet Season)**		
Task #2	Clarks Creek Upstream/Downstream Monitoring **(Wet Season)**			Clarks Creek Upstream/Downstream Monitoring **(Dry Season)**						Clarks Creek Upstream/Downstream Monitoring **(Wet Season)**		
				SOD Monitoring 2 events during the dry season **(Dry Season)**								

Note: Task #1 – Grab sample collection and field meter results of 6 water quality samples collected per storm event (4storm events characterized) at each sampling location.
Task #2 – Grab sample collection and field meter results of 12 water quality samples collected per storm event (4 storm events characterized).

8.2 Sample Collection and Handling

Recommended sample sizes, containers, preservation techniques, and holding times for measurement of the conventional water quality parameters are listed in Table 8-2. Sample containers will be kept closed until each set of sample containers is filled. All samples will be placed immediately in a cooler and kept cool and dark until delivered to the lab.

Water samples will be collected for each monitoring program using specific devices that minimize potential for contamination and that enable samples to be collected safely. Each of the monitoring programs presents challenges in locating and collecting a representative water sample. The following collection devices and locations for sampling will be used for each monitoring program:

1. Stormwater Structure Sampling: cleaned collection vessel from bank or in the pond.
2. Creek Sampling: Surface water collected from bank or while standing downstream of the sample collection location.

Note:

a. Bank sampling or instream/pond sampling will be conducted by filling collection bottles supplied by the contract laboratory.

Total phosphorus and soluble reactive phosphorus will be collected in polyethylene or glass bottles provided by the laboratory. Sample bottles and laboratory glassware for lake-related sampling shall be reserved for ultra-low P waters (i.e. lakes, streams, or basins) and can never be used for sampling or analyzing wastewater or agricultural runoff where there is a potential to exceed 100 µg/L. All sample bottles are to be acid washed with 1N HCL six times followed by 6 rinses with de-ionized water (for low-level nutrient analysis and to ensure acid is rinsed away, especially in soft water). Dissolved oxygen samples will be collected in glass bottles.

Whenever possible, samples will be processed within the recommended holding time. However, when volunteers are available for monitoring duties there may be a delay on delivery of samples when collected on weekends; not delivered to the laboratory until Monday. This would exceed the recommended holding time for select variables like soluble reactive phosphorus samples. Lab results from samples exceeding holding times may be accepted as usable data depending on sample storage conditions following collection. Data Management Section 16.0 further outlines how to record variation from QAPP protocol or DQOs (Data Quality Objectives).

Table 8-2. Containers, preservation techniques, and holding times for measurement of water quality and sediment parameters.

Parameters	Sample Container	Sample Volume	Preservation	Recommended Holding Time
Surface Water				
Total Phosphorus	Polyethylene, Glass	50 ml	Cool, <4ºC	28 days
Soluble Reactive Phosphorus	Polyethylene, Glass	125 ml	Filter within 12 hours, Cool <4ºC	48 hours
Total Kjeldahl Nitrogen	Polyethylene, Glass	125 mL	Cool,<4° C	28 days
Ammonia	Polyethylene, Glass	125 mL	Cool,<4° C	48 h
Nitrate-nitrite	Polyethylene, Glass	125 mL	Cool, 4° C	48 h
DOC	HDPE	60 mL	Filter within 12 hours, Cool,<4° C	28 days
Bicochemical Oxygen Demand	Plastic Cubitainer	4 L	Cool, 0° C - 6° C	48 hours
Totals Suspended Solids	Polyethylene	1000 mL	Cool, <4° C	7 days
Volatile Suspended Solids	Polyethylene	1000 mL	Cool, <4° C	7 days
Fecal Coliform	Glass	250-500mL	Cool, 0° C - 10° C	24 hours
Sediment				
Sediment Oxygen Demand	SOD Chamber	Chamber Volume ECY EAP036	In-Situ	Continuous

TBD=to be determined

8.3 Field Recording Methods

When visiting a sampling station, the sample collector will record the following information on water-proof field sheets. Detailed information on field observations should include the following:

- Date
- Time
- Names of sampling personnel

- Number/type of samples collected
- Weather
- Descriptions of any photographs taken
- On-site field measurement (e.g., temperature, water level)
- Color of water
- Unusual conditions (changes in land uses, presence of oil sheens, odors, nuisance conditions).

8.4 Sampling Identification and Custody

Each sample bottle will have a waterproof sample identification label or tag. All sample bottles will be labeled with an indelible marker before the time of collection. Sample labels will include station designation, date, time, collectors' initials and type of sample. Special analyses to be performed and any pertinent remarks will also be recorded on the label.

All water quality samples will be delivered by courier to the contract commercial laboratory. Samples will be accompanied by the sample tracking forms with sample numbers, requested analyses, number of bottles, bottle sizes and contact information. An example of the sample tracking (or Chain-of-Custody) form that may be used for the Clarks Creek project is presented in Appendix A.

Water samples will be collected, placed in the labeled transfer bottles, and delivered to the laboratory as soon as possible following collection. Bottleware for each parameter, including the container types and preservatives, will be supplied by the contract laboratory and used to collect samples. Handling requirements for samples collected in the Clarks Creek Stormwater Monitoring study area will also be provided by the laboratory. The samples taken for laboratory analysis will be stored in coolers containing re-sealable bags of ice. The temperature inside the coolers and acid preservation for samples will be verified by the receiving laboratory as a component of field quality control.

All samples will be transferred to the receiving analytical laboratory using Chain of Custody forms. The sample Chain of Custody form (included in Appendix A) acts as a record of sample shipment and a catalog of the contents of each shipment (coinciding with information on the field record), in addition to maintaining a complete record of evidentiary custody transfer. It will contain the following, at a minimum:

- Sampler's name
- Project name
- Page number (e.g., 1 of 1)
- Sample location (facility name, waste stream, sampling point)
- Collection date and time
- Sample number
- Number of containers
- Type of analysis required
- Laboratory recipient signature
- Laboratory receipt date and time

Immediately following the packing of each shipping container, each container (cooler) will be secured with packaging tape.

9.0 SAMPLE HANDLING AND CUSTODY

All fish collected within the sample reach will be identified to species. Specimens that cannot be identified in the field are preserved in a 10% formalin solution and stored in labeled jars for subsequent laboratory identification.

10.0 ANALYTICAL METHODS

All analysis methods used for this project are approved standard analytical methods approved for use by the EPA and Ecology (Table 7-1). Water quality parameters including pH, dissolved oxygen, conductivity and temperature will be measured in the field during each sampling event using a YSI®, Hydrolab®, or other similar multi-parameter probe. Routine maintenance on the multi-parameter probe will be conducted according to schedules described in the manual provided by the manufacturer and recorded in the maintenance log for each instrument. All technical maintenance or repairs of the instrumentation while in use will be reported to the suppliers' trained staff upon completion of each sampling event for suggestions on corrective action.

The contracted laboratory for the program must be Ecology-certified for drinking-water analyses, and this lab will perform all other physicochemical analyses for this study. The contract laboratory QMP (Quality Management Plan) must be on file with Ecology detailing their quality assurance procedures.

10.1 Field Sampling Procedures and Laboratory Analysis Procedures

Procedures describing field sampling are fully described for each parameter in Section 8. Laboratory Analysis procedures are described in Section 4. All water sample analyses except the field measurements of temperature, DO (dissolved oxygen), conductivity, and pH will be completed by fully qualified subcontract laboratories. The analytical chemistry methods to be used, as well as the sample volume requirements, detection limits, and holding times, will be consistent with the laboratory's QA and QC plans and SOPs.

10.2 Calibration of Equipment

Care will be taken to ensure that the multi-parameter probes used for field measurement are calibrated and adjusted prior to sampling by using known buffer solutions (low ionic strength buffers) that are included with the instrument. The multi-parameter probes will be calibrated following the manufacturer's designated procedures. Field measurements that exceed the normal range of values for each parameter will require that a calibration check of the instrument be completed upon return from the field. If the calibration check falls outside the acceptable calibration limits, the instrument will be re-calibrated and a new field measurement will be taken at the site. All calibration checks and remediation actions taken will be recorded on field forms and in calibration logs and be available upon request.

Laboratory turnaround times must be within 10 to 20 working days. Any issues regarding analytical data quality will be resolved by the Tetra Tech and Puyallup Tribe Project Managers.

Laboratory analytical procedures will follow U.S. EPA (1983, 1991) or APHA et al. (2005) methods. Detection limits and methods are summarized in Section 4 and in Table 4-5.

Table 10-1. Measurement methods for laboratory analysis of surface water samples.

Analyte	Sample Matrix	Samples [Number/ Arrival Date]	Expected Range of Results	Reporting Limit (RL)	Sample Prep Method	Analytical (Instrumental) Method
Laboratory Results						
Total Phosphorus	Water	180		2.0 µg/L	Persulfate, autoclave	EPA 365.1
Soluble Reactive Phosphorus	Water	180		1.0 µg/L	0.45u filtration	EPA 365.1
Total Kjeldahl Nitrogen	Water	180		50 µg/L	Persulfate, autoclave	SM 4500
NO3+NO2-N	Water	180		10 µg/L	None	EPA 353.2
Ammonia-N	Water	180		5.0 µg/L	None	EPA 350.1
Total Suspended Sediment	Water	180		0.5 mg/L	None	SM2540D
Volatile Suspended Sediment	Water	180		0.5 mg/L	None	SM2540E
Dissolved Organic Carbon (DOC)	Water	180		0.250 mg/L	None	EPA 415.1
Biochemical Oxygen Demand (5-day)	Water	180		2.0 mg/L	None	SM5210B
Fecal Coliform	Water	180		1 cfu/100 mL	None	SM9222D
Field Results						
Dissolved Oxygen (DO)b	Water	180	RL to 12 mg/L	<0.1 mg DO/L	None	Standard Methods 4500-O G [a]
pH [b]	Water	180	pH 3-9	pH<1	None	Standard Methods 4500-H^{+} [a]
Temperature [b]	Water	180	0-30 ^{0}C	32°C	None	Standard Methods 2550B a
Conductivity [b]	Water	180	RL to 200 µsiemens/cm	1 Microsiemens/cm[c]	None	USGS NFM 6.3.3A-SW
Sediment						
SOD Chamber	Sediment	18		0.2 mg/L	None (field reagents for samples if using Winkler Titration)	ECY EAP036 SOP

NOTES:

a. All Standard Methods are from Standard Methods for the Examination of Water and Wastewater, 21st Edition, American Public Health Association, 2005
b. This is a field measurement.
c. Cell chosen, based on anticipated conductance will determine reporting limit.

11.0 QUALITY CONTROL

Data quality is addressed, in part, by consistent performance of valid procedures documented in Standard Operating Procedures (SOPs). It is enhanced by the training and experience of project staff (Section 5.0) and documentation of project activities (Section 6.0). This QAPP and other supporting materials will be distributed to all sampling personnel. A QC Officer will ensure that samples are taken according to the established protocols and that all forms, checklists, and measurements are recorded and completed correctly during the sampling event.

To establish the precision, accuracy, and representativeness of data obtained from the sampling effort, QC samples for laboratory analyses will be analyzed according to methods reported in Table 10-1 and

collected at the frequency described in Figure 11-2. Three types of QA and QC samples will be analyzed during each sampling event: field blanks, sample QC, and laboratory QC.

Field blanks will be collected during each sampling event for all the chemical parameters listed in Section 4.2 to ensure that no contamination was introduced during sample collection, preservation, and handling. At the same time samples are collected, field blanks will be prepared by running analyte-free deionized water through the same equipment used to collect the samples, collecting it in the appropriate sample containers, and preserving it with the same procedures used to preserve the samples. The field blanks will be collected, stored, shipped, and analyzed with the associated samples. In addition, a transport blank will be included in the cooler to determine if cross-contamination among samples occurs. If field blank target analyte concentrations are detected, the field blanks will be examined to determine the source of contamination.

Analyte concentrations measured in samples collected during the event will be considered valid when no corresponding field blank analyte concentrations are detected or when the sample analyte concentrations are at least 10 times the field blank analyte concentrations. If a sample analyte concentration is at least 5 times but less than 10 times the field blank analyte concentration, the laboratory will report the numerical result as an upper limit of the true analyte concentration by the laboratory. If a sample analyte concentration is less than 5 times the field blank sample concentration, the results for that analyte will be considered unacceptable, and the result will be reported as undetected using the value as the limit of quantitation for the sample.

Analytical QC samples must be collected for 10 percent of the samples for each sampling event. The additional volumes collected for analytical QC are used to perform duplicate and spiked sample analyses or matrix spike and matrix spike duplicate analyses, depending on method requirements. For the purpose of this collection, sample QC will be evaluated using the criteria established in Table 4-5 (Target analytes, analysis methods, and quantitation limits), and as detailed in the reference methods and the laboratory QA Plan. Any results noted as deviating from program or laboratory QC acceptance criteria require immediate investigation, and thorough documentation as detailed in the assessment and response actions of this QAPP. Corrective actions might vary widely from re-preparation and reanalysis to disqualification of sample data for use. Under no circumstances will outlying sample or QC results be submitted without a detailed explanation. The Project Manager should be contacted immediately regarding deviations for which there is not a suitable analytical corrective action due to holding time or other restrictions, so that recollection can be requested, if possible.

In addition, **laboratory QC** analyses will be performed concurrently with sample preparation and analysis. Laboratory QC includes analysis of appropriate reagent or method blanks for each analytical method or technique, as well as analysis of laboratory control sample or certified standard reference materials as appropriate. Method and reagent blanks should be free from analytes of interest at levels above the project quantitation limits. The same criteria applied to field blanks will be applied to laboratory blanks in sample data interpretation for use. (Analyte concentrations measured in samples collected during the event will be considered valid when no corresponding field blank analyte concentrations are detected or when the sample analyte concentrations are at least 10 times the field blank analyte concentrations. If a field blank analyte concentration is at least 5 times, but less than 10 times the sample analyte concentration, the numerical result will be reported as an upper limit of the true analyte concentration by the laboratory. If a blank sample analyte concentration is less than 5 times the sample analyte concentration, the results for that analyte will be considered unacceptable.)

Following data entry operations, all spreadsheets or database printouts will be proofread using the original handwritten field and laboratory data sheets, where available. Someone other than the data entry specialist will conduct this review.

Measurement performance criteria for data to be collected during this project are discussed in the following sections.

11.1 Precision

Precision is a measure of internal method consistency. It is demonstrated by the degree of mutual agreement between individual measurements or enumerated values of the same property of a sample, usually under demonstrated similar conditions. Precision of sampling methods is estimated by taking duplicate samples at the same sampling station at approximately 10 percent of the sites, usually at the final sampling point(s). Duplicate sampling for this system, due to its current impairment status, might indicate significant variability for some parameters because of differing amounts of suspended biological (algal) and organic materials. The usability assessment will include consideration of this condition in evaluating field duplicates as a measure of the entire measurement system. Although precision evaluations within 20 percent relative percent difference (RPD) are generally considered acceptable for water quality studies and analyses, no data validation or usability action will be taken for results in excess of the 20 percent limit. Instead, the results will be noted and compared with the balance of the parameters analyzed for a more comprehensive assessment before any negative assessment, disqualification, or exclusion of data.

This QC calculation also addresses uncertainty due to natural variation and sampling error. Precision is calculated from two duplicate samples by RPD as follows:

$$RPD = \frac{|C_1 - C_2|}{\overline{(C_1, C_2)}} \times 100\%$$

equation 11-1

where C_1 = the first of the two values and C_2 = the second of the two if precision is to be calculated from three or more replicate samples (as is often the case in laboratory analytical work), the relative standard deviation (RSD) will be used and is calculated as

$$RSD = \frac{s}{\overline{\chi}}$$

equation 11-2

where χ is the of the replicate samples, and s is the standard deviation and is determined by the following equation:

$$SD = \sqrt{\frac{\sum_{i=1}^{n} \left(\chi_i - \overline{\chi}\right)^2}{n-1}}$$

equation 11-3

where χ_i is the measured value of the replicate, $\overline{\chi}$ is the mean of the measured values, and n is the number of replicates.

For this project, duplicate field samples will be collected to assess sampling precision and field blanks will accompany samples to assess the potential for contamination in the sample collection process.

11.2 Accuracy

Accuracy is defined as the degree of agreement between an observed value and an accepted reference or true value. Accuracy is determined by using a combination of random error (precision) and systematic error (bias) due to sampling and analytical operations. Bias is the systematic distortion of a measurement process that causes errors in one direction so that the expected sample measurement is always greater or lesser to the same degree than the sample's true value. EPA now recommends that the term *accuracy* not be used and that *precision* and *bias* be used instead.

Because accuracy is the measurement of a parameter and comparison to a *truth*, and the true values of environmental physicochemical characteristics cannot be known, use of a surrogate is required. Accuracy of field measurements will be assumed to be determined through use of precision. Accuracy of laboratory chemical measurements will be determined by analysis of matrix spikes and matrix spike duplicates, laboratory control samples (fortified blanks), and other method-specified QC samples. Analyses for specific nutrients will include the use of spiked samples or certified standard reference materials, where appropriate, to determine percent recovery. In the absence of manufacturers' certified range, the recoveries for spiked analytes should not exceed $\pm$ 20 percent of the true values to be acceptable (unbiased). Bias is assessed in terms of recovery of a known value for control samples and matrix spikes and is calculated as follows:

% Recovery (LCS):

$$\%\,\mathrm{Recovery} = \frac{analytical\,result}{truevalue} \times 100\%$$

equation 11-4

% Recovery (MS):

$$\%\,\mathrm{Recovery} = \frac{(spikedsampleresult - sampleresult)}{amountspiked} \times 100\%$$

equation 11-5

The accuracy of field equipment for the measurement of temperature, DO, conductivity, salinity, and pH will be determined at a minimum of two points that span the expected range of values for these parameters. Instruments used and procedures for determining accuracy include the following:

Temperature sensors:

The accuracy of temperature sensors used in this project will be checked using a standard thermometer.

DO sensors:

The accuracy of DO sensors and methods used in this project will have higher standards based on performance of the optical probes. The LDO (luminescent dissolved oxygen) sensor uses luminescent technology that results in the lowest level of drift over continuous use. Calibration is completed using air-saturated water equilibrated over a 12-24 hour period. Determination of dissolved oxygen concentration is adjusted according to barometric pressure at the time of calibration and the probe meter adjusted to the calculated dissolved oxygen concentration.

Conductivity sensors:

The accuracy of the salinity and conductivity sensor used in this project will be checked using the autocal solution provided by the manufacturer. The conductivity sensor is calibrated from the autocal solution, which contains a certified 0.449 µS/cm solution (or other low-level conductivity solution).

pH sensors:

The accuracy of pH sensors used in this project will be checked using calibration solution provided by the manufacturer (or equivalent quality), which contains any two of three buffer solutions (pH 4, pH 7, pH 10). These solutions will be low-ionic strength with meter calibration accounting for temperature of the solution at the time of meter adjustment.

11.3 Representativeness

Data representativeness is defined as the degree to which data accurately and precisely represents a characteristic of a population, parameter, and variations at a sampling point, a process condition, or an environmental condition. It therefore addresses the natural variability or the spatial and temporal heterogeneity of a population. The number of sampling points and their location within the study area will be examined to ensure that representative sample collection of each area of the watersheds and each target analyte series occurs. Multiple sampling episodes will be conducted over a period of 6 months to obtain sufficient data to determine analyte concentration variability.

11.4 Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and entered into the data management system. To achieve this objective, every effort is made to avoid accidental or inadvertent sample or data loss. Accidents during sample transport or lab activities that cause the loss of the original samples will result in irreparable loss of data. Lack of data entry into the database will reduce the ability to perform analyses, integrate results, and prepare reports. Samples will be stored and transported in unbreakable (plastic) containers wherever possible. All sample processing (sub-sampling, sorting, identification, and enumeration) will occur in a controlled environment within the laboratory. Field personnel will assign a set of continuous identifiers to a batch of samples.

Percent completeness (*%C*) for measurement parameters can be defined as follows:

$$\%C = \frac{V}{T} \times 100\% \qquad \text{equation 11-6}$$

where V = the number of measurements judged valid and T = the total number of measurements planned. For this project, sampling will be considered complete when no less than 90 percent of the samples collected during a particular sampling event are judged valid.

11.5 Comparability

Two data sets are considered to be comparable when there is confidence that the two sets can be considered equivalent with respect to the measurement of a specific variable or group of variables. Comparability is dependent on the proper design of the sampling program and on adherence to accepted sampling techniques, SOPs, and QA guidelines.

Table 11-1. Quality Control samples; sample types and frequency.

	Matrix	Field		Laboratory (%)			
Parameter		**Blanks**	**Replicates**	**Check Standards**	**Method Blanks**	**Analytical Duplicates**	**Matrix Spikes**
Laboratory Parameter							
Total Phosphorus	Water	1	1	Minimum once per quarter	One per analysis batch of 20 samples	Minimum 10% of samples	Minimum 10% of samples

Parameter	Matrix	Field		Laboratory (%)			
		Blanks	Replicates	Check Standards	Method Blanks	Analytical Duplicates	Matrix Spikes
Soluble Reactive Phosphorus	Water	1	1	Minimum once per quarter	One per analysis batch of 20 samples	Minimum 10% of samples	Minimum 10% of samples
Total Kjeldahl Nitrogen	Water	1	1	Minimum once per quarter	One per analysis batch of 20 samples	Minimum 10% of samples	Minimum 10% of samples
Nitrate+Nitrite-Nitrogen	Water	1	1	Minimum monthly (frequency not specified in method)	Two reagent blanks after instrument calibration before sample analysis	Minimum 10% of samples	Minimum 10% of samples
Ammonia	Water	1	1	Minimum once per quarter	One per analysis batch of 20 samples	Minimum 10% of samples	Minimum 10% of samples
Totals Suspended Solids	Water	1	Minimum once per quarter	One per analysis batch of 20 samples	Minimum 10% of samples	Minimum 10% of samples	
Volatile Suspended Solids	Water	1	Minimum once per quarter	One per analysis batch of 20 samples	Minimum 10% of samples	Minimum 10% of samples	
Dissolved Organic Carbon (DOC)	Water	1	1	After each new calibration curve, or at least quarterly	Filter blank per analysis batch of 20 samples	One per analysis batch of 20 samples	One per analysis batch of 20 samples
Biochemical Oxygen Demand	Water	1	Minimum once per quarter	One per analysis batch of 20 samples	Minimum 10% of samples	Minimum 10% of samples	
Fecal Coliform	Water	1	Minimum once per quarter	One per analysis batch of 20 samples	Minimum 10% of samples	Minimum 10% of samples	
Field Parameters							
Dissolved Oxygen (DO)	Water	N/A	N/A	N/A	N/A	N/A	N/A
pH	Water	N/A	N/A	N/A	N/A	N/A	N/A
Temperature	Water	N/A	N/A	N/A	N/A	N/A	N/A
Conductivity	Water	N/A	N/A	N/A	N/A	N/A	N/A
Sediment Parameter							
Sediment Oxygen Demand	Sediment	1	1	One per analysis	One per analysis	One per analysis batch of 20 samples	N/A

Measurement performance criteria for data to be collected during this project are discussed in the following sections.

12.0 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Periodic regular inspection of equipment and instruments is needed to ensure the satisfactory performance of the systems. Equipment to be used during the sampling event is listed in the appropriate SOPs. Before any piece of sampling or measurement equipment is taken into the field, it will be inspected to ensure that the equipment is appropriate for the task to be performed, all necessary parts of the equipment are intact, and the equipment is in working order. In addition, the equipment will be visually inspected before its use. Broken equipment will be labeled "DO NOT USE" and returned to the Tt office to receive necessary repairs, or it will be disposed of. Backup field equipment will be available during all field activities in the event of equipment failure.

The objective of preventive maintenance is to ensure the availability and satisfactory performance of the measurement systems. All field measurement instruments will receive preventive maintenance in accordance with the manufacturer's specifications.

13.0 INSTRUMENT CALIBRATION AND FREQUENCY

Calibrated field instruments will be used for in-field, instantaneous measurement of temperature, DO, conductivity, salinity, and pH. Instruments will be calibrated in accordance with manufacturer's specifications and as described in the measurement SOPs (Appendix B to this QAPP). The SOPs include pre- and post-calibration verification on each sampling date. Verification of pH measurement accuracy will be checked against standard solutions in the field and adjustments made to the meter prior to the next measurement, if necessary.

The calibration of temperature, DO, conductivity/salinity, and pH probes will be checked before and after each sampling event, or as deemed necessary by the multiprobe's manufacturer, using certified standard solutions. Field calibrations will be recorded in the field sampling log book. Individual sensors will be considered to be operating correctly if the instrument reading is within 15 percent of the calibration standard value. If the two values are not within 15 percent of each other, the probe will be cleaned and recalibrated. If these two values are still not within 15 percent of each other following cleaning and recalibration, the probe itself will be replaced.

14.0 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Supplies and consumables are those items necessary to support the sampling and analysis operation. They include bottleware, calibration solutions, hoses, decontamination supplies, preservatives, and various types of water (e.g., potable, deionized, organic-free). Upon delivery of supplies, Tt will ensure that types and quantities of supplies received are consistent with what was ordered, and with what is indicated on the packing list and invoice for the material. If any discrepancies are found, the supplier will be contacted immediately.

While preparing for specific sampling events, the field sampling Task Leaders will be responsible for acquiring and inspecting materials and solutions that will be used for obtaining the samples for field measurements. Other materials must also meet specific requirements as indicated by the appropriate manufacturer; for example, only certified standard solutions will be used for the multiprobe calibration. Buffers and standards will be checked for expiration dates and appearance (correct color).

15.0 NONDIRECT MEASUREMENTS

Comparison of any data collected during this field effort to historical data will be used for qualitative assessment only. Assessment of applicability for historical data is outside the scope of this document and is not addressed further in this data collection QAPP.

16.0 DATA MANAGEMENT

Samples will be documented and tracked on Field Data Record forms, Sample Identification labels, and Chain of Custody records (Appendix A). The Field Task Leader will be responsible for ensuring that these forms are completed and reviewed for correctness and completeness by the designated field QC Officer. Tetra Tech, Inc. will maintain copies of these forms in the project files. A sampling report will be prepared following each sampling event. Another person will manually check data entered into any spreadsheet or other format against the original source to ensure accurate data entry. If there is any indication that requirements for sample integrity or data quality have not been met (for samples or measurements collected by Tetra Tech, Inc.), the Tetra Tech Project Manager will be notified immediately (with an accompanying explanation of the problems encountered).

Laboratory data will be managed in accordance with established protocols. The data will be submitted to the Puyallup Tribe in hard copy and in electronic database format (Excel spreadsheet for addition to an Access® database), as well as scanned data recorded on CD-ROM. The electronic data will be submitted in a format to be negotiated with the lab. At a minimum, the electronic data files will include the date and time of sample collection, date received, date of preparation or analysis, requested parameter, analytical batch ID, results, and data qualifiers. Electronic data will be provided for all samples and QC, including laboratory blanks, control samples, duplicates, and spiked samples analyzed in a format compatible with the requirements of Puyallup Tribe's (or contractor) statistical and modeling software routines.

Hard copy data packages will be paginated, fully validated raw data packages that include an analytical narrative with a signed certification of compliance with this QAPP and all method requirements; copies of Chain of Custody forms; sample inspection records; laboratory sample and QC results; calibration summaries; example calculations by parameter; and copies of all sample preparation, analysis, and standards logs adequate to reconstruct the entire analysis. The CD-ROM data will include a full copy of the paginated report scanned and stored in portable document format (PDF) for potential future submission to the client, if requested, and for long-term storage in the project files. Initially, the full raw data package will be submitted to the Tetra Tech QAO for assessment of compliance with the program goals and guidance.

All computer files associated with the project will be stored in a project sub-directory by Tetra Tech (subject to regular system backups) and will be copied to disk for archive for 5 years subsequent to project completion (unless otherwise directed).

Data obtained during sampling activities will be entered into field notebooks.
The following is a list of data information that will be kept at Tetra Tech (Seattle Surface Water Group) or the contract laboratory for review upon request:

- Field equipment and chemicals maintenance, cleaning and calibration records;
- Field notebooks;
- Sample Data Sheets;
- Photographs of sampling stations and events;
- Chain-of-Custody forms;
- Laboratory equipment maintenance, cleaning and calibration records;

- Laboratory bench sheets, control charts, and SOPs;
- Records of QA/QC problems and corrective actions (field and/or laboratory);
- Laboratory data QC records;
- Records of data review sheets;
- Duplicate, performance evaluation records and other QA/QC control records (field and laboratory); and
- Data review, verification and validation records.

Data handling equipment will include computer software applications Microsoft Excel® (in an Access® compatible format).

Field notebooks will be filled out using *Write in the Rain*® ink or pencil, and will not be erased. Changes will be made by crossing out errors, initialing, and adding correct information. Field notebooks will be bound with numbered pages.

Laboratory data results will be recorded on laboratory data sheets, bench sheets and/or in laboratory logbooks for each sampling event. These records as well as control charts, logbook records of equipment maintenance records, calibration and quality control checks, such as preparation and use of standard solutions, inventory of supplies and consumables, check-in of equipment, equipment parts and chemicals will be kept on file at the laboratory.

Any procedural or equipment problems will be recorded in the field notebooks. Any deviation from this Stormwater Sampling Workplan (SSW) will also be noted in the field notebooks. Data results will include information on field and/or laboratory QA/QC problems and corrective actions.

Standard turnaround time for the analytical samples taken to the contract laboratory will be seven to ten working days.

Chain-of-custody forms will be kept with the sample during transport and will accompany data results back to the Puyallup Tribe Project Manager. Training records and data review records will be kept on file at Puyallup Tribe Offices and be available on request. All sample analysis records and documents are kept at the contract laboratory and will be available for inspection at any time. In addition to any written report, data collected for the project will be provided electronically via a CD-ROM or e-mail ZIP file.

All records will be retained by the contract laboratory for five years. All project records at Tetra Tech should be retained permanently.

A Microsoft Access® data management system should eventually be developed for use in analyzing and interpreting results. The system should be a relational database that enables the analyst to aggregate data from a variety of tables and identify correlates among media and settings in each study reach.

17.0 ASSESSMENT AND RESPONSE ACTIONS

The QA program under which this task order will operate includes technical system audits, with independent checks of the data obtained from sampling, analysis, and data-gathering activities. This process is illustrated in Figure 17-1 as an example for how QA decision-making progresses. Tt will review QA programs that all project staff follow to ensure similar levels of QA and QC are attained. The essential steps in the QA program are as follows:

- Identify and define the problem
- Assign responsibility for investigating the problem

- Investigate and determine the cause of the problem
- Assign and accept responsibility for implementing appropriate corrective action
- Establish the effectiveness of and implement the corrective action
- Verify that the corrective action has eliminated the problem

Many of the technical problems that might occur can be solved on the spot by the staff members involved; for example, by modifying the technical approach, repairing instrumentation that is not working properly, or correcting errors or deficiencies in documentation. Immediate corrective actions form part of normal operating procedures and are noted in records for the project. Problems not solved this way require more formalized, long-term corrective action. If quality problems that require attention are identified, Tt or the subcontractor will determine whether attaining acceptable quality requires short- or long-term actions. If a failure in an analytical system occurs (e.g., performance requirements are not met), the appropriate QC Officer or subcontractor QA Manager will be responsible for corrective action and will immediately inform the Tt PM or QAO, as appropriate. Subsequent steps taken will depend on the nature and significance of the problem, as illustrated in Figure 17-1.

The Tt Project Manager has primary responsibility for monitoring the activities of this project and identifying or confirming any quality problems. These problems will also be brought to the attention of the Tt QAO, who will initiate the corrective action system described above, document the nature of the problem, and ensure that the recommended corrective action is carried out. The Tt QAO has the authority to stop work on the project if problems affecting data quality require extensive effort to resolve and are identified.

The Puyallup Tribe and Tt Project Managers will be notified of major corrective actions and stop work orders.

Corrective actions might include the following:

- Reemphasizing to staff the project objectives, the limitations in scope, the need to adhere to the agreed-upon schedule and procedures, and the need to document QC and QA activities
- Securing additional commitment of staff time to devote to the project
- Retaining outside consultants to review problems in specialized technical areas
- Changing procedures
- The Tt Project Manager may replace a staff member or subcontractor, as appropriate, if it is in the best interest of the project to do so.
- The Tt QC Officers are responsible for overseeing work as it is performed and periodically conducting checks during the data entry and analysis phases of the project. As data entries, calculations, or other activities are checked, the person performing the check will sign and date a hard copy of the material or complete a review form, as appropriate, and provide this documentation to the Tt Project Manager for inclusion in the project files. Field audits and technical system audits will not be conducted under this task order.

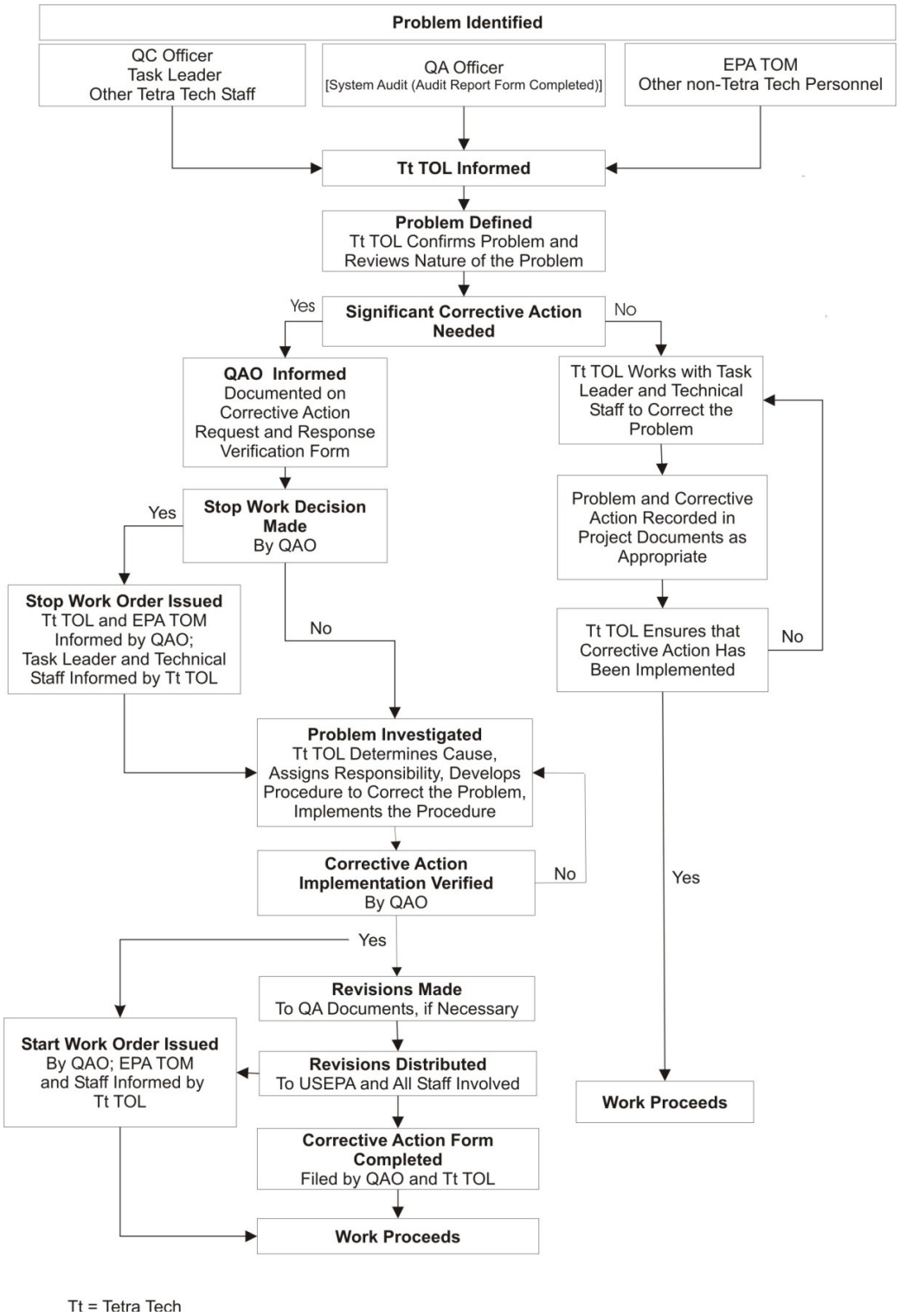

Figure 17-1. Problem assessment and correction operations.

19.0 DATA REVIEW, VERIFICATION, AND VALIDATION

Analytical results will be reviewed and validated in accordance with EPA documents, including the *USEPA Guidance on Environmental Data Verification and Validation* (EPA QA/G-8), 2002b; the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (EPA 540/R-94/012), 1999; and the *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA 540/R-94/013), 1994b. Tetra Tech will conduct data review and validation using the following methods on 10% of the primary project samples, including their associated quality control duplicates and laboratory quality control samples.

- A review of sample handling and analytical and field data for completeness, accuracy, holding time compliance, and quality control (QC) sample frequency compliance.
- Evaluation of laboratory blank samples.
- Evaluation of the accuracy and precision of field duplicate samples, laboratory control samples (LCS), and matrix spike/spike duplicate (MS/MSD) samples.
- Assignment of data qualifiers, when necessary, to reflect limitations identified in the data assessment process.
- Estimation of completeness.

20.0 VERIFICATION AND VALIDATION METHODS

Analytical results will be reviewed and validated in accordance with EPA documents, including the *USEPA Guidance on Environmental Data Verification and Validation* (EPA QA/G-8), 2002b; the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (EPA 540/R-94/012), 1999; and the *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA 540/R-94/013), 1994b. Tetra Tech will conduct data review and validation using the following methods on 10% of the primary project samples, including their associated quality control duplicates and laboratory quality control samples.

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- Evaluation of the accuracy and precision of field duplicate samples, laboratory control samples (LCS), and matrix spike/spike duplicate (MS/MSD) samples.
- Assignment of data qualifiers, when necessary, to reflect limitations identified in the data assessment process.
- Estimation of completeness.

20.1 Validation and Verification Methods

The following procedures will be used to determine if data meets the measurement and data quality objectives and criteria specified in Section 4. If data QA/QC procedures do not meet the specified criteria, the Quality Assurance Officer will review all field and laboratory records to determine the cause. If equipment failures are limiting the usability of the data, calibration and maintenance procedures will be reviewed and changed as needed. If sampling or analytical procedures are the source of failures, methods will be reviewed to resolve the errors. Any changes or modifications to quality control procedures will be approved by the Project Manager prior to inclusion in the QAPP.

Review of Sample Handling

Proper sample handling techniques are required to ensure sample integrity. During data review, the sample handling procedures identified below are evaluated to determine potential effects on data quality.

- Review of field sample collection and preservation procedures to determine whether they were completed in accordance with the requirements specified by the analytical methods.

- Review of chain-of-custody documentation to ensure control and custody of the samples was maintained.
- Review of sample holding times between sample collection, extraction, and analysis (see Table 8-2 in Section 8).
- Review of sample conditions upon receipt at the contract laboratory.
- Review of Quality Assurance/Quality Control (QA/QC) Samples. Specific procedures for review of QA/QC samples are included in the sections below.

Laboratory Blank Samples
Laboratory blank samples (method and instrument blanks) are laboratory-prepared, analyte-free samples used to detect the introduction of contamination or other artifacts into the laboratory sample handling and analytical process. These blanks play an especially important role in sampling programs involving trace-level analyses or analytes that are common solvents found in a laboratory. None of the analytes of concern for this project are common laboratory contaminants. If a contaminant is discovered in the analytical sample at less than five times the concentration it is found in the laboratory blank, it will be considered a laboratory contaminant. Otherwise, it will be reported as an environmental contaminant.

Laboratory Control Samples
Laboratory control samples are used to assess analytical performance under a given set of standard conditions. Synthetic samples, containing some or all of the analytes of interest at known concentrations, are prepared independently from calibration standards. The samples consist of laboratory control samples (LCS) and laboratory control sample duplicates (LCSD). Laboratory control samples will be analyzed with each analytical batch. LCS may be used to estimate analytical accuracy and precision by comparing measured results to actual concentrations. LCS/LCSD percent recoveries will be checked on laboratory reports to ensure they are within the limits set by the EPA methods listed in Table 4-3.

LCS are also duplicated in the laboratory and then analyzed in an identical manner by the laboratory to assess the laboratory's internal precision. The analytical precision is expressed by the relative percent difference (RPD) (equation 11-1). Analytical precision and accuracy should meet the method criteria listed in Table 4-3 in Section 4.

Matrix Spike and Matrix Spike Duplicates
Matrix spike samples are actual field samples to which known amounts of select compounds (one, or more, of the analytes of interest) are added. Both spiked and unspiked aliquots (sample portions) are analyzed. The difference between the concentration of the spike compound(s) in the spiked and unspiked aliquots is compared to the amount of spike added before the extraction process. Since actual samples are used for the recovery determination, the matrix effects can be evaluated. Usually expressed as a percentage of the mass of the spiked amount, spike recovery is the measurement of accuracy anticipated for the sample matrix. Percent recoveries will be compared to EPA method specific recoveries listed in Table 4-3.

Matrix spike samples are also duplicated in the laboratory and then analyzed in an identical manner by the laboratory to assess sample reproducibility and the laboratory's internal precision. The analytical precision is expressed by the RPD between the measurement results of the two duplicate samples. Analytical precision and accuracy should meet the criteria provided in Table 4-3. MS/MSD samples will be run on each batch of samples.

Field Duplicate Samples
Field duplicate samples will be collected simultaneously with a primary project sample. Duplicates are treated in the same manner as the primary sample during all phases of sample collection, handling, and

analysis. Duplicate sample results are used to assess precision, including variability associated with both the laboratory analysis and the sample collection process (i.e., QC purposes). At least one duplicate field sample will be collected and submitted blind to the laboratory during each sampling date for this program.

Analytical results will be reviewed for agreement with each other or their respective reporting limits and evaluated for comparability. Estimated results quantified below the reporting limit and qualified with a "J" flag are not considered significant for the purpose of data agreement. The comparison between project and field duplicate sample results should meet RSD (relative standard deviation) criteria for each method listed in Table 4-3.

Reporting Limits
The reporting limits are the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory conditions. For many analytes, the reporting limit analyte concentration is selected by the laboratory as the lowest non-zero standard in the calibration curve. Sample reporting limits vary based on sample matrix and dilution of the samples during analysis. Reporting limits should be equal to or below the PQLs (Practical Quantitation Limits) provided in Table 10-1 for each method.

Data Qualification
Qualifiers will be applied to QC samples when acceptance criteria are not met and corrective action is not performed or is unsuccessful. These same qualifiers will be applied to the associated sample data, as defined in the following table.

Table 20-1. Data Qualifiers.

Qualifier	Description
J	The analyte was positively identified, the quantitation is estimated.
U	The analyte was analyzed for, but not detected. The associated numerical value is at or below the method detection limit (MDL).
F	The analyte was positively identified but the associated numerical value is below the reporting limit (RL).
R	The data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria.
B	The analyte was found in an associated blank, as well as in the sample.
M	A matrix effect was present.
H	Analysis was performed outside of the recommended holding time.

Completeness
Completeness is calculated after the QC data have been evaluated, and the qualifiers have been applied to the sample data. Invalid results, broken or spilled samples, and samples that are unable to be analyzed for other reasons are included in the assessment of completeness. The criteria and calculation to determine completeness are provided in Section 5. If data cannot be qualified to meet completeness goals, Tetra Tech will consult with the Project Manager to determine if additional sampling should be performed to accomplish data quality objectives.

20.2 Reconciliation with User Requirements

The Project Manager will review all data deliverables upon receipt from the lab. Laboratory results will be checked for data qualifiers entered by the lab to ensure that sample collection and preservation procedures were adequate and that laboratory analysis procedures met quality assurance objectives. Any outstanding issues will be addressed immediately with the lab and/or sampling staff to ensure that project quality assurance objectives are met.

The Project Manager will review and validate the data during interim reporting to management and final reporting stages of the project. If there are any problems with quality sampling and analysis, these issues will be addressed immediately and methods will be modified to ensure that data quality objectives are being met. Modifications to monitoring will require notification to the Project Manager and subsequent edits to the approved QAPP.

21.0 RECONCILIATION WITH USER REQUIREMENTS

As soon as possible following completion of the sample collection and analyses, Tt will assess the precision, accuracy, and completeness measures and compare them with the criteria discussed in Section 4.0. This will be the final determination of whether the data collected are of the correct type, quantity, and quality to support their intended use for this project. Any problems encountered in meeting the performance criteria (or uncertainties and limitations in the use of the data) will be discussed with the project QA personnel and Puyallup Tribe and Tetra Tech Project Managers, and will be reconciled if possible.

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