Exhibit O

Stormwater Monitoring

Stormwater Monitoring Requirements: Lawson Hills Master Planned Development (MPD) and The Villages MPD

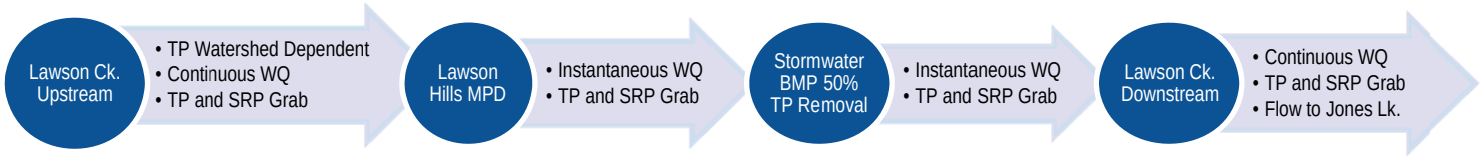
Background: Total phosphorus (TP) concentrations in Lake Sawyer are limited to 16 µg/L as a steady state in-lake mean total P concentration (total external and internal P load following WTP diversion) during any time of the year[1]. This concentration is a predicted value based on hypothetical exclusion of the WTP that was present during the time of the TMDL Model development. Further, the TP limit of 16 µg/L was selected, using a probability function, in order to minimize the chance (<5%) for a lake shift to a eutrophic state. Contributions of TP load from additional development in any of the 3 Sub-basins (e.g., Lake Sawyer surrounding area, Ravensdale Creek, and Rock Creek) have been limited and cannot result in increasing TP concentrations beyond the Load Allocation (LA). A 50 percent TP removal goal from the influent pollutant is the basic treatment performance goal identified by Ecology's 2005 *Stormwater Management Manual for Western Washington*. The target concentrations for TP in each of these sub-watersheds is well below the load allocation predicted by the TMDL model. Influent concentrations are based on published values for phosphorus leaching from Puget Sound land use types identified in the Lake Sawyer Basin. Estimates for influent total phosphorus were consistent with land use contributions reported in the Ecology (2009) Water Quality Implementation Plan and the EIS for the MPDs (Kindig 2008). Ecology's 2009 Water Quality Implementation Plan states that, for the City of Black Diamond, compliance with the applicable stormwater permit, which requires compliance with the 2005 *Stormwater Management Manual for Western Washington*, constitutes compliance with the TMDL. Triad Associates has estimated that to achieve the 50 percent TP removal goal, TP concentrations from the stormwater BMPs may not exceed 0.048 mg/L[2] from the Lawson Hills development and 0.055 mg/L[2] from The Villages development. This monitoring plan is consistent with and includes all of the elements identified in the MPD Approval Conditions as Ex. NR-TV-7, except that it adds additional explanation and water quality parameters to the monitoring program.

Stormwater Monitoring Objectives: To determine whether annual average TP concentrations that discharge from the Lawson Hills MPD and The Villages MPD are reduced by 50 percent compared to the inflow.

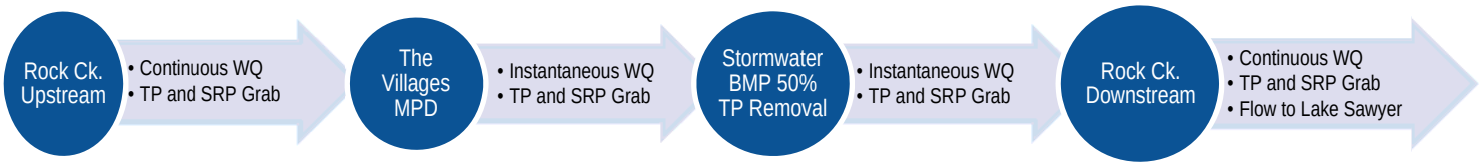
[1] Washington Department of Ecology. 1993. Lake Sawyer Total Daily Maximum Load. Publication # 93-10-201.
[2] Treated stormwater concentrations from the Developments are estimates based on typical TP contributions originating from land use types in Puget Sound; the treated stormwater TP concentrations may be higher if influent concentrations from outside the Developments are higher.

Monitoring Schematics: To aide in visualizing the monitoring program, the following schematics are provided. Abbreviations used include: TP=Total phosphorus, SRP=soluble reactive phosphorus, WQ=water quality, and BMP=best management practices, which include tools and techniques to address sources of pollution, such as physical structures like stormwater treatment ponds and facilities.

Lawson Hills MPD Stormwater Monitoring Schematic



The Villages MPD Stormwater Monitoring Schematic



STORMWATER MONITORING REQUIREMENTS[3]		
	Stormwater structure inflow	Stormwater structure outflow
Objectives	To measure TP concentration entering the structure	To determine removal efficiency by the stormwater structure
Samples Collected	Grab samples for TP and SRP during storm events	Grab samples for TP and SRP during storm events
Water Quality Parameters	*Instantaneous* field monitoring of baseline parameters (temperature, pH, dissolved oxygen, specific conductance) with HydroLab® MS5 Datasonde	*Continuous* monitoring of baseline parameters (temperature, pH, dissolved oxygen, specific conductance) with HydroLab® MS5 Datasonde
Term of Monitoring	October 1st through March 31st of each calendar year for five years. Ideally, up to 8 sampling events corresponding with storms of at least 0.2 inches of rainfall. At least 3 samples collected during a single storm event (0.5 hrs. following the beginning of a storm, 1 hr. after beginning of a storm, and 2 hrs. after beginning of a storm event)	October 1st through March 31st of each calendar year for five years. Monitoring frequency is recommended at 15 minute intervals so that a 7-day average of the daily maximum temperatures (7-DADMax) can be calculated from the continuous monitoring data
	Receiving Creek (upstream) Temperature May 1st through October 31st of each calendar year for two summer seasons Temperature monitoring frequency is recommended at 15 minute intervals and downloaded every three months from Onset instruments; record when pond is discharging following storm events	Receiving Creek (downstream) Temperature May 1st through October 31st of each calendar year for two summer seasons Temperature monitoring frequency is recommended at 15 minute intervals and downloaded every three months from Onset instruments
Data Interpretation	N/A	TP loads to receiving waters will be calculated from sample data collected at the inflow and outflow A 7-day average of the daily maximum temperatures (7-DADMax) will be calculated from the continuous temperature monitoring data
Allowable Deviation from Design Objectives	N/A	Performance of BMP will be 50% TP removal and effluent will achieve 0.048 mg/L TP (Lawson Hills) and 0.055mg/L TP (The Villages) for the stormwater structure discharge
Adaptive Management in Response to Deviations	Retrofit existing practices by a. Developing a maintenance strategy b. Implementing project(s) within the Lake Sawyer basin that collectively provides TP discharge levels and minimizes temperature impacts pursuant to the Development Agreement c. Developing alternative design strategies for retrofitting stormwater facilities	

[3] See the Quality Assurance Project Plans (QAPP) for further details regarding sampling processes and procedures, measurement procedures, quality control, data management and related matters.

References

Kindig, A.C. 2008. The Villages MPD Water Quality Technical Analysis Evaluation. Appendix M in the Villages FEIS. September 10, 2008.

Washington State Department of Ecology (WSDOE). 2009. Lake Sawyer Total Phosphorus Total Maximum Daily Load: Water Quality Implementation Plan. Publication No. 09-10-053. Olympia, WA. 75p.

MEMORANDUM

Date:	February 25, 2011
To:	City of Black Diamond
From:	Alan D. Fure, PE
Re:	No Net Phosphorous Implementation Plan
Triad Job No.:	05-336
Copies To:	Yarrow Bay Holdings

Requirement: Minimize impacts to water quality in Lake Sawyer by assuring no net increase in phosphorous to Lake Sawyer occurs associated with The Villages and Lawson Hills MPD development within basins that drain to Lake Sawyer. No net increase can be accomplished by on-site or off-site source control or physical/chemical/biological interception (treatment and removal from water system).

Summary of Approach: Establish existing baseline phosphorous contributions from relevant project drainage basins[1] and from potential compensating projects located outside the developed MPD that currently contribute phosphorous to Lake Sawyer. Determine strategies for meeting the no net phosphorous goal ahead of project construction. Implement strategies and then monitor post implementation phosphorous levels to confirm compliance with the requirement. If onsite measures do not meet the requirement, implement compensatory project mitigation. Measure post implementation phosphorous reductions from compensatory projects to confirm the amount of offset.

Baseline Monitoring: In conjunction with City of Black Diamond review, plan and institute the following:

1. Monitor pre-development phosphorous levels at pre-determined locations within the project drainage basins. Monitoring is to occur consistently over the course of at least one water year (October to September) in accordance with the procedures and criteria outlined in Chapters 6 through 12 of the QAPP (see Attachment 1). Use data collected over the water year to establish a baseline phosphorous load from the project. This load should be factored to an average year rainfall volume for future comparisons of phosphorous loads for years where the rainfall is more or less than the average.

2. Select one or two possible compensation projects. Offsite compensation projects will be on land not being actively developed for the MPD but that includes features that

[1] The first areas of The Villages project planned to be developed are in drainage basins that do not drain to Lake Sawyer.

currently contribute phosphorus to Lake Sawyer that are amenable to reductions of phosphorus, such as roadway segments or intersections, pastures with farm animals, or existing developed property all lacking modern stormwater controls, or erosive slopes or streams. Monitor pre-mitigation phosphorous levels at pre-determined locations within the compensating project drainage basin. Monitoring is to occur consistently over the course of at least one water year (October to September) in accordance with the procedures and criteria outlined in Chapters 6 through 12 of the QAPP (see Attachment 1). Use data collected over the water year to establish a baseline phosphorous load from the compensating project. This load should be factored to an average year rainfall volume for future comparisons of phosphorous loads for years where the rainfall is more or less than the average.

Project Design Phase: In conjunction with City of Black Diamond review, prepare drainage designs with phosphorous mitigation solutions which include the following:

1. Phosphorous control menu items from the 2005 DOE Manual (or later manuals if adopted and imposed for later Project phases).
2. Any additional AKART (all known and reasonable technologies) not identified in 1. above, that are in compliance with The Villages MPD Permit Approval Condition No. 76 or the Lawson Hills MPD Permit Approval Condition No. 79.
3. Drainage designs should include contingency planning for augmentation of treatment so that future interventions can be made if needed.

Project Construction Phase: Upon commencement of project construction the following shall be instituted:

1. Monitoring shall be performed at all drainage outlet points to establish post-mitigation phosphorous levels. This monitoring is to occur consistently over the course of the water year in accordance with the procedures and criteria outlined in the QAPP (see Attachment 1).
2. Regular comparisons shall be made to determine if mitigation strategies are achieving goals established in the design phase. If levels are exceeding goals, source control interventions shall be implemented immediately.
3. Upon completion of the water year compare actual loads to pre-development loads. If loads are exceeding pre-development loads, institute compensatory project(s).

Project Build-Out Phase: Continue monitoring of drainage outlets for five years following acceptance of each constructed facility to confirm compliance with the no net phosphorous goal as per procedures noted above. If data show variations from the standard, institute source control or improved maintenance solutions. If these interventions are insufficient, institute alternate compensatory projects or mitigations.

Attachment 1

Quality Assurance Project Plans for:

- **Nutrient Removal Effectiveness by The Villages to Rock Creek**
- **Nutrient Removal Effectiveness by Basin A (Wet Pond #1 & #2) to Lawson Creek**

Quality Assurance Project Plan
for
Nutrient Removal Effectiveness
by The Villages to Rock Creek:
Lake Sawyer Implementation Plan

Yarrow Bay Development Company
Contract Work 20-15-101-00
Contract/Project Number:

January 2011

Prepared by

Robert Plotnikoff, Harry Gibbons, Shannon Brattebo and Gene Welch

Tetra Tech, Inc.
1420 Fifth Avenue
Seattle, WA 98101

Prepared for

BD Village Partners LP.

Approval Signatures:

_____ Date: _____
Project Manager

_____ Date: _____
Senior Technical Staff

_____ Date: _____
Additional

_____ Date: _____
Additional

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APPENDIX A **40**

Distribution List

Name, Title	Phone, Fax, E-mail	Mailing Address
Yarrow Bay Development Company		
Triad Associates, Inc.		
Tetra Tech, Inc. Surface Water Group		

1.0 Background

1.1 Study Area and Surroundings

Lake Sawyer is located near the city of Black Diamond, and is a popular recreational resource for the area. Lake Sawyer is 280 acres in size and its watershed occupying approximately 8,300 acres. The watershed is divided into three sub-basins: Rock Creek, Ravensdale Creek, and the nearshore area of Lake Sawyer that serve as management areas for water quality improvement. Lake Sawyer serves is part of the migratory pathway for late-winter Coho salmon (*Oncorhynchus kisutch*) and spawn in Ravensdale Creek and Rock Creek drainages. Resident rainbow trout, cutthroat trout, kokanee, and several warm-water fish species are present in Lake Sawyer (King County 2000).

The lake has generally good water quality, but has elevated phosphorus concentrations. Historically, in the 1970's Black Diamond lacked sewage treatment plant facilities and effluent was treated by septic tanks and drainfields, including a city septic tank located just south of Auburn-Black Diamond Road that discharged to Ginder Creek. These methods for effluent treatment also resulted in elevated concentrations of fecal coliform, nitrogen, and biochemical oxygen demand in Ginder Creek.

High nutrient concentrations were likely associated with high phosphorus concentrations which would have promoted increased loading to Lake Sawyer. The Black Diamond Wastewater Treatment Plant (WWTP) began operation in 1981 and discharged effluent to a natural wetland coincident with the mouth of Rock Creek. The strategy for use of a natural wetland as part of the treatment train used to abate the pollutants in WWTP effluent rapidly became ineffective with signs of eutrophication in Lake Sawyer. Algal blooms were commonly detected in the late 1980's. The treatment using the wetland system was closed. Department of Ecology developed a TMDL (Total Maximum Daily Load) model predicting phosphorus concentrations under various loading scenarios.

2.0 Project Description

2.1 Tasks

The following tasks for this project have been developed:

Task 1. Evaluate Water Quality conditions in the stormwater pond structure to determine total phosphorus load reduction from The Villages development.
Task 2. Determine effectiveness of the stormwater structure from the Villages development area, conveyance of treated surface water to the natural creek channel, and influence of the treated water once introduced into Rock Creek.

2.2 Objectives

Information in this Quality Assurance Project Plan (QAPP) is organized to provide sampling and analysis methods that will generate data and interpretations necessary to address the following objective:

1. To determine whether annual average total phosphorus discharge concentrations from a representative stormwater structure as predicted in the EIS water quality technical report (FEIS Appendix M, A.C. Kindig & Co. 2008) for the Villages MPD (Master Planned Development) is meeting regulatory requirements of the approved MPD permit.

2.3 BMP and Stream Sampling

The proposed project describes a monitoring strategy that evaluates nutrient (phosphorus input) introduction to the constructed BMP, the efficiency of the BMP in removing entrained nutrients, and the resulting output concentration. The second step in the monitoring strategy measures the nutrient load in the receiving water (Rock Creek) to determine the nutrient portion originating from the BMP and the background load originating from other sources. This QAPP has been developed to ensure that all methods used and all data collected during the project is defensible and repeatable. The QAPP has been developed for monitoring effectiveness of BMP implementation as required by the Washington Department of Ecology's QAPP Guidance.

a) BMP/LID Effectiveness Monitoring

Purpose: Determine efficiency of BMP facilities in removal of phosphorus routed to each structure from overland flow in the Development during storm events. The parameter of concern is phosphorus.

Sampling of BMP facilities within the Development will occur during 6 to 8 storm events per year. Storm water samples will be collected during the wet season which is defined as October 1st through March 31st. Samples will be collected from the input and outflow of each BMP facility in order to determine nutrient removal efficiencies. Samples will be collected manually. The grab samples will be delivered to an accredited Washington Laboratory and analyzed for total phosphorus and soluble reactive phosphorus.

For the purposes of defining a single storm event, the minimum amount of rainfall should be at least 0.2 inches and the event must be preceded by a dry period of at least 4 hours. Two of the 8 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 pond 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 at the facility input and outflow will be measured continuously with a data logger. Flow data will be used to volume and time-weight nutrient concentrations in and out of each facility over a storm event.

b) Rock Creek Monitoring

Purpose: Determine the nutrient load contributed from The Villages Development to the receiving water (Rock Creek). Use results from the nutrient loading analysis to inform on contributions from the Development versus other non-point sources.

Grab samples will be collected in Rock Creek at two points on the creek to characterize both baseline nutrient conditions and conditions during storm events. Grab samples will be collected in Rock Creek just upstream of the point of treated effluent discharge, upstream and downstream of the BMP facility within the Development, as well as upstream of all Development property. Collecting nutrient samples from these locations will provide information on nutrient loading not only from the Development but also from other non-point sources within the watershed. Baseline nutrient monitoring in Rock Creek will include collection of samples at the above mentioned locations on a monthly basis. Baseline monitoring of Rock Creek will provide information on nutrient concentrations and conditions without influence or impact from the Development. Samples will also be collected in Rock Creek during storm events to help characterize nutrient loading associated with stormwater runoff. Storm event sampling in Rock Creek will correspond with sampling of BMP facilities within The Villages Development. All samples collected in Rock Creek will be analyzed for total phosphorus and soluble reactive phosphorus. Continuous flow measurements and field parameters (e.g., temperature, pH, conductivity, and dissolved oxygen) will also be collected during each sampling event.

2.4 Water Quality Constituents to Monitor (Primary Monitoring Program)

Phosphorus, both soluble reactive (SRP) and TP is the most important constituent ultimately controlling the DO levels. Analytical procedures are extremely important. Laboratory quality control can be acceptable, while determined concentrations in the river may be in error, especially for TP due to different digestion procedures and contamination. SRP should be determined on samples filtered through P-free filters using the EPA 365.1 ascorbic acid method. TP should be determined by the same method for SRP following digestion with persulfate according to Standard Methods (APHA 2005). A contract laboratory that can meet these rigorous reporting limit and laboratory performance requirements is required for analysis of P forms.

Other constituents to monitor 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 phosphorus and loading present in the basin.

Precipitation

Phosphorus content should be determined in bulk and wet fall (rain-containing phosphorus in dry and wet forms. Review of data collected in the fall from the October 1st through March 31st will be used to forecast volume and intensity of rainfall events throughout this monitoring period.

One location for a unit to monitor wet and dry fall (use a rain gage) on a weekly- or twice-monthly basis should be adequate. The rainfall patterns measured during the proposed monitoring period will provide perspective on the amount of airborne phosphorus that might be expected to be loading into the Basin and the receiving stream (Rock Creek).

3.0 Organization and Schedule

The purpose of this document is to present the quality assurance project plan (QAPP) for collecting water quality and other data to assess the chemical, physical, and biological characteristics of non-point sources of pollution affecting Lake Sawyer, Washington. A team of technical professionals will conduct journey-level scientific investigations that include: 1) collection of environmental data (routine monitoring and source-tracing), 2) collection and interpretation of phosphorus loading data from the stormwater Basin, and 3) interpreted technical information used to inform on effectiveness of BMP operation.

This QAPP provides general descriptions of the work to be performed to collect the samples, the standards 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. It describes the procedures used to obtain concentrations of the desired chemical analytes and other parameters of concern.

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 key personnel and responsibilities for this project for The Villages MPD (Master Planned Development) in the Lake Sawyer drainage in urban Black Diamond are listed in Table 3.0-1.

Table 3.0-1. Project/Task organization and responsibility summary.

Personnel	Responsibility	Address/E-Mail	Phone Number
Al Fure, Triad Associates, Inc.	Project Manager	Al Fure Triad Associates, Inc. 12112 115th Avenue NE Kirkland, WA 98034 afure@triadassociates.net	(425)216-2110
Harry Gibbons, Tetra Tech, Inc. Robert Plotnikoff, Tetra Tech, Inc.	Co-Project Leads	Tt Surface Water Group 1420 Fifth Avenue, Ct. E Seattle, WA 98101 harry.gibbons@tetratech.com robert.plotnikoff@tetratech.com	(206)728-9655
Name, Position, Tetra Tech, Inc.	Field Lead	Tt Surface Water Group Address City, WA Email address	Contact Information
Name, Position, Tetra Tech, Inc.	Quality Assurance Officer (QAO)	Tt Surface Water Group Address City, WA Email address	Contact Information
Name, Position, Tetra Tech, Inc.	Data Manager	Tt Surface Water Group Address City, WA Email address	Contact Information

Each component of the Nutrient Removal Effectiveness Monitoring Study has specific milestones and products. The project schedule contains several deliverables in draft and final form. The schedule for each of these products is outlined here:

Table 3.0-2. Project deliverables and typical target calendar dates for The Villages MPD monitoring.

Deliverables	**Target Date**
Final Approved QA Project Plan	One month prior to start of sampling
Sampling Start/End	October 1st/March 31st
Draft Study Report	May 31st
Final Study Report	July 15th
Submit Data to Client	Within 45 days following each sampling event

3.1 Priority of Task Implementation

The monitoring strategies described in this QAPP are implemented simultaneously in order to determine source and quantity of phosphorus loading. Each of the monitoring strategies will build upon the base of information informing on source and magnitude of non-point pollution originating from The Villages MPD Basins and from other sources. The following is the suggested priority for implementing each monitoring strategy:

1. The Villages Stormwater Structure Sampling (nutrient sources)
2. Rock Creek Receiving Water Sampling (transport to Lake Sawyer)

4.0 Quality Objectives

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 Decision (Data) Quality Objectives

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 lake quality by using monitoring data will require generation of an adequate quantity of data influenced by numbers, locations, and frequency of samples from sites that must be analyzed. 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.

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 particular data set is some measure of the types and amount of error associated with the data.

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

1. *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).
2. *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 laboratory analysis and database management to reduce sources of errors and uncertainty in the use of the data.

4.2 Measurement Quality Objectives

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 4.0-1 and Table 4.0-2. Additional quality

control sampling will be conducted in the field and is detailed in Section 8.0 Quality Control Procedures.

Table 4.2-1. 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.

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.

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

$$RPD = \frac{|C_1 - C_2|}{Mean(C_1, C_2)} x100$$

where C_1 = the first of the two values and C_2 = the second of the two values.

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.

Table 4.2-2. 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

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 a measure of confidence that describes how close a measurement is to its "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.

Analytical laboratory accuracy is normally determined by the percent recovery of the target analyte in spiked samples and also by the recoveries of the surrogates in all samples and Quality Control samples. Laboratory accuracy ranges are specified in the contract laboratory Quality Management Plan and depend on the parameter being measured. Accuracy is calculated as follows:

$$\%Rec = \frac{\text{Analyzed value}}{\text{True value}} \times 100$$

The Tetra Tech Technical Lead will ensure the contract laboratory accuracy by meeting %Recovery (Rec) values specified by EPA methods and listed in Table 4.0-3.

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 4.0-4). Accuracy for field measurements cannot be measured directly, but can be evaluated based on description of equipment performance.

Table 4.2-3. 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

[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 5.0-1.

Table 4.2-4. 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
River and Lake Level	0.5 inches	N/A	0.5 inches

[a] Luminescent Dissolved Oxygen Probe.
[b] The Minimum Detection Limit is listed in Table 5.0-1.
[†] Parameters collected continuously at 15-minute intervals.

5.0 Sampling Process Design

5.1 Sampling Design and Rationale

Nutrient introduction into Lake Sawyer has been identified as a primary cause for promoting nuisance algal blooms caused by periodic high total phosphorus concentrations during portions of the year. Following almost two decades of phosphorus reduction efforts, concentrations of this nutrient are generally being met throughout the year. The Washington Department of Ecology (Ecology) and the City of Black Diamond have expended effort in fixing some of the obvious source problems for nutrient in the drainage; primarily on-site septic systems and drainage from a wetland originally expected to treat effluent discharged from a wastewater treatment plant. Other basin-wide implementation measures have been identified by the Department of Ecology (WSDOE 2009).

The Villages MPD permit approval includes conditions to identify the estimated maximum annual volume of total phosphorus from the MPD site and that will comply with the TMDL for Lake Sawyer, and to monitor phosphorus coming from the MPD site. The sampling design and rationale presented are intended to provide information that can be used in an adaptive management program and continually update/upgrade the phosphorus monitoring program.

The sampling design meets the requirements from the City of Black Diamond as Conditions of Approval for the Lawson Hills Master Planned Development approval (Exhibit C: Conditions 76, 82, and 85) that monitoring of the stormwater treatment facility and the influence on receiving water be described. Exceedence of the allowable estimated maximum annual volume of total phosphorus discharged from the Development site will require a redesign of existing structures, modify the design of new treatment facilities, or implementation of another project in the Lake Sawyer basin that results in a reduction in total phosphorus so the annual maximum load is below the target quantity outlined in the Condition.

The proposed monitoring strategy addresses each of the potential sources of non-point nutrient total phosphorus contributions and methods that would detect presence of this pollutant and directly address tasks described in Section 2.0. The Sampling Process Design is described here based on each of these tasks:

Task 1. Evaluate Water Quality conditions in The Villages stormwater structures to determine total phosphorus load from The Villages Development Basin.

THE VILLAGES STORMWATER STRUCTURES

Locations: Outlet/Inlet of the stormwater structure or treatment train (BMP)

A. Parameters:
   The stormwater structures are designed to remove phosphorus from surface water runoff originating in The Villages Development. The efficiency and the effectiveness of this BMP or treatment train will determine whether the structure is operating properly, needs retrofitting or maintenance, or informs on contaminant loads in stormwater that were greater than expected. The data from these monitoring efforts serve as a feedback

mechanism for making future decisions in meeting treated water requirements. The monitoring effort and decision-making process in determining effectiveness of stormwater phosphorus mitigation is directed by Conditions of the MPD agreement.

Parameters will be measured below the stormwater structure Outlet and the Incoming conduit to the stormwater structure. Total Phosphorus will be sampled as well as flow (both incoming and outgoing). Continuous field monitoring will be conducted at the outlet of the stormwater structure in order to isolate effects of any potential temperature increases from the standing water. In addition, 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 Total Phosphorus.

The Total Phosphorus load will be calculated using the flow estimates from both incoming and outgoing conduits associated with the stormwater structure(s). Since loading rates combine flow and parameter concentration, data comparisons can be made directly among months or years. These comparisons provide insight into short and long-term patterns for determining the effectiveness of the implementation plan for this drainage.

B. Reasons for Monitoring Design and Parameter Analysis:
Requirements for discharge of Total Phosphorus from the stormwater structures are set by The Villages MPD permit and guidelines and expected to be entrained in surface water runoff from storm events. For this reason, the winter wet season is targeted for most of the monitoring and is the time of year when water levels are sufficiently high to enable the stormwater structures to begin working as designed.

Task 2. Determine effectiveness of the stormwater structure(s) in removing phosphorus load and conveyance to receiving water (Rock Creek).

ROCK CREEK (Conveyance from the stormwater structures to receiving water)

The stormwater structures may change some of the physical characteristics of the water depending on residence time, incoming volume, and time of year. These factors may influence surface water temperature which is of concern during the warmer months of the year (when water is present). A sampling design describing temperature was recommended in order to demonstrate the potential for the stormwater structure(s) to increase temperature of surface water in a natural receiving water stream. This sampling schedule targets a period of the year when this parameter is most likely to increase due to climate conditions and when declining flows cease to dissipate heat energy. Although the primary concern is during the storm season and lower water temperatures, surface water characteristics may change with increasing human activity during the cold weather seasons.

5.2 Sampling Locations and Frequencies

The two tasks described in Section 5.1 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 5.2-1). The proposed discrete sites for sampling will be field-verified prior to final location. Once selections are made for sites they will be monumented by using a GPS locational unit.

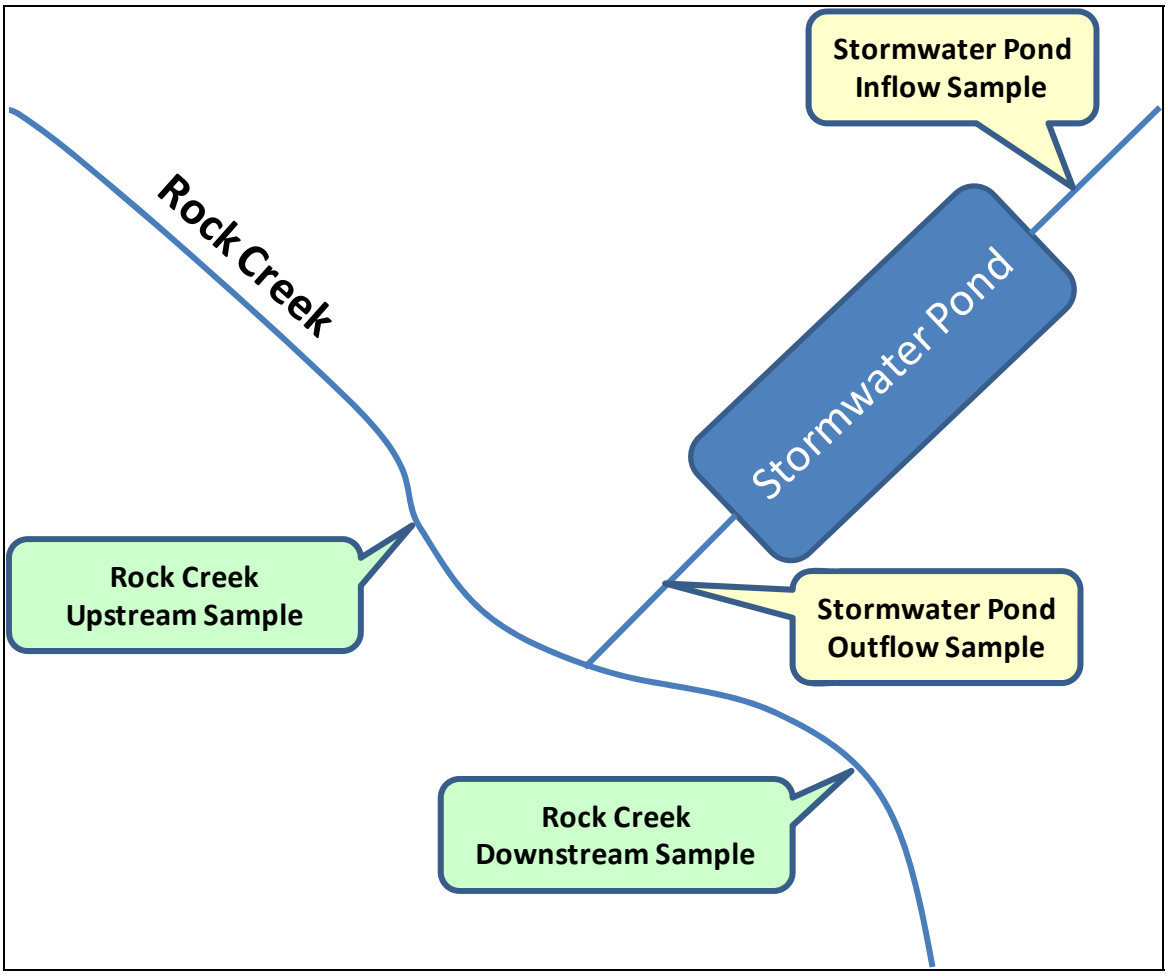

Figure 5.2-1. Proposed sample sites and locations for collection of surface water data.

Task 1. The Villages Stormwater Structure(s)

A. Frequency of Sample Collection:

Sample collection timing and frequency is determined by the occurrence of storm events. Ideally, monitoring will be completed at 6-8 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 optimum effectiveness of the BMP (stormwater structures) under varying storm conditions. The period of monitoring is established from October 1st through March 31st of each calendar year for five years.

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, how water travels to and from the stormwater structures, 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.

Task 2. Rock Creek

A. Upstream of Discharge

a. Surface Water temperature (Continuous data logging)

The upstream site for monitoring surface water temperature will serve as the control for determining if the stormwater structure discharge is a cause for increased downstream temperatures. The monitoring frequency is recommended at 15 minute intervals so that 7-day average of the daily maximum temperatures (7-DADMax) can be calculated from the continuous monitoring data. Additional monitoring effort will be conducted at both the upstream and downstream site; including continuous monitoring with a HydroLab® unit. Additional parameters that will be collected are:

- Water Temperature
- Dissolved Oxygen concentration
- Conductivity
- pH

These additional parameters are important for understanding how the receiving water assimilates effects from additional nutrient 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 nutrient sources will assist in making drainage-level management decisions to assure The Villages MPD permit Conditions are met.

B. Downstream of Discharge

a. Surface Water temperature (Continuous data logging)

Comparison between upstream and downstream (of the stormwater structure outfall) water quality characteristics will evaluate the effect treated stormwater pond water has on receiving water. The upstream/downstream sample design with site located in close proximity to the outfall will isolate effects from the BMP output. Water quality parameter measurements will be sampled identical to those described for the upstream site above. In addition, flow monitoring will be conducted using pressure transducers calibrated using a flow-rating curve. The total phosphorus loads originating from upstream of the stomrwater structure outfall will be combined with stormwater structure loads and the resulting load compared against the downstream estimate. This analytical exercise is intended to reveal the dynamic nature of nutrients in natural streams receiving treated stormwater.

5.3 Order (Timing) of Sampling

Non-point source pollutants enter streams and lakes 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 nutrient pollution into nearby receiving streams 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 nutrient pollution load introduced during a time period. Distinguishing seasons and differences in pollution load is used as a guide to suggest abatement of pollution by using BMPs (best management practices). The suggested monitoring interval is has been determined from previous

studies and has sufficient flows to enable measurement of effectiveness of phosphorus removal from surface water.

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

Task 1

- Sampling Intervals for the constructed stormwater BMP(s); Rainfall Events and No. of Visits
  October 1st – March 31st (6-8 visits)

Task 2

- Rock Creek upstream/downstream sampling:
- October 1st – March 31st
- Continuous Surface Water Temperature monitoring (15-minute intervals)
- Dissolved Oxygen concentration (15-minute intervals)
- Conductivity (15-minute intervals)
- pH (15-minute intervals)
-
- April 1st – September 30th
- Continuous Surface Water Temperature monitoring (15-minute intervals)

5.4 Representativeness

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.

Stormwater Structure Water Quality
Representativeness will be achieved through collection of samples aimed at capturing the complexity and dynamics of the treatment pond. Locations surrounding the treatment pond will be sampled to characterize water quality at multiple depths to adequately describe nutrient levels and other conditions related to dissolved oxygen. Sampling will be concentrated during summer to determine worst-case conditions and magnitude of internal P loading.

Rock Creek Water Quality
Data will be gathered to characterize water quality constituents 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 5.2, Task 2). Loading estimates will characterize storm flow.

5.5 Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and are entered into the data management system. Lack of data entry into the database will reduce the ability to perform analyses, integrate results, and prepare reports. Therefore, 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. 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:

$$\%C = \frac{V}{T} x100$$

where V = the number of measurements judged valid and T = the total number of measurements taken

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. At any time where data are not complete, decisions regarding re-sampling and/or re-analysis will be made by Tetra Tech. These decisions will take into account the project data quality objectives as presented above.

Completeness will also be judged by comparison to the monitoring parameters and frequency laid out in the monitoring schedule. For this criterion, completeness is defined as the number of measurements taken divided by the number of measurements scheduled. While the goal for this criterion is 100 percent completeness, a lower percent completeness may be acceptable for a volunteer monitoring program.

5.6 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 Villages Study Area 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 Villages projected are listed in Table 5.0-1.

Table 5.6-1. Reporting limits and analytical methods for surface water 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
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/Basin level	inches	0.5	±0.5	Pressure Transducer

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 of the Stormwater Basin will be continuously monitored for level (pressure transducer) in order to estimate flow for determining loading estimates of nutrient pollutants.

6.0 Sampling Procedures

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 The Villages MPD 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).

6.1 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 6.1-1.

Table 6.1-1. 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	Inflow/Outflow Monitoring									Inflow/Outflow Monitoring		
Task #2	Upstream/Downstream Monitoring			Continuous Temperature Monitoring						Upstream/Downstream Monitoring		

Note: Task #1 – Continuous field monitoring parameters and 12 water quality samples collected per storm event (6-8 storm events characterized).
Task #2 - Continuous field monitoring parameters and 12 water quality samples collected per storm event (6-8 storm events characterized).

6.2 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 6.2-1. 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 9.0 further outlines how to record variation from QAPP protocol or DQOs (Data Quality Objectives).

Table 6.2-1. 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

6.3 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).

6.4 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 Villages project is presented in the 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 Lawson Hills 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.

7.0 Measurement Procedures

All analysis methods used for this project are approved standard analytical methods approved for use by the EPA and Ecology (Table 5.0-1). 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.

7.1 Field Sampling Procedures and Laboratory Analysis Procedures

Procedures describing field sampling are fully described for each parameter in Section 6. Laboratory Analysis procedures are described in Section 5. 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.

7.2 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 Triad Associates Program Directors through regular communication with the laboratory project manager.

Laboratory analytical procedures will follow U.S. EPA (1983, 1991) or APHA et al. (2005) methods. Detection limits and methods are summarized in Section 5 and in Table 5.0-1.

Table 7.2-1. Measurement methods for laboratory analysis of surface water and sediment samples.

Analyte	Sample Matrix	Samples [Number/ Arrival Date]	Expected Range of Results	Reporting Limit (RL)	Sample Prep Method	Analytical (Instrumental) Method
Total Phosphorus	Water	TBD		2.0 µg/L	Persulfate, autoclave	EPA 365.1
Soluble Reactive Phosphorus	Water	TBD		1.0 µg/L	0.45u filtration	EPA 365.1
Dissolved Oxygen (DO)[a]	Water	TBD	RL to 12 mg/L	<0.1 mg DO/L	None	Standard Methods 4500-O G [b]
pH [a]	Water	TBD	pH 3-9	pH<1	None	Standard Methods 4500-H^{+} [b]
Temperature [a]	Water	TBD	0-30 ^{0}C	32°C	None	Standard Methods 2550B [b]
Conductivity a	Water	TBD	RL to 200 µsiemens/cm	1 Microsiemens/cm[e]	None	USGS NFM 6.3.3A-SW

NOTES:

a. This is a field measurement.
b. Cell chosen, based on anticipated conductance will determine reporting limit.

8.0 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 3.0) and documentation of project activities (Section 5.0). 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 5.0-1 and collected at the frequency described in Figure 4.0-2. 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 5.0-1 (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.

8.1 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:

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

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

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

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

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

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.

8.2 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):

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

% Recovery (MS):

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

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.

8.3 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.

8.4 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:

$$\%C = \frac{V}{T} \times 100\%$$

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.

8.5 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 8.5-1. Quality Control samples; sample types and frequency.

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

9.0 Data Management Procedures

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. Triad Associates, 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 Triad Associates, Inc. or contractors), the Triad Associates 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 Triad Associates and shared with Yarrow Bay Development Company in hard copy and in electronic database format, 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 Spokane County'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 and Triad Associates 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 and Triad Associates (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 and Triad Associates 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® and Access®. Data will be entered into the Access® database in a form compatible with requirements specified by the developer.

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 Quality Assurance Project Plan 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 Spokane County. Training records and data review records will be kept on file at Spokane County 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 and Triad Associates should be retained permanently.

A Microsoft Access data management system should 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.

10.0 Audits and Reports

Upon completion of periodic sampling activities, the Project Leader will summarize sampling team progress. Following completion of field sampling, the Project Leader will prepare a field sample collection summary (detailed listing of all sampling participants, sampling locations, and specimens collected) for review by the Project Manager.

Following the completion of each data quality assessment, the Project Manager or designee will prepare a Data Quality Assessment Report and submit copies to the Project Manager for inclusion in project records. The data quality assessment will include any required qualification of data based on observations, relevant laboratory or field QC analyses, or other observations that might affect data quality. The laboratory data can then be incorporated into final sampling event reports to consolidate the information corresponding to each event.

When required, reports summarizing incidents of technical direction requests from laboratory or field staff, required corrective actions, and any other issues affecting data quality or usability will be submitted to the Project Leader. These observations will be compiled and submitted in interim QA reports where warranted, in informal file memoranda to the Project Manager for inclusion in the project files. These regular QA reports and memoranda, along with routine data quality assessments performed throughout the data collection will be the basis of the final QA report for this collection effort.

10.1 Audits

Should the sampling staff, laboratory personnel or Project Manager find errors in sampling or analysis, the Project Manager will notify the party responsible for the error or deficiency and recommend methods of correcting the deficiency. The responsible party will then take action to correct the problem and will report corrections to the QAO and Project Manager.

The Quality Assurance Officer will review the QA/QC procedures used for the sampling and analytical program. Procedures for this review, included in Section 8, will meet the data quality criteria specified in Section 4. The Project Manager will ensure the documentation of these assessment records in the Draft and Final Reports.

10.2 Reports to Management

Sampling results will be summarized in the draft and final reports completed for this project. These reports will include the field and laboratory results of project assessments listed above. Reports will be submitted to the Project Manager at Triad Associates. Email updates will be submitted to the Project Manager after each sampling event providing notification of any issues or problems for which corrective actions have been taken. The results of all corrective actions or data quality assessments will be reported to the Project Manager from Triad Associates upon completion.

Standard reporting formats will be developed and approved by Triad Associates Managers. These will be used to produce interim and final reports following completion of this study.

Consistency in reporting of progress, data generation, and interpretations will be maintained in order to improve comparability between related studies and where data-sharing is needed between monitoring efforts that address each of the project tasks (*e.g.*, mass loading analysis, stormwater runoff, etc.).

11.0 Data Verification and Validation

Data validation and review services provide a method for determining the usability and limitations of data and provide a standardized data quality assessment. All Field Data forms and Chain of Custody forms will be reviewed by the Project Leader (assisted by the Project Manager, as needed) for completeness and correctness. The Project Leader will be responsible for reviewing data entries and transmissions for completeness and adherence to QA requirements. Data quality will be assessed by comparing entered data to original data or by comparing results to the measurement performance criteria summarized in Section 4.2 to determine whether to accept, reject, or qualify the data. Results of the review and validation processes will be reported to the Program Manager. Analytical data provided by the laboratories will be reviewed before its release by the laboratory QAO, and laboratory manager, and will include a certifying statement that the data included have been reviewed for compliance with the reference methods and this QAPP.

The Project Lead or designee will review all Field Data Record forms and Chain of Custody forms. The Project QAO will review a minimum of 5 percent of the Field Data Record forms and other records. Any discrepancies in the records will be reconciled with the appropriate associated field personnel and will be reported to the Project Lead. Laboratory validation and verification methods are outside the scope of this QAPP; however, it is expected that the laboratory validation and verification will include an assessment of completeness and method compliance, including verification of sample calculations and of any required manual data entry. The analytical narrative reports will include discussions of attainment of the program goals as established herein. Samples submitted to the sample analysis laboratory will include Chain of Custody forms documenting sampling time and date. This information will be checked by the analytical laboratory to ensure that holding times have not been exceeded. Violations of holding times will be reported (by the laboratory) to the Project Lead, who will consult with the Project QAO to develop corrective action recommendations and define any recommended technical directives. Finally, the Project Manager will be consulted with deficiencies, observations, and findings, as well as with corrective action and technical directive recommendations for consideration and approval.

Data verification and validation includes completeness of data entry into a data management system, correctness of data entry, and assurance that entries fall within the expected range for each analyte. These exercises prevent generation of poor results when analyzing data for cause-and-effect relationships or for status of environmental resources. Missing or incorrect data can bias description of environmental resources and result in false conclusions.

11.1 Data Review, Validation & Verification Requirements

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.

11.2 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 6.2-1 in Section 6).
- 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 4.0-3.

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 11.2-1). Analytical precision and accuracy should meet the method criteria listed in Table 4.0-3 in Section 4.

$$\frac{X_1 - X_2}{X_{ave}} x100 = RPD$$

X_1 = duplicate no. 1
X_2 = duplicate no. 2
X_{ave} = mean of two sample duplicates
RPD = relative percent difference

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 4.0-3.

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 4.0-3. 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 4.0-3.

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 7.0-1 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 11.2-1. 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.

11.3 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.

12.0 Data Quality (Usability) Assessment

As soon as possible following completion of the sample collection and analyses, Tetra Tech and Triad Associates 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 will be reconciled if possible.

12.1 Interpreting Data

Task 1
Total phosphorus loads will be calculated (inflow and outflow of the stormwater pond) and compared against the performance goal of 50% removal. This goal for removal applies to influent concentration ranges from 0.1 – 0.5 mg/L total phosphorus.

Task 2
Total phosphorus concentrations and loads will be compared between upstream and downstream of the treated stormwater input location to Rock Creek. Continuous temperature monitoring data generated for each of the monitoring periods (October 1st - March 31st and April 1st – September 30th) will be compared (upstream to downstream of the point of entry of stormwater), especially during the warmer months, for influence, if any, on temperature of the receiving water (Rock Creek).

13.0 References

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King County. 2000. Lake Sawyer Management Plan. King County Surface Water Management. July 2000.

The Lawson Hills Master Planned Development Permit: Conditions of Development Approval. Exhibit C: Conditions #16, #81, and #85.

United States Environmental Protection Agency (USEPA). 1990. Recommended Protocols for Measuring Conventional Water Quality Variables and Metals in Fresh Water of the Puget Sound Region. Prepared by Tetra Tech, Inc. Bellevue, WA for the USEPA Region X Office of Puget Sound, Seattle, WA.

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Washington State Department of Ecology (WSDOE). 2001. Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies. February 2001. No. 01-03-003. Olympia, WA.

Washington State Department of Ecology (WSDOE). 2009. Lake Sawyer Total Phosphorus Total Maximum Daily Load: Water Quality Implementation Plan. Publication No. 09-10-053. Olympia, WA. 75p.

Appendix A

Chain-of-Custody Form
Field Data Report Form
Meter Calibration Log Form

Aquatic Research Inc.
3927 Aurora Avenue N, Seattle, WA 98103
P 206.632.2715 | F 206.632.2417

www.aquaticresearchinc.com

SHEET _____ OF _____

CLIENT: **CHAIN-OF-CUSTODY RECORD**
SAMPLING DATE: _____
SAMPLERS: _____

PROJECT ID: _____
CASE FILE NO.: _____
DATA RECORDED BY: _____

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	PARAMETERS																			BOTT #	NOTES

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.): _____

3927 Aurora Ave. N | Seattle, WA 98103 | 206.632.2715

TETRA TECH

FIELD DATA REPORT FORM

Y M M D D
0

SURVEY ..... SAMPLER ..... PAGE ..... OF .....

STATION NO.	STATION NAME	TIME	TEMP ºC	DO mg/L	DO #	pH	TRUE pH / METER	COND. µMHOS/CM	REDOX POTENTIAL	*L/M/R	DEPTH (meters)	COMMENTS

WEATHER:

ADDITIONAL COMMENTS:

Tt (Rev. 11/07)

* L = Left Bank; M = Middle Bank; R = Right Bank

Project: _____ Date: _____

Meter Calibration Log Form

Cond Meter# _____ Initial Cell Constant _____ Standard _____ µmhos/cm Meter _____ µmhos/cm

pH Meter # _____ pH Probe # _____

Thermistor # _____ Thermistor _____ °C Thermometer _____ °C Correction _____

DAY 1

Low Ionic Strength pH Value vs. Temp. °C

	7	10
10	7.01	9.27
15	6.99/7.00	9.23
20	6.98	9.19

Slope _____ 92-102%
mv @ pH 7 _____ ± 30 mv
mv @ pH 4/10 _____ Difference between mv @ pH7 160-180
Response Time _____ < 90 seconds
Time of Day _____

	true pH	meter	time of day		
QA Check #1	_____	_____	_____	Recalibrated	Y / N
QA Check #2	_____	_____	_____	Recalibrated	Y / N
QA Check #3	_____	_____	_____	Recalibrated	Y / N

If meter pH is not within 0.10 pH units of true value in pH 7 buffer, then recalibrate & re-read sample.

Conductivity Standard _____ µmhos/cm Meter _____ µmhos/cm

DAY 2

Initial Cell Constant _____ Standard _____ µmhos/cm Meter _____ µmhos/cm

Slope _____ 92-102%
mv @ pH 7 _____ ± 30 mv
mv @ pH 4/10 _____ Difference between mv @ pH7 160-180
Response Time _____ < 90 seconds
Time of Day _____

	true pH	meter	time of day		
QA Check #1	_____	_____	_____	Recalibrated	Y / N
QA Check #2	_____	_____	_____	Recalibrated	Y / N
QA Check #3	_____	_____	_____	Recalibrated	Y / N

If meter pH is not within 0.10 pH units of true value in pH 7 buffer, then recalibrate & re-read sample.

Conductivity Standard _____ µmhos/cm Meter _____ µmhos/cm

DAY 3

Initial Cell Constant _____ Standard _____ µmhos/cm Meter _____ µmhos/cm

Slope _____ 92-102%
mv @ pH 7 _____ ± 30 mv
mv @ pH 4/10 _____ Difference between mv @ pH7 160-180
Response Time _____ < 90 seconds
Time of Day _____

	true pH	meter	time of day		
QA Check #1	_____	_____	_____	Recalibrated	Y / N
QA Check #2	_____	_____	_____	Recalibrated	Y / N
QA Check #3	_____	_____	_____	Recalibrated	Y / N

If meter pH is not within 0.10 pH units of true value in pH 7 buffer, then recalibrate & re-read sample.

Conductivity Standard _____ µmhos/cm Meter _____ µmhos/cm

Quality Assurance Project Plan
for
Nutrient Removal Effectiveness by Basin A (Wet Pond #1 & #2) to Lawson Creek: Lake Sawyer Implementation Plan

Yarrow Bay Development Company
Contract Work 20-15-010-00
Contract/Project Number:

January 2011

Prepared by

Robert Plotnikoff, Harry Gibbons, Shannon Brattebo and Gene Welch

Tetra Tech, Inc.
1420 Fifth Avenue
Seattle, WA 98101

Prepared for

BD Lawson Partners, LP

Approval Signatures:

_____ Date: _____
Project Manager

_____ Date: _____
Senior Technical Staff

_____ Date: _____
Additional

_____ Date: _____
Additional

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Distribution List

Name, Title	Phone, Fax, E-mail	Mailing Address
Yarrow Bay Development Company		
Triad Associates, Inc.		
Tetra Tech, Inc. Surface Water Group		

1.0 Background

1.1 Study Area and Surroundings

Lake Sawyer is located near the city of Black Diamond, and is a popular recreational resource for the area. Lake Sawyer is 280 acres in size and has a watershed of approximately 8,300 acres. The watershed is divided into three sub-basins: Rock Creek, Ravensdale Creek, and the nearshore area of Lake Sawyer. These sub-basins of the Lake Sawyer watershed serve as management areas for water quality improvement. Lake Sawyer serves as part of the migratory pathway for late-winter Coho salmon (*Oncorhynchus kisutch*) which spawn in Ravensdale Creek and Rock Creek drainages. Resident rainbow trout, cutthroat trout, kokanee, and several warm-water fish species are present in Lake Sawyer (King County 2000).

The lake has generally good water quality, but experiences elevated phosphorus concentrations. In the 1970's Black Diamond lacked sewage treatment plant facilities and effluent was treated by septic tanks and drainfields, including a city septic tank located just south of Auburn-Black Diamond Road that discharged to Ginder Creek. These methods for effluent treatment also resulted in elevated concentrations of fecal coliform, nitrogen, and biochemical oxygen demand in Ginder Creek.

High nutrient concentrations from the treated sewerage effluent were likely associated with high phosphorus concentrations which promoted increased loading to Lake Sawyer. The Black Diamond Wastewater Treatment Plant (WWTP) began operation in 1981 and discharged effluent to a natural wetland coincident with the mouth of Rock Creek. The strategy for use of a natural wetland as part of the treatment train used to abate pollutants in the WWTP effluent rapidly became ineffective as signs of eutrophication in Lake Sawyer appeared. Algal blooms were commonly detected in the late 1980's. The treatment plant using the wetland system was closed. The Department of Ecology (Ecology) developed a Total Maximum Daily Load (TMDL) model for Lake Sawyer predicting phosphorus concentrations under various loading scenarios.

2.0 Project Description

2.1 Tasks

The following tasks for this project have been developed:

Task 1. Evaluate Water Quality conditions in Wet Pond #1 to determine total phosphorus load from The Lawson MPD development areas into Basin A.
Task 2. Determine effectiveness of the Wet Pond in removing phosphorus load and conveyance to receiving water (Lawson Creek a tributary to Jones Lake and Rock Creek).

2.2 Objectives

Information in this Quality Assurance Project Plan (QAPP) is organized to provide sampling and analysis methods that will generate data and interpretations necessary to address the following objective:

2. To determine whether annual average total phosphorus discharge concentrations from a representative Large Wet Pond are as predicted in the EIS water quality technical report (FEIS Appendix M, A.C. Kindig & Co. 2008) for the Lawson Hills MPD (Master Planned Development) and are meeting regulatory requirements of the approved MPD permit.

2.3 BMP and Stream Sampling

The monitoring strategy for this project includes elements that evaluate nutrient (phosphorus input) introduction to the constructed stormwater Best Management Practice (BMP) (Wet Pond #1), determine the efficiency of the BMP in removing entrained nutrients, and describe the resulting output phosphorus concentration. The second step in the monitoring strategy measures the nutrient load in the receiving water (Lawson Creek and ultimately to Rock Creek) to determine the nutrient portion originating from the stormwater BMP (Wet Pond #1) and the background load originating from other sources in the watershed. This QAPP has been developed to ensure that all methods used and all data collected during the project is defensible and repeatable. The QAPP has been developed for monitoring effectiveness of BMP implementation as required by the Washington Department of Ecology's QAPP Guidance.

a) BMP/LID Effectiveness Monitoring

Purpose: Determine efficiency of BMP facilities in removal of phosphorus routed to each structure from overland flow in the Development during storm events. The parameter of concern is phosphorus.

Sampling of the BMP facility (Wet Pond #1) within Lawson Development will occur during 6 to 8 storm events per year. Storm water samples will be collected during the wet season which is defined as October 1st through March 31st. Samples will be collected from the input and outflow of each BMP facility in order to determine nutrient removal efficiencies. Samples will be collected manually. The grab samples will be delivered to an accredited Washington Laboratory and analyzed for total phosphorus and soluble reactive phosphorus.

For the purposes of defining a single storm event, the minimum amount of rainfall should be at least 0.2 inches and the event must be preceded by a dry period of at least 4 hours. Two of the 8 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 pond 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, which will result in 4 or less nutrient samples per storm event. Flow at the facility input and outflow will be measured continuously with a data logger, which will be installed prior to the start of monitoring activities. Flow data will be used to volume and time-weight nutrient concentrations in and out of each facility over a storm event.

b) Lawson Creek Monitoring

Purpose: Determine the nutrient load contributed from the Lawson Development to the receiving water (Lawson Creek). Use results from the nutrient loading analysis to inform on contributions from the Development versus other non-point sources.

Grab samples will be collected in Lawson Creek at several locations to characterize both baseline nutrient conditions and conditions during storm events. Grab samples will be collected in Lawson Creek just upstream of and downstream of each BMP facility within the Development, as well as upstream of all Development property. Collecting nutrient samples from these locations will provide information on nutrient loading not only from Lawson Development but also from other non-point sources within the watershed. Baseline nutrient monitoring in Lawson Creek will include collection of samples at the above mentioned locations on a monthly basis. Baseline monitoring of Lawson Creek will provide information on nutrient concentrations and conditions without influence or impact from the Lawson Development. Samples will also be collected in Lawson Creek during storm events to help characterize nutrient loading associated with stormwater runoff. Storm event sampling in Lawson Creek will correspond with sampling of BMP facilities within the Lawson Development. All samples collected in Lawson Creek will be analyzed for total phosphorus and soluble reactive phosphorus. Flow measurements and field parameters (e.g., temperature, pH, conductivity, and dissolved oxygen) will also be collected during each sampling event.

2.4 Water Quality Constituents to Monitor (Origin of Phosphorus Sources)

Phosphorus, both soluble reactive and total phosphorus are important constituents ultimately controlling DO levels in receiving water and in Lake Sawyer. Analytical procedures used to determine concentration of phosphorus are extremely important and need to be consistent. Soluble reactive phosphorus should be determined on samples filtered through phosphorus-free filters using the EPA 365.1 ascorbic acid method. Total phosphorus should be determined with the exception of filtering, by the same method for soluble reactive phosphorus following digestion with persulfate according to Standard Methods (APHA 2005). A contract laboratory

that can meet these rigorous reporting limit and laboratory performance requirements is required for analysis of phosphorus forms.

Other constituents that will be monitored include temperature, dissolved oxygen concentration, pH, and specific conductance. These constituents 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 phosphorus and loading present in the basin.

Precipitation

Phosphorus content within precipitation should be determined in bulk and wet fall (rain-containing phosphorus in dry and wet forms). Review of precipitation data collected in the fall from the October 1st through March 31st will be used to forecast volume and intensity of rainfall events throughout this monitoring period.

One location for a unit to monitor wet and dry fall (use a rain gage) on a weekly- or twice-monthly basis should be adequate. The rainfall patterns measured during the proposed monitoring period will provide perspective on the amount of airborne phosphorus that might be expected to be loading into the Wet Pond and the receiving stream (Lawson Creek).

3.0 Organization and Schedule

The purpose of this document is to present the quality assurance project plan (QAPP) for collecting water quality and other data to assess the chemical, physical, and biological characteristics of non-point sources of pollution affecting Lake Sawyer. A team of technical professionals will conduct scientific investigations that include: 1) collection of environmental data (routine monitoring), 2) collection and interpretation of phosphorus loading data from a stormwater BMP (Wet Pond #1), and 3) interpret technical information used to inform on effectiveness of the BMP operation.

This QAPP provides general descriptions of the work to be performed to collect the samples, the standards 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. It describes the procedures used to obtain concentrations of the desired chemical analytes and other parameters of concern.

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 key personnel and responsibilities for this project for Lawson Hills MPD (Master Planned Development) in the Lake Sawyer drainage in urban Black Diamond are listed in Table 3.0-1.

Table 3.0-1. Project/Task organization and responsibility summary.

Personnel	Responsibility	Address/E-Mail	Phone Number
Al Fure,Triad Associates, Inc.	Project Manager	Al Fure Triad Associates, Inc. 12112 115th Avenue NE Kirkland, WA 98034 afure@triadassociates.net	(425)216-2110
Harry Gibbons, Tetra Tech, Inc. Robert Plotnikoff, Tetra Tech, Inc.	Co-Project Leads	Tt Surface Water Group 1420 Fifth Avenue, Ct. E Seattle, WA 98101 harry.gibbons@tetratech.com robert.plotnikoff@tetratech.com	(206)728-9655
Name, Position, Tetra Tech, Inc.	Field Lead	Tt Surface Water Group Address City, WA Email address	Contact Information
Name, Position, Tetra Tech, Inc.	Quality Assurance Officer (QAO)	Tt Surface Water Group Address City, WA Email address	Contact Information
Name, Position, Tetra Tech, Inc.	Data Manager	Tt Surface Water Group Address City, WA Email address	Contact Information

Each component of this project has specific milestones and products. The project schedule contains several deliverables in draft and final form. The schedule for each of these products is outlined in Table 3.0-2.

Table 3.0-2. Project deliverables and typical target calendar dates for Lawson Hills MPD monitoring.

Deliverables	Target Date
Final Approved QA Project Plan	One month prior to start of sampling
Sampling Start/End	October 1st/March 31st
Draft Study Report	May 31st
Final Study Report	July 15th
Submit Data to Client	Within 45 days following each sampling event

3.1 Priority of Task Implementation

The monitoring strategies described in this QAPP are implemented simultaneously in order to determine source and quantity of phosphorus loading. Each of the monitoring strategies will build upon the base of information informing on source and magnitude of non-point pollution originating from The Lawson Hills Development stormwater basin and from other sources. The following is the suggested priority for implementing each monitoring strategy:

3. Wet Pond #1 Stormwater Sampling (nutrient sources)
4. Lawson Creek Receiving Water Sampling (transport to Jones Lake)

4.0 Quality Objectives

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 Decision (Data) Quality Objectives

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 lake quality by using monitoring data will require generation of an adequate quantity of data influenced by numbers, locations, and frequency of samples from sites that must be analyzed. 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.

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 particular data set is some measure of the types and amount of error associated with the data.

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

3. *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).
4. *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 laboratory analysis and database management to reduce sources of errors and uncertainty in the use of the data.

4.2 Measurement Quality Objectives

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 4.0-1 and Table 4.0-2. Additional quality control sampling will be conducted in the field and is detailed in Section 8.0 Quality Control Procedures.

Table 4.2-1. 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.

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.

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

$$RPD = \frac{|C_1 - C_2|}{Mean(C_1, C_2)} x100$$

where C_1 = the first of the two values and C_2 = the second of the two values.

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.

Table 4.2-2. 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

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 a measure of confidence that describes how close a measurement is to its “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.

Analytical laboratory accuracy is normally determined by the percent recovery of the target analyte in spiked samples and also by the recoveries of the surrogates in all samples and Quality Control samples. Laboratory accuracy ranges are specified in the contract laboratory Quality Management Plan and depend on the parameter being measured. Accuracy is calculated as follows:

$$\%Rec = \frac{\text{Analyzed value}}{\text{True value}} \times 100$$

The Tetra Tech Technical Lead will ensure the contract laboratory accuracy by meeting %Recovery (Rec) values specified by EPA methods and listed in Table 4.0-3.

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 4.0-4). Accuracy for field measurements cannot be measured directly, but can be evaluated based on description of equipment performance.

Table 4.2-3. 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

[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 5.0-1.

Table 4.2-4. 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
Flow	0.5 inches	N/A	0.5 inches

[a] Luminescent Dissolved Oxygen Probe.
[b] The Minimum Detection Limit is listed in Table 5.0-1.
[†] Parameters collected continuously at 15-minute intervals.

5.0 Sampling Process Design

5.1 Sampling Design and Rationale

Nutrient introduction into Lake Sawyer has been identified as a primary cause for promoting nuisance algal blooms caused by periodic high total phosphorus concentrations during portions of the year. Following almost two decades of phosphorus reduction efforts, concentrations of this nutrient are generally being met throughout the year. Ecology and the City of Black Diamond have expended effort in fixing some of the obvious source problems for nutrient in the drainage; primarily on-site septic systems and drainage from a wetland originally expected to treat effluent discharged from a wastewater treatment plant. Other basin-wide implementation measures have been identified by the Department of Ecology (WSDOE 2009).

The Lawson Hills MPD permit approval includes conditions to identify the estimated maximum annual volume of total phosphorus from the MPD site and that will comply with the TMDL for Lake Sawyer, and to monitor phosphorus coming from the MPD site. The sampling design and rationale presented are intended to provide information that can be used in an adaptive management program and continually update/upgrade the phosphorus monitoring program.

The sampling design meets the requirements from the City of Black Diamond as Conditions of Approval for the Lawson Hills Master Planned Development approval (Exhibit C: Conditions 76, 82, and 85) that monitoring of the stormwater treatment facility and the influence on receiving water be described. Exceedence of the allowable estimated maximum annual volume of total phosphorus discharged from the Development site will require a redesign of existing structures, modify the design of new treatment facilities, or implementation of another project in the Lake Sawyer basin that results in a reduction in total phosphorus so the annual maximum load is below the target quantity outlined in the Condition.

The proposed monitoring strategy addresses each of the potential sources of non-point nutrient total phosphorus contributions and methods that would detect presence of this pollutant and directly address tasks described in Section 2.0. The Sampling Process Design is described here based on each of these tasks:

Task 1. Evaluate Water Quality conditions in Wet Pond #1 (Basin A) to determine total phosphorus load from the Lawson Hills Development Basin.

WET POND #1

Locations: Outlet/Inlet of the first constructed Wet Pond (BMP)

C. Parameters:
   The Wet Ponds are designed to remove phosphorus from surface water runoff originating in the Lawson Hills Development. The efficiency and the effectiveness of this BMP will determine whether the structure is operating properly, needs retrofitting or maintenance, or informs on contaminant loads in stormwater that were greater than expected. The data from these monitoring efforts serve as a feedback mechanism for making future decisions in meeting treated water requirements. The monitoring effort and decision-making

process in determining effectiveness of stormwater phosphorus mitigation is directed by Condition #85 in Exhibit C of Lawson Hills MPD agreement.

Parameters will be measured below the Wet Pond Outlet and the Incoming conduit to the Wet Pond. Total Phosphorus will be sampled as well as flow (both incoming and outgoing). Continuous field monitoring will be conducted at the outlet of the Wet Pond in order to measure direct effects of stormwater on the natural streams and delayed effects once the storms have subsided. In addition, 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 total phosphorus.

The total phosphorus load will be calculated using the flow estimates from both incoming and outgoing conduits associated with the Wet Pond. Since loading rates combine flow and parameter concentration, data comparisons can be made directly among months or years. These comparisons provide insight into short and long-term patterns for determining the effectiveness of the implementation plan for this drainage.

D. Reasons for Monitoring Design and Parameter Analysis:
Requirements for discharge of total phosphorus from the Wet Pond #1 are set by the Lawson Hills MPD Permit Conditions, and expected to be entrained in surface water runoff from storm events. For this reason, the winter wet season is targeted for most of the monitoring and is the time of year when water levels are sufficiently high to enable the Wet Pond to begin working as designed.

Task 2. Determine effectiveness of Wet Pond #1 in removing phosphorus load and conveyance to receiving water (Lawson Creek).

LAWSON CREEK (Conveyance from Wet Pond #1 to receiving water)

The Wet Pond may change some of the physical characteristics of the water depending on residence time, incoming volume, and time of year. These factors may influence surface water temperature which is of concern during the warmer months of the year. A sampling design describing temperature was recommended in order to demonstrate the potential for the Wet Pond to increase temperature of surface water in a natural receiving water stream. This sampling schedule targets a period of the year when this parameter is most likely to increase due to climate conditions and when declining flows cease to dissipate heat energy.

5.2 Sampling Locations and Frequencies

The two tasks described in Section 5.1 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 5.2-1). The proposed discrete sites for sampling will be field-verified prior to final location. Once selections are made for sites they will be monumented by using a GPS locational unit.

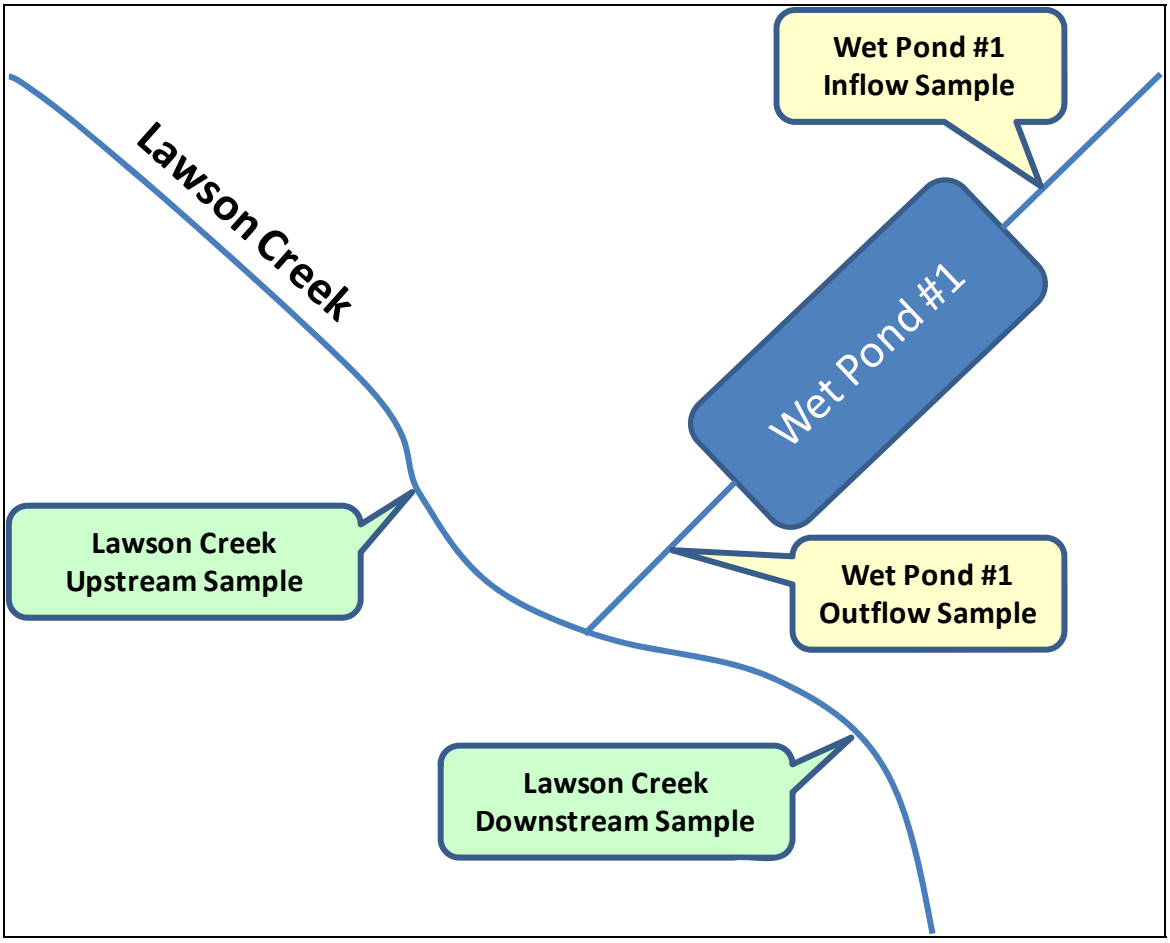

Figure 5.2-1. Proposed sample sites and locations for collection of surface water data.

Task 1. Wet Pond #1

B. Frequency of Sample Collection:

Sample collection timing and frequency is determined by the occurrence of storm events. Ideally, monitoring will be completed at 6-8 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 optimum effectiveness of the BMP (Wet Pond) under varying storm conditions. The period of monitoring is established from October 1st through March 31st of each calendar year for five years.

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, how water travels to and from the Wet Pond, 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.

Task 2. Lawson Creek

C. Upstream of Discharge

b. Surface Water Parameters (Continuous data)

The upstream site for monitoring surface water quality will serve as the control for determining if the Wet Pond discharge is a cause for increased downstream temperatures. The monitoring frequency is recommended at 15 minute intervals so that 7-day average of the daily maximum temperatures (7-DADMax) can be calculated from the continuous monitoring data. Additional monitoring effort will be conducted at both the upstream and downstream site; including continuous monitoring with a HydroLab® unit. Additional parameters that will be collected are:

- Water Temperature
- Dissolved Oxygen concentration
- Conductivity
- pH

These additional parameters are important for understanding how the receiving water assimilates effects from additional nutrient 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 nutrient sources will assist in making drainage-level management decisions to meet the goals of the TMDL Implementation Strategy.

D. Downstream of Discharge

a. Surface Water Parameters (Continuous data)

Comparison between upstream and downstream (of the Wet Pond outfall) water quality characteristics will evaluate the effect Wet Pond water has on receiving water. The upstream/downstream sample design with site located in close proximity to the outfall will isolate effects from the BMP output. Water quality parameter measurements will be sampled identical to those described for the upstream site above. In addition, flow monitoring will be conducted using pressure transducers calibrated using a flow-rating curve. The total phosphorus loads originating from upstream of the Wet Pond outfall will be combined with Wet Pond loads and the resulting load compared against the

downstream estimate. This analytical exercise is intended to reveal the dynamic nature of nutrients in natural streams receiving treated stormwater.

5.3 Order (Timing) of Sampling

Non-point source pollutants enter streams and lakes 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 nutrient pollution into nearby receiving streams 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 nutrient pollution load introduced during a time period.

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

Task 1

- Sampling Intervals for the constructed Wet Pond #1; Rainfall Events and No. of Visits
  October 1st – March 31st (6-8 visits)

Task 2

- Lawson Creek upstream/downstream sampling:
  <u>October 1st – March 31st</u>
  Continuous Surface Water Temperature monitoring (15-minute intervals)
  Dissolved Oxygen concentration (15-minute intervals)
  Conductivity (15-minute intervals)
  pH (15-minute intervals)

  <u>April 1st – September 30th</u>
  Continuous Surface Water Temperature monitoring (15-minute intervals)

5.4 Representativeness

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.

Wet Pond #1 Water Quality

Representativeness will be achieved through collection of samples aimed at capturing the characteristics of the stormwater entering and exiting the BMP. The Wet Pond #1 will be sampled to characterize water quality during multiple storms of varying sizes.

Lawson Creek Water Quality

Data will be gathered to characterize water quality constituents during dry and wet seasons of the year. Additional detail is provided for description of storm events in Western Washington and the characteristics that will be described by stormwater monitoring (see Section 5.2, Task 2).

5.5 Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and are entered into the data management system. Lack of data entry into the database will reduce the ability to perform analyses, integrate results, and prepare reports. Therefore, 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. 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:

$$\%C = \frac{V}{T} x100$$

where V = the number of measurements judged valid and T = the total number of measurements taken

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. At any time where data are not complete, decisions regarding re-sampling and/or re-analysis will be made by Tetra Tech. These decisions will take into account the project data quality objectives as presented above.

Completeness will also be judged by comparison to the monitoring parameters and frequency laid out in the monitoring schedule. For this criterion, completeness is defined as the number of measurements taken divided by the number of measurements scheduled. While the goal for this criterion is 100 percent completeness, a lower percent completeness may be acceptable for a volunteer monitoring program.

5.6 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 Lawson Hills Development will be ensured through application of standardized sampling procedures and convergence with methods and practices of existing monitoring programs (e.g., 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 Lawson Hills project are listed in Table 5.0-1.

Table 5.6-1. Reporting limits and analytical methods for surface water 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
Temperature	ºC	0.5	±0.5	[a] Thermometer
		0.01	±0.1	[a] HydroLab
Dissolved Oxygen	mg/L	0.2 (test kit) 0.01 (meter)	±0.4 (test kit) ±0.2 (meter)	Bioluminescence Probe
pH	pH units	0.1	±0.2	HydroLab
Conductivity	µmhos/cm	5	±1	HydroLab
[b] Creek/Basin level	inches	0.5	±0.5	Pressure Transducer

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 of the Stormwater Basin will be continuously monitored for level (pressure transducer) in order to estimate flow for determining loading estimates of nutrient pollutants.

6.0 Sampling Procedures

Sampling methods focus on characterization of surface water chemistry (e.g., phosphorus, 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 Lawson Hills 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).

6.1 Sampling Schedule

Wet Pond 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 6.1-1.

Table 6.1-1. 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	Inflow/Outflow Monitoring									Inflow/Outflow Monitoring		
Task #2	Upstream/Downstream Monitoring			Continuous Temperature Monitoring						Upstream/Downstream Monitoring		

Note: Task #1 – Continuous field monitoring parameters and 12 water quality samples collected per storm event (6-8 storm events characterized).
Task #2 - Continuous field monitoring parameters and 12 water quality samples collected per storm event (6-8 storm events characterized).

6.2 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 6.2-1. 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:

3. Wet Pond #1 Sampling: cleaned collection vessel from bank or in the pond.
4. Creek Sampling: Surface water collected from bank or while standing downstream of the sample collection location.

Note:

b. 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). Whenever possible, samples will be processed within the recommended holding time. 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 9.0 further outlines how to record variation from QAPP protocol or DQOs (Data Quality Objectives).

Table 6.2-1. 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

6.3 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).

6.4 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 Lawson Hills 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 Lawson Hills 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.

7.0 Measurement Procedures

All analysis methods used for this project are approved standard analytical methods approved for use by the EPA and Ecology (Table 5.0-1). 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.

7.1 Field Sampling Procedures and Laboratory Analysis Procedures

Procedures describing field sampling are fully described for each parameter in Section 6. Laboratory Analysis procedures are described in Section 5. 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.

7.2 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 Triad Associates Program Director through regular communication with the laboratory project manager.

Laboratory analytical procedures will follow U.S. EPA (1983, 1991) or APHA et al. (1998) methods. Detection limits and methods are summarized in Section 5 and in Table 5.0-1.

Table 7.2-1. Measurement methods for laboratory analysis of surface water and sediment samples.

Analyte	Sample Matrix	Samples [Number/ Arrival Date]	Expected Range of Results	Reporting Limit (RL)	Sample Prep Method	Analytical (Instrumental) Method
Total Phosphorus	Water	TBD		2.0 µg/L	Persulfate, autoclave	EPA 365.1
Soluble Reactive Phosphorus	Water	TBD		1.0 µg/L	0.45u filtration	EPA 365.1
Dissolved Oxygen (DO)[a]	Water	TBD	RL to 12 mg/L	<0.1 mg DO/L	None	Standard Methods 4500-O G [b]
pH [a]	Water	TBD	pH 3-9	pH<1	None	Standard Methods 4500-H^{+} [b]
Temperature [a]	Water	TBD	0-30 ^{0}C	32°C	None	Standard Methods 2550B [b]
Conductivity a	Water	TBD	RL to 200 µsiemens/cm	1 Microsiemens/cm[e]	None	USGS NFM 6.3.3A-SW

NOTES:

c. This is a field measurement.
d. Cell chosen, based on anticipated conductance will determine reporting limit.

8.0 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 3.0) and documentation of project activities (Section 5.0). 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 5.0-1 and collected at the frequency described in Figure 4.0-2. 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 5.0-1 (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.

8.1 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:

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

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

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

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

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

where χ_i is the measured value of the replicate, $\bar{\chi}$ 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.

8.2 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)*:*

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

% Recovery (MS):

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

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.

8.3 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.

8.4 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:

$$\%C = \frac{V}{T} \times 100\%$$

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.

8.5 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 8.5-1. Quality Control samples; sample types and frequency.

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

9.0 Data Management Procedures

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. Triad Associates, 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 Triad Associates, Inc. or contractors), the Triad Associates 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 Triad Associates and shared with Yarrow Bay Development Company in hard copy and in electronic database format, 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 ofTriad Associate'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 Triad Associates and 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 and Triad Associates (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 and Triad Associates 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® and Access®. Data will be entered into the Access® database in a form compatible with requirements specified by the developer.

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 Quality Assurance Project Plan 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 toTetra Tech. Training records and data review records will be kept on file at Tetra Tech 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 and Triad Associates should be retained permanently.

A Microsoft Access data management system should 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.

10.0 Audits and Reports

Upon completion of periodic sampling activities, the Project Leader will summarize sampling team progress. Following completion of field sampling, the Project Leader will prepare a field sample collection summary (detailed listing of all sampling participants, sampling locations, and specimens collected) for review by the Project Manager.

Following the completion of each data quality assessment, the Project Manager or designee will prepare a Data Quality Assessment Report and submit copies to the Project Manager for inclusion in project records. The data quality assessment will include any required qualification of data based on observations, relevant laboratory or field QC analyses, or other observations that might affect data quality. The laboratory data can then be incorporated into final sampling event reports to consolidate the information corresponding to each event.

When required, reports summarizing incidents of technical direction requests from laboratory or field staff, required corrective actions, and any other issues affecting data quality or usability will be submitted to the Project Leader. These observations will be compiled and submitted in interim QA reports where warranted, in informal file memoranda to the Project Manager for inclusion in the project files. These regular QA reports and memoranda, along with routine data quality assessments performed throughout the data collection will be the basis of the final QA report for this collection effort.

10.1 Audits

Should the sampling staff, laboratory personnel or Project Manager find errors in sampling or analysis, the Project Manager will notify the party responsible for the error or deficiency and recommend methods of correcting the deficiency. The responsible party will then take action to correct the problem and will report corrections to the Project Manager.

The Project Manager will review the QA/QC procedures used for the sampling and analytical program. Procedures for this review, included in Section 8, will meet the data quality criteria specified in Section 4. The Project Manager will ensure the documentation of these assessment records in the Draft and Final Reports.

10.2 Reports to Management

Sampling results will be summarized in the draft and final reports completed for this project. These reports will include the field and laboratory results of project assessments listed above. Reports will be submitted to the Project Manager at Triad Associates. Email updates will be submitted to the Project Manager after each sampling event providing notification of any issues or problems for which corrective actions have been taken. The results of all corrective actions or data quality assessments will be reported to the Project Manager from Triad Associates upon completion.

Standard reporting formats will be developed and approved by Triad Associates Managers. These will be used to produce interim and final reports following completion of this study.

Consistency in reporting of progress, data generation, and interpretations will be maintained in order to improve comparability between related studies and where data-sharing is needed between monitoring efforts that address each of the project tasks (*e.g.*, mass loading analysis, stormwater runoff, etc.).

11.0 Data Verification and Validation

Data validation and review services provide a method for determining the usability and limitations of data and provide a standardized data quality assessment. All Field Data forms and Chain of Custody forms will be reviewed by the Project Leader (assisted by the Project Manager, as needed) for completeness and correctness. The Project Leader will be responsible for reviewing data entries and transmissions for completeness and adherence to QA requirements. Data quality will be assessed by comparing entered data to original data or by comparing results to the measurement performance criteria summarized in Section 4.2 to determine whether to accept, reject, or qualify the data. Results of the review and validation processes will be reported to the Program Manager. Analytical data provided by the laboratories will be reviewed before its release by the laboratory QAO, and laboratory manager, and will include a certifying statement that the data included have been reviewed for compliance with the reference methods and this QAPP.

The Project Lead or designee will review all Field Data Record forms and Chain of Custody forms. The Project QAO will review a minimum of 5 percent of the Field Data Record forms and other records. Any discrepancies in the records will be reconciled with the appropriate associated field personnel and will be reported to the Project Lead. Laboratory validation and verification methods are outside the scope of this QAPP; however, it is expected that the laboratory validation and verification will include an assessment of completeness and method compliance, including verification of sample calculations and of any required manual data entry. The analytical narrative reports will include discussions of attainment of the program goals as established herein. Samples submitted to the sample analysis laboratory will include Chain of Custody forms documenting sampling time and date. This information will be checked by the analytical laboratory to ensure that holding times have not been exceeded. Violations of holding times will be reported (by the laboratory) to the Project Lead, who will consult with the Project QAO to develop corrective action recommendations and define any recommended technical directives. Finally, the Project Manager will be consulted with deficiencies, observations, and findings, as well as with corrective action and technical directive recommendations for consideration and approval.

Data verification and validation includes completeness of data entry into a data management system, correctness of data entry, and assurance that entries fall within the expected range for each analyte. These exercises prevent generation of poor results when analyzing data for cause-and-effect relationships or for status of environmental resources. Missing or incorrect data can bias description of environmental resources and result in false conclusions.

11.1 Data Review, Validation & Verification Requirements

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.

11.2 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 6.2-1 in Section 6).
- 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 4.0-3.

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 11.2-1). Analytical precision and accuracy should meet the method criteria listed in Table 4.0-3 in Section 4.

$$\frac{X_1 - X_2}{X_{ave}} x100 = RPD$$

X_1 = duplicate no. 1
X_2 = duplicate no. 2
X_{ave} = mean of two sample duplicates
RPD = relative percent difference

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 4.0-3.

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 4.0-3. 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 4.0-3.

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 7.0-1 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 11.2-1. 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.

11.3 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.

12.0 Data Quality (Usability) Assessment

As soon as possible following completion of the sample collection and analyses, Tetra Tech and Triad Associates 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 will be reconciled if possible.

12.1 Interpreting Data

Task 1
Total phosphorus loads will be calculated (inflow and outflow of Wet Pond #1) and compared against the performance goal of 50% removal. This goal for removal applies to influent concentration ranges from 0.1 – 0.5 mg/L total phosphorus.

Task 2
Total phosphorus concentrations and loads will be compared between upstream and downstream of the treated stormwater input location to Lawson Creek. Continuous temperature monitoring data generated for each of the monitoring periods (October 1st, 2010 - March 31st, 2011 and April 1st, 2011 – September 30th, 2011) will be compared (upstream to downstream of the point of entry of stormwater), especially during the warmer months, for influence, if any, on temperature of the receiving water (Lawson Creek).

13.0 References

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Appendix A

Chain-of-Custody Form
Field Data Report Form
Meter Calibration Log Form

Aquatic Research Inc.
3927 Aurora Avenue N, Seattle, WA 98103
P 206.632.2715 | F 206.632.2417

www.aquaticresearchinc.com

SHEET _____ OF _____

CHAIN-OF-CUSTODY RECORD

CLIENT: _____
SAMPLING DATE: _____
SAMPLERS: _____

PROJECT ID: _____
CASE FILE NO.: _____
DATA RECORDED BY: _____

SAMPLE INFORMATION

SAMPLE ID	DATE/TIME COLLECTED	PARAMETERS																			BOTT #	NOTES

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.): _____

3927 Aurora Ave. N | Seattle, WA 98103 | 206.632.2715

TETRA TECH

FIELD DATA REPORT FORM

Y M M D D
0

SURVEY ..... SAMPLER ..... PAGE ..... OF .....

STATION NO.	STATION NAME	TIME	TEMP ºC	DO mg/L	DO #	pH	TRUE pH / METER	COND. µMHOS/CM	REDOX POTENTIAL	*L/M/R	DEPTH (meters)	COMMENTS

WEATHER:

ADDITIONAL COMMENTS:

Tt (Rev. 11/07)

* L = Left Bank; M = Middle Bank; R = Right Bank

Project: _____ Date: _____

Meter Calibration Log Form

Cond Meter# _____ Initial Cell Constant _____ Standard _____ µmhos/cm Meter _____ µmhos/cm

pH Meter # _____ pH Probe # _____

Thermistor # _____ Thermistor _____ °C Thermometer _____ °C Correction _____

DAY 1

Slope _____ 92-102%
mv @ pH 7 _____ ± 30 mv
mv @ pH 4/10 _____ Difference between mv @ pH7 160-180
Response Time _____ < 90 seconds
Time of Day _____

Low Ionic Strength pH Value vs. Temp. °C

	7	**10**
10	7.01	9.27
15	6.99/7.00	9.23
20	6.98	9.19

	true pH	meter	time of day		
QA Check #1	_____	_____	_____	Recalibrated	Y / N
QA Check #2	_____	_____	_____	Recalibrated	Y / N
QA Check #3	_____	_____	_____	Recalibrated	Y / N

If meter pH is not within 0.10 pH units of true value in pH 7 buffer, then recalibrate & re-read sample.

Conductivity Standard _____ µmhos/cm Meter _____ µmhos/cm

DAY 2

Initial Cell Constant _____ Standard _____ µmhos/cm Meter _____ µmhos/cm

Slope _____ 92-102%
mv @ pH 7 _____ ± 30 mv
mv @ pH 4/10 _____ Difference between mv @ pH7 160-180
Response Time _____ < 90 seconds
Time of Day _____

	true pH	meter	time of day		
QA Check #1	_____	_____	_____	Recalibrated	Y / N
QA Check #2	_____	_____	_____	Recalibrated	Y / N
QA Check #3	_____	_____	_____	Recalibrated	Y / N

If meter pH is not within 0.10 pH units of true value in pH 7 buffer, then recalibrate & re-read sample.

Conductivity Standard _____ µmhos/cm Meter _____ µmhos/cm

DAY 3

Initial Cell Constant _____ Standard _____ µmhos/cm Meter _____ µmhos/cm

Slope _____ 92-102%
mv @ pH 7 _____ ± 30 mv
mv @ pH 4/10 _____ Difference between mv @ pH7 160-180
Response Time _____ < 90 seconds
Time of Day _____

	true pH	meter	time of day		
QA Check #1	_____	_____	_____	Recalibrated	Y / N
QA Check #2	_____	_____	_____	Recalibrated	Y / N
QA Check #3	_____	_____	_____	Recalibrated	Y / N

If meter pH is not within 0.10 pH units of true value in pH 7 buffer, then recalibrate & re-read sample.

Conductivity Standard _____ µmhos/cm Meter _____ µmhos/cm